

BOOK OF ABSTRACTS

11th International Conference on Ecological Informatics

(ICEI 2020+1)



INTERNATIONAL CONFERENCE
ON ECOLOGICAL INFORMATICS

09-13 November 2021



Curating a responsible digital world

**C V Raman Laboratory of Ecological Informatics,
School of Informatics, Digital University Kerala,
Thiruvananthapuram**

Book of Abstracts

**11th International Conference on
Ecological Informatics**

(ICEI 2020+1)



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Book of Abstracts

This is a compilation of the original abstracts selected for oral presentation in the 11th International Conference on Ecological Informatics (ICEI 2020+1). The authors are responsible for the contents in the abstracts and the views expressed are theirs. The multi media recordings of presentations in ICEI 2020+1 will be made publicly available. Selected presentation will be brought out in a special issue of Ecological Informatics.

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Thiruvananthapuram, India

ISBN:



Foreword

It is a great privilege to present the Book of Abstracts of the 11th International Conference on Ecological Informatics (ICEI 2020+1). As evident from the conference acronym, the eleventh edition of ICEI was initially planned to be held as a physical event during November 2020 at the Indian Institute of Information Technology and Management- Kerala (IIITM-K). However, due to the global pandemic, it had to be rescheduled as a virtual event from 09-13 November 2021. Meanwhile, the Government of Kerala elevated and transformed IIITM-K as the Kerala University of Digital Sciences Innovation and Technology (Digital University Kerala - DUK).

ICEI 2020+1 presents a virtual-intellectual pedestal to champion the prospects of leveraging the potentials offered by emerging technologies and to position ecological informatics as a travelator to our common, sustainable future. The conference attempts to integrate ecology, technology, and society for transformative changes towards sustainability. It accommodates a diverse array of novel concepts, brilliant ideas and improved techniques for efficient utilization of ecological data and knowledge using the state of the art data collection, computing, and connecting technologies.

The response to the call for papers was good. The submissions are consolidated as oral presentations under special and regular sessions, respectively. While the former is more focused, the latter assimilates an assorted mix of papers. We believe both sessions will be vibrant and inspiring. We have narrowed down from slightly more than 100 submissions to 41 papers in four special sessions and 43 papers in five regular sessions. With the limited globally convenient timewindow available for virtual events, ICEI 2020+1 is tightly packed.

Nine plenary lectures, delivered by renowned scientists across a wide swath of topics, will be the icing on the event. ICEI 2020+1 has something for the youngsters. Two networking sessions and one consolidating session are planned to get to know each other, discuss career prospects, and deliberate upon the rising prospects of ecological informatics.

Hitherto undiscovered possibilities of applying the divergent technological advancements for Ecological studies would have a kaleidoscopic view in ICEI 2020+1. Brought to the table are variegated topics like the role of Machine and Deep Learning in environmental monitoring and protection, essentially a subset of Artificial Intelligence in Ecological studies that is evolving rapidly with

outstanding works in human-wildlife conflicts, acoustic ecology, invasion ecology, earth observation and predicting the spread of plant/animal diseases.

Ecological Data Science using AI/ ML would hoist up contemporary ecological research that attempts to solve complex and challenging issues like the anticipation of environmental threats and the construction of predictive models to evaluate possible risks, causes, and future developments, most prominently climate change prediction. It is instrumental that the transformation from knowledge discovery to applications is facilitated by relevant research and discussions. GIS and Remote Sensing-based, Genome and Phenome-based Monitoring and Data Synthesis, Uncertainty Analysis and Hybrid Modelling are a few resourceful domains in this category.

The need of the hour is for active minds that come together in ICEI 2020 +1 to saddle up and gallop towards realizing Sustainable Development Goals through environmental policy analytics and innovations. The necessary step to make substantial changes that can override temporal constraints in policymaking is harvesting a wide variety of data on biodiversity, demography, soil properties, the spread of epidemics, emission of pollutants and pressing issues of the like that can be analyzed in order to develop a better understanding of its trends and eventually to formulate policies. For instance, Blockchain technology helps in smarter farming by facilitating the use of data-driven technologies. It can track the origin of food and develop reliable food supply chains, thereby building trust between producers and customers. It finds applications in food supply chains and agricultural insurance, and transaction of agricultural products.

With diverse topics nested under three main themes, ICEI 2020+1 spearheads discussions in Ecological Informatics from data to knowledge discovery to applications and SDGs. This conference, at its best, would serve to floodlight research in the cross fields of ecology and technology in India, Asia and across the world. We envision multitudes of promising research to be set in motion in the turf of ideas sown by ICEI 2020+1. We hope ICEI 2020+1 will rekindle the fire of passion in professionals and excite and inspire youngsters into this interdisciplinary domain.

R. Jaishanker

On behalf of the Organizing Committee
Conference Chair

CV Raman Laboratory of Ecological Informatics
School of Informatics
DIGITAL UNIVERSITY KERALA



Thiruvananthapuram, India
09 November 2021



Message

World is in the cusp of a radical change. The exponential development in digital technologies is rapidly defining new contours of a post-industrial world leading to the emergence of a new knowledge economy. As digital, physical and biological world are converging, there are fundamental changes happening in various domains of science, arts, humanities and engineering. The Kerala University of Digital Sciences, Innovation and Technology (popularly known as Digital University Kerala) was formed by Government of Kerala to lead this new revolution by developing talent, conducting in-depth research and develop applications relevant for overall development of the Society. The University, formed by upgrading Indian institute of Information Technology and Management Kerala (IIITM-K), a two-decade year old Centre of excellence in information technology, has several schools focusing on various aspects of digital transformation in science, arts and humanities

The School of Informatics at DUK is focusing on applications of Digital technologies on various functional domains like ecology, agriculture, health, media, sports etc.. With the perception of informatics being a binder that can transform and levitate applied domains, which are increasingly relied upon to address emerging challenges, strong interdisciplinary approach is followed in the design of research and academic programs of the school of informatics. Research at the C V Raman Laboratory of Ecological Informatics of the School of Informatics follow the thematic areas Ecological Physics, Earth observation, Sustainable Development, Traditional Ecological Knowledge, Invasion Ecology, Floral Radiometry and Bioacoustics. I am happy to note that 11th forum of The International Conference of Ecological Informatics (ICEI2020) is organized by School of Informatics in alignment with the larger vision of the University.

It is heartening to note that the International Conference of Ecological Informatics is being hosted for the first time by an Institution from the Indian subcontinent. Given the grave challenges in the biodiversity space due to climate changes and ecological degradation, there is an imminent

need for developing innovative solutions to address issues of sustainability and growth. The topical nature of the conference has attracted over hundred instinctual contributions from researchers across the world and I am sure the conference will provide an enriching experience to all participants. The conference also has special sessions on relevant themes like Get the most out of biodiversity knowledge graphs, Machine and Deep learning in environmental monitoring and protection, Digital science for environment, Understanding and improving earth system predictions with emulator, surrogate, and hybrid modeling, Earth observation and data analytics for ecological monitoring etc., organised by leading universities and institutions from around the globe. We welcome the organizing institutes of special sessions ; Institute for Computer Science, Friedrich Schiller University Jena, Germany, Università di Napoli Parthenope, Italy and Wageningen University and Research, Netherlands, Oak Ridge National Laboratory, USA, Space Applications Centre, ISRO, India to collaborations and networking.

The keynote addresses by eminent scientists Dr Forrest M Hoffman, Prof. Almo Farina, Dr Friedrich Recknagel, Dr V B Mathur, Dr Natrajan Ishwaran, Dr K V Gururaja, Dr Trevor Dhu, Dr V K Dadhrwal on a broad spectrum of topics ranging from ML in Ecology, Ecoacoustics, Earth Observation, Data sciences for environment Ai & Sustainability will provide deeper insights into the challenges and opportunities in this emerging area.

It is with great pride that DUK hosts this forum for transformative future where responsible research and timely action can save and sustain our existence. I wish all the participants an invigorating experience at ICEI 2020+1.



Dr. Saji Gopinath

Vice Chancellor

Kerala University of Digital Sciences,

Innovation and Technology (Digital University Kerala)

Thiruvananthapuram, India

09 November 2021



Message

It is with great pleasure to welcome you to the 11th International Conference on Ecological Informatics hosted by the Kerala University of Digital Sciences, Thiruvananthapuram, India. After having previous conferences in France, Italy, Australia, South Korea, Belgium, USA, Mexico, Brazil, China and Germany, this conference is the first on the Indian subcontinent and the first to be delivered on-line.

The Abstract Book is an impressive display of the current scope of Ecological Informatics as schematically represented in Fig. 1.

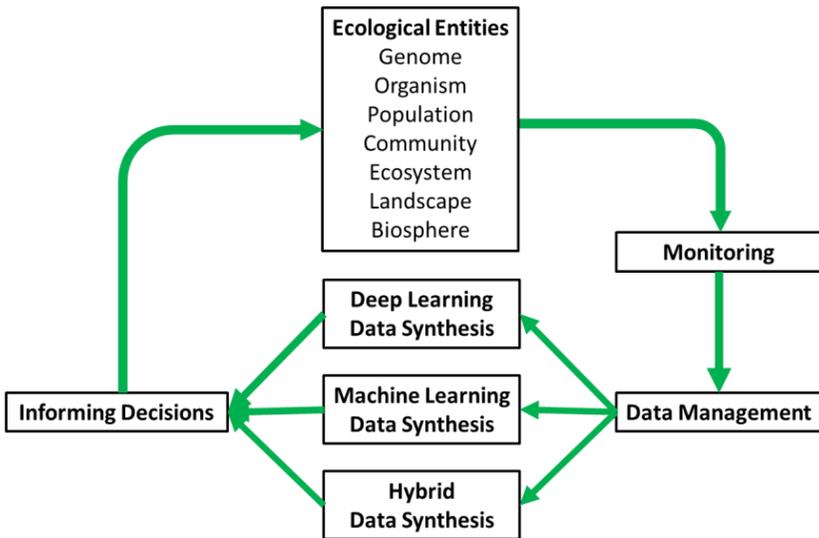


Figure 1: Scope of Ecological Informatics

The conference program of ICEI 2020+1 captures well current trends and challenges of Ecological Informatics towards: regional, continental and global sharing of ecological data; integration of complementary monitoring technologies; sophisticated data synthesis by deep learning, machine learning

and hybrid modelling; and informing decisions for biodiversity conservation and sustainable ecosystem management in light of global changes. The program also reflects India's impressive R&D capacity specifically in the field of computer science.

I herewith wish all delegates an inspiring conference. Adelaide, 3rd November 2021

Friedrich Recknagel

Friedrich Recknagel
University of Adelaide, AUSTRALIA
Editor-in-Chief
Ecological Informatics, Elsevier



Message

I am thrilled to welcome you to the 11th International Conference on Ecological Informatics hosted by the Kerala University of Digital Sciences, Thiruvananthapuram, India. This is the first conference on the Indian subcontinent and the program provides overwhelming evidence of India's unprecedented progress in the fields of ecological informatics and computer science. Consistent with the scope of the journal Ecological Informatics, the program reflects our interdisciplinary focus on a multitude of techniques for image- and genome-based monitoring and interpretation, sensor- and multimedia-based data acquisition, internet- based data archiving and sharing, data assimilation, modelling and prediction of ecological patterns. It is also very exciting to see a wide range of submissions related to machine and deep learning, or Bayesian inference that ultimately aim to shape decisions on environmental issues, like sustainability, climate change, biodiversity, and protection of our precious natural resources.

I congratulate the organizers of ICEI 2020+1 for their efforts to keep the momentum of our community. I am confident that the conference will offer an excellent learning experience and I wish all delegates to enjoy the outstanding scholarship that will be presented this week!

Toronto, November 5 2021

George Arhonditsis

George Arhonditsis

Professor and Chair

Physical and Environmental Sciences University of

Toronto Scarborough Editor-in-Chief Ecological Informatics

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Scientific program committee

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Dr. R Jaishanker

Professor, C V Raman Laboratory of Ecological Informatics, School of Informatics, Digital University Kerala



Mr. Sajeev C Rajan

Researcher (Acoustic Ecology) C V Raman Laboratory of Ecological Informatics, School of Informatics, Digital University Kerala.



Mr. Sooraj N P

Project Scientist (Invasion Biology) C V Raman Laboratory of Ecological Informatics, School of Informatics, Digital University Kerala



Ms. Minu Merin Sabu

Researcher (Acoustic Ecology), CV Raman Laboratory of Ecological Informatics, School of Informatics, Digital University, Kerala



Dr. Athira K

Assistant Professor, CV Raman Laboratory of Ecological Informatics, School of Informatics, Digital University, Kerala



Ms. Anjaly Unnikrishnan

Researcher (Remote Sensing) C V Raman Laboratory of Ecological Informatics, School of Informatics, Digital University, Kerala



Vishnu M

Researcher (Ecological Complexity) C V Raman Laboratory of Ecological Informatics, School of Informatics, Digital University, Kerala



Lijimol Dominic

Senior Research Fellow (Ecological Statistics) C V Raman Laboratory of Ecological Informatics, School of Informatics, Digital University, Kerala



Arjun C P

Researcher (Human animal Interaction, Anthro zoology) C V Raman Laboratory of Ecological Informatics, School of Informatics, Digital University, Kerala

Speakers -Pleanary lectures



Dr. Vinod B Mathur
Chairperson, National Biodiversity Authority, India



Dr. Trevor Dhu,
Asia Lead, Sustainability Science, Microsoft



Dr. Natarajan Ishwaran,
Executive Director, International Relations and Secretariat
Head, Deep Time Digital Earth



Dr. Almo Farina,
Urbino University, Italy



Dr. Friedrich Recknagel,
University of Adelaide, Australia



Dr. V K Dadhwal,
National Institute of Advanced Studies, India



Dr. George Arhonditsis,
University of Toronto Scarborough



Dr. Forrest Hoffman,
Oak Ridge National Laboratory, USA



Dr. K V Gururaja,
Srishti Manipal Institute of Art, Design and Technology, India

PROGRAM SCHEDULE

Conference Outline

Day Time	DAY 1 09 Nov 2021	DAY 2 10 Nov 2021	DAY 3 11 Nov 2021	DAY 4 12 Nov 2021	DAY 5 13 Nov 2021
4.30 – 6.00 PM (IST)	Inaugural session 4.30 – 5.00 PM	Plenary Lecture -2 4.30 – 5.15 PM	Plenary Lecture -4 4.30 – 5.15 PM	Plenary Lecture -6 4.30 – 5.15 PM	Plenary Lecture -8 4.30 – 5.15 PM
	Plenary Lecture -1 5.00– 5.45 PM	Plenary Lecture -3 5.15 – 6.00 PM	Plenary Lecture -5 5.15– 6.00 PM	Plenary Lecture -7 4.30 – 5.15 PM	Plenary Lecture -9 5.15 – 6.00 PM
6.30 – 9.00 PM (IST)	Special Session -I 6.30 – 8.45 PM 09 Presentations D1SS1P01 – D1SS1P09	Special Session-II 6.30 – 9.00 PM 10 Presentations D2SS2P01– D2SS2P10	Special Session-III 6.30 – 8.45 PM 09 Presentations D3SS3P01– D3SS3P09	Special Session-III –(Contd) 6.30 – 8.45 PM 09 Presentations D4SS3P10– D4SS3P18	Special Session-IV 6.30– 7.30 PM 04 Presentations D5SS4P01– D5SS4P04
	Regular Session 6.30 – 8.45 PM 09 Presentations D1RSP01-D1RSP09	Regular Session 6.30 – 9 PM 09 Presentations D2RSP10-D2RSP18	Regular Session 6.30 – 8.30 PM 08 Presentations D3RSP19-D3RSP26	Regular Session 6.30 – 8.45 PM 09 Presentations D4RSP27-D4RSP35	Regular Session 6.30-8.45 PM 09 Presentations D5RSP36-D5RSP44
	Networking Session Young Researchers Meet 7.00 -8.00 PM		Networking Session Young Researchers Meet 7.00 -8.00 PM	Networking Session Young Researchers Meet (Consolidation) 7.00 - 8.00 PM	Valediction 8.45-9.00

Special Session I - Machine and Deep Learning in Environmental Monitoring and Protection

Special Session II - Digital Science for Environment

Special Session III - Earth Observation and Data Analytics for Ecological Monitoring

Special Session IV - Understanding and Improving Earth System Predictions with Emulator, Surrogate, and Hybrid Modeling

Day 1

Tuesday, 09 November 2021

Time: 4.30 PM – 8.45 PM

Indian Standard Time (GMT + 5.30)

Inauguration and Plenary Lecture

4.30 – 5.00 PM	Inaugural session	Virtual room 1
5.00- 5.45 PM	Plenary lecture 1– Dr. V. B. Mathur, Chairperson, National Biodiversity Authority, India	Virtual Room 1

Oral Sessions

Time (pm)	Virtual room 1	Virtual room 2
6.30 -8.45	<p>Special Session I Machine and Deep Learning in Environmental Monitoring and Protection Chair: Dr. Antonino Staiano Università di Napoli Parthenope, Italy Co-Chair: Dr. Ioannis N. Athanasiadis Wageningen University, The Netherlands</p>	<p>Regular Session Chair: Dr. Santanu Ray, Visva Bharati University, India</p>

6.30-6.45	<p>D1SS1P01 Jie Xie Investigation of Imbalance Learning for Animal Sound Classification</p>	<p>D1RSP01 Debanjan Sarkar Predicting the impacts of future Climate Change and range-shifts of the Bucerotidae family in India</p>
6.45-7.00	<p>D1SS1P02 Keshav Bhandari Augmentations to Improve Rare Bird Call Classification for a Highly Imbalanced Multi-Label Soundscape Environment</p>	<p>D1RSP02 Dhavalkumar Varagiya Heavy metal contamination in the mixed feathers of 12 waterbirds species from Porbandar, Gujarat</p>
7.00-7.15	<p>D1SS1P03 Giovanni Scardino Assessing the energetic balance of rocky coastal systems via video monitoring and Convolutional Neural Networks</p>	<p>D1RSP03 Lei Chen A Floating-threshold Acoustic Diversity Index for Rapid Biodiversity Assessment</p>
7.15-7.30	<p>D1SS1P04 Ayushi Kurian Predicting the Current and Future Potential Habitat Distribution of Lantana camara using Machine learning techniques</p>	<p>D1RSP04 Prakasam C Impact Assessment of Hydropower Project on Fish Habitat and Suggesting Environmental Flow as Mitigation Measure</p>
7.30-7.45	<p>D1SS1P05 Kanda Naveen Babu Ecological drivers and spatial prediction of forest-fire in a human-dominated landscape using machine learning techniques</p>	<p>D1RSP05 Félix Michaud Data-driven ecoacoustics: how to improve the quality of training datasets to automatically monitor bird populations</p>

7.45-8.00	D1SS1P06 Rutuja Rajendra Patil Severity Estimation of Rice Diseases using Artificial Intelligence Techniques	D1RSP06 Kristin Vanderbilt The EDI Repository for Environmental Data
8.00-8.15	D1SS1P07 Antonio Morelli Beach Litter Monitoring by Deep Learning Techniques	D1RSP07 Neha Jaiswal Change detection and forest fragmentation analysis in Corbett National Park, Uttarakhand, India: A geospatial approach
8.15-8.30	D1SS1P08 Rutuja Rajendra Patil Comparison of Artificial Intelligence Algorithms in Plant Disease Prediction	D1RSP08 George Arhonditsis Implementation of a watershed modelling framework to support adaptive management in the Canadian side of the Lake Erie basin
8.30-8.45	D1SS1P09 Kriti Rastogi High-Resolution Urban areas extraction from combined optical LISS-IV & Sentinel-1 SAR data using optimized random forest classifier	D1RSP09 Rahul Nigam Satellite Derived Agromet Informatics for Farmers' Advisory Services

7.00 -8.00 PM	Networking Session Young Researchers Meet- Future prospects of Ecological Informatics	Virtual room 3
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Day 2

Wednesday, 10 November 2021

Time: 4.30 PM – 9.00 PM

Indian Standard Time (GMT + 5.30)

Plenary lectures

4.30 – 5.15 PM	Plenary lecture 2 – Dr. Trevor Dhu, Asia Lead, Sustainability Science, Microsoft	Virtual Room 1
5.15 - 6.00 PM	Plenary lecture 3– Dr. Natarajan Ishwaran, Executive Director, International Relations and Secretariat Head, Deep Time Digital Earth	Virtual Room 1

Oral sessions

Time (PM)	Virtual Room 1	Virtual Room 2
6.30 -9.00	<p>Special Session II</p> <p>Digital Science for Environment</p> <p>Chair: Dr. Manoj Kumar T K, Digital University Kerala, India</p> <p>Co-Chair: Mr. Ajith Kumar R & Mr. Radhakrishnan T Digital University Kerala, India</p>	<p>Regular Session</p> <p>Chair: Dr. C Sudhakar Reddy National Remote Sensing Centre (ISRO), India</p>

6.30-6.45

D2SS2P01 Beulah Evelyn Lazarus
Urban CO₂ emissions – a sector-wise climate inventory for Chennai, India (a longitudinal study)

D2RSP10 Ashaq Dar
Ecological drivers facilitating understory vegetation communities in Gurez valley of Kashmir Himalayas: Application of multivariate techniques to analyze indicator species

6.45-7.00

D2SS2P02 Sukanya Ghosh
Google Earth Engine (GEE) for Assessing Vegetation Trend Analysis (2000-2020): A case study of Delhi-NCR

D2RSP11 Anil Prasad V A
Spatial Prediction of Soil Properties/Nutrients of Alappuzha District Using Hybrid Machine Learning Algorithms

7.00-7.15

D2SS2P03 Anoop V S
Blockchain for Sustainable and Resilient Agricultural Supply Chain

D2RSP12 Sam Mathew Saji
Machine Learning Based Spatial Prediction of Soil Properties/Nutrients of Alappuzha District using Dynamic Environmental Covariates

7.15-7.30

D2SS2P04 Gurpreet Singh
Spatiotemporal exploration of dengue and its association with climatic and environmental conditions in Punjab, India

D2RSP13 Lankesh Yashwant Bhaire
Male mating competency in response to its mating status in *Zygogramma bicolorata* Pallister (Coleoptera: Chrysomelidae)

7.30-7.45

D2SS2P05 Sherin D R
Molecular simulations of CRANADs to disclose a specific cyanide sensor in aqueous media

D2RSP14 Rajit Gupta
Machine learning predictive analysis of forest height with spaceborne LiDAR, Optical and SAR

<p>7.45-8.00</p>	<p>D2SS2P06 Girish Gopinath Development of hyperspectral signatures of paddy for improving its productivity at different altitudes and nutrient management practices</p>	<p>D2RSP15 Laxmikant Sharma A Maxent modelling integrated with eco-saline indicators for the Habitat suitability of Flamingos in the Ramsar site (Sambhar Lake, India) using geospatial approach</p>
<p>8.00-8.15</p>	<p>D2SS2P07 Surendran U Soil Discrimination and property estimation using hyperspectral Data in Humid Tropical Regions of Kerala</p>	<p>D2RSP16 Vincy K Wilson Long-term ecological monitoring of tropical evergreen forests in the central Western Ghats, Karnataka</p>
<p>8.15-8.30</p>	<p>D2SS2P08 Devaki Nair Citation Network Analysis of Nanotoxicity Research Articles</p>	<p>D2RSP17 Niket Alashi Using zeta (ζ) diversity for understanding effects of environmental variations on species composition of arboreal frogs in India</p>
<p>8.30-8.45</p>	<p>D2SS2P09 R. Prakash Chandran Tracking the Evolution of Green Chemistry via Citation Network Analysis</p>	<p>D2RSP18 Baijuraj M V Morphometric and mark-recapture study on rescued Indian rock python (<i>Python molurus molurus</i>) in Agra, Uttar Pradesh, India.</p>
<p>8.45-9.00</p>	<p>D2SS2P10 Radhakrishnan T Novel application of the concepts of network science to analyze Geo spatial soil nutrients data</p>	

Day 3

Thursday, 11 November 2021

Time: 4.30 PM – 8.45 PM

Indian Standard Time (GMT + 5.30)

Plenary lectures

4.30 – 5.15 PM	Plenary Lecture 4 – Dr. Almo Farina, Urbino University, Italy	Virtual Room 1
5.15 - 6.00 PM	Plenary lecture 5 – Dr. Friedrich Recknagel, University of Adelaide, Australia	Virtual Room 1

Oral sessions

Time (PM)	Virtual Room 1	Virtual Room 2
6.30 -8.45	<p>Special Session III Earth Observation and Data Analytics for Ecological Monitoring</p> <p>Chair: Dr. Shashikant Sharma, Space Applications Centre, India</p> <p>Co-chair: Dr. Bhattacharya B K Space Applications Centre, India</p>	<p>Regular Session</p> <p>Chair: Dr. Girish Gopinath Centre for Water Resources Development and Management, India</p>

6.30-6.45	<p>D3SS3P01 Harpinder Singh Land degradation mapping of Punjab state using Marco Baldoemote sensing and open source tools.</p>	<p>D3RSP19 Athira K Altitudinal Variability of Floral Color With Special Emphasis on Intraspecific Level</p>
6.45-7.00	<p>D3SS3P02 Marco Baldo Remote Sensing Analysis on Dynamics of Forest Structure: A Western Ghats case study</p>	<p>D3RSP20 Vishnu M Morphological Diversity of Plant Leaf shapes using Fractal Image Analysis</p>
7.00-7.15	<p>D3SS3P03 Ayan Das Opti-SAR Remote Sensing based Sugarcane Yield Modeling through Ensemble Machine Learning at Mill Level Ecosystem</p>	<p>D3RSP21 Sooraj N P Multi-temporal analysis of the land use changes around the Peppara Wildlife Sanctuary, Kerala, associated with plant invasion</p>
7.15-7.30	<p>D3SS3P04 Syed Moosa Ali Mapping bathymetry and bio-optical parameters of Dal Lake using remote sensing measurements</p>	<p>D3RSP22 Anjaly Unnikrishnan Identification of Steady-State Vegetation Condition Patches within a Landscape Using Spatial Data Analytics: A Case Study of Kanha Tiger Reserve, Madhya Pradesh, India</p>
7.30-7.45	<p>D3SS3P05 Arvind Sahay Detection of Tricodesmium blooms in Ocean waters using in-situ and satellite data</p>	<p>D3RSP23 Athira K AI-based Higher-order Chromatic System for Floral Color Representation</p>
7.45-8.00	<p>D3SS3P06 Gonzalo Sotomayor Assessing the streams water quality of the Paute River Basin (Ecuador) using biological traits of benthic macroinvertebrates families</p>	<p>D3RSP24 Ajith Kumar R Adoption of Mobile Apps by Farmers in 5 Agro-ecological Zones in Kerala for Agriculture Information Management – A statistical Model Validation</p>

<p>8.00-8.15</p>	<p>D3SS3P07 Jincy Rachel Mathew Estimating alpine treeline physiognomic traits using terrestrial and space borne LiDAR in parts of Tungnath Himalaya</p>	<p>D3RSP25 Sajeev C Rajan An image based approach for automatic detection of avian species</p>
<p>8.15-8.30</p>	<p>D3SS3P08 Tushar Shukla Analysis and Visualization using ISRO Datacube for BIMSTEC Region</p>	<p>D3RSP26 Arjun C P Footprint Identification Technology to track individual wildlife: An Indian case study with large felids.</p>
<p>8.30-8.45</p>	<p>D3SS3P09 Agradeep Mohanta Potential of Satellite Data in Identifying Water Resources through Plants Species in Dediapada Taluka</p>	

<p>7.00 -8.00 PM</p>	<p>Networking Session Young Researchers Meet- Future prospects of Ecological Informatics</p>	<p>Virtual Room 3</p>
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Day 4

Friday, 12 November 2021

Time: 4.30 PM – 8.45 PM

Indian Standard Time (GMT + 5.30)

Plenary lectures

4.30 – 5.15 PM	Plenary lecture 6– Dr. V K Dadhwal, National Institute of Advanced Studies, India	Virtual Room 1
5.15 - 6.00 PM	Plenary lecture 7– Dr. George Arhonditsis, University of Toronto Scarborough	Virtual Room 1

Oral sessions

Time (PM)	Virtual Room 1	Virtual Room 2
6.30 - 8.45	Special Session III (Contd) Chair: Dr. Shashikant Sharma, Space Application Centre (ISRO), India Co-chair: Dr. Bhattacharya B K Space Application Centre (ISRO), India	Regular Session Chair: Dr. Jaishanker R Digital University Kerala, India Co- chairs: Mr. Sooraj N P & Mr. Sajeev C Rajan Digital University Kerala, India

<p>6.30-6.45</p>	<p>D4SS3P10 Rojalin Tripathy Towards development of gross primary productivity product for agro-ecosystems over India using time-series multi-spectral satellite data</p>	<p>D4RSP27-Mohamed Nisin K M Increasing invasion risk of Snowflake corals during climate change: An ensemble modelling approach</p>
<p>6.45-7.00</p>	<p>D4SS3P11 Alpana Revdandekar The operational role of RS-GIS for delineation of forest land area for its sustainable management</p>	<p>D4RSP28 Reshma B A semi-automatic probabilistic deep learning and feedback based approach for efficient coral segmentation</p>
<p>7.00-7.15</p>	<p>D4SS3P13 Sanobar Mansuri Change Detection of Wetlands of Vadodara City from the year 2013-2020.</p>	<p>D4RSP29 Twinkle Sebastian Dwindling seagrasses: A multi-temporal analysis on Google Earth Engine</p>
<p>7.15-7.30</p>	<p>D4SS3P14 Suman Das Assessment of Change in Coastal Waterbodies with Synthetic Aperture Radar data Using Geo-spatial Techniques</p>	<p>D4RSP30 M. Devika Menon Understanding tropical phenology of the Western Ghats: Combining citizen science and expert based approach</p>
<p>7.30-7.45</p>	<p>D4SS3P15 Amritha K S Inventory of trees and Remote sensing-based estimation of the above-ground biomass in the tropical wet evergreen forest of southern Western Ghats</p>	<p>D4RSP31 Sonia K B Impact of Tree species <i>Senna spectabilis</i> invasion on native flora, phytochemistry of leaf and seed germination rate in Wayanad Wildlife Sanctuary, Kerala</p>

<p>7.45-8.00</p>	<p>D4SS3P16 Akhil Murali Diversity, stand structure and biomass of a tropical wet evergreen forest of southern Western Ghats, india</p>	<p>D4RSP32 Usha Pandya Reconfiguration of Ward into an Eco-ward using spatial Approach: A Case Study of Vadodara</p>
<p>8.00-8.15</p>	<p>D4SS3P17 Muhammed Afsal A Temporal and spatial analysis of mangrove vegetation from selected patches of Western Coast, India</p>	<p>D4RSP33 Kavi Oza Ecological Informatics of selected Plant Taxa form North Gujarat for Sustainable Management</p>
<p>8.15-8.30</p>	<p>D4SS3P18 Anurupa Paul Monitoring Forest Ecological Health Dynamics using Different Spectral Phenological Indices and Sentinel-1A SAR Data: A Case Study in Shivamogga District, Karnataka</p>	<p>D4RSP34 Saba Riyaz Analyzing Groundwater Quality Parameters by Exploratory Data Analysis using R</p>
<p>8.30-8.45</p>	<p>D4SS3P19 Debabrata Behera Integration of Sentinel-1 and Sentinel-2 for the estimation of biomass in a tropical wet evergreen forest</p>	<p>D4RSP35 Shrishti Rajput Ecological informatics in biodiversity studies.</p>

<p>7.00 -8.00 PM</p>	<p>Networking Session Young Researchers Meet- Future prospects of Ecological Informatics (Consolidation)</p>	<p>Virtual Room 3</p>
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Day 5

Saturday, 13 November 2021

Time: 4.30 PM – 9.00 PM

Indian Standard Time (GMT + 5.30)

Plenary lectures

4.30 – 5.15 PM	Plenary Lecture 8- Dr. Forrest Hoffman, Oak Ridge National Laboratory, USA	Virtual Room 1
5.15 - 6.00 PM	Plenary lecture 9 – Dr. K V Gururaja, Srishti Manipal Institute of Art, Design and Technology, India	Virtual Room 1

Oral sessions

Time (PM)	Virtual Room 1	Virtual Room 2
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6.30-6.45	<p>D5SS4P01 Dan Lu (Invited talk) Physics-informed, Interpretable Machine Learning for Improving Terrestrial Ecosystem Predictions</p>	<p>D5RSP36 Amrita Chaurasia Tree diversity and density mapping of Mudumalai Tiger reserve utilising imaging spectroscopy data</p>
6.45-7.00	<p>D5SS4P02 Xin Huang A Model-Independent Data Assimilation (MIDA) module and its applications in ecology</p>	<p>D5RSP37 Amrutha Rajan Establishing a detection framework for the Forest Owllet using Automated Recording Units</p>
7.00-7.15	<p>D5SS4P03 Zheng Shi Soil carbon-climate feedback during 21st century</p>	<p>D5RSP38 Rutuja Rajendra Patil The Role of Internet of Things (IoT) in Plant Disease Detection: A Bibliometric and Word Cloud Analysis</p>
7.15-7.30	<p>D5SS4P04 Xiangzhong Luo Global variation in the fraction of leaf nitrogen allocated to photosynthesis</p>	<p>D5RSP39 Divya Soman Insurance value of an ecosystem function provided by the natural forests in Parambikulam Tiger Reserve, Kerala, India</p>
7.30-7.45		<p>D5RSP40 Roshnath Ramesh Colonization pattern of heronry birds though network analysis</p>
7.45-8.00		<p>D5RSP41 Eunsong Jung Cascading Effects of Global Climate Oscillations on Taxonomic Structure of Phytoplankton in an Asian River</p>

8.00-8.15		D5RSP42 Sumit Kumar Smart fertilizer recommendation system based on IoT
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Special Session 1

**MACHINE AND DEEP LEARNING IN
ENVIRONMENTAL MONITORING AND
PROTECTION**

Beach Litter Monitoring by Deep Learning Techniques

**Antonio Morelli¹, Pietro Aucelli¹, Angelo Casolaro¹, Angela Rizzo²,
Giovanni Scardino², Giovanni Scicchitano², Antonino Staiano^{1*}**

¹ *Dipartimento di Scienze e Tecnologie, Università di Napoli Parthenope, Naples, Italy*

² *Dipartimento di Scienze della Terra e Geomateriali, Università di Bari, Bari, Italy*

antonino.staiano@uniparthenope.it*

ABSTRACT

Anthropogenic debris, mainly composed of plastic materials, in the marine and coastal environments is increasing at a dramatic pace, thus becoming a global environmental issue for the coastal areas. Beach litter is of particular concern because of its high potential impact on coastal systems, human health, society, and the economy. Beach litter may represent a terminal phase of oceanic transport or may represent transient storage, with some deposits washed again to sea following severe storms. In any case, beach litter needs to be accounted for when properly monitoring debris entering the coastal environment. In the very recent years, a few strategies, based on the use of machine learning techniques, have been explored to improve more traditional approaches based on in-situ visual census which are characterized by a not negligible human effort, and being very time-consuming. While the results, from scientific literature, are interesting and encouraging, more sophisticated and powerful approaches need to be adopted to come up with an actual effective and reliable monitoring system for assessing and quantifying beach litter. Here, we present some preliminary results by employing deep learning

techniques, mainly based on recent Convolutional Neural Network models for instance segmentation, able to identify several beach litter classes (e.g., types of litter) by analyzing images extracted from orthophotos acquired by UAV (Unmanned aerial vehicle) at the *Torre Guaceto* nature reserve, located on the Adriatic coast of upper Salento, and at *Torre Canne* area, about 50 Km from Brindisi, both sites located in the Puglia region in southern Italy.

Keywords: Marine and Beach Litter; Coastal Monitoring; Convolutional Neural Networks; Computer Vision; Instance Segmentation

Augmentations to Improve Rare Bird Call Classification for a Highly Imbalanced Multi-Label Soundscape Environment

Keshav Bhandari^{1*}, Akshay Anand¹, Siddharth Biniwale¹, Pravar Mourya¹, Pooja Choksi², Vijay Ramesh²

¹Independent Researcher

²Department of Ecology, Evolution and Environmental Biology, Columbia University
keshavbhandari@gmail.com*

ABSTRACT

Bioacoustic monitoring in conjunction with machine learning can provide ecologists and wildlife conservationists the means to better understand ecological patterns and species-specific behavioral responses to natural and anthropogenic events. Innovations in automated recognition using deep learning range from classification of regionally rare birds to livestock, amphibians, aquatic mammals and bats. However, there remains a large potential to improve the automated classification of multiple avian species in soundscape recordings with no distinction between foreground and background labels. In this study, we present a deep learning solution to classify multiple bird vocalizations in a multi-species soundscape environment without a clear distinction between foreground and background species. Specifically, we test the effectiveness of various data augmentation methods to improve the classification of rare bird calls (<100 training samples) despite facing key challenges typical to a soundscape dataset - multiple overlapping bird calls, high environmental noise and high class imbalance. Our training data, collected from the Western Ghats and central

India, comprises over 80 hours of labeled audio recordings that span 139 bird species. We train our model by fine-tuning a pre-trained computer vision based deep learning architecture that allows us to maximize performance at the cost of reduced training data and time. We employed various raw audio and spectrogram based data augmentation methods such as pitch and time shifting, frequency and time masking, additive white noise, time stretching and audio mixing. Our augmentation methods yielded improvements of 13% in the F1 macro score across all target labels and 13% for 40 rare labels. Notable gains for rare species include the Great hornbill (9%), Flame-throated bulbul (11%), Brown capped pygmy woodpecker (22%) and Nilgiri flycatcher (35%) among several others. Our multi-label soundscape dataset and augmentation methods serve as a benchmark for future research work and can be adopted easily across acoustic domains.

Keywords: Bird call recognition; Automated bioacoustics monitoring; Audio classification; Audio augmentation

Assessing the energetic balance of rocky coastal systems via video monitoring and Convolutional Neural Networks

Giovanni Scardino^{1*}, Teresa Denora¹, Giuseppe Mastronuzz¹,
Arcangelo Piscitelli², Gianfranco Mazza³ and Giovanni Scicchitano¹

¹ *Dipartimento di Scienze della Terra e Geomateriali, Università di Bari, Bari, Italy*

² *Environmental Surveys S.r.l., Spin-off Università di Bari, Taranto, Italy*

³ *Area Marina Protetta del Plemmirio, Siracusa, Italy*

giovanni.scardino@uniba.it*

ABSTRACT

Coastal systems are characterized by energetic and mass balances which influence the physical and biological features on the coasts. Waves, currents, and tides define the energetic balance of the coastal system at different time scales, while marine and continental processes together with biogenic ones determine the sedimentary volumes for the mass balance. Changes in the energetic and mass balances determine different coastal landforms and sedimentary supply on the coasts, with annexed erosion/accretion phenomena. For these reasons, the video monitoring represents an innovative tool for a continuous coastal monitoring. In this work, the surveillance video records of Marine Protected Area of Plemmirio (Siracusa, south-eastern Sicily), were analysed to assess the parameters of energetic balance on the rocky coast. In particular, the video records allowed to obtain a series of continuous frames in which tide phases and wave impact are clearly observable. A convolutional neural network was trained in Matlab environment, developing a training set where it is possible to detect the tide phases, wave

flow, and wave height. Tide phases were assessed through classification and semantic segmentation techniques, while tracking and optical flow techniques were used to assess the wave flow and wave height impacting on the rocky coasts. Neural network results were compared with field data obtained from tide gauge and buoy of Catania. Furthermore, water level and wave height have been estimated through reference points obtained from topographic surveys in the proximity of video locations, so to improve the agreement between network results and field data. The application of convolutional neural networks allowed to automatically obtain a lot of continuous data without direct monitoring by users and its dissemination is a step forward for coastal monitoring.

Keywords: Video Monitoring; Classification; Semantic Segmentation; Tracking; Optical flow

Predicting the Current and Future Potential Habitat Distribution of *Lantana camara* using Machine learning techniques

Kurian Ayushi^{1,2}, Narayanan Ayyappan^{1*}, Kanda Naveen Babu^{1,3}, C. Sudhakar Reddy⁴

¹ Department of Ecology, French Institute of Pondicherry, India

² Manipal Academy of Higher Education, India

³ Department of Ecology and Environmental Sciences, School of Life Sciences, Pondicherry University, India

⁴ Forest Biodiversity and Ecology Division, National Remote Sensing Centre, Indian Space Research Organisation, India
ayyappan.n@ifpindia.org*

ABSTRACT

Lantana camara L., one of the major invasive alien species, affects the native biodiversity directly by occupying suitable niches or indirectly by increasing the fire risk. It has been suggested that climate change may increase the likelihood of invasion via modification of species ranges and invasibility in some regions. This study aims at providing the baseline information on the current distribution status of *L. camara* in Karnataka, India using machine learning techniques (MLTs) by generating Species Distribution Models (SDM), along with its future distribution under climate change. A correlative approach was used to model the distribution of the species while utilizing 521 current occurrence locations of the species. The SDM models are also coupled with 19 bioclimatic variables to investigate its impact on the *Lantana* range. The MLTs viz., artificial neural network (ANN), Boosted Regression Tree (BRT), Classification Tree algorithm (CTA), Generalized

Boosting Model algorithm (GBM), MAXENT and Random Forest (RF) showed a varying level of performances with receiver operating characteristics-area under curve (ROC-AUC). It ranged from 0.758 (CTA) to 1 (RF). The SDM with the maximum accuracy was used for Climate Change projection modelling using two General circulation models/global climate models (GCM) namely GFDL2.1 and MIROC 3 with three global warming scenarios (Representative Concentration Pathways) - RCP 2.6 (low carbon emission), RCP 4.5 (Intermediate emission), RCP 8.5 (High carbon emission) for the year 2050 and 2070. This study reveals that, by 2050, under the maximum carbon emission scenario, the habitat of the species will extend to about 16922 km² with only 21 km² area under no change. It also shows a change in the species fractional extent by 48088.5 km² (RCP 8.6, 2050) and 70590.3 km² (RCP 8.6, 2070). The study also predicts that about 175338 km² have low expansion rate as a result of increase in the precipitation in those areas.

Keywords: Climate change; Invasive species; Machine Learning; Modelling

Severity Estimation of Rice Diseases using Artificial Intelligence Techniques

Rutuja Rajendra Patil¹, Sumit Kumar^{2*}

¹ *Symbiosis International (Deemed University), Symbiosis Institute of Technology, Pune, Maharashtra, India*

² *Symbiosis International (Deemed University), Symbiosis Institute of Technology, Pune, Maharashtra, India*
er.sumitkumar21@gmail.com*

ABSTRACT

Early identification and accurate diagnosis can subdue the spread of diseases and ensure the quality of the crop. The quantification of disease severity for various rice diseases is vital as loss in rice yield ranging from 10% to 60% can occur. As a result, disease symptoms should be detected as soon as possible and should implement appropriate measures at the earliest to prevent the disease from spreading or progressing. The use of disproportionate pesticides to treat rice crop diseases raises the cost and pollutes the environment. Therefore, pesticide use must be reduced. By estimating disease severity, this can be realized by targeting the diseased area with the appropriate amount of pesticide concentration. A Modified Faster R-CNN model is proposed by hyperparameter tuning the CNN model for severity estimation of diseases like Brown spot, Leaf blast, Hispa, and healthy leaves in rice. The dataset used to develop the proposed model comprises 4000 images of rice disease. Training data and test data were composed of different rice plant diseases. Before training, a 90-10% ratio is used to divide the images into training and test sets randomly.

Annotations were done around the disease area. Furthermore, the proposed approach was compared with Mask R-CNN and Faster R-CNN architectures. The modified Faster R-CNN architecture outperformed the modern methods, and the overall classification accuracy of 90.58% is achieved. The newly proposed rice disease grading approach will benefit an integrated management system for rice disease across diverse geographical locations.

Keywords: Faster R-CNN, severity, estimation, rice disease

High-Resolution Urban areas extraction from combined optical LISS-IV & Sentinel-1 SAR data using optimized random forest classifier

Kriti Rastogi^{1*}, Shashikant A. Sharma¹

¹Space Applications Centre, Ahmedabad-380015

kritirastogi@sac.isro.gov.in*

ABSTRACT

Accurate and timely mapping of urban areas are the prerequisite for urban planning and ensuring sustainable development for performing socio-economic activities. With the availability of multi-sensor satellite data, the process of extracting urban areas have become faster and more accurate, which otherwise are not achieved by the use of single sensor. In this study, we propose the combination of high-resolution optical and synthetic aperture radar (SAR) data for extracting urban areas using an improved random forest classifier with optimized hyper parameters. The motivation is to explore the potential of high spatial resolution IRS Resourcesat-2 with LISS IV sensor data along with backscatter images from ascending/descending orbits of Sentinel-1 SAR. The backscatter images of SAR have unique characteristics of double bouncing and corner reflector as identified in urban areas. The textural characteristics of SAR data along with spectral and spatial information from optical data makes the classifier more robust. A systematic method for automatically tune and optimize the hyperparameters called Bayesian parameter optimization is used for the random forest classifier. This results in accurate extraction of urban areas with average accuracy of 95.62% which is significantly higher when compared with the individual sensor data.

Keywords: SAR; Optical; Random forest classifier; hyperparameter optimization

Investigation of Imbalance Learning for Animal Sound Classification

Jie Xie¹, Mingying Zhu² *

¹*School of Internet of Things Engineering, Jiangnan University, Wuxi, PR China*

²*School of Economics, Nanjing University, Nanjing, PR China*

zhumy@nju.edu.cn *

ABSTRACT

Automated classification of calling animal species is useful for large-scale temporal and spatial environmental monitoring. Recent advance in acoustic sensor techniques makes it possible to continuously collect animal sounds in various locations. Meanwhile, the development of machine learning algorithms provides a novel way to automatically analyze the collected sounds. Naturally, different animal species often have different population sizes, which leads to a class imbalance in building an acoustic classification model. However, the sounds of those rare species are difficult to be obtained, but accurate recognition of those species is more important, which poses a challenge for building an animal sound classification system. Most machine learning algorithms do not work very well with imbalanced data. To improve the classification performance of those rare species, in this study, we investigate different imbalance learning methods aiming to improve bioacoustic classification performance. Specifically, we first investigate several standard data resampling methods to balance the animal sounds, where classical machine learning algorithms are then used. In addition, we propose a new data resampling method. First, we use bootstrap sampling to create

an ensemble, where minority samples are oversampled and majority samples are undersampled. Then, an evolutionary algorithm is used to simultaneously optimize both oversampling and undersampling methods. Experimental results on both bird and frog call classification demonstrate the effectiveness of imbalance learning.

Keywords: Bioacoustics classification; Imbalance learning; instance hardness; Multivariate Gaussian Distribution

Ecological drivers and spatial prediction of forest-fire in a human-dominated landscape using machine learning techniques

Kanda Naveen Babu^{1,2}, Rahul Gour¹, Kurian Ayushi^{2,3}, N. Ayyappan² * and N. Parthasarathy¹

¹ Department of Ecology and Environmental Sciences, School of Life Sciences, Pondicherry University, Puducherry – 605014, India

² Department of Ecology, French Institute of Pondicherry, Puducherry – 605001, India

³ Manipal Academy of Higher Education, Manipal – 576104, India
ayyappan.n@ifpindia.org*

ABSTRACT

Fire is considered by many to be the most critical management concern in the ecologically sensitive zones such as the Western Ghats. The recurrent forest fires between December and May are challenging to the forest departments in mitigation. Hence, characterizing and predicting the fire vulnerable areas are of great importance in the protected area management. This study assesses forest-fire susceptibility in Shettihalli Wildlife Sanctuary, a landscape vulnerable to anthropogenic disturbances in the central Western Ghats, India, using widely used machine-learning techniques. In this study, we used distribution modelling to (1) assess the independent contributions of climate, topography, vegetation, and anthropogenic disturbances on fire distributions; (2) provide spatial predictions of habitat susceptibility for fire monitoring and conservation planning. We collated comprehensive data retrieved from NASA's FIRMS database for the years 2012–2020 with the field data collected during 2019–2020. All the five machine-learning

techniques (MLTs) were assessed using an area under the receiver operating characteristic (AUC-ROC) and True skill statistic (TSS) curves for fitting the model. Subsequently, the best-fitting model was chosen for generating a forest-fire susceptibility map. The maximum entropy (MaxEnt) exhibited slightly higher prediction accuracy while validating with the independent test data (AUC-ROC = 0.79; TSS = 0.47) compared to other MLTs. Among the 12 predictor variables considered, normalized differential value index, land-use and land-cover, temperature, vapour pressure, and distance to the settlements positively influenced the higher fire occurrences. The findings reveal that areas with higher rainfall composed of evergreen vegetation are less susceptible to fire. About 26% of the forested landscape is highly susceptible to forest fires and are located mainly around the eastern slopes of the landscape, where deciduous forests are prominent. The generated fire susceptibility map with defined zones at a high spatial resolution (10m) will aid the forest department to undertake necessary preventive measures to mitigate the fire occurrence.

Keywords: Distribution modelling; Geospatial analysis; Land-use and land-cover; Maxent; Western Ghats

Comparison of Artificial Intelligence Algorithms in Plant Disease Prediction

Rutuja Rajendra Patil¹, Sumit Kumar^{2*}

¹ *Symbiosis International (Deemed University), Symbiosis Institute of Technology, Pune, Maharashtra, India*

² *Symbiosis International (Deemed University), Symbiosis Institute of Technology, Pune, Maharashtra, India*
er.sumitkumar21@gmail.com*

ABSTRACT

The occurrence or change in the diseases in a specific area can be predicted in advance with the help of plant disease forecasting model. This helps to undertake suitable management measures to avoid the losses well in advance. Disease forecasting predicts probable outbreaks or increased disease intensity over a period of time in a particular area. This technique helps in timely application of chemicals to plants, which also involve all activities of crop protection and also intimate the farmers in the community via text messages or e-mail etc means of communication. Environment controls the evolution and survival period of various pathogens. Environmental conditions like minimum leaf wetness duration, soil moisture, micro-level relative humidity etc. contribute in evolution of disease causing pathogens. Disease forecasting system thus helps in predicting and avoiding evolution and spread of diseases. This paper uses Machine Learning (ML) and Deep Learning (DL) algorithms to detect, classify and predict the possible pathogens/diseases in the particular type of crop/plant considering based on weather conditions. Temperature, moisture and humidity are the

parameters taken into consideration. Convolution Neural Networks (CNN), Recurrent Neural Network (RNN), Artificial Neural Network (ANN), Support Vector Machines (SVM) and K-Nearest Neighbours (KNN) are the five algorithms implemented and compared based on the obtained output accuracy.

Keywords: Artificial Intelligence; Machine Learning; Deep Learning; Plant disease; Prediction

Special Session 2

**UNDERSTANDING AND IMPROVING EARTH
SYSTEM PREDICTIONS WITH EMULATOR,
SURROGATE, AND HYBRID MODELING**

Soil carbon-climate feedback during 21st century

Zheng Shi¹; Forrest Hoffman¹; Min Xu¹; Umakant Mishra²;
Steven Allison²; James Randerson²

¹ Oak Ridge National Lab, United States

² University of California, Irvine

zshi.grit@gmail.com*

ABSTRACT

The soil carbon-climate feedback has the potential to considerably increase atmospheric CO₂ levels and make it more challenging to stabilize the climate system. The direction and strength of this feedback remain uncertain under changing climate and land use. Here, we explore this feedback in multiple Earth system models of the Coupled Model Intercomparison Projects (CMIP5 and CMIP6). Earth system models predict negative feedback of soil carbon to climate change during the 21st century, on average sequestering 43.9 Pg [95%CI: 9.2 - 78.5 Pg] carbon for the RCP85 or SSP585 scenario. The key variables underlying the spatial variation of soil carbon change varied among models. These variables include net primary productivity (NPP), surface air temperature and initial soil carbon content, and changes in NPP and air temperature. The predicted variation of global total soil carbon change among models showed a weak but significant relationship with change in NPP only. We further evaluated the contributions of model structure and inputs to the predicted change in soil carbon. Model structure accounted for nearly 60% of the variation in projected changes of global soil carbon stock, whereas

changing model inputs accounted for an additional 20%. The residual variance of 20% was explained by the interaction between the two drivers. Our findings highlight the importance of model structure in predicting soil carbon change and have implications for benchmarking Earth system models.

Keywords: Climate change; Carbon cycling; Climate feedback;
Soil carbon sequestration

Global variation in the fraction of leaf nitrogen allocated to photosynthesis

Xiangzhong Luo

National University of Singapore

xzluo.remi@nus.edu.sg*

ABSTRACT

Plants invest a considerable amount of leaf nitrogen in the photosynthetic enzyme ribulose-1,5-bisphosphate carboxylase-oxygenase (RuBisCO), forming a strong coupling of nitrogen and photosynthetic capacity. Variability in the nitrogen-photosynthesis relationship indicates different nitrogen use strategies of plants (i.e., the fraction nitrogen allocated to RuBisCO; fLNR), however, the reason for this remains unclear as widely different nitrogen use strategies are adopted in photosynthesis models. Here, we use a comprehensive database of in-situ observations, a remote sensing product of leaf chlorophyll and ancillary climate and soil data, to examine the global distribution in fLNR using a random forest model. We find global fLNR is $18.2 \pm 6.2\%$, with its variation largely driven by negative dependence on leaf mass per area and positive dependence on leaf phosphorus. Some climate and soil factors (i.e., light, atmospheric dryness, soil pH, and sand) have considerable positive influences on fLNR regionally. This study provides insight into the nitrogen-photosynthesis relationship of plants globally and an improved understanding of the global distribution of photosynthetic potential.

Keywords: Photosynthesis; Machine learning; Nitrogen; Climate change; Earth system models

A Model-Independent Data Assimilation (MIDA) module and its applications in ecology

Xin Huang¹, Yiqi Luo¹

¹Northern Arizona University
xh59@nau.edu*

ABSTRACT

Models are an important tool to predict Earth system dynamics. An accurate prediction of future states of ecosystems depends on not only model structures but also parameterizations. Model parameters can be constrained by data assimilation. However, applications of data assimilation to ecology are restricted by highly technical requirements such as model-dependent coding. To alleviate this technical burden, we developed a model-independent data assimilation (MIDA) module. MIDA works in three steps including data preparation, execution of data assimilation, and visualization. The first step prepares prior ranges of parameter values, a defined number of iterations, and directory paths to access files of observations and models. The execution step calibrates parameter values to best fit the observations and estimates the parameter posterior distributions. The final step automatically visualizes the calibration performance and posterior distributions. MIDA is model independent and modelers can use MIDA for an accurate and efficient data assimilation in a simple and interactive way without modification of their original models. We applied MIDA to four types of ecological models: the data assimilation linked ecosystem carbon (DALEC) model, a surrogate-based energy exascale earth system model: the land component

(ELM), nine phenological models and a stand-alone biome ecological strategy simulator (BiomeE). The applications indicate that MIDA can effectively solve data assimilation problems for different ecological models. Additionally, the easy implementation and model-independent feature of MIDA breaks the technical barrier of applications of data-model fusion in ecology. MIDA facilitates the assimilation of various observations into models for uncertainty reduction in ecological modeling and forecasting.

Keywords: Parameter uncertainty quantification; Data assimilation; Modules; Ecological models

Physics-informed, Interpretable Machine Learning for Improving Terrestrial Ecosystem Predictions

Dan Lu¹, Siyan Liu¹, Daniel Ricciuto¹, Goutam Konapala²,
Scott Painter¹, Shih-Chieh Kao¹

¹*Oak Ridge National Laboratory*

²*NASA Goddard Space Flight Center*

lud1@ornl.gov*

ABSTRACT

Incomplete representations of physical processes often lead to structural errors in process-based hydrological and ecological models and affects terrestrial ecosystem predictions. Machine learning (ML) algorithms, long short-term memory (LSTM) networks in particular, have shown success in hydrological and ecological simulations. However, ML models are purely data-driven and have no explicit process representations, which makes them less generalizable to future hydroclimatic projections where climates and land use patterns can be different from historical training data, and less interpretable to earth scientists for understanding underlying cause-effect mechanisms. In this study, we investigate physics-informed, interpretable ML models for improving terrestrial ecosystem predictions. We developed a hybrid model by integrating process-based model outputs into the LSTM networks. The hybrid model enables physical consistency, enhances spatiotemporal generalizability, and addresses the requirement of large number of training data. Additionally, we developed an interpretable LSTM network. It can not only

capture different dynamics in multi-variable time series and distinguish the contribution of environmental drivers to the prediction, but also interpret the input variables' importance and variable-wise temporal importance. This interpretation helps us understand which environmental drivers are more important to the prediction, and for the important variables whether they have short-term or long-term correlation to the predicted targets (i.e., how is the memory effect). We applied the hybrid model to simulate streamflow in 531 catchments representing diverse conditions across the Conterminous United States. Results indicated that the hybrid model outperformed the standalone process-based and LSTM models, and it provided highest improvement in catchments where process-based models fail completely. Furthermore, we applied the interpretable LSTM model to 29 forest sites in United States and investigated the influence of different environmental drivers such as temperature, precipitation and radiation on net ecosystem exchange. Insights about which input variable has a strong memory can help us guide process-based model development.

Keywords: Machine learning (ML); Physics-informed ML; Interpretable ML; Terrestrial ecosystem prediction

Special Session 3

DIGITAL SCIENCE FOR ENVIRONMENT

Spatiotemporal exploration of dengue and its association with climatic and environmental conditions in Punjab, India

Gurpreet Singh¹, Biju Soman¹, Gagandeep Singh Grover²

¹India Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum

²Department of Health and Family Welfare, Punjab

drgurpreet.md.afmc@gmail.com*

ABSTRACT

Routine data analysis using reproducible open-source algorithms, data linkages, and spatiotemporal models have the potential to develop early warning systems. However, the utilization of routine data for disease forecasting to aid public health decision-making is scarce in low- and middle-income countries. In the present study, we did an exploratory analysis of routine dengue surveillance data (2015-19) from Punjab, India. Further, data linkage with publicly available satellite imagery was performed to understand relationships with climatic and environmental variables. Exploratory spatial, time-series, and spatiotemporal analyses were conducted. Moran's I was calculated to estimate spatial clustering. Weekly, monthly, and seasonal time series datasets were prepared. Time series decomposition, autocorrelation, and cross-correlation analyses were performed. Standardized incidence rates were calculated for spatiotemporal disease mapping. A total of 64,454 lab-confirmed dengue cases were reported, with annual dengue incidence from 33.36 - 52.03 per lakh population. Spatial clustering was statistically significant for multiple timestamps (Moran's I:- Highest: 0.16 ($p = 0.0001$, Oct 2016) ; Lowest:

0.02 ($p = 0.01$, Jun 2015)). Dengue incidence was seasonal, with peaks from September to November. Significant positive autocorrelation for dengue for weekly, monthly, and seasonal time series were at the lag of 1-6 weeks, one month, and four seasons respectively ($p < 0.05$). Significant cross-correlations of monthly dengue incidence were found with minimum temperature (lag 1-5), mean day land surface temperature (lag 3-5), mean night land surface temperature (lag 1-5), relative humidity (lag 1-3), specific humidity (lag 1-4), precipitation (lag 2-4), Dew/frost point (lag 1-4), normalized difference vegetation index (lag 1) and atmospheric pressure (lag 2-5). To conclude, the present study demonstrates the application of spatiotemporal methods to understand dengue patterns and their association with climatic and environmental variables using routine data. The development of forecasting models based on the insights will facilitate optimal use of limited resources and strengthen public health systems to transform reactive into proactive disease control strategies..

Keywords: Dengue; Routine Data; Spatiotemporal; Disease mapping; Climate; Remote sensing

Molecular simulations of CRANADs to disclose a specific cyanide sensor in aqueous media

Sherin D R¹, Manojkumar T K¹

¹ Kerala University of Digital Sciences, Innovation and Technology

sherin.dr@iitmk.ac.in*

ABSTRACT

Chemical pollutants are the major contaminants in natural water samples, can be introduced either through natural processes or as a result of human activities. Some of the ions such as cyanide, lead, mercury, and arsenic are dangerous even at extremely low concentrations. The fatal effects of cyanide ions to the ecosystem has led to extensive research in the advancement of methods for rapid and specific detection of cyanide. We already reported the theoretical and experimental studies on the specific cyanide sensing capacity of curcuminoid-BF₂ complex, CRANAD-1. However, the theoretical investigation on sensing mechanism of these type of CRANADs pointed out the structural features which are capable in generating a better fluorophore for the rapid detection of cyanide in aqueous media even in trace quantities. Herein, we designed a novel selective and efficient fluorescent probe for cyanide detection based on these features. The DFT(Density Functional Theory) approach explore the significance of the probe in quantitative detection of cyanide concentration in natural water samples. Comprehensive examination on the binding energies of the designed CRANADs in presence of various anions such as CN⁻, F⁻, Cl⁻, Br⁻, AcO⁻, SCN⁻ and NO₃⁻ were carried out using B3LYP level of density functional theory using 6-

311++G** as basis set. The λ_{\max} absorption values and NBO (Natural Bond Orbital) analysis reveals the better cyanide sensing of D–A–D (Donor–Acceptor–Donor) system like in CRANADs, which helps in quick charge transfer.

Keywords: Cyanide; CRANAD; Fluoroprobe

Tracking the Evolution of Green Chemistry via Citation Network Analysis

R. Prakash Chandran

¹ *Department of Chemistry, Mannam Memorial NSS College, Kottiyam*
chandranprakash@gmail.com*

ABSTRACT

Rapid industrialization, especially in the chemical sector which commenced in the nineteenth century has led to a massive scale pollution of air, water and land. The growing concern over the dire consequences of chemical pollution has triggered considerable interest among researchers in the past few decades, which has led to the emergence of the new branch of chemistry called Green Chemistry. The work presented in this communication aims at investigating the evolution of the novel concept which has been envisioned to bring about significant reduction in environment pollution.

Keywords: Green Chemistry; Citation Network Analysis; Bibliometrics; Chemical Pollution

Novel application of the concepts of network science to analyze Geo spatial soil nutrients data

Radhakrishnan T¹, Manikantan R Nair², Manoj Kumar T K³,
K Satheesh Kumar¹

¹ Cochin University of Science and Technology, Kochi, Kerala, 682022

²Department of Futures Studies, University of Kerala, Karyavattom, Thiruvananthapuram

³Kerala University of Digital Sciences Innovation and Technology, Thonnakkal, Kerala, 695317
chandranprakash@gmail.com*

ABSTRACT

Rapid industrialization, especially in the chemical sector which commenced in the nineteenth century has led to a massive scale pollution of air, water and land. The growing concern over the dire consequences of chemical pollution has triggered considerable interest among researchers in the past few decades, which has led to the emergence of the new branch of chemistry called Green Chemistry. The work presented in this communication aims at investigating the evolution of the novel concept which has been envisioned to bring about significant reduction in environment pollution.

Keywords: Network analysis; Soil nutrients; Data analysis; Agricultural policy

Blockchain for Sustainable and Resilient Agricultural Supply Chain

Anoop V S^{1*}

¹ Kerala Blockchain Academy, IIITM-K, Thiruvananthapuram, India
anoop.vs@iiitm.ac.in*

ABSTRACT

Blockchain is one of the promising disruptive technologies that is being most celebrated ever since the Internet. Introduced as a back-end infrastructure for the famous cryptocurrency Bitcoin, this technology has gained greater momentum in recent years. The immutability and tamper-proof properties of blockchain make it an ideal technology that can establish trust among various stakeholders of a system. The mathematically verifiable infrastructure of the blockchain platform has the potential to bring in the notion of trust to the infrastructure where it is being conventionally kept with the organizations. This disruptive technology has tremendous potential to change the way organizations do their business and started impacting several domains where multi-party involvements are necessitated. Agriculture is one such sector where this exponential technology can solve several challenges and issues no other technology can find an answer to. The vast, very complex, and mostly the middlemen-controlled ecosystem of agriculture faces diverse concerns primarily with trust and traceability. The current agricultural supply chain is facing several issues that are multifold that include but are not limited to the post-harvest losses, fraud and counterfeit transactions, safety of the food items, traceability of the agricultural products, challenges with agricultural financing, to

name a few. Blockchain technology can be an enabler to reduce the impact of these issues and eliminate the middlemen involved in the processes mentioned. For example, the agricultural producers can be compensated by the insurance for a post-harvest loss through a direct beneficiary transfer which is powered by blockchain. This will reduce the cost, save time, and reduces the chances of fraudulent activities that are faced In the current centralized systems. This paper addresses some of the challenges associated with current agricultural supply chain processes and investigates how blockchain technology can create sustainable and resilient supply chain practices in the agricultural sector.

Keywords: Blockchain; Agriculture; Sustainability; Supply-chain; Innovation

Soil Discrimination and property estimation using hyperspectral Data in Humid Tropical Regions of Kerala

Surendran U^{1*}, Girish Gopinath², Rama Subramanian S³

¹ Centre for Water Resources Development and Management (CWRDM), Kozhikode

² Kerala University of Fisheries and Ocean Studies (KUFOS), Cochin

³ NRSC, National Remote sensing Centre, Bengaluru

suren@cwrmdm.org*

ABSTRACT

Soil is one of the crucial resources for maintaining a sustainable future of Indian agriculture for ensuring food security. More than 121 million agricultural fields across India, needs to be tested and the capacity of the soil testing laboratories far lags behind the requirement. Precise mapping of soil using conventional analysis is laborious and time consuming. Advanced remote sensing techniques such as SWIR spectra can be used to help this challenge by developing soil spectral libraries. Soil spectral library contains spectral signatures of specific soil types that can be linked to a range of soil properties and derive nutrient recommendations. With this background an attempt was made to use these sensing spectroscopy for the development of spectral signature repository of humid tropical soils of Kerala. Soil samples were collected from the grids micro watershed in Palakkad district of Kerala and it was done with the support of Agricultural Department of both the states. Field and lab level spectral signatures were collected using a portable Spectroradiometer with a spectral range of 350-2500 nm (Make: ASD, USA). The collected

spectra were pre-processed using different transformation techniques like smoothing, binning, absorbance, de-trend, continuum removal, Savitzky-Golay derivatives (SGD), standard normal variate (SNV), multiplicative scatter correction (MSC), and normalizations were carried out. Simultaneously soil samples were processed and analyzed for the physico chemical properties using standard procedures in CWRDM laboratory. The lab analyzed values were compared with the spectral data using advanced statistical techniques such as Multiple Linear Regression (MLR), Partial least Squares Regression (PLR), Support Vector Machines (SVM), Random Forest (RF), and Gaussian Process Regression (GPR) for selection of best possible bands to predict the soil properties. With the development of bands for different nutrients of benchmark soils, these spectral libraries can help rapid analysis of thousands of samples in a short time and also to suggest the nutrient recommendations for improving the crop productivity.

Keywords: Hyperspectral data; Spectral library; Chemical Properties; Soil Health

Footprint Identification Technology to track individual wildlife: An Indian case study with large felids

Arjun C P¹, Zoe Jwell², Jaishankar R^{3*}, Jacob Alexander⁴

¹ India Indian Institute of Information Technology and Management-Kerala,
Thiruvananthapuram, India

² WildTracks, United States

³ School of Informatics, Kerala University of Digital Sciences, Innovation and
Technology, Thiruvananthapuram, India

suren@cwrdrm.org*

ABSTRACT

Acquiring reliable data on large carnivores is crucial for effective conservation and conflict management. Tagging and following individuals with a radio collar or GPS tools are the standard approaches. However, the associated costs and invasiveness restrict the use of these techniques at population or landscape levels. Animal-tracks posits as valuable data to be explored. It is possible to monitor wildlife from their footprints. The authors present early results of an Artificial Intelligence-based Indian case study to identify species, age and gender of individual Bengal tigers (*Panthera tigris*) and Indian Leopard (*Panthera pardus*). The combination of traditional wildlife knowledge with emerging technologies opens a new non-invasive vista to understand human-wildlife conflict..

Keywords: Human wildlife conflict; Artificial Intelligence, Information Technology, Felids

Citation Network Analysis of Nanotoxicity Research Articles

Devaki Nair

¹ Delhi University

devakinairb@gmail.com*

ABSTRACT

In recent days many industries are adopting nanotechnology for improving and diversifying their products. As of now, there are no strict regulations concerning the production and disposal of nanoparticles into the environment. Many experts warn that if left unchecked, this could lead to high levels of nano-ecotoxicity in water bodies which may adversely affect the surrounding environment and its inhabitants. Therefore, there is an urgent need to understand the nature and effects of the toxicity caused by nanoparticles in various ecosystems. This study reviews the key research articles published in the field of nano-ecotoxicology till mid-2021, in a systematic way using citation network analysis by identifying main paths. Main path analysis traces the development trajectory of a field of research using citation networks and helps identify the major ideas that have defined the field so far. The Pajek program has been used to create the main path from the large citation network obtained. This study consolidates the important research done in the field of nano-ecotoxicology so far and identifies the evolutionary path of ideas that are formed in the process of its scientific inquiry.

Keywords: Nanoparticles; Nanotoxicity; Environment; Citation Analysis; Review

Urban CO₂e Emissions – A Sector-Wise Climate Inventory for Chennai, India (A Longitudinal Study)

Beulah Evelyn Lazarus¹, Edsley Daniel Robinson²

¹ National Biodiversity Authority, India

² Asian Development Bank, India

evelyn7766@gmail.com*

ABSTRACT

In recent days many industries are adopting nanotechnology for improving and diversifying their products. As of now, there are no strict regulations concerning the production and disposal of nanoparticles into the environment. Many experts warn that if left unchecked, this could lead to high levels of nano-ecotoxicity in water bodies which may adversely affect the surrounding environment and its inhabitants. Therefore, there is an urgent need to understand the nature and effects of the toxicity caused by nanoparticles in various ecosystems. This study reviews the key research articles published in the field of nano-ecotoxicology till mid-2021, in a systematic way using citation network analysis by identifying main paths. Main path analysis traces the development trajectory of a field of research using citation networks and helps identify the major ideas that have defined the field so far. The Pajek program has been used to create the main path from the large citation network obtained. This study consolidates the important research done in the field of nano-ecotoxicology so far and identifies the evolutionary path of ideas that are formed in the process of its scientific inquiry.

Keywords: Climate Change; Climate inventory; Climate

Google Earth Engine (GEE) for Assessing Vegetation Trend Analysis (2000-2020): A case study of Delhi-NCR

¹Sukanya Ghosh, ¹Deepak Kumar, ²Rina Kumari

¹ Amity University Uttar Pradesh

² Central University of Gujarat

sukanyaghosh772@gmail.com*

ABSTRACT

Abstract - Rapidly expanding urbanization in Delhi-NCR caused unprecedented large-scale urban challenges and extensively altered the vegetation status. Enhanced geoprocessing techniques and cloud-based platforms due to their high-performance computing power help monitoring these multifaceted urban challenges. Google Earth Engine (GEE) is a cloud-based platform that is increasingly used to monitor environmental and urban studies on a large scale through a huge collection of big geospatial datasets with exceptional geospatial processing capability. However, the vast potential of GEE in environmental modeling is still less explored. This study aimed to develop a robust classification technique to map the intricacies of multi-temporal vegetation cover and land-use changes of Delhi-NCR. Furthermore, evaluate the performance of algorithms for growth dynamics using vegetation indices. Comparative time-series analysis of remotely sensed vegetation indices like enhanced vegetation index (EVI), normalized vegetation index (NDVI), and standardized vegetation index (SVI) from Moderate Resolution Imaging Spectroradiometer (MODIS) are estimated from 2000 to 2020.

The results showed a decline in the vegetation cover and are later evaluated using indices that signified an enormous difference among the EVI, NDVI, and SVI anomalies in 2000 and 2020 for the same location. The obtained results are validated against google earth observations and the assessment of the results indicated an effective overall accuracy is achieved. Thus, the case study successfully analyzed and monitored the spatial disparities and temporal dynamics of the vegetation growth of Delhi-NCR. It also envisioned that the new analytical workflow and the algorithms applied in this study can be adopted by the ecologists and urban modelers in the near future for instant results and wide applicability in different regions.

Keywords: Google Earth Engine (GEE), Cloud-based platform; Environmental monitoring; Vegetation Indices; Delhi-NCR

Development of hyperspectral signatures of paddy for improving its productivity at different altitudes and nutrient management practices

Girish Gopinath¹, Surendran U²

¹Kerala University of Fisheries and Ocean Studies (KUFOS)

²Centre for Water Resources Development and Management (CWRDM)

gg@cwrdm.org*

ABSTRACT

This paper reports the result of first attempt to study the variation in spectral signature of rice grown at different altitude and nutrient management practices using spectroradiometer in Kerala. The comparative analysis of spectra from the plots of Wayanad and Alappuzha, districts of Kerala at different growth stages elucidates that the variation in type of soil and altitudinal fluctuation affects the growth rate of the rice in a critical manner and this is clearly evident from spectral signatures obtained. The findings from the calculation of 15 indices covering vegetative and water indices were significantly different at various physiological stages. Leaf Area Index for Wayanad was higher than Alappuzha plot (i.e., 1.10, 0.972) at the stage of panicle initiation stage and followed the same pattern up to harvest stage. Spectral signature could be able to understand the water stress and its mechanical processes could be understood with the help of vegetative and water indices and also by way of comparing with relative water content, and membrane leakage. In addition, spectral signatures clearly indicated the water stress observed in rice field. Field experiment

results showed significant difference in spectral reflectance, for method of planting and nutrient management treatments. The spectral signature strongly correlated with the rice yield obtained and the difference in management practices were also captured in a statistically significant way. Regression analysis showed higher correlation between spectral and lab analyzed values for different physiological and nutrient parameters. To conclude, these spectral library and indices can be used to understand the growth stages of the crop, water or nutrient stress and also for predicting yield estimation.

Keywords: Rice; Spectral reflectance; LAI; Nutrient; Chlorophyll; Spectro radiometer

Morphometric and mark-recapture study on rescued Indian rock python (*Python molurus molurus*) in Agra, Uttar Pradesh, India

Baijuraj M V¹, Jaishanker R², Prerna Sharma³, Illayaraja S¹

¹Wildlife SOS, New Delhi

²Digital University Kerala

³Wildlife Institute of India, Dehradun

baiju@wildlifesos.org*

ABSTRACT

Snakes play an important role in our ecosystem. Human-snake interaction is one of the major concerns because of its high frequency and potential threat to humans and snakes. The fast-growing urbanization and industrialization of rural areas have also resulted an increased snake human interaction. Several trained individuals and conservation organizations carry out rescue and release operations scientifically. Records of each operation is maintained meticulously. However, removing a snake from one area and releasing it to another is a topic of concern and research. Wildlife SOS an NGO, along with Uttar Pradesh Forest Department rescues and rehabilitate wild animals including snakes. This study was conducted in and around Agra- Mathura districts during November 2020 - April 2021. One of the objectives of the study was to understand the possibility of site fidelity in rescued Indian rock pythons (*Python molurus molurus*) from the release site by using non-invasive method of mark and recapture. A total of 23 individuals were rescued during this period. The individuals were marked by photographing of their unique blotch patterns.

The individuals were identified using photographs in pattern recognition software HotSpotter followed with manual confirmation. Software algorithm was also used to test the feasibility of identifying a large number of individuals. During the study period, no site fidelity was observed. no marked pythons were re-captured and no road kills were reported. The project is ongoing with an aim to estimate population of python within the sanctuaries and reserve forest. We propose to take this study forward and develop a citizen science project to identify individuals and understand site fidelity of python.

Keywords: Site-fidelity; Python; Mark-recapture; Blotch pattern; Human-snake interaction

Special Session 4

**EARTH OBSERVATION AND DATA
ANALYTICS FOR ECOLOGICAL
MONITORING**

Remote Sensing Analysis on Dynamics of Forest Structure: A Western Ghats case study

Marco Baldo¹, Duccio Rocchini¹, Kurian Ayushi², Narayanan Ayyappan²

¹ *Alma Mater Studiorum - University of Bologna*

² *French Institute of Pondicherry*

marco.baldo2@studio.unibo.it*

ABSTRACT

This research aims to investigate a standardized method to study the dynamics of forest structure and their changes in primary productivity by linking the classic forest fieldwork sampling with satellite vegetation monitoring. The study area is the Central Western Ghats region (CWG) with a focus on the Kadamakal Reserve Forest and Pushpagiri Wildlife Sanctuary (KRFPWS) which harbors a low elevation dipterocarp evergreen forest. The reserve has been subject to selective logging between 1974 and 1983. We performed multiple time series analyses between 1999 and 2020 on the CWG with 1Km spatial resolution satellite products (VITO) of Normalized Difference Vegetation Index (NDVI), Fraction of Absorbed Photosynthetically Active Radiation, and Dry Matter Productivity. We performed an NDVI differential analysis with 10m Sentinel 2-L2A products to assess the forest dynamics of KRFPWS from the 2016-2021 period. All the statistical and graphical analyses have been carried out in the R environment and described in the dedicated algorithm named SVIT. At the 1Km scale, we found a slight increase of all the three analyzed vegetation indices with fluctuations by employing a simple smooth transition autoregressive model on

the raster data medians of our datasets. These fluctuations were majorly due to the climatic variability among the different years. Finer resolution analysis of KRFPWS reveals a growth in the vegetation cover on the top of Pushpagiri mountains and a previously landslide area. The study also found erosion of the reserve's S-W mountainside due to the run-off processes. Satellite data have highlighted generalized positive vegetation trends in the last 22 years in the study area of the CWG, underscoring an improvement in the environmental management of this world biodiversity hotspot, and explains towards achieving the REDD+ targets. Notably, through this work, we also developed a framework to monitor the vegetation remotely during periods of inaccessibility for fieldwork due to pandemics.

Keywords: Biodiversity Hotspot; Multiple Time Series; Primary Productivity; Spatial Data; Vegetation Indices

Opti-SAR Remote Sensing based Sugarcane Yield Modeling through Ensemble Machine Learning at Mill Level Ecosystem

Ayan Das¹, Mukesh Kumar¹, Amit Kushwaha², Bimal Bhattacharya¹

¹ Space Applications Centre- Indian Space Research Organisation

² Anand Agricultural University

marco.baldo2@studio.unibo.it*

ABSTRACT

Field-scale pre-harvest estimate of sugarcane production is required by sugar mills for selling or buying of sugarcane if expected production is more or less than mill's crushable capacity. Optical remote sensing based yield modeling offers an excellent solution for field-scale monitoring and mapping of crop production, though during monsoon, presence of clouds often obscures the effect of increasing biomass on final yield. This study aims at estimating yield of a long duration crop like sugarcane using Sentinel-2 optical and Sentinel-1A/B C-band synthetic aperture radar (SAR) time-series data for two sugar mills each in Gujarat and Maharashtra for two cropping seasons of 2017-18 to 2019-20. Sensitivity of seven optical multispectral vegetation indices vis-à-vis VV, VH and VV/VH polarization combinations from March to September covering the active growing period of sugarcane were tested through several feature selection algorithms. Enhanced Vegetation Index and Water Scalar of May and VH backscatter of September were found to be most sensitive to sugarcane biomass variations. For predicting sugarcane biomass using sensitive parameters, model outputs from five machine learning models such as neuralnet,

bagEarth, gradient boosting machine, cubist and support vector machine were stacked using random forest meta-learner model within an ensemble machine learning framework. Prediction using both optical and SAR data shows better R2 of 0.72 and 0.74 and RMSE of 31% and 26 % than optical or SAR alone in Gujarat and Maharashtra, respectively. In SAR or optical based modeling alone, R2 varied from 0.17 to 0.68 in Gujarat and 0.4 to 0.72 in Maharashtra, respectively. While RMSE varied from 33 to 55 % in Gujarat and 27 to 39% in Maharashtra, in either optical or SAR based modeling, respectively. This study shows the capability of remote sensing based sugarcane yield estimation 1 to 2 months before harvesting.

Keywords: Machine Learning; Opti-SAR; Sugarcane; Crop yield modeling; Satellite

Mapping bathymetry and bio-optical parameters of Dal Lake using remote sensing measurements

Syed Moosa Ali¹, Shabir A. Khanday², Arvind Sahay¹,
Shakil Ahmad Romshoo², Prakash Chauhan³

¹ Space Applications Centre- Indian Space Research Organisation

² University of Kashmir

³ Indian Institute of Remote Sensing, Dehradun

moosa_ali@sac.isro.gov.in*

ABSTRACT

Dal Lake, situated in north east part of Srinagar, is a fresh water lake spread across an area of 25 km². Degradation of water quality parameters of the lake due to anthropogenic activity and climate change is having serious impact on its utility. The biogeochemistry and water quality of the lake is governed by various factors including (but not limited to) influx of nutrients into the lake, organic matter decomposition, growth of phytoplankton, spatial variations in the water depth, etc. Regular monitoring and mapping of these parameters spatially and temporally using remote sensing is very crucial. In this study, bio-optical parameters along with bottom depth of Dal Lake were derived using remote sensing reflectance (Rrs) obtained from LANDSAT-8 OLI sensor. To do that, we first generated a look-up-table (LUT) consisting of ~21000 Rrs spectra for various combinations of three bio-optical parameters namely: chlorophyll-a concentration (Chl-a), absorption by colored dissolved organic matter (CDOM) + detritus (adg (λ)) and backscattering by suspended particulate matter (bbp (λ)),

along with various water depth. We then used spectral matching (SM) technique for estimating the bio-optical parameters by comparing measured $R_{rs}(\lambda)$ (either in-situ or satellite derived) to the LUT spectra and obtaining the closest match. The model was tested on in-situ measured R_{rs} from a field campaign in Dal Lake during November-2014 (total 22 stations). Validation of Chl-a and water depth were made using field measured values and the root-mean-squared-error (RMSE) were found to be 2.13 mg m⁻³ and 1.10 m respectively. It was particularly encouraging to see that the model could explain spatial variability in bio-optical parameters and bottom depth of Dal Lake when applied to LANDAT-8 OLI dataset.

Keywords: Bathymetry; Bio-optical parameter; Chlorophyll; Dal Lake; LANDSAT

Assessing the streams water quality of the Paute River Basin (Ecuador) using biological traits of benthic macroinvertebrates families

Gonzalo Sotomayor¹, Henrietta Hampel², Raúl F. Vázquez²,
Marie Anne Eurie Forio¹,

¹ Ghent University

² Universidad de Cuenca

gonzalo.sotomayor@ugent.be*

ABSTRACT

Generalized Additive Mixed Models (GAMMs), Cluster analysis (CA) and Random Forest (RF) were used to search an adequate functional diversity (FD) metric and significant water quality (WQ) variables in a dataset collected over five years (2008, 2010-2013) in the Paute River Basin (PRB, Ecuador). Macroinvertebrate and 26 physical, chemical, microbiological and hydro-geomorphological variables were collected in 64 sites. Biological traits were allocated as scores to the macroinvertebrates data through fuzzy coding using literature. The GAMMs were used to compare the suitability of six FD indices (dependent variables) as regards transformed 26 WQ parameters (independent variables). The FD based on dendrograms including the species community (wFDc) was the most accurate metric. CA was performed using the wFDc values and PRB sub-basins as categorical variable. A priori to CA, the clusters-number was defining to three (FD levels). RF was used to find the significant WQ parameters that explain the FD variability. RF was performed using the three groups of sites corresponding to the CA output as dependent variable, and the 26 WQ parameters as independent

variables. In cross-validation, 89% of RF yield was observed. After RF validation using GAMMs, the best predictors for the three FD groups were the habitat quality, order river, elevation, slope, water temperature, electric conductivity and dissolved oxygen.

Keywords: Functional diversity; Macroinvertebrates; Water quality

Estimating alpine treeline physiognomic traits using terrestrial and space borne LiDAR in parts of Tungnath Himalaya

Jincy Rachel Mathew¹, C.P. Singh¹, Ritesh Agarwal¹, Hitesh Solanki²,
Sudeep Chandra³, Ankit Singh³, M.C. Nautiyal³

¹ *Space Applications Centre, ISRO, Ahmedabad*

² *Department of Environmental Sciences, Gujarat University, Ahmedabad*

³ *High Altitude Plant physiology Research Centre, Tungnath*

jincyrachelmathew@gmail.com*

ABSTRACT

Accurate measurements of forest's physiognomic-structural parameters are important elements for management, habitat monitoring and essential for development of climate driven forest growth models. Terrestrial Laser Scanning (TLS) and Space based LiDAR sensors can provide three-dimensional data on trees at in-situ and regional level, respectively. The climate sensitive alpine treeline ecotone is defined by treeline tree species, which are having tree height of 3 m and above. The traditional NDVI method, rely on abrupt change on NDVI gradient in order to demarcate the alpine treeline ecotone; however, it lacks the height information. Therefore, the use of LiDAR data offers new potential to delineate the treeline with information on tree height and other biophysical parameters. TLS data offers precise below-crown information using non-destructive methods and it aids in the precise estimation of the physiognomic properties of the ecosystem. The information from TLS data can be combined with large footprints of space borne LiDAR such as GEDI (Global Ecosystem and

Dynamics Investigation) for better understanding of ecosystems functioning with respect to environmental variables (temperature, precipitation, topographic, edaphic conditions and solar radiation). We have characterized vegetation structure using tree height information from GEDI LiDAR data in alpine treeline ecotone of Tungnath Himalaya. The study area is dominated by species *Abies spectabilis* and *Rhododendron campanulatum*. Estimation of tree height varied between 3 and 37 m and mean tree height was found to be 25 ± 7 m. As computed from Cartosat-1 DEM (Digital Elevation Model), the mean elevation was 3268 m in Tungnath treeline position. Furthermore, we demonstrated the potential of TLS to capture forest structure in treeline ecotone, by estimating key parameters (e.g. tree height, plant area index, canopy cover fraction, foliage height diversity etc.) deduced from TLS and GEDI LiDAR data. The ecological informatics generated from this study will benefit ecosystem modelers in long run.

Keywords: Alpine treeline; Physiognomy; Terrestrial Laser Scanning; GEDI

Analysis and Visualization using ISRO Datacube for BIMSTEC Region

Tushar Shukla¹, Indranil Misra¹, Sampa Roy¹, Vivek Sharma¹,
S Manthira Moorthi¹, Debajyoti Dhar¹

¹Indian Space Research Organisation
tushar@sac.isro.gov.in*

ABSTRACT

Recent years have seen an unprecedented increase in the uptake and applications of Earth Observation (EO) satellite data for supporting forefronts of nation's development agendas like crop monitoring, urban and rural infrastructure development, disaster management, weather forecasting, forest preservation, pollution awareness and national security. Apart from scientific use-cases, EO data is also finds major use in augmenting public services. These trends will only increase with the launch of new satellites and ever-growing data volume. The conventional approach of 'scene-based data archival and download' pales in comparison to modern data architectures such as Earth Observation Datacube (EODC), which propose a new methodology by shifting the scenario of data products from scenes to pixels. Due to the data volume challenge, adopting ARD (Analysis Ready Data) strategy and developing our own Datacube architecture will not only help solve current and future demands for societal benefits but also bring ISRO's remote sensing data at-par to international standards of usage by boosting inter-operability among the Resource Monitoring satellites such as IRS-RS2/2A, Landsat etc. CEOS (Committee on Earth Observation Satellites) has taken steps in this direction

by facilitating the development of Open Data Cube (ODC) framework. In this context, ISRO has developed its own datacube platform, Analysis and Visualization using ISRO Datacube (AVID) by integrating metadata standards such as STAC (Spatio-Temporal Asset Catalog) and CEOS's ODC to remove data pre-processing burdens from the users and in turn easing the adoption of data by the user community. AVID provides large set of web-based tools and APIs for data scientists and organizations looking for quick access to curated earth observation datasets. AVID also provides a Python and R compatible platform to users aiming to run their custom scripts for generating data insights. Currently, AVID hosts the ARD for Bangladesh, Nepal, Bhutan and soon will incorporate all BIMSTEC Countries.

Keywords: AVID, BIMSTEC Datacube, ISRO, Open Data Cube (ODC), ARD, STAC, CEOS

Potential of Satellite Data in Identifying Water Resources through Plants Species in Dediapada Taluka

Agradeep Mohanta¹, Sandhya Kiran¹

¹The Maharaja Sayajirao University Baroda
agradeep111@gmail.com*

ABSTRACT

Satellite data is one of the potential tools for identifying groundwater resources and recharge sites for any area. It aids in preparing and distributing groundwater prospects zone maps, which is the need for the country's hour for rural areas. Combining the satellite-derived information with the location of the water indicator species (precisely like *Pongamia pinnata* (L.) Pierre, *Polygonum glabrum* Wild., etc.) would help locate the groundwater areas squarely in rural areas. This study summarises groundwater resources for rural areas with the help of satellite data and groundwater indicating plant species in the area of Dediapada Taluka, Narmada district, Gujarat, India. Extensive fieldwork was conducted to identify the groundwater indicator species, which were then plotted on a hydrogeological map created with spatial data. Co-related values of NDVI and NDWI were generated (0.95). A water potential map is also constructed, which provides information about the water availability in that area.

Further, species distribution maps have been generated using the geospatial approach to identify potential areas of high groundwater resources. A regression model was developed to

determine the groundwater level. (Water level = $1.3079 + 25.2686$ (NDVI) - 12.2120 (NDWI)). This study will be significantly helpful to the rural people to find new groundwater resources for irrigation and household purposes. In a similar general, techniques can be used or applied for mapping and monitoring groundwater resources at a larger scale (e.g. state or national level). It will help in water resource management at large and thus help in sustainable development.

Keywords: Groundwater Level; Water Indicator; Species Satellite Data

Towards development of gross primary productivity product for agro-ecosystems over India using time-series multi-spectral satellite data

Rojalin Tripathy^{1*}, Devansh Desai¹, K N Chaudhari¹,
B. K Bhattacharya¹

¹Space Applications Centre, ISRO, Ahmedabad
rojasoham@gmail.com*

ABSTRACT

Regular monitoring of gross primary productivity (GPP) from agricultural system is vital for indicating crop productivity as well as the net carbon exchange from crop field. This study was carried out to develop a technique for generating GPP product from agricultural system of India using data from multiple satellites. For demonstrating the methodology, we have generated the monthly product for rabi season (October-March) of 2017-18 using input data from INSAT3D, MODIS-TERRA and Land use land cover (LULC) map. Rabi season agricultural classes were extracted from the LULC map and GPP was computed over these area using the Vegetation Photosynthesis Model (VPM) that use radiation use efficiency (RUE), photosynthetically active radiation (PAR), fraction of PAR absorbed by crop (fAPAR), and stress factors as scalars. fAPAR was derived from the NDVI using field derived relationship between NDVI (from Sentinel 2) and the field measured fAPAR. Whole agricultural pixels were divided into four crop classes (C3-cereal, C4- cereal, pulses, others); GPP was computed for each crop group at 500m pixel level. The estimated GPP was validated using the GPP from two

Eddy Covariance (EC) tower data and available GPP product from MODIS. GPP from the EC tower was computed using the net ecosystem exchange and the ecosystem respiration (ER). The correlation coefficient (r) between estimated GPP from satellite data and that computed from EC tower was found to be 0.73 and 0.88 in the two EC tower sites. The comparison with GPP product from MODIS showed good agreement throughout the season except for the last date in most of the 15 sites selected randomly for validation based on the value range of GPP (Pooled $R^2 = 0.79$). This technique can be used to generate the GPP product using data from future Indian geostationary satellite like GISAT.

Keywords: GPP, Agriculture, Multispectral Satellite data, EC tower, VPM

The operational role of RS-GIS for delineation of forest land area for its sustainable management

Alpana Revdandekar^{1*}, Sandhya Garge¹

¹ *The Maharaja Sayajirao University of Baroda*
arevdandekar@gmail.com*

ABSTRACT

Sustainable Development Goal 15 aims to protect, restore and promote sustainably manage forests, and halt biodiversity loss. In this context, globally various policies, methods & mechanisms are adopted to support trees, forests, and forest lands, and thus, their multiple ecological, economic, social, and cultural benefits will be rewarded consecutively. The availability of timely, cost-effective, and comprehensive information on the condition and development trends of these forest areas is a prerequisite for their sustainable management. Remote sensing has always been an essential source of such information and forestry has long benefited from these techniques. In the present research work, remote sensing (RS) and Geographical Information System (GIS) Techniques have been exploited to generate and integrate a large set of databases for learning logical and sustainable management solutions for the Pavagadh forest area. With RS - GIS data, the present approach has aided in generating a model methodology to understand, analyze and design management practices through which this forest area can be handled and managed sustainably. Based on the sustainability criteria, the forest area has been spatially distributed into various categories of sustainability. Total

nineteen areas have been thus, identified and designated as Plots, out of which five have been falling in sustainable, eight under moderately sustainable, while the rest six have been categorized as less sustainable areas. Also, a precise plan, in terms of the changes required in different plots to escalate them to a higher level of sustainability if they are at a lower level or maintain the higher level of sustainability for the posterity, is prepared. Thus, these science-driven solutions can serve as an important tool for knowledge transfer between researchers and forest stakeholders/policymakers/end users.

Keywords: Sustainable management; Forest area; Remote Sensing and Geographical Information System; Database; Criteria

Inventory of trees and Remote sensing-based estimation of the above-ground biomass in the tropical wet evergreen forest of southern Western Ghats

Amritha K S¹, Alan T X¹, Sreejith K A¹, Sreekumar V B^{1*},
Mayamanikandan T², Sudhakar Reddy C²

¹*Department of Forest Ecology, Forest Ecology and Biodiversity Conservation Division,
Kerala Forest Research Institute*

²*Forest Biodiversity and Ecology Division, National Remote Sensing Centre, Indian
Space Research Organisation, Hyderabad*
kalpuzhasreejith@gmail.com*

ABSTRACT

Understanding of biomass and species diversity of biologically rich forests are important in addressing sustainable forest management and to combat climate change. This research aims to map the above-ground biomass in a Tropical wet evergreen forest patch of southern Western Ghats, one of the global hotspot of biodiversity. To determine the diversity and distribution patterns of tree species, inventory in sixty 0.1 hectare plots were conducted, in the tropical evergreen patches of Vazhachal Forest Division, Kerala, India. A total of 2596 trees (above 10cm DBH size class) were enumerated, encompassing 82 species, 58 genera, and 15 families. Hierarchical cluster analysis was performed based on IVI of dominant species and Dendrogram was derived. The analysis indicated thirteen distinct groups. In 7 groups *Palaquium ellipticum*(Dalz.)Baill and in 5 groups *Cullenia exarillata* Robyns were one among the five dominant species. Diameter class-wise distribution showed

an L-shaped curve, a sign of good regeneration status. The global wood density (GWD) database, available at the R project, was used to estimate wood density based on tree species identity. To determine the AGB for each plot BIOMASS, an R package for estimating above-ground biomass and its uncertainty in Tropical forests, was deployed. The AGB was ranged in between 82.38 Mg/ ha and 958.3 Mg/ ha with an average of 381.88 Mg ha⁻¹. *Cullenia exarillata* Robyns., *Palaquium ellipticum* (Dalz.) Baill., and *Mesua ferrea* L. had the highest AGB in the area surveyed. A multiple linear regression model between the reflectance (Sentinel-2) and backscatter (Sentinel-1) with field AGB was used to estimate remote sensing-based AGB. The correlation between NDVI and AGB was performed, which showed a positive correlation. The equation obtained was applied to produce a remote sensing-based AGB map.

Keywords: Above-ground biomass; Tropical wet evergreen forest; Tree species; Diversity remote sensing

Diversity, Stand Structure and Biomass of a Tropical Wet Evergreen Forest of Southern Western Ghats, India

Sreejith K. A¹, Sreekumar V. B¹, Sanil M.S¹, Prejith M. P¹,
Prasad T.S¹, Akhil Murali^{1*}

¹Kerala Forest Research Institute
akhilmurali7100@gmail.com*

ABSTRACT

Tropical forests have long been accepted for their productivity and ecosystem services on account of their high diversity and stand structural attributes. In spite of their significance, tropical forests, and especially those of Asia, remain understudied. Until recently, most forest inventories in Asia have concentrated on trees 10 cm in diameter. Floristic composition, plant species diversity, above ground biomass, basal area and diversity were investigated across different life form and two-diameter classes in a large scale 10-ha plot, in the undisturbed tropical seasonal rain forest of Southern Western Ghats, Kerala, India. Regeneration pattern of the study area was examined by evaluating fisher's alpha and IVI (Important Value Index) across three layer of vegetation (seedling, sapling, and tree). Within the plot, we enumerated 25,390 woody plant species ≥ 1 cm dbh from 45 families, 91 genera, and 106 species. Average plant density was 2539 woody individuals/ha, basal area 47.72 m²/ha, and above-ground biomass 421.77 Mg/ha. Rubiaceae and Sapotaceae and Malvaceae were the most important families by basal area, density and frequency. Small-diameter trees (1 cm \leq dbh \leq 10 cm) comprised 78% of

the total tree population, 20.2% of basal area, and 1.4% of the above-ground biomass. They also had diversity 6% higher at family level, 10% higher at genus level, and 12% higher at species level than trees ≥ 10 cm dbh. Woody individuals of treelets life form and small-diameter classes were much more diverse and dense than the other groups, indicating that results based only on larger canopy trees and larger diameter class may be not an appropriate representation of the diversity status of a particular tropical forest type. Lower density of individuals in initial girth class indicates the vulnerability of the forest system to anthropogenic, natural disturbance and a changing climate. Reduce the minimum diameter limit down to 1 cm, in contrast to 10 cm limit used in most of the evergreen forest inventories, revealed a high density and diversity in the lower stories.

Keywords: Permanent plot; Tropical forest; Diversity; Life form; Regeneration Dynamics

Temporal and spatial analysis of mangrove vegetation from selected patches of Western Coast, India

Muhammed Afsal A^{1*}, Sreejith K A¹,
Narayanaswamy Parthasarathy²

¹Kerala Forest Research Institute

²Pondicherry University

afsalshahid@gmail.com*

ABSTRACT

Mangrove forest is one of the ecologically and economically important ecosystems that thrive in brackish water environment of tropical countries. Worldwide mangrove forest cover was declining due to both natural and anthropogenic causes. The aim of this study is to conduct phytosociological studies and change detection in vegetative health and to estimate and compare above ground biomass of selected mangrove patches of Western Coast, India by using remote sensing and ground-based data. In this study spatial and temporal change of mangrove vegetation for the years of 2013 and 2021 were analyzed and NDVI maps were created using Landsat 8 images. A total of 2479 (trees > 10 cm gbh) enumerated. For the enumeration 200 quadrates of 10x10 m size were laid in the study area. From the quadrat data obtained from the field density, frequency, abundance, IVI (Importance Value Index), and diversity indices were calculated. The aboveground biomass (AGB) at individual and site level were calculated using allometric equation. The species diversity was more in Kerala part as evidenced by 11 species of mangroves from six families but Maharashtra part was represented by only

two species. The AGB of mangrove Kerala ranged from of 1.53 tons/ha to 95.92 tons/ha and Maharashtra ranged from 21.02 tons/ha To 58.3 tons/ha The average biomass for Kerala is 21.02 tons/ha and that of Maharashtra is 32.33 tons/ha. According to the comparison, Maharashtra's AGB is higher than Kerala's. Using NDVI, we discovered a variation in the area of healthy vegetation in different areas of Kerala and Maharashtra. The findings of this study fill in a knowledge deficiency in a large mangrove ecosystem in India, allowing for more accurate and informed management decisions. As a result, as a climate change mitigation tool, it is critical that mangrove ecosystems be restored and maintained.

Keywords: Mangrove 1; above-ground biomass 2; NDVI 3; Importance Value Index 4

Monitoring Forest Ecological Health Dynamics using Different Spectral Phenological Indices and Sentinel-1A SAR Data: A Case Study in Shivamogga District, Karnataka

Anurupa Paul^{1*}, Subhajit Mandal¹, Subhankar Naskar², Saroj Maity³,
Jatisankar Bandyopadhyay¹

¹*Department of Remote Sensing & GIS, Vidyasagar University, Midnapore-721102, W.B*

²*Haryana Space Application Centre (HARSAC), HISAR*

³*Space Applications Centre (SAC), ISRO, Ahmedabad*
anurupapaul2017@gmail.com*

ABSTRACT

The coastal region of India is undergoing rapid land use changes, but little attention is paid to assess the implications of these changes towards rural community. The study area has been selected as Uttara Kannada coastal blocks for its natural beauty of rocky coastal geomorphology and the tropical rainforest environment of Western Sahyadri range which is morphologically diversified with the coastal rocky features, coastal erosional and depositional features in the mid-south western part of Shivamogga district of Uttar Kannada. The forest dynamism plays a significant role in biological cycles and environmental regulations in the present study area. Earth observation data has provided earth system components i.e. ecosystem & biodiversity services, phenology, and natural resources of the worldwide tropical and sub-tropical forest. The present study has been carried out to evaluate the relationship between Sentinel 1 (SAR-C band) backscattering coefficients and the Above Ground Biomass (AGB) of tropical evergreen

forest in the central part of Shivamogga district, Karnataka. Over 90 percent areas of the region are occupied by dense forests of evergreen, semi evergreen, littoral and mangrove vegetations. The estimated biomass is showing very high values for the southeastern-central parts of Hosanagar, Kunchikall Falls, Keladi, Sakrebailu Elephant camp, Shivamogga and Ikkeri areas. The highest biomass is estimated in the central part around Hosanagar & Shivamogga of the tropical evergreen forest is 679 metric ton/hect., and the field-based (10x10 m quadrant) estimated AGB is 21.14 metric ton/hect. in sub-tropical forest, but the least amount of carbon stock is recorded as 9.98 metric ton/hect. in the region. The biomass model is positively correlated in between VV & VH polarization and vegetation biophysical parameters i.e. LAI, GCI, NDVI & EVI were used to reflect the forest health monitoring in the study area. The conservation of the habitats is needed at present with consideration of the habitat assessment approach. The above study reveals that the existence of rich ecological diversity of the study area is the result of the presence of dense tropical evergreen forests, semi-evergreen forests, littoral vegetations with tidal swampy forest along the topographic transect from east to west in the tropical hot and humid environment with maritime influences.

Keywords: Above Ground Biomass (AGB), Backscattering Coefficient, Leaf Area Index (LAI)

Integration of Sentinel-1 and Sentinel-2 for the estimation of biomass in a tropical wet evergreen forest

Debabrata Behera^{1,2}, M. Devika Menon^{1,2}, Vincy K Wilson^{1,3},
Pulakesh Das⁴, N. Ayyappan^{1*}

¹Department of Ecology, French Institute of Pondicherry, Puducherry 605001, India

²Manipal Academy of Higher Education, Manipal 576104, Karnataka, India

³Department of Ecology and Environmental Sciences, Pondicherry University, Puducherry

⁴World Resources Institute, New Delhi 110016, India

ayyappan.n@ifpindia.org*

ABSTRACT

Biomass estimation is an important parameter to assess the functional diversity of a forest and carbon sequestration. The Sentinel-2 Multispectral Imager (MSI) provides surface reflectance data in the visible to shortwave infrared ranges, enables to extract vegetation biophysical parameters. In comparison, the Sentinel-1 C-band synthetic aperture radar (SAR) data allows characterizing plants structural attributes. This study estimated the aboveground biomass (AGB) by integrating Sentinel-1 SAR and Sentinel-2 optical data in a lowland dipterocarp forest in the Western Ghats, India. A permanent plot (size: 300m × 330m: 9.9 ha) was inventoried during April – May 2021, in a wet-evergreen forest, wherein 110 subplots (30m × 30m) were laid, and all trees ≥ 30 cm girth at breast height (GBH) were recorded. The Dipterocarpus indicus, Kingiodendron pinnatum, Humboldtia brunonis have been seen as the dominant species in this region, wherein the GBH value varied between 30 cm to 574 cm with a mean value

of 75.42 cm, whereas the tree density in the surveyed plots varied between 23 to 88 (mean 57 trees/ plot). The species-wise allometric equations were used to calculate AGB, and the estimated values were linked with Sentinel-2 data-derived vegetation indices and Sentinel-1 backscatter coefficients. The random forest (RF) machine learning algorithm was employed for regression analysis, wherein 70% and 30% of the randomly selected samples were used for model development and validation. It was found that the combination of optical and SAR data outperformed the models developed on single variable. The validation results indicated an acceptable accuracy ($R^2=0.58$) with a mean absolute error (MAE) of 12.66 Mg/0.09ha and root mean square error (RMSE) 15.81 Mg/0.09ha. The field observed AGB ranges between 19.53 Mg/0.09ha and 86.73 Mg/0.09ha (mean 49.96 Mg/0.09ha), while the satellite data estimated AGB varies from 36.31 Mg/0.09ha to 73.48 Mg/0.09ha (mean 55.82 Mg/0.09ha). Very high and low AGB are estimated for a few subplots on the ground due to very high and low tree density, respectively. The moderate accuracy could be indicating the limitations due to the lower wavelength of Sentinel-1 C-band (~ 5 cm) data and saturation effect of Sentinel-2 data in assessing the high AGB. More training samples corresponding to very high and low AGB could help to capture the entire range of AGB using satellite data. The study demonstrated the effectiveness of the multi-sensor (Sentinel-1 and Sentinel-2) data merging technique and machine learning models in estimating biomass, which can be extrapolated to assess time-series alteration since 2015/16.

Keywords: Synthetic aperture radar (SAR); Multispectral Imager (MSI); Machine learning; Permanent plot; Western ghats

Land degradation mapping of Punjab state using remote sensing and open source tools

Harpinder Singh^{1*}, Aarti Kochhar¹, P.K. Litoria¹, B.Pateriya¹

¹*Punjab Remote Sensing Centre, Ludhiana*

harpinder13@gmail.com*

ABSTRACT

In the last few decades, the pace of land degradation has increased in Punjab state. The main reasons are the increasing pressure on agriculture, urbanization and extreme weather events. United Nation's, Sustainable Development Goal(SDG) 15.3 strives to achieve a degradation neutral world by 2030. In order to assess the progress to this goal, the SDG 15.3.1 indicator can be calculated. It is the proportion of land area degraded over total land area. This indicator combines three sub-indicators: change in land productivity, change in land cover and change in soil organic carbon. In this research work, SDG 15.3.1 has been calculated over the Punjab state (2000-2018) using the Trends.Earth (<https://trends.earth>) plugin of QGIS (<https://qgis.org>) software. Both software are free and open source. Trends.Earth calculations are based on several remotely sensed data sources, and the processing is done on the cloud-based Google Earth Engine (GEE). The remotely sensed parameters used by the plugin for the calculations are Normalized Difference Vegetation Index (NDVI), soil moisture, precipitation, evapotranspiration, land cover and soil carbon. Punjab state statistics show that degraded land is 5.54% of total land area, land area stable is 14.88%, land area improved is 74.49% while 0.09 % of land is with no data. The results were

in the form of maps and tabular statistics. The analysis was done with default parameters and can be improved by using customized data and settings. Calculation of SDG 15.3.1 indicator for a whole state is a complex geospatial data analysis task as it requires a lot of time, computational and trained human resources. The Trends.Earth plugin with a simple and easy to use graphical user interface(GUI) simplifies the process of land degradation mapping over large study areas.

Keywords: Punjab; Land Degradation; Trends.Earth; SDG 15.3

Detection of Trichodesmium blooms in Ocean waters using in-situ and satellite data

Arvind Sahay^{1*}, Mini Raman¹, Syed Moosa Ali¹, Anurag Gupta¹,
Bimal Kumar Bhattacharya¹

¹Space Applications Centre, Ahmedabad-380015
arvindsahay@sac.isro.gov.in*

ABSTRACT

Algal blooms in oceanic waters are anomalous increase in concentrations of phytoplankton from few cells/milliliter to several hundred thousand cells/milliliter or more. It depends on the availability of nutrients, light field and surrounding environmental factors in the water. Excessive blooms may cause eutrophication and anoxia in the water causing threat to marine lives. Some phytoplankton blooms e.g. Trichodesmium fix atmospheric nitrogen and affecting biogeochemistry of the ocean waters. Here in this study, we have studied the optical properties of Trichodesmium blooms from in-situ data collected during Sagar Sampda cruise (SS-359) in coastal waters of Maharashtra (India) off Arabian Sea in 2017. In this cruise radiance and irradiance spectra have been collected using Satlantic hyperspectral underwater radiometer at bloom stations. From these radiance and irradiance profiles remote sensing reflectance (Rrs) is calculated at these stations. Rrs is then inverted using Quasi Analytical bio-optical model to retrieve phytoplankton absorption coefficients. The high absorption near 560 nm (due to the strong absorption by phycoerythrin pigment) shows the presence of Trichodesmium

blooms present in ocean waters using in-situ data. The same has been implemented on Sentinel-3/OLCI radiance data. High absorption at 560 nm has also been observed in the satellite imagery due to the presence of Trichodesmium blooms.

Keywords: Algal blooms; Trichodesmium; Sentinel/OLCI;
Coastal waters; In-situ

Change Detection of Wetlands of Vadodara City from the year 2013-2020

Sanobar Mansuri¹, G. Sandhya Kiran^{1*}

¹ *The Maharaja Sayajirao University of Baroda*

sandhyakiran60@yahoo.com*

ABSTRACT

Wetlands are a kind of ecosystem saturated by water on a regular or seasonal basis and where the oxygen-free process predominates. Wetlands are abundant in India, and they are essential to the people both economically and culturally. For different reasons, the majority of the Indian population is reliant on the wetlands. Even in ancient times, the existence of wetlands was essential for the establishment of human civilization. Despite their significance, wetlands are being degraded due to population growth, urbanization, and climate change. Many studies have been conducted in order to protect wetlands and their ecosystems over the last few decades. The Ramsar Convention is a treaty created to protect wetlands all over the world. Using LANDSAT 8 data and ArcGIS and ENVI software, this paper examines the shift in the area of the wetlands of Vadodara city over a period of seven years, from 2013 to 2020. As assumed a significant decrease was noted in certain wetlands with a parallel increase in certain wetlands. Though a distinct decrease was observed in the year 2013-2015 due to several factors like population growth and urbanization, and climate change, but the ameliority activity carried out by the VMC Vadodara has brought out ground importance of wetlands and exhibited in increase in the same. Such information proves to be relevant for the ecological management of wetlands in the urban areas.

Keywords: Remote sensing; Wetlands; Vadodara city; Change detection; LANDSAT 8

Assessment of Change in Coastal Waterbodies with Synthetic Aperture Radar Data Using Geospatial Techniques

Suman Das^{1*}, Nirupam Acharyya⁺, Lal Mohammad²,
Joydeb Sardar², Jatisankar Bandyopadhyay¹, Saroj Maity³

¹*Dept. of Remote Sensing and GIS, Vidyasagar University*

²*Centre for Environmental Studies, Vidyasagar University*

³*Space Applications Centre (SAC), ISRO, Ahmedabad*

vu.sumandas@gmail.com*

ABSTRACT

Purba Medinipur district and Sundarbans region of West Bengal is blessed with the significance of water resources in the form of a large number of river systems, ponds, floodplains, and wetlands. Aquaculture in the coastal areas is one of the most rapid-growing economic and nutrient sources of the growing population. In this study, we delineate the waterbodies using multi-temporal C band dual-polarized (VV+VH) Synthetic-Aperture Radar (SAR) Sentinel-1A data to analyze the YAAS cyclone effect (May, 2021) and seasonal variation in the year of 2015 and 2020. The binarization technique is applied to extract the water bodies and also inundation part over the study area. Backscatter coefficient values of inundated parts during cyclone time varied from -12 dB to -17 dB, whereas -10 dB to -15 dB is observed during normal time. The result shows that the area of water bodies were changed 3.87 Sq. Km to 4.62 Sq. Km in G Plot, 1.33 Sq. Km to 4.77 Sq. Km in L Block of Sundarban and 17.16 Sq. Km to 66.3 Sq. Km in the part of Purba Medinipur district respectively in pre and post YAAS

Cyclone. It is observed that the water bodies are increased due to more submergence during monsoon season and YAAS cyclone time. The physicochemical parameter of the different water bodies throughout the study area is also measured to analyze the suitable water conditions for aquaculture. The study demonstrates that SAR is capable of mapping and area estimation of coastal water bodies at the time of natural disasters.

Keywords: Aquaculture; Synthetic Aperture Radar; YAAS Cyclone; Backscatter coefficient

REGULAR SESSION

Assessing the habitat suitability of near threatened *Gluta travancorica* Bedd. in Agasthyamala Biosphere Reserve using MaxEnt model

L H Namitha^{1*}, Achu A L², Suhara Beevy S¹

¹Department of Botany, , University of Kerala, Thiruvananthapuram-695 581, Kerala, India

²Department of Remote Sensing and GIS, Kerala University of Fisheries and Ocean Studies (KUFOS), Kochi-682 508, Kerala, India.

namithahelen@gmail.com*

ABSTRACT

Gluta travancorica Bedd. ('Chenkurinji') is an evergreen, narrowly endemic tree native to the Southern Western Ghats. The tree is in the Near Threatened category according to IUCN Red List database and has been constantly under threat since the British colonial era. The present study aims to identify the potential habitat suitability of *Gluta travancorica* in the Agasthyamala Biosphere Reserve. An extensive field survey was conducted and 509 species occurrences were identified and thereafter the dataset was randomly divided into 70% for model training and remaining 30% for model testing. Thirty habitat suitability influencing factors were collected, among which 19 Bioclimatic variables were computed using observed data from Indian meteorological department, soil properties such as soil cation exchange capacity (CEC), total nitrogen, soil pH, sand, silt and clay content and soil organic carbon were collected from SoilGrid database, and parameters such as distance to road, distance to streams, elevation and slope were generated from different data sources. In order to eliminate the highly

correlated variables, multicollinearity analysis was carried out and subsequently eight variables such as B3, B11, soil pH, clay, silt, CEC, distance from the stream and slope angle were used for modelling. In this study, Maximum Entropy (MaxEnt) model was implemented to model habitat suitability. The predicted models were validated using receiver operating characteristics curve and area under curve values (ROC-AUC), Kappa index, Sensitivity, specificity and True Skill Statistic (ie., 0.827, 0.542, 0.619, 0.923, 0.542 respectively). The study shows that MaxEnt model is capable of producing distribution maps with acceptable accuracy. The predictive MaxEnt modeling approach for mapping this specific tree species gave positive result and will help significantly in drawing suitable conservation plans.

Keywords: *Gluta travancorica*; SDM; MaxEnt; Agasthyamala Biosphere; Conservation

Change detection and forest fragmentation analysis in Corbett National Park, Uttarakhand, India: A geospatial approach

Neha jaiswal¹, S. Jayakumar^{1*}

¹ *Ecology and Environmental science, school of Life Sciences, Pondicherry University, Kalapet-605014.*

s.jkumar1@gmail.com*

ABSTRACT

Corbett National park is the first national park in India that possesses great importance in terms of biodiversity and hold rich flora and fauna. For better conservation of the vegetation of CNP and to maintain its biodiversity, the current status of the forest and better planning for the future is a prerequisite. With this, the aim of the study includes the current trends as well as future projections in CNP using the geospatial technique.

The present study tends to investigate the land use land cover changes along with the change detection and fragmentation analysis within the park from 1999 to 2019 using Landsat imageries. The changes were verified by interviews with some local people and forest staff. In addition, the study also explains the future projection using the MOLLUSCS plugin in QGIS software over two decades (1999 and 2019). The result revealed the 5 major types of land classes that have been converted or fragmented into other land classes over the 20 years of the time period. It was observed in the study that there is a negative change in the class of open forest from 1999 to 2019. Whereas, the core area by means the dense forest is intact, remain constant and safe from human encroachments as well other activities.

Keywords: Decadal change; Land use land cover; Forest: Biodiversity; Projections

Implementation of a watershed modelling framework to support adaptive management in the Canadian side of the Lake Erie basin

George Arhonditsis^{1*}

¹ *University of Toronto*
george.arhonditsis@utoronto.ca*

ABSTRACT

The present study aims to provide guidelines with respect to the implementation of a watershed modelling framework that can support adaptive management in the Canadian side of the Lake Erie basin. Our primary objective is to highlight the establishment of a multimodel ensemble as an appealing strategy that can address a wide range of conceptual and operational uncertainties typically underlying any modelling exercise. We identify three ensemble strategies that have different implications for the granularity of the analysis, empirical knowledge and data input demands to constrain the individual models, and required timeframe to operationalize them. The first option partly resembles the watershed modelling work in the Maumee River watershed, where the characterization of the watershed attributes and functioning that modulate nutrient loading will be based on multiple independent SWAT applications with different process characterizations. Before implementing SWAT, we propose the use of SPARROW—a data-driven model—to delineate hot-spots, examine landscape predictors for nutrient mobilization and retention, and use these results to inform the SWAT models. Alongside the SPARROW

and SWAT applications, the second option considers two additional models (HYPE, HSPF) that are conceptually sound, have been applied in the area, and can increase the structural and functional diversity of the ensemble of catchment models by offering alternative representations of fundamental processes/functions associated with the water cycle, soil erosion, biogeochemical cycles, and soil-plant interactions. The third option introduces local (farm, urban or natural vegetation) and edge-of-field monitoring and modelling (EPIC or APEX tools) to refine the spatial resolution and design in-field conservation practices that mitigate nonpoint source pollution from agriculture and other sources. In addition, we pinpoint data monitoring needs to elucidate critical unknowns of the watershed functioning, such as the role of legacy phosphorus (P), the causes and consequences of the increasing long-term trends in dissolved reactive P loading, the challenges in reproducing spring-freshet or event-flow conditions, and the dynamic characterization of water/nutrient cycles under the non-stationarity of a changing climate. We believe that the lessons learned from the present critical review can be useful for the on-going modelling practices and governance framework to support environmental policy decisions and catalyze an open rapport among researchers, resource managers, and the broad spectrum of stakeholders involved with the management of Lake Erie.

Keywords: Best management practices; Multimodel ensemble; Uncertainty analysis; Adaptive management implementation; Lake Erie; Edge-of-field data

Machine learning predictive analysis of forest height with spaceborne LiDAR, Optical and SAR

Rajit Gupta¹, Laxmikant Sharma^{1*}

¹ Central University Of Rajasthan

laxmikant_ews@curaj.ac.in*

ABSTRACT

Gaining knowledge on forests and dynamics is crucial in terms of understanding the global carbon budget. Forests are to be critically investigated using advanced approaches and remote sensing. Many advancements could be effectively helpful in the estimation of forest variables and management. Light detection and ranging (LiDAR) illustrate the vertical forest structure; therefore, a crucial tool in forests applications. The high cost of airborne and terrestrial LiDAR causes limited use of LiDAR. However, spaceborne LiDAR provides a cost-effective help in the understanding of forest dynamics and Carbon mapping. Machine learning (ML) is one of the best predictive methods that provide accurate forest attributes estimates. Many studies attempted to use different ML algorithms on remote sensing datasets. It is important to obtain a good set of data as input in various ML algorithms. ICESat -2 (Ice, Cloud, and land Elevation Satellite) provides critical and continuous Earth observations. Variables derived from ICESat-2 data, including canopy height (ATL08 height product) and canopy structure, help estimate above-ground biomass. ATL08 product is produced based on the classified photons over the vegetation recorded by the ICESat-2 with a spatial resolution (100 m). Various ML algorithms

include Random Forest (RF), Artificial neural network (ANN), Support Vector Regression (SVM), and k-nearest neighbor (k-NN), demonstrated the ability for prediction of spatially explicit forest height mapping. We used a height product from ICESat-2 for Shoolpaneshwar wildlife sanctuary, India, as training data inputs, then used various predictors variables from optical and SAR data. Finally, accuracy, validation from independent datasets, and predictive analysis were performed to estimate forest structural attributes, including height mapping. A preliminary evaluation revealed that using ML RF on ICESat-2 data with optical and SAR data is beneficial in forest attributes and inventory generation, which could play a role in forest management.

Keywords: Machine learning; ICESat-2; Canopy Height; SAR; Optical

Long-term ecological monitoring of tropical evergreen forests in the central Western Ghats, Karnataka

Vincy K. Wilson^{1,2}, N. Ayyappan^{1*}, N. Parthasarathy²

¹*Department of Ecology, French Institute of Pondicherry, Puducherry - 605001, India*

²*Department of Ecology and Environmental Sciences, School of Life Sciences, Pondicherry University, Puducherry – 605014, India*

ayyappan.n@ifpindia.org*

ABSTRACT

Long-term monitoring of natural ecosystems is necessary for the management of biodiversity and sustenance of human life on the Earth. In particular, such observations are intended to understand the ecological processes and to identify the impacts of anthropogenic and climatic drivers on ecosystem functions. Hence the present study was undertaken to assess temporal changes in tree diversity, biomass and forest structure of logged and unlogged forests at Uppangala, situated in the descending region of the south Malanad of Karnataka plateau in the Western Ghats. Six 1ha permanent plots, one was established in 1990 in an unlogged forest and 5 other plots (four in logged and one in unlogged) were established in 2010 in order to understand forest dynamics of both natural and anthropogenic. In this study, we analyzed the datasets of the initial census and the recent 2021 census. The recensus yielded 128 species of 41 families with 2 new additions. The number of species increased in each plot, in a range of 1-5 species. Five plots showed higher mortality than the recruitment except one plot wherein recruitment was slightly higher than the mortality.

Individual tree growths pattern was found to be inconsistent between logged and unlogged plots. Similarly, biomass was always higher in unlogged plots than the logged plots across the study period. The increase in biomass was consistent among all the logged plots, which are mostly contributed by the medium storey and canopy trees. One of the unlogged plots monitored since 1990 showed an increasing trend in biomass except the last decade due to the mortality of voluminous canopy trees. In the logged plots, we found a higher proportion of recruitment in primary species compared to the secondary indicating recovery of forest to similar to that of the unlogged forest. The study concludes that logged forest requires more recovery time to become similar to that of the unlogged forest.

Keywords: Biomass; Forest dynamics; Logged and unlogged forest; Permanent plots; Trees

Understanding tropical phenology of the Western Ghats: Combining citizen science and expert based approach

M.Devika Menon^{1,2}, Debabrata Behera^{1,2}, S. Aravajy¹, N. Ayyappan^{1*}

¹Department of Ecology, French Institute of Pondicherry, Puducherry - 605001, India

²Manipal Academy of Higher Education, Manipal 576104, Karnataka, India

ayyappan.n@ifpindia.org*

ABSTRACT

Phenology is the study of seasonality in the expression of biological events in an organisms' lifespan. Such events are highly coupled to its environment and any change in environment can affect the fecundity of species. Traditionally, phenological assessment of species involves direct observation of phenophases (viz., leaf flushing, senescence, budding, flowering and fruiting) at regular intervals on several individuals of one or more species. In recent times, there are amateurs or citizen scientists who like to help out in fieldwork directly as volunteers or contributing to data by sharing images of species with geo coordinates through social media or in dedicated biodiversity portals like the Indian Biodiversity Portal (IBP). Increasingly, citizen science-based approaches have proven to greatly contribute to scientific knowledge. This study aims to shed light on the trade-offs of citizen science based and expert approaches in generating data on assessing the phenology of tropical evergreen tree species from the Western Ghats region. The combined data includes 796 individuals representing 57 species from IBP (data chosen by the filter option of the

presence of fruits and flowers on shared images) and 650 individuals (86 species) from long term monitoring plots in the Kadamakal forest reserve and Pushpagiri Wildlife Sanctuary, Western Ghats. Citizen science provided macro-level data on species with varying temporal (1997- till date) and spatial scales covering the entire Western Ghats hotspot with information such as the presence and absence of their reproductive states. We found that the data is incomplete, requiring curation to make a remarkable contribution to research. Such data has immense potential to understand the phenological expression of a relatively larger area by integrating climate information. On the other hand, data acquired by experts is usually collected from a single geographical site and provides detailed and accurate micro-level information on phenophases of species. But such an approach involves very few participants and is very time consuming and tedious. Gaining an understanding of the pros and cons of these methods of data collection can help in improving methodologies adopted for data acquisition and to generate models combining datasets to decipher the trends in expression of phenophases with reference to climate, and to formulate strategies for conservation of species and forests.

Keywords: Indian biodiversity portal; Phenophases; Tree; Tropical evergreen forest; Western Ghats

Cascading Effects of Global Climate Oscillations on Taxonomic Structure of Phytoplankton in an Asian River

Eunsong Jung¹, Gea-Jae Joo¹, Kwang-Seuk Jeong^{2*}

¹*Pusan National University, Busan, Republic of Korea*

²*Dongju College, Busan, Republic of Korea*

kjeong@gsdongju.ac.kr*

ABSTRACT

Understanding patterns of climate change provides not only important clues in identifying long-term ecological changes but also opportunity to develop relevant management strategies for the ecosystem. In aquatic ecosystems, phytoplankton dynamics attract particular interests in relation with climate variations. However, there is knowledge gap of intermediate routes of the linkage between the climate oscillation and phytoplankton. Furthermore, at the organizational level there is a missing link. In this study, we have examined long-term changes in phytoplankton in relation to five global climate oscillations teleconnected to North East Asian region. We used the non-stationary time-frequency analysis (Ensemble Empirical Mode Decomposition and Wavelet Analysis) on time series from 1993 to 2016 in the Nakdong River. Then we synthesized the similarities and phase differences between time series into cascades of climate-meteorology-hydrochemistry-phytoplankton. These pathways have changed their mediating elements (for example, precipitation or air temperature for the meteorology step) during the study period. We identified an increasing trend in the time scales of phytoplankton response against the climate

oscillations when the taxonomic rank became lower from phylum to genus. Ecological mechanisms relating the phytoplankton dynamics to the climate oscillations were also discussed.

Keywords: Wavelet analysis; Climate oscillation; Phytoplankton; Taxonomic ranks

The EDI Repository for Environmental Data

**Kristin Vanderbilt^{1*}, Corinna Gries², Susanne Grossman-Clarke²,
Paul Hanson², Jon Ide², Margaret O'Brien³, Mark Servilla¹, Colin
Smith², Robert Waide¹, Kyle Zollo-Venecek²**

¹*University of New Mexico, Albuquerque, NM 87123 USA*

²*University of Wisconsin-Madison, Madison, WI 53706 USA*

³*University of California-Santa Barbara, Santa Barbara, CA 93106 USA*

krvander@fiu.edu*

ABSTRACT

With the research community's increasing emphasis on reproducible science and data synthesis, scientists are often required by funders and journal publishers to archive their data in a data repository. The US National Science Foundation's-funded Environmental Data Initiative (EDI) operates a data repository that has become popular with ecologists and environmental scientists because of the quality of the services and infrastructure it provides. Archiving a dataset with EDI is simple. EDI offers a user-friendly, web-based metadata editor, called ezEML, that uses a wizard to lead scientists through the process of entering metadata. Once a data package is submitted to EDI, a data curator shepherds the data through a staging environment, where the data creator can review their submission, and into the production environment. EDI staff respond promptly to questions submitted by email or the EDI slack channel.

EDI exemplifies a repository that adheres to the FAIR principles. The EDI repository is built on the robust and secure PASTA+ architecture, ensuring the long-term findability and

access to the data it houses. Detailed metadata to accompany data submissions are required, and EDI checks data and metadata congruence before publishing a dataset. Congruence between metadata and data facilitates data access and readability via the repository's API. Rich metadata help ensure that a secondary data user will be able to understand the data well enough to reuse it. To support interoperability of EDI data, EDI (in a partnership with the US National Ecological Observing Network (NEON)), has developed and implemented a design pattern with which to transform community ecology data into a harmonized format.

Keywords: Data repository; FAIR; Data curation; Environmental science

Satellite Derived Agromet Informatics for Farmers' Advisory Services

Rahul Nigam^{1*}, Bimal K Bhattacharya¹, Shashikant Sharma¹

¹*Earth Ocean Atmosphere Planetary Sciences and Applications Area (EPSA)
Space Applications Centre (ISRO) Ahmedabad 380015
rahul.agmet@gmail.com**

ABSTRACT

For sustainable growth of agriculture and to safeguard our natural resources there is a need to optimize the usage of farm resources to minimize the cost of production and crop loss. The anomalous behavior of weather poses various threat for agriculture community. In the past, an economic impact assessment showed that the agromet advisories issued from India Meteorological Department (IMD) through present framework could reduce 5-10% cost of farming operations (Rathore and Maini, 2008) and increase in crop yield varying from 10-25%. The present advisory network of IMD is highly dependent on point measurements of agromet parameters at 137 Agro-Met Field Units (AMFUs) and meso-scale forecast at block level. The point measurements having limitation for (i) large-area monitoring and (ii) to capture variability across a district. To target the block specific advisory to assist farm operations we need better representation of the agromet parameters at spatial scale. In this regard, the regular generated agromet products from polar and geostationary satellites can be used. To initiate the fusion of satellite based daily agromet products in Gramin Krishi Mausam Seva (GKMS) of IMD, Space Applications Centre is providing biweekly block level

agromet products to six AFMU's covering 672 blocks of 98 districts. At present Normalized Difference Vegetation Index (NDVI) from OCM-2 (360m), Potential Evapotranspiration (PET), Surface Aridity Index (SAI), Land Surface Temperature (LST) from INSAT 3D (4000m) and Surface Soil Moisture (SSM), from SMAP (9000m) are provided to AFMUs through a dedicated web link from VEDAS (<https://vedas.sac.gov.in>) portal. The regular validation of these products is done by respective AFMU's with ground data showed RMSE of 1.2 mm, 1.5 K and 0.10 m³m⁻³ for PET, LST and SSM, respectively. In future, block specific-agromet parameters will be provided to all AFMUs at better spatial resolution to translate weather forecast to finer-scale advisories.

Keywords: Agromet Products; VEDAS; Farmers advisories; Satellite

Spatial Prediction of Soil Properties/Nutrients of Alappuzha District Using Hybrid Machine Learning Algorithms

Anil Prasad V A^{1*}, Radhakrishnan T¹, Manoj Kumar T.K¹, Ajith Kumar R¹, Sam Mathew Saji¹

¹Digital University Kerala, Thiruvananthapuram
anilanirudhanv@gmail.com*

ABSTRACT

Soil nutrients are important for soil health, crop suitability, fertility, and essential for sustainable agricultural development. Soil nutrients play a significant role in soil aggregation, water holding capacity, cation /anion exchangeability etc., which promotes plant growth. The lack of scientific knowledge on nutrient availability on soil and the spatial variation often leads to a blanket approach of fertilization adversely affecting the soil health.

Accessible information on soil nutrients can result in investment saving, ensure crop safety for farmers, and control over fertilization problems. Readily available soil nutrients information for the farmer is currently not available. The soil nutrients are tested from soil samples collected from the field. This soil nutrient result data is mostly managed as spreadsheets. The number of samples available in a geographical region will be sparse owing to the cost and time involved in sampling and analysis. Converting this data to geospatial formats as well as generating a seamless continuous geospatial layer of multiple nutrients is essential for decision making. Conversion of

geospatial format is straightforward as the data contain geographical coordinates. But the spatial estimation poses challenges in ensuring accuracy. Conventionally, Geostatistical techniques are employed for the purpose. In this study we investigated a method by combining machine learning algorithms with Geostatistical techniques to improve the accuracy of spatial prediction.

We used Geostatistical model and hybrid (Geostatistical Machine learning model) models to predict the spatial distribution of soil nutrients of Alappuzha, Kerala, India. Remote sensing data has been used to generate topographic environmental covariates. Elevation derivatives were taken as predictors (Elevation, slope, flow accumulation, etc.). The models are trained with 1982 surface samples, and 15 predictors. From this study, Comparing R², RMSE and VECV (Variance explained by predictive models based on cross-validation) values of each model, we found that GBMOK (Generalized Boosted Regression modelling & Ordinary Kriging) Hybrid model (R² 0.56) is a more accurate machine learning model for soil nutrients/properties prediction compared to Geostatistical estimation.

Keywords: SRTM DEM; Hybrid Machine Learning; Digital Soil Mapping; Random Forest; R Programming

Machine Learning Based Spatial Prediction of Soil Properties/Nutrients of Alappuzha District using Dynamic Environmental Covariates

Sam Mathew Saji¹, Radhakrishnan T¹, Manoj Kumar T.K¹, Ajith Kumar R^{1*}, Anil Prasad V A¹

¹ Kerala University of Digital Sciences, Innovation and Technology-Thrivanthapuram kerala
ajithr@iitmk.ac.in*

ABSTRACT

Soil nutrients are essential for the growth of crops and is inevitable for sustainable agricultural development. The spatial variability of soil nutrients is highly related to the soil-forming factors including the climate (precipitation and temperature); organisms (vegetation), relief (terrain attributes), etc. The lack of scientific knowledge on the spatial variability of the nutrients often leads to a blanket approach on fertilization which will adversely affect the soil health. Hence prediction and mapping of soil nutrients from sparse samples to a continuous surface and its spatial variability across the space is necessary for making management decisions and informed farming.

Utilizing the techniques of remote sensing the remotely sensed data can be used to obtain dynamic environmental covariates and these can be used to predict the soil nutrient content. Conventional method for the prediction of soil nutrient parameters mainly depends on geostatistical techniques. This study focusses on the utilization of machine learning algorithms with geostatistical methods to enhance the accuracy of the spatial prediction compared to geostatistical techniques alone.

Sentinal 2, Landsat 8 and monthly precipitation data of the year 2019 has been used to estimate the environmental covariates. Monthly Land Surface Temperature (LST), Soil Moisture Index (SMI), Precipitation, Normalized Difference Vegetation Index (NDVI), Soil Adjusted Vegetation Index (SAVI), Enhanced Vegetation Index (EVI), Modified Soil Adjusted Vegetation Index (MSAVI), and Normalized Difference Water Index (NDWI) were calculated and then averaged to three consecutive months and was treated as a season. Hence each parameter will be having four set of values. Various Hybrid Machine Learning and Geostatistical Models like Spatial and Spatio-Temporal Geo-statistical Modelling (GSTAT), Generalized Boosted Regression Modelling and Ordinary Kriging (GBMOK), Random Forest and Ordinary Kriging (RFOK) have been used to predict spatial distribution of soil nutrients of Alappuzha, Kerala, India. From the results of pH prediction, the Root Mean Square Error(RMSE) and Variance Explained by predictive models based on cross-validation (VECV) values of GSTAT and GBMOK (GSTAT, GBMOK) are (0.5169092, 52.1034) and (0.8443296, 63.24798) respectively, which shows the accuracy of the hybrid model is comparatively higher than that of geostatistical model alone and is similar for case of other nutrients also, which proves the use of machine learning algorithms with geostatistical methods gives more accurate results.

Keywords: Dynamic Covariates; R Programming; GSTAT; GBMOK; RFOK

Dwindling seagrasses: A multi-temporal analysis on Google Earth Engine

Twinkle S^{1,2*}, Sreenath K. R², Miriam P. S², Ranith R³

¹*Cochin University of Science and Technology, Kochi, Kerala, India – 682016*

²*ICAR-Central Marine Fisheries Research Institute, Kochi, Kerala, India – 682018*

³*Nansen Environmental Research Centre India, Amenity Centre, Kerala University of Fisheries and Ocean Sciences, Madavana Junction, Kochi, Kerala, India - 682506*

twinkle7895@gmail.com*

ABSTRACT

Seagrasses, one of the blue carbon ecosystems, have high relevance in this era of climate change, as they are considered as effective carbon sinks, with a higher rate of carbon storage compared to the Boreal and tropical forests. Hence it finds its name in greenhouse gases (GHG) abatement schemes. In addition, they also provide a plethora of ecosystem services and functions. However, the rapid decline of seagrass is a matter of concern worldwide. The protection and conservation of the seagrass beds are of great significance. It requires long-term monitoring to understand the irreversible changes in this sensitive ecosystem and to know the dynamics that they share with their environment. This study assesses the temporal changes of the seagrasses in the Kalpeni lagoon of Lakshadweep from 2003 to 2020 with the help of Google Earth Engine, a cloud-based platform. The methodology involves a linear spectral unmixing method using Landsat 7 and 8 images. The study results showed a drastic decline of 99 % coverage in the abundance of seagrasses, indicating a threat to the seagrass ecosystem. With such a drastic shrinkage in the seagrass

coverage, the hysteresis must be strong, and the recovery of these meadows may require intense interventions. To the best of our knowledge, the study is the first to construct and analyse the temporal variations in the spatial spread of seagrasses in India using satellite image analysis.

Keywords: Landsat data; Spectral unmixing; Lakshadweep; Vulnerable Ecosystem

Reconfiguration of Ward into an Eco-ward using spatial Approach: A Case Study of Vadodara

Usha Pandya^{1*}, G.Sandhya Kiran²

¹Government College, Daman

²The Maharaja Sayajirao University of Baroda

ushajosh12@gmail.com*

ABSTRACT

Vadodara, one of the rapidly urbanizing cities of The Gujarat state of India is facing many challenges due to its quick and rapid expansion. It has expanded by 135.86 km² during the span of 120 years. This haphazard and unsustainable urban growth of the city has led to increased entropy as consequence. This emphasizes the need for reconfiguration of urban areas of the city based on the principle of sustainable planning, i.e. Eco-city planning. The present study uses spatial techniques to reconfigure the selected ward of Vadodara city into the Eco-ward. Out of the three techniques of eco-ward planning, viz. Information on various parameters considered for eco-ward design like transportation network, slope, contour, soil texture, waterbody, land use, etc. was procured using advanced LISS IV satellite data. GIS-based Land Suitability Analysis (LSA) Module integrated these various parameters and generated the outputs based on four different models. Output generated from Model No. 4 was considered as an input for Eco-ward designing because this model gave the higher weightage to the land use parameter which is a vital component for the planning. Suggestions acquired from the citizens of the ward were also

incorporated for generating an Eco-ward map. Such a plan generated using the latest spatial technology can provide a new direction for intelligent urban planning that can be extended to other cities.

Keywords: Spatial approach; Vadodara; Eco-ward; LSA

Heavy metal contamination in the mixed feathers of 12 waterbirds species from Porbandar, Gujarat

Dhaval Vargiya^{1,2*}, Devang Pandya¹, Bharat Jethva³

¹*School of Pharmacy, RK University, Bhavnagar Highway, Kasturbadham, Rajkot, Gujarat, India. PIN 360020*

²*Mokarsagar Wetland Conservation Committee, Porbandar, Gujarat, India, PIN 360575*

³*Green Support Services, Sargasan Circle, Gandhinagar, Gujarat, India PIN 382421*
dhaval.mwcc@gmail.com*

ABSTRACT

Heavy metal concentrations in waterbirds have been the focus of many publications over the last few decades. Feather concentration is an excellent bioindicator since it can be sampled nondestructively, simple to collect, and resilient due to birds' ability to retain and excrete metals in the feathers. Mixed feathers were gathered and sealed from the breast, tail, primaries, and secondaries of dead waterbirds from Porbandar, Gujarat, India. The samples were kept dry and copper, zinc, iron, chromium, lead, and cadmium were analyzed by an inductive coupled plasma-mass spectrometer (ICP-MS). The mixed feathers of 28 individuals of 12 different waterbird species were collected. Cadmium levels were below the detection limit in all 28 samples. The highest metal concentration of Iron (1937.64 ppm) and zinc (412.29 ppm) were detected in a Red-naped Ibis, rescued from the Vadi Plot region of Porbandar. The highest and above-threshold (4 ppm) concentration of Lead was 4.56 ppm in a Black-headed Gull from Subhashnagar, bird was already dead when rescued, probably died due to lead toxicosis.

Lesser Flamingo has the highest copper concentration (18.32 ppm). Pond Heron which also had the most polluted plumage had the highest concentration of Chromium (2.16 ppm). The Cattle Egret has the highest publications of heavy metal toxicity in its feathers from Asian countries. In cattle Egret feathers, the highest concentration of Zinc was 529.9 ppm from Lahore, Pakistan, and the lowest was 1.8 ppm from Taunsa, Pakistan. Cranes are a significant waterbird species that serves as a link between agriculture and wetlands. Zinc, lead, copper, and chromium pollution in cranes from Sheyang, China, is higher than in our study area. Lesser flamingos are at the bottom of the food chain, feeding mainly on blue-green algae and small invertebrates. Nonetheless, as compared to other waterbirds, the heavy metal concentration was higher.

Keywords: Copper; Zinc; Iron; Chromium; Lead; Cadmium

Using zeta (ζ) diversity for understanding effects of environmental variations on species composition of arboreal frogs in India

Niket Alashi^{1*}, Nikhil Modak²

¹ Department of Biodiversity, M.E.S., Abasaheb Garware College, Karve Road, Pune 411 004, Maharashtra, India

² Wildlife Institute of India, Chandrabani, Dehradun 248 001, Uttarakhand, India
niket02.alashi@gmail.com*

ABSTRACT

Interpretation of the patterns and determining factors of amphibian species richness and turnover are getting more attention as the ecosystems are getting endangered by changing climate and anthropogenic pressures. Conservation strategies or their maintenance tend to confound relationships at one spatial scale and may not work at another. We tried to interpret the turnover and environmental determinants for the arboreal frogs (Anura: Rhacophoridae) in the Indian landscape. The study is based on quantitative research methods using the digital mapping methods, zeta-diversity analysis, and multi-site generalised dissimilarity modelling (MS-GDM) approach, an advanced regression method that compares multiple parameters over a larger spatial scale. The distribution of arboreal frogs in India was collected from published scientific literature and processed for zeta diversity analysis. Data from global environmental databases are being used to interpret the effects of different parameters over a spatial scale. The analysis shows the dominance of turnover while interpreting the species composition in the Indian landscape. Also, there is quite a difference in the zeta

decline of the genera considered for the study. It shows that considerably more species are lost with an increasing number of sites for the genus *Raorchestes*, followed by *Rhacophorus*. *Pseudophilautus* seems to be stable in the landscape with chances of a higher number of rarer species. Similarly, The zeta decline and the retention rate for *Polypedates* is steady and shows the presence of moderate site-specificity of the genus in the landscape. *Ghatixalus* is a newly described genus that shows a higher rarity. Meanwhile, *Theلودerma*, *Chirixalus*, two highly restricted species, and *Zhangixalus*, are stable in their distribution with a gradual decrease in the retention rate. Multi-site dissimilarity modelling analysis is underway and will provide a better overview of the impact of factors on the diversity of the anurans.

Keywords: Diversity; Zeta-decline; Dissimilarity modelling; *Rhacophoridae*; India

Increasing invasion risk of Snowflake corals during climate change: An ensemble modelling approach

Nisin M.^{1,2*}, Sreenath K. R², Miriam P. S², Joshi K. K²

¹*Cochin University of Science and Technology, Kochi, Kerala, India – 682016*

²*ICAR-Central Marine Fisheries Research Institute, Kochi, Kerala, India - 682018*
nisinnisai@gmail.com*

ABSTRACT

Climate change has been a prime topic of debate, discussion, and deliberation of the present century. Due to its impact on foundational biological processes and link with other existing stressors, climate change will influence the distribution and ecology of the invasive species. Snowflake coral, *Carijoa riisei*, is an octocoral belonging to the family Clavulariidae and order Alcyonacea. It is a soft coral with fast growth, vegetative propagation, and superior competitive ability. It forms dense multi colonies, making them excellent invaders, aiding them to establish themselves in a new habitat. They pose a significant threat to the benthic communities as they are found from the intertidal zones to a depth greater than 100m. In this study, we used ensemble distribution modelling to combine occurrence data of the species with predictor variables (Temperature, Salinity, Current Velocity, Bathymetry and Distance to shore) to come up with a projection of habitat suitability and probable distribution of the species. Biomod2 package in R was used for ensemble modelling. The future projections of distributional shifts were constructed for the IPCC Representative Concentration

Pathways (RCP) in 2040-2050 and 2090-2100. The current and future projections were studied and compared to identify potential invasion areas. It is observed that climate change will aid *C. riisei* to venture into previously unoccupied areas. It is observed that *C. riisei* will expand its range, thereby increasing the number of potential areas for invasion. With a global distribution of the species and its possible expansion in the future, it can become a severe threat to the benthic and coastal ecosystems around the world unless managed.

Keywords: Invasive ecology; Ensemble modelling, Octocoral, RCP, Distributional shifts

A semi-automatic probabilistic deep learning and feedback based approach for efficient coral segmentation

Reshma B.^{1,2*}, Rahul B³, Joshi K. K², Sreenath K. R², Grinson George⁴

¹*School of Engineering, Cochin University of Science and Technology, Kochi, India*

²*Central Marine Fisheries Research Institute, Kochi, India- 682 018*

³*Indian Institute of Technology, Madras, IIT P.O., Chennai, India- 600 036*

⁴*SAARC Agriculture Centre, Dhaka-1215, Bangladesh*

reshmababuraj89@gmail.com*

ABSTRACT

Coral reefs remain the backbone of marine life and sustain more than half a billion human life around the world. They are most biologically diverse but fragile and globally threatened ecosystems. Identifying and quantifying the status of the existing coral reef species is necessary for making a management decision to protect this critically endangered ecosystem. Due to the taxonomic complexity of the corals, the identification task only happens with domain expertise; the expert even needs a considerable amount of time to identify the species from images; causes delays in any protection strategy and drag many of the species to extinction. Of late, data-centric approaches using deep neural networks have greatly benefited in terms of time and accuracy. Previous works have contributed deep neural network-based automatic segmentation of underwater and coral reef images mostly based on the widely used U-Net. In practice, such solutions for specific use cases such as Lakshadweep underwater species, require quality domain data and a meticulous annotation process. However, the heterogeneous

nature of coral reefs will often lead to misidentification and thence faulty conclusions. In this work, the relative time duration and the accuracy tradeoff are estimated and compared among automated and semi-automated segmentation methods. We are proposing a semi-automated method that uses probabilistic U-Net to model a segmentation map along with its error distribution. Our model can thus suggest high error patches in the results, which can assist the manual segmentation process. Our solution fits well into a human-machine collaboration approach and has been shown to cut coral coverage estimation time by up to 10 times.

Keywords: Coral reefs; Under water images; Convolutional Neural Networks (CNNs); Semantic segmentation; Coverage estimation.

Ecological Informatics of selected Plant Taxa form North Gujarat for Sustainable Management

Kavi K. Oza^{1*}, G. Sandhya Kiran¹

*¹Department of Botany, Faculty of Science, The Maharaja Sayajirao University of
Baroda, Vadodara – 390002, Gujarat, India*

kavioza3018@gmail.com*

ABSTRACT

The increasing size of the human population, along with its associated economic activities, has huge impact on global environment and biodiversity. Countries across the world are concerned about the growing resource consumption and the capacity of ecosystems to provide enough resources. There are two different approaches to solve the present scenario. Either decrease the consumption of resources or look for the alternatives of available resources. Plants are the essential part of any human society. Over exploitation and widespread usage of these plant species has become a threat to their survival. In the present study we have explored the north Gujarat area which comprises of six districts viz. Patan, Mehsana, Gandhinagar, Sabarkantha, Banaskantha and Aravali. We have gathered ecological information of various plant taxa observed and collected from tribal people. Sampling was carried out at microlevel with distinct replicates to avoid potential errors. Combining different attribute information in GIS mode species suitability maps of selected species. Have been generated. Utility of SDM (species distribution modelling) and MAXENT is exploited to achieve precise results related to species habitat

suitability. This information can prove significant in guiding the tribal people about habitat preferences of that species. This study not only focuses on understanding traditional knowledge of species but also providing conservation strategies beneficial for tribals.

Keywords: Biodiversity; Conservation; Ethnobotany; GIS; Traditional knowledge.

Tree diversity and density mapping of Mudumalai Tiger reserve utilising imaging spectroscopy data

Amrita Chaurasia^{1*}, Reshma Parmar¹, Krishnayya Nadiminti¹

¹The M. S. University of Baroda
ami.gem3579@gmail.com*

ABSTRACT

Tropical forest covers are the most diverse terrestrial ecosystems providing ecological and economic services. Information on tree species is vital to understand these ecosystems better. High resolution remote sensing data have been widely tested for the estimation of various forest inventory attributes with variable success rates. The present study attempts to develop abundant species diversity and density map of Mudumalai Tiger Reserve (MTR) using Airborne Visible/Infrared Imaging Spectrometer Next Generation (AVIRIS-NG) data. Support Vector Machine (SVM) classifier was used to generate abundant species map of 21 tree species belonging to 18 genera and 13 families. The results were cross validated against ground reference data. Developed map showed an overall accuracy of 81% and 0.80 kappa coefficient. At the tree species level, average accuracy of evergreen and deciduous species was 85.8% and 70.3% respectively. The relatively low accuracy of some of the deciduous species could be due to smaller crowns and lesser green foliage. Pixel statistics of the abundant species map and crown size of tree species coming from ground reference data were utilised to estimate tree density. This

approach estimated tree density (ha⁻¹) with a 20% error limit. The study shows the potential of high resolution imaging spectroscopy data for tree diversity and density mapping of tropical forest covers. The study can provide a meaningful metric to guide tropical forest management and conservation.

Keywords: Tropical forests; Species diversity; Species density; AVIRIS NG; SVM

Adoption of Mobile Apps by Farmers in 5 Agro-ecological Zones in Kerala for Agriculture Information Management – A statistical Model Validation

R Ajith Kumar^{1*}, V P Jagathy Raj¹

¹*Cochin University of Science and Technology, Cochin, Kerala, India.*
ajithrnair@gmail.com*

ABSTRACT

Historically farmers are always adaptable to new technologies towards improving their productivity and economic conditions. Recent advancements in smartphone based mobile applications shaped farmer's decision making process much easier. This study focuses mainly on the adoption of agriculture related mobile applications by farmers' for agricultural information management in particular. We selected 600 farmers across 5 different Agro Ecological Zones in Kerala, India to conduct the study using set of constructs drawn from unified theory of acceptance and use of technology² (UTAUT²). The aim of the study is to investigate latent factors affecting farmers' adoption in using mobile Apps by applying UTAUT² model framework. Descriptive statistics techniques, exploratory factor analysis and Principal Component Analysis (PCA) were applied to verify the normality, correlation and variance of the constructs across the model.

Keywords: Smartphone; Apps; Farmer; Agriculture; AEZ; UTAUT²; Principal Component Analysis

Ecological informatics in biodiversity studies

Shrishti Rajput^{1*}, Janki Kalani¹, Sandhya Kiran¹

¹*The Maharaja Sayajirao University of Baroda*

shrishtirajput2000@gmail.com*

ABSTRACT

Peoples' Biodiversity Register is a document which is developed by the people, related to information on biodiversity around them and knowledge for biodiversity conservation. It contains comprehensive information on locally available Bio-resources including landscape and demography of a particular area or village. Bio-resources mean plants, animals and micro-organisms or parts thereof, their genetic material and by-products (excluding value-added products) with actual or potential use or value but does not include human genetic material. Basically, ecological informatics combines information technology and ecological concepts with applications that facilitate research and the dissemination of results to scientists and the public. Thus, in the present paper PBRs for different villages of selected villages of Central Gujarat have been integrated in GIS mode to develop baseline information system for these areas. The detailed information generated for different species used by different locals and tribal will be integrated and further knowledge generated from the same will be beneficial for the society. Moreover, such type of information system can prove to be beneficial for designing different biodiversity conservation strategies.

Keywords: Biodiversity; Conservation; Peoples' Biodiversity Register; GIS

Analyzing Groundwater Quality Parameters by Exploratory Data Analysis using R

Saba Riyaz^{1*}, Iftikhar Hussain Beigh², Tariq Rashid Jan¹

¹*Department of Statistics, University of Kashmir, Srinagar, J&K, India*

²*Department of Civil Engineering, National Institute of Technology, Srinagar, J&K, India*
sabazainab@gmail.com*

ABSTRACT

Water, being a natural resource essential for life, is sometimes a determining factor for the socio-economic development of a country. Its quality impacts its suitability for human, animal, agricultural, and industrial usage. Water quality assessment entails assessing the chemical, physical, and biological characteristics of water in connection to natural quality, human effects, and intended applications, particularly those that may have an impact on human health and the aquatic system. Groundwater is a primary hotspot for drinking, domestic, and agribusiness. To maintain the ecosystem, protect drinking water sources, and avoid well water contamination, groundwater must be protected against the negative impacts of agricultural and industrial pollution. This study provides an overview of groundwater conditions in plains of an Indian Himalayan region, concerning different water quality parameters. Groundwater samples were collected at over 200 locations from different sources, i.e., deep bore wells, shallow open wells, and tube wells covering an entire district of Jammu, in Jammu and Kashmir, India. Concentrations of various physiochemical parameters like fluoride, iron, nitrate, pH, total hardness, calcium, magnesium, sodium, sulfate, potassium, chloride,

bicarbonate, and total dissolved solids within the samples were assessed for characterizing groundwater quality using standard methods. This paper presents exploratory data analysis of naturally occurring chemical parameters in groundwater as clearly outlined in the Groundwater Directive (GWD); as a tool for facilitating collaboration and hypothesis generation in assessing groundwater quality. The offered study is about groundwater quality analysis, but the mentioned method and experience can be applied to various fields.

Keywords: Water testing; Box plot; Pair plot; Heat map; Correlation analysis; R Codes

The Role of Internet of Things (IoT) in Plant Disease Detection: A Bibliometric and Word Cloud Analysis

Rutuja Rajendra Patil¹, Sumit Kumar^{2*}

¹*Symbiosis International (Deemed University), Symbiosis Institute of Technology,
Pune, Maharashtra, India*
er.sumitkumar21@gmail.com *

ABSTRACT

Since independence, considerable improvement has been made in the agriculture field. Agricultural methods have changed over time, and the Green Movement has played a crucial part in this. Smart farming is rising at an unprecedented pace because it benefits both farmers and customers by helping them to budget more efficiently for their crops. Farmers use Internet of Things (IoT) to enforce irrigation management, crop yield estimation, plant disease management. Farmers can also learn about environmental patterns and, as a result, which crops to grow, as well as how to distribute insecticides and fungicides. The research focuses on 146 scientific records in numerous publications, including journals, book chapters, and patents. After querying the Scopus databases with keywords related to IoT and agriculture, these 146 documents were retrieved. The articles were reviewed for several months. Open source tools are used to evaluate this model, including Node XL, Gephi, and VOSviewer. The survey includes bibliometric and word cloud analysis that focuses on the types of publications, publication by region, spatial locations, and documents by year, subject area, association, and authors. It was noticed that English was a common language used in the paper published in the research area of IoT in plant disease detection.

Keywords: Bibliometric Analysis; Word cloud; Internet of Things (IoT); Plant disease detection

Insurance Value of an Ecosystem Function Provided by the Natural Forests in Parambikulam Tiger Reserve, Kerala, India

Divya Soman^{1*}, Anitha V¹, Syam Viswanath¹, Sandeep S¹

¹ Kerala Forest Research Institute
somandivya7@gmail.com*

ABSTRACT

The degradation in the form of land use change and other anthropogenic activities have affected the quality of forest and compromised its ability to provide Ecosystem Services (ES). Integrating the ES into planning and decision-making can be attained through valuation studies, while its continued conservation needs to address its insurance value. Insurance value signifies the ability of the ecosystem to reduce the negative impacts from a rapid change by providing a buffer against the risk and cost associated to it thereby bridging the gap between preservation, sustainable use, restoration of an ecosystem and their governance arrangements. The value generated will look upon governance solutions for ecosystem services through activities from observed perceptions of decision-makers for ecological sustainability and resilience to uncertainty and potential losses. Moreover, climate change induced events with implications on the ecological functions of forest ecosystem can have cascading effects. The present study looks at the insurance value as a monetary term by considering the ecosystem characteristics contributing to benefits of its dependents. The erosion rate for the soil from the watershed of

Parambikulam Tiger Reserve (PKMTR) in Kerala was arrived at 0.98 t/ha/year using the Revised Universal Soil Loss Equation (RUSLE, which also highlighted the least soil erosion from forest covered areas compared to other land uses. The erosion rate is further used to assess the insurance value and compare it with artificial processes for soil maintenance. This can result in the development of an operational approach with policies on ecosystem services emphasizing adaptation to climate change, thereby promoting nature-based solutions. Incorporating the Insurance Value of forest ecosystem services into natural hazard policies is of prime importance in a developing nation like India, as it supports planning in forest ecosystem and its successful implementation in other ecosystems as well.

Keywords: Insurance value; RUSLE; Forest Ecosystem; Soil erosion prevention; Parambikulam Tiger Reserve

Predicting the impacts of future Climate Change and range-shifts of the Bucerotidae family in India

Debanjan Sarkar¹, Gautam Talukdar^{1*}

¹ *Wildlife Institute of India, Chandrabani, Dehradun-248001, Uttarakhand, India*
gautamtalukdar@gmail.com*

ABSTRACT

Global climate change is affecting the distribution of species and is considered to represent a threat to biodiversity. Hornbills (Family: Bucerotidae) are seed dispersers and are considered keystone species as they play a critical role in maintaining the structure of an ecological community by aiding in forest regeneration. They are thus known as the farmers of the forests, and their presence signifies a healthy ecosystem. Future range-shifts of Hornbills raise concern as the long-term persistence of these species is already threatened by human disturbances. The study's objective is to model the current and future potential climatic niche for eight hornbill species found in India. We used GBIF mediated species occurrences and 8 WorldClim V2.1 variables in Maxent to model the present suitable climatic niche and projected it to future (mid-century, i.e., 2061-80 and end of the century, i.e., 2081-2100) for four CMIP6 based Shared socioeconomic pathway (SSPs) (i.e., SSP126, SSP245, 370 and 585). We identified the potential climatic refugia for the Indian Bucerotidae family, analyzed range-shifts and centroid changes for each species in different climatic scenarios. The mean AUC value for all average models was 0.94. Our result indicates that among all future scenarios

for eight species, 34% species range-shift is towards west, followed by northwest (20.3125%) and northern (17.1875%) shifts. All modeled species likely to lose >40% of their present climatic niche under the SSP 585 scenario 2081-2100. Maximum range contraction was observed for *Ocyrceros birostris* in all scenarios. Major centroid changes (Approx. 600 km) were observed for *Anthracoseros albirostris* in SSP585 2081-2100 scenario. Our study provides a detailed insight into the range shifts of Indian Hornbills caused by future climatic conditions. The projected temporal and spatial patterns of the distribution & range shifts will be valuable references in developing conservation policies for hornbills in the Indian context.

Keywords: Hornbill; Maxent; SDM; Range-shift; Climate change

A Floating-threshold Acoustic Diversity Index for Rapid Biodiversity Assessment

Lei Chen¹, Zhao Zhao¹, Zhiyong Xu^{1*}, Bryan Pijanowski²

¹*School of Electronic and Optical Engineering, Nanjing University of Science and Technology*

²*Department of Forestry and Natural Resources, Purdue University*
ezyxu@njust.edu.cn*

ABSTRACT

In recent years, passive acoustic monitoring (PAM) has become increasingly popular. Many acoustic indices have been proposed for rapid biodiversity assessment; however, most of them have been shown to be susceptible to ambient noise, such as wind, which greatly limits the application of these acoustic indices for this purpose. In the work here, we address this shortcoming by analyzing the influence of ambient noise on the default parameters of the Acoustic Diversity Index (ADI). It was revealed that the peak value in the spectrogram will no longer correspond to the biotic sounds of interest as signal-to-noise ratio (SNR) decreases, leading to erroneous results of the proportion of sound occurring in each frequency band when calculating ADI. Based on this observation, we proposed an improved ADI-class index; namely, a Floating-threshold Acoustic Diversity Index (FADI) in which floating thresholds adaptive to the noise level along each frequency bin were incorporated with the fixed threshold previously used in ADI (−50 dBFS below the peak value as default). In order to objectively evaluate the performance, a controlled experiment was designed and conducted using real-world avian audio

recordings. Experimental results showed that, compared with ADI, FADI was much less sensitive to ambient noise. Furthermore, FADI performed significantly better than ADI when different sound unit shapes were considered. Our results highlight the potential of FADI to provide relatively more robust metrics in applications of PAM.

Keywords: Acoustic index; Geophysical noise; Floating threshold; Biodiversity; Passive acoustic monitoring

Impact Assessment of Hydropower Project on Fish Habitat and Suggesting Environmental Flow as Mitigation Measure

C Prakasam^{1,*}; Saravanan R¹

¹*Department of Civil Engineering, Chitkara University, Himachal Pradesh
cprakasam@gmail.com**

ABSTRACT

The definition for the environmental flow varies based on parameters. Environmental flow is the minimal flow required to maintain healthy environmental condition. The Larji hydropower dam (126 MW) is constructed across the Beas river in the Kullu District of the Himachal Pradesh obstructing its natural free-flowing flow to produce the hydropower. This causes the health of the fish ecosystem and as a mitigation measure environmental flow should be maintained and the amount of flow to be maintained is questionable. This research work focuses on assessing the environmental flow requirement using the HEC modules i.e., HEC-RAS and HEC-EFM to incorporate the hydraulic- habitat approach for the Larji Hydropower downstream. Among the selected species, rainbow trout is the key stone species, hence environmental flow corresponding to the brown trout is taken as the required environmental flow. The results show that the current environmental flow isn't sufficient to maintain the healthy fish habitat.

Keywords: HEC-EFM; HEC-RAS; Environmental Flow; Fish Species; Larji

Data-driven ecoacoustics: how to improve the quality of training datasets to automatically monitor bird populations

Félix Michaud^{1*}, Sylvain Hauptert¹, Jérôme Sueur¹

¹*Systématique, Évolution, Biodiversité (ISYEB), Muséum national d'Histoire naturelle, CNRS, Sorbonne Université, EPHE, 57 rue Cuvier, 75005 Paris, France*
felixmichaudlnhrdt@gmail.com*

ABSTRACT

One of the major challenges in ecoacoustics is to infer species occurrence in soundscape recordings where signals greatly overlap. So far, most bird sound detection algorithms have used deep learning methods. Such algorithms need a substantial amount of data to be ready for inference. For example, the Birdclef2020 challenge dataset represents 70,000 files for 960 species.

The most common paradigm for the dataset rather considers the quantity of audio data over the quality of it. However, noise in the dataset can lead to slow down training, to reduce the algorithm performance for detection and to unequal detection performance between bird species.

The goal of the study is to automatically build a dataset with increased data quality by cleaning an online available database such as xeno-canto through appropriate signal detection and classification without supervision. By the use of an automatic detection of regions of interest in the spectrogram, followed by clustering, our algorithm isolates bird songs. For

the most common species, the clustering algorithm stands at an average precision and recall score of 90%. A test was run on a dataset built on a selection of the xeno-canto online collection which is extensively used in bird sound classification. The performance enhancement for bird sound detection was evaluated with a convolutional neural network architecture.

Keywords: Ecoacoustics; Deep learning; CNN; Birds; Bird songs

Male mating competency in response to its mating status in *Zygogramma bicolorata* Pallister (Coleoptera: Chrysomelidae)

Lankesh Yashwant Bhaisare^{1*}, Anjali Mishra¹, Desh Deepak Chaudhary¹

¹BMEBRL, Department of Zoology, Indira Gandhi National Tribal University

Amarkantak, Madhya Pradesh- 484887

mr.lankesh10@gmail.com*

ABSTRACT

In case of the sexual selection, male insects, and their response to females is associated with their expectation of benefits and costs. Its benefit is that it avoids or reduces sperm competition and allows a male to assure its paternity. The cost, however, is more varied which includes predation risk, lower sperm generation, decreased growth rate, and increased energy expenditure. Moreover, mating with unsuitable females, males missed opportunities for feeding or mating with other females. Thus, female mate selection and competition for suitable mates is important for fathering of the more offspring. Here, the laboratory study was performed to evaluate the plasticity of male mating competency in response to its mating status in *Zygogramma bicolorata* Pallister, which is widely known for the potential biocontrol agent of *Parthenium hysterophorus*. For the objective, 10 days old virgin female was introduced in plastic Petri dish with two 10 days old males having different mating status, unmated and once mated respectively, for the mating. The pre-copulatory parameters such as the times to commencement of mating (TCM), latent period (LP) and mating duration (MD) were recorded. After complete mating,

the female was isolated post-mating and reared individually on daily replenished ad libitum supply of *P. hysterophorus* and daily oviposition and percent egg viability rerecorded over the next 5 days. A total of 10 replicates were conducted. The results of the present study revealed insignificant effect of the mating status on mating competency. Whereas the times to commencement of mating, latent period and mating duration were higher in case of unmated male than the mated ones but showed insignificant effect of male mating status on LP and MD. On the other hand, oviposition and percent egg viability were significantly influenced by the mating status of the male partners. In conclusion, the mating status of male did not show affects on the pre-copulatory parameters but significantly influenced the post-copulatory parameters in *Z. bicolorata*.

Keywords: Mating competency; mating duration; Fecundity; Percent egg viability

A Maxent modelling integrated with eco-saline indicators for the Habitat suitability of Flamingos in the Ramsar site (Sambhar Lake, India) using geospatial approach

Laxmi Kant Sharma^{1*}, Alok Raj¹, Kshitij Divyansh², Rajashree Naik¹

¹Department of Environmental Science, School of Earth Science, Central University of Rajasthan, Bandar Sindri Ajmer, 305817.

*²Department of Remote Sensing, Birla Institute of Technology Meshra, Ranchi 83521
mr.lankesh10@gmail.com**

ABSTRACT

Wetlands play a crucial role in the biosphere and provide numerous services such as groundwater recharge, water purification, conservation of biological resources, act as a carbon sink and habitat of amphibians and birds. Sambhar Lake, largest inland saline Ramsar site in the arid region of Rajasthan, India. It has unique habitat for migratory birds, halophytes, and halophiles. In the last few decades, it has been continuously desiccating due to illegal saltpan encroachment and subsequently reduction of migratory birds. The current study used the Maxent Habitat Suitability model integrating with eco-saline indicators such as Normalized Difference Water Index, Surface Algal Bloom Index & Moisture Stressed Index, and Land Use Land Cover using Landsat-5 and Sentinel-2 imagery for 1996 and 2019. In maxent modeling, we used bird occurrence data for flamingos, 14-different bio-climatic parameters, and RCP-4.5 combinedly to predict future species distribution. The habitat suitability model for flamingo value lies between 0.0091 (unsuitable habitat) to 1.0 (most suitable),

where the western region has the least value, but the eastern part has a high value, and LULC indicates that increase salt crust and vegetation class by 87.0315 km² and 10.322 km² while the decrease in water areas 69.51 km² between 1996-2019. Hence it indicates that remarkable loss of breeding sites of animals, particularly avian fauna (flamingos), is seen in recent years due to different types of threats due to anthropogenic activities. This study signifies alternation in Sambhar Lake and affecting migratory birds. Therefore, govt. and NGO's need to focus on.

Keywords: Maxent modeling; Geospatial; Eco-saline indicators; Habitat suitability; Flamingos

Impact of Tree species *Senna spectabilis* invasion on native flora, phytochemistry of leaf and seed germination rate in Wayanad Wildlife Sanctuary, Kerala

Sonia K B^{1*}, Ranjith D¹

¹ Kerala Veterinary and Animal Sciences University Pookode Wayanad Kerala
1403soni@gmail.com*

ABSTRACT

One of the major threats to ecosystem after habitat destruction is the exotic species invasion in the natural forest. Invasive species remains as a threat to not only native flora and fauna but also alter the environment and soil properties. *Senna spectabilis* a tree species of legume family spreads rapidly in the tropical forest. Vegetation composition, phytochemical composition of leaf extract and seed germination capacity of *Senna* was studied in the Wayanad Wildlife Sanctuary from Jan 2021 to Mar 2021. The effect of *Senna* invasion on native flora was assessed by sampling across varying densities of *Senna spectabilis* in two different forest types (Dry and Moist deciduous). A total of 36 plots, size of 250 sqm were laid in the control (Without invasion), moderate and high density. Tree, shrub, herb and grass composition were assessed in the nested subplots within this. The tree species diversity and evenness values were least in the high invasion areas. Among shrub and tree regenerations species, *Lantana camara* densities were high in the high invasion areas. Tree regenerations tend to be higher in the high invasion areas. Shrub densities, richness, percentage

of grass were significantly low in high invasion. Multiple regression analysis revealed that Shrub density had primary influence on grass/herb availability followed by Senna sp density, tree density and other weed density. Phytochemical analysis of leaf extract indicated the presence of alkaloids, flavonoids, phenolics, tannins, glycosides, saponins, carbohydrates, terpenoids, protein and amino acids. In the seed germination experiment, the number of seeds grown in the experimental, that is treated with different temperature (50-150°C) across different duration (1 to 30 min) have shown significantly higher growth. Thus, native flora diversity, density is low in high invasion areas and germination experiment indicated that the percentage growth of *Senna spectabilis* seeds was influenced by temperature and duration of treatment.

Keywords: *Senna spectabilis*; Wayanad Wildlife Sanctuary; Impact on native flora; Phytochemistry; Seed germination

Establishing a detection framework for the Forest Owlet using Automated Recording Units

Amrutha Rajan^{1,2}, Aditi Neema², Viral Joshi¹, Rajah Jayapal²,
Shomita Mukherjee², V. V. Robin^{1*}

¹Indian Institute of Science Education and Research (IISER) Tirupati, Tirupati, India

²Sálim Ali Centre for Ornithology and Natural History (SACON), Coimbatore, India
robinvijayan@gmail.com*

ABSTRACT

Documenting biodiversity, especially threatened and endangered taxa is critical for conserving and managing such diversity in the Anthropocene. Traditional methods for the survey and detection of species are changing with various technological innovations. The clear advantage of using Automated Recording Units is the ability to obtain long-term data with vocalizations of rare species over large landscapes and with minimum disturbance to the species. Rare species may be difficult to detect over large areas, using conventional methods and with infrequent human visits. The study focuses on establishing an advanced method for the automated detection and long-term monitoring of endangered Forest Owlet by passive recorders. The study was conducted in the Dang district of Gujarat, located in the northern end of the Western Ghats region. We deployed the Song meter recorders in 16 positive locations. The performance of two signal detector algorithms, Raven and Kaleidoscope in detecting Forest Owlet vocalizations were tested. Detection distance was measured by placing the recorders at different distances ranging from 100 to 1000 meters from the acoustic active site of the bird. A

disyllabic call with a frequency of 500 to 1100 Hz and a monosyllabic song with a frequency of 400 to 1400 Hz were detected from the ARUs and confirmed the presence of Forest Owlet. Raven performed 70% better than Kaleidoscope in terms of F-Score in detecting Forest Owlet vocalizations. The Forest Owlet song detection outperforms its call with higher recall and precision. Detection distance suggests placing the recorder within 300 meters from the response site to get clear recordings. The Jungle Owlet vocalization has a negative effect on the Forest Owlet detection. Our results suggest that passive recorders coupled with automatic signal detectors are efficient over large landscapes for long-term monitoring of a wide range of species, especially those that vocalize infrequently.

Keywords: Automated Recording Units; Long-term monitoring; Signal detection algorithms; Detection distance; Conservation

Altitudinal Variability of Floral Color with Special Emphasis on Intraspecific Level

Athira K^{1*}

¹ *C V Raman Laboratory of Ecological Informatics, School of Informatics, Kerala University of Digital Sciences, Innovation and Technology (Digital University Kerala) Thiruvananthapuram.*

athira.kakkara@gmail.com*

ABSTRACT

Ecological intensification process is high in demand in the world of declining pollinator as well as angiosperm population. The first global thematic assessment by the Intergovernmental Science Policy Platform on biodiversity and Ecosystem Services (IPBES) has confirmed a mass decline in the population of wild bee pollinators- the common pollinators of angiosperm species. This led to the development of national pollinator strategy with high political commitments and scientific backing by the convention on biological diversity. The national pollinator strategy aims to intensify the biodiversity through ecological intensification process. The global initiative of the strategy requires primary scientific studies and monitoring framework to identify the key traits to intensification of the pollinator as well as the angiosperm species. Since, the floral color has crucial role in attracting pollinators, we selected the floral color trait for this work. The inter and intraspecific variability of floral colour across altitude in human as well as pollinator perspective were analysed using the numerical representations of floral spectral reflectance. The floral spectral reflectance of 686 angiosperm species measured

from Kerala, India using Ocean Optics USB 4000 field spectroradiometer were used to assess the interspecific variability of floral colour. Among these, 9 angiosperm species common to all altitude were used to assess the intraspecific variability of floral colour across altitude. The results from the study reveals the physical basis of floral colour distribution of angiosperms. Significant difference in inter and intra specific variability of floral color distribution was evident and has a strong effect in which pollinator species are most abundant. The results obtained from this study will be invaluable to Global Strategy for Plant Conservation (GSPC), national pollinator strategies and in floriculture industry.

Keywords: Angiosperms, Floral colour, Trait variability, Floral radiometry National Pollinator Strategy

An image based approach for automatic detection of avian species

Sajeew C Rajan¹, Jaishanker R^{1,2*}

¹*C V Raman Laboratory of Ecological Informatics, Indian Institute of Information Technology and Management-Kerala, Trivandrum, Kerala - 695581, India*

²*Kerala University of Digital Sciences, Innovation and Technology, Technocity Campus, Thiruvananthapuram, Kerala - 695317, India*

jrnair@duk.ac.in*

ABSTRACT

Acoustic data are now becoming a critical tool for conservation and biodiversity monitoring. Now a days a variety of researches are underway in the field of ecoacoustic. One of the major and challenging research on this field is automatic recognition of species from acoustic data. This work deals with automatic detection of avian species. Avian phonation evince immutable individual peculiar patterns. Comprehending the sonic patterns are essential for automatic identification of avian species from complex acoustic data. Here we present the use of sonographs in automatic detection of avian species from complex acoustic data. It is a monotonous effort and to conquer this, we are introducing Image Based Algorithm to identify avian species from the complex acoustic data. In this work we used raster images of Mel frequency sonographs to create the model. Leveraging this raster model and signal processing techniques we were able to detect sound of common species found in Kerala, India.

Keywords: Ecoacoustics; Biodiversity; Image based algorithm; Avian species

Morphological Diversity of Plant Leaf shapes using Fractal Image Analysis

Vishnu M¹, Jaishanker R^{1,2*}

¹*C V Raman Laboratory of Ecological Informatics, Indian Institute of Information Technology and Management-Kerala, Trivandrum, Kerala - 695581, India*

²*Kerala University of Digital Sciences, Innovation and Technology, Technocity Campus, Thiruvananthapuram, Kerala - 695317, India*

jrnair@duk.ac.in*

ABSTRACT

Plant leaf-form evolved to facilitate enhanced dissipation of free energy. The energy exchange requirements are accomplished by increasing the diversity of leaf shapes. However, the diversity of plant leaf shape renders studying their patterns difficult. The varying arrangement of leaf lamina and the waviness of the edges makes plant leaves a natural fractal structure. We represent the morphological diversity of plant leaf shapes by relating fractal dimensions (FD) to topological entropy (S). The diversity of leaf-form of 30 common plant species in Trivandrum, India, was studied by box-counting fractal analysis using HarFA software. The leaf of *Bauhinia purpurea* (Lobed) showed the highest FD and that of *Phyllanthus emblica* (Pinnate) showed the lowest. S calculated from FD doesn't show significant variation to discriminate the leaf forms. Most of the leaves are comparable. However, the leaves are visually diverse in form. S doesn't have significant variation with lobes and compound leaves. S is inversely related ($r = -0.51$) with the leaf dissection index. While box-counting fractal analysis of leaf shapes is a widely used method

to capture self-similarity, they are vulnerable to the bulk of the leaves. Further, they fail to capture the spatial positioning of the edges and provide only a partial representation. Hence there exists a need for a more inclusive fractal complexity measure of plant leaf shapes.

Keywords: Leaf morphology; Diversity; Fractal dimension; Topological entropy; HarFA

Multi-temporal analysis of the land use changes around the Peppara Wildlife Sanctuary, Kerala, associated with plant invasion

N P Sooraj^{1,2}, U Anajaly², R Jaishanker^{2*}, J Ammini¹

¹School of Environmental Studies, Cochin University of Science and Technology, Kochi-22, Kerala

²C V Raman Laboratory of Ecological Informatics, Indian Institute of Information Technology and Management-Kerala, Technopark Campus, Thiruvananthapuram
jrnair@iitmk.ac.in*

ABSTRACT

Protected areas are the cornerstone of the conservation efforts to protect biodiversity and the ecosystem. Despite strict regulations that control human interventions, protected areas face various threats. Plant invasion has been recognized as one of the major threats to the protected areas nowadays. Among the various drivers of plant invasion, human-induced land-use land cover changes within the surrounding landscape play a prominent role in establishing invasive alien plants in protected areas. In the present study, we quantified the land-use land-cover changes within the surrounding area of the Peppara wildlife sanctuary (5 km buffer from its boundary) from 2001 to 2021 by classifying Landsat imageries into seven LULC classes viz. Natural vegetation (NV), plantation (PL), agriculture/cropland/plantation clearance (ACPC), built-up (BU), rocky outcrops (RO), Open/scrub vegetation (OSV) and waterbody (WB). We identified PL, ACPC and BU as the potential drivers of plant invasion. The study showed that a large portion of the sanctuary's peripheral area is highly

dynamic in human land use. Natural vegetation (NV) is the dominant land cover in the study area, with a rising trend across the years. The area of PL and ACPC class showed a fluctuating trend, and a good correspondence was observed between their class area. The built-up class (BU) showed a rising trend across the years. OSV class showed a consistently decreasing trend from 2001-2021. RO and WB were almost invariant across the years. The land use dynamics of PL, ACPC and BU revealed the susceptibility of Peppara Wildlife Sanctuary to plant invasion.

Keywords: Plant invasion, LULCC, Land use dynamics, Protected Area, Conservation

AI-based Higher-order Chromatic System for Floral Color Representation

K Athira¹, N P Sooraj^{1,2}, K S Sushanth³, R Jaishanker^{1,2*}

¹*C V Raman Laboratory of Ecological Informatics, Indian Institute of Information Technology and Management-Kerala, Technopark Campus, Thiruvananthapuram*

²*School of Informatics, Digital University Kerala, Thiruvananthapuram*

³*Department of Health, Insurance and Life Sciences Data & Analytics Practice Virtusa Corporation, New York City, USA*

jrnair@iiitmk.ac.in*

ABSTRACT

Color is a universal language of nature. It underpins the evolutionary success of living organisms. Angiosperms represent a classic example of the articulation of colour for reproductive success. Albeit sound physical basis, the colour of an object is a perception rendered by light reflected off its surface in the visual system of an observer. The colour of a flower is governed by the interaction of electromagnetic energy off or within the petals. The perception of floral colours is governed by the spectral sensitivity of the observer. Human beings and the majority of insect pollinators have distinct trichromatic visual systems. An ocular system limited to three sensitivity peaks is bound to compromise information contained in another region of the electromagnetic spectrum. A higher-order chromatic system of floral colour will help assimilate information contained in other regions of the electromagnetic spectrum. colours. The authors use AI to explicate an imperceptible higher-order floral color system by revealing the heterogeneity within 11 flowers that are perceived

as white by human visual system. The higher-order chromatic system will help to objectively represent floral color – an important plant trait – and can be extended to a metric used in plant taxonomy.

Keywords: Flower color, Angiosperm, floral spectral reflectance, AI

Identification of Steady-State Vegetation Condition Patches with a Landscape Using Spatial Data Analytics: A Case Study of Kanha Tiger Reserve, Madhya Pradesh, India.

Anjaly Unnikrishnan¹, Malu G¹, Sooraj N P¹, M S Pillai²,
Elizaeth Sherly¹, Jaishaker R Nair^{1*}

¹*Kerala University of Digital Sciences, Innovation and Technology*

²*Department of Statistics, University of Kerala*

jrnaier@iitmk.ac.in*

ABSTRACT

Earth observation satellites are generating massive real time data of the earth surface day to day, for systematically handling this immense data in order to extract patterns, correlations, and other information in certain instances where there is no exact formula or physical laws present, data analytics techniques had proved to be extremely efficient. The big data problem here is to identify resilient tracts of forested landscapes using time series satellite imagery. A per pixel based thresholding technique is used for identifying intact patches of forested landscapes over a period of 15 years. Kanha Tiger Reserve mainly having tropical dry deciduous type of forest is showing a total of 11 % of its total area remaining intact over a period of past 15 years. Since Kanha being one among the 14 globally recognized tiger reserve for good conservation, substantiates our result. Identification of resilient forest tracts helps in acquiring better understanding of natural habitats of various flora and fauna, thereby helping policy makers to devise better conservation plans.

Keywords: Spatial Data Analytics; Conservation; Satellite Data; Time Series

Smart fertilizer recommendation system based on IoT

Sumit Kumar¹, Rutuja Rajendra Patil¹, Vasu Kumawat¹,
Yashovardhan¹, Navaneeth Krishnan¹, Shubham Kumar Singh¹

¹*Symbiosis Institute of Technology (SIT) Symbiosis International (Deemed University),
Pune, India*

jrnair@iiitmk.ac.in*

ABSTRACT

Fertilizers are the key factor due to which crops replenish their roots and gain the required nutrients. They play a pivotal role to enhance productivity and quality of crops. In this paper an automated IoT(Internet of things) system is developed to measure moisture, humidity levels for fertilization using sensors like soil moisture, temperature, Node MCU. N(Nitrogen), P(Phosphorus) ,K(Potassium) estimations of fertilizers for best yield development. The data sensed by the designed NPK sensor from the crops parameters are sent to Google cloud database to support fast derivation of data. The values of temperature, humidity and other various parameters are being used to determine suggestions for whether the proposed IoT system supplies the fertilizers to the crop according to the data derived and helps to improve the yield and quality of crop. The system would also focus on suggesting fertilizers to farmers based on factors such as nitrogen, phosphorus and potassium levels of the soil.

Keywords: Crops, IOT, Humidity, Moisture, Fertilizers.

Ecological Niche Modelling Improvised to Predict Potential Habitats of Threatened Tree Species for Effective Management

Amitha Bachan K. H¹, Devika M. A²

¹Research and PG Department of Botany MES Asmabi College, Kodungallur, 680691, Kerala, India.

²Western Ghats Hornbill Foundation, Kerala, India.
amithabmes@gmail.com*

ABSTRACT

Prediction of potential habitats of a species is essential and the most challenging aspect in species conservation and management. This has become very crucial in the paradigm of ecosystem restoration or ecorestoration of habitats of threatened species. Precise prediction can exclude the possibility of interference to the niche of other species along with increased efficiency in ecorestoration practice. The traditional methods of defining habitat of a species are restricted to the vegetation type, elevation, rainfall or a combination of these. The concept of bioclimate has brought a new dimension and the WorldClim bioclimatic data-based ecological niche modelling provides interactive Ecological Niche Modelling (ENM) for prediction of habitat suitability. The present study used an improvised methodology, a combination of Maxent based niche modelling and QGIS based terrain mapping to cover some of the limitations of ENM for the prediction of potential habitat. It is tested here with prediction of potential habitats for two red listed tree species *Prioria pinnata* (Roxb. ex DC.) Breteler and *Cryptocarya anomala* Gamble endemic to Western Ghats.

The former has numerous records of occurrence throughout the Western Ghats and the latter has very restricted distribution. The results were compared both for normal ENM and for the improvised method and also with the ground level knowledge in the predicted locations. The predictions based only on ENM have provided potential distribution sites including areas which lack terrain suitability. The combined methodology provided a high degree of precision to the predictions. The procedure adopted for the modelling is provided in detail.

Keywords: IUCN Red List; Ecosystem management; Western Ghats; Ecorestoration; Niche profiling

Ecological drivers facilitating understory vegetation communities in Gurez valley of Kashmir Himalayas: Application of multivariate techniques to analyze indicator species

Ashaq Ahmad Dar¹, Narayanaswamy Parthasarathy^{1*}

¹*Department of Ecology and Environmental Sciences, School of Life Sciences,
Pondicherry University, Puducherry, 605 014 India
nparthasarathypu@gmail.com**

ABSTRACT

In ecological research, the application of computer-assisted statistical algorithms for vegetation description is well-established. We performed multivariate statistical analysis including TWINSpan, Indicator species analysis, analysis of similarity, ordination and variation partitioning tests to categorize vegetation subunits, ranking and placement of species within respective groups, compositional differences among vegetation groups and recognizing vegetation–environment relationships and importance of latent environmental drivers across the landscape. The TWINSpan grouped 131 plant species representing 103 genera and 39 families from 32 sampling sites of temperate Kashmir Himalaya of Gurez valley into three major plant communities. The highest number of plant species (87 species), density (43.26 ± 3.36 Ind. m⁻²), maximum alpha (Shannon = 2.07 ± 0.14 ; Simpson = 0.80 ± 0.04 and Fisher's $\alpha = 8.88 \pm 1.16$) and beta diversity (Whittaker $\beta = 4.3$) was found in northern low-elevation (2758.71 ± 66.45 m) Taraxacum-Trifolium-Plantago (TTP) community. However, Pielou's evenness (0.77 ± 0.04) and

community maturity (21.05) was greater in high elevation (3208.00±190.50 m) Tanacetum-Pedicularis-Aconitum (TPA) community. The ANOSIM results predicted that the overall model, besides all pairwise comparisons, was significantly different ($R^2 = 0.64$; $p = 0.001$) regarding their species composition. Similarly, a comparison of diversity, climate, topography and anthropogenic variables employing ANOVA/Kruskal-Wallis test showed that most variables differ significantly among the plant communities. Non-metric Multidimensional Scaling (NMDS) ordination grouped different species with similar habitats and plots within respective communities with common species. Canonical Correspondence Analysis (CCA) interpreted 43% of explained inertia and detected the significant contribution of most of the considered explanatory variables in plant distribution patterns. The latter in descending order included elevation ($p = 0.001$), moisture index ($p = 0.006$), latitude ($p = 0.007$), invasive aliens ($p = 0.008$), and grazing ($p = 0.014$). Similarly, variation partitioning results depicted that disturbance (21%) was the leading driver governing vegetation distribution, followed by climate (14%) and topographic (11%) factors. The adopted analytical techniques and subsequent results may help species conservation and management planning of the studied area and similar temperate ecosystems.

Keywords: Temperate forests; Species diversity; Plant community; Ordination; Environmental drivers

Colonization pattern of heronry birds through network analysis

R. Roshnath^{1*}, C. Prem Sankar², P.A Sinu¹

¹*Department of Zoology, Central University of Kerala, Periyar, Kerala, India.*

²*Department of Futures Studies, University of Kerala, Kariavattom, Kerala, India*

roshnath.r@gmail.com*

ABSTRACT

Network science is gaining popularity among ecologists as a great tool to explore interactions among individuals within and between populations and among species within communities. Heronries are nesting colonies of waterbirds such as herons, egrets, cormorants, storks, etc. which show temporal and spatial clumping of nests during the breeding season. We recorded every new, old and abandoned or lost colony of heronry birds in our surveys and used this data in network analysis to understand their pattern of colonization in the Kannur district of Kerala. This study was based on our observations, literature reviews and personally contacting people living near nesting sites (to estimate the age and fate of the nesting sites). Our ground survey suggests that two factors determine colonization pattern and distribution of heronry sites. since most of the nesting sites are located along with human habitations, the first factor was anthropogenic pressure. Due to the nuisance caused, people distract the nesting birds, cut down the branches or the whole nesting trees. The second factor is the population inflation of breeding birds that find a dearth of space for nesting. The analysis suggests that six major 'feeder' colonies existed in the district, which later gave away

several colonies which, however, are vulnerable to urbanization and other developmental activities. This study provided a general framework for topological-temporal characterization of colonization patterns of heronry birds.

Keywords: Heronry; Colonization; Network analysis; Threats; Urbanization.
