LAKE 2022:Conservation of Wetlands: Ecosystem-based Adaptation of Climate Change

[THE 13TH BIENNIAL LAKE SYMPOSIUM]

Date: **28-30th December 2022**

Venue: Auditorium, Ground Floor, New Biological Sciences Building [Near D Gate], **Indian Institute of Science, Bangalore** 560012, Phone: +91 080-22933503/22933099

Symposium Web: **http:**//wgbis.ces.iisc.ernet.in/energy

E Mail: tvr@iisc.ac.in; energy.ces@iisc.ac.in; lake2022.iisc@gmail.com

LAKE 2022 - Organising Committee:	
T. V. Ramachandra, CES	Rejini Simpson, CEE, Bangalore
M.D. Subash Chandran, CES, IISc	Tejaswini Ananthkumar, Adamya Chetana
Bharath Settur, CES, IISc, Bangalore	C. Rajasekara Murthy, Environment Canada
Bharath. H. Aithal, EURG, IIT Kharagpur	Vrijulal. M. V, CEE, Bangalore
Uttam Kumar, IIIT-Bangalore	Ananth Ashisar, Vrikshalaksha
M.A. Khan, K.K. High School, Bangalore	Vinay S, CES, IISc and S R University, Warangal
Harish K,Vagdevi Vilas Institutions, Bangalore	Sara Kunnath, Koshy Institute of Management Studies
Vijaikrishna R, Vidyaniketan Public School,	Umashankar, Vidyanjali Primary and High School
Sreevidya, Bangalore Blaze Girls High School	Rajshree Nair, BGS National Public School

Lake 2022: - 13th Biennial Lake Symposium

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13th International Biennial Lake Symposium

LAKE 2022 Schedule

28th to 30th December [Hybrid Mode]

Offline – Venue I: Auditorium, Ground Floor, New Biological Sciences Building, IISc		Venue II: School Students **Seminar Hall, 3rd Floor, New Biological Sciences Building**

Online - Zoom (only for experts delivering a talk) Live streaming at You Tube

The proceedings of Lake 2022 International Symposium will be streamed live at

https://www.youtube.com/@EWRGENVIRONMENTALEDUCATIONIISC/streams

You may subscribe to EWRG channel at YOU TUBE (so that you will receive auto-notification as and when new video / lecture is streamed)

Lake 2022 – Auditorium, Presentations (Live streaming)		
https://www.youtube.com/@EWRGENVIRONMENTALEDUCATIONIISC/streams		
Parallel sessions		
Programme	Venue	You tube link
School students 29 December 2022	Seminar Hall, 3rd Floor	https://www.youtube.com/watch?v=yqRnTRRWbRs
UG, PG and Phd Scholars 29 December 2022	MRDG Seminar Hall, 1st floor	https://www.youtube.com/watch?v=cCzUk58-ERU

In case you need any assistance during the virtual meeting –
Contact numbers - country code 91, **Abhishek B** (8884855739), Dr. Bharath Settur 9483832144 / 9606828799, Dr. **Vinay S** - 9916488990

LAKE 2022 Schedule
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Date	Time	Session	Venue
28-12-2022	**8.30 – 9.00**	**Lake Symposiums**: Capacity Building Programmes at IISc – Overview	**Venue I: Auditorium,** Ground Floor, New Biological Sciences Building [Near D Gate], IISc campus **Venue II: Seminar Hall,** 3rd Floor, New Biological Sciences Building **[School Children]**
	9.00 - 10.30	**Inaugural Session**	
	11.00 - 1 30	**Keynote talks**	
	2:15 - 4.00	**Technical Session 1**	
	4 30 – 5.30	**Technical Session 2**	
	6.00 – 7.35	**Technical Session 3**	
28-12-2022 Parallel Session	**2.15 - 4.00**	**Johny Biosphere Session -I (co-ordinated by Johny Biosphere, M A Khan) – Inter active session with school students**	**Food Court (behind auditorium)** **Co-ordinators** • M A Khan • Manoj Kr. Singh • Chaturved Shet • G R Rao • Vrijulal • Ranjit Rao
	4. 30 - 6.00	**Johny Biosphere Session -II (co-ordinated by Johny Biosphere) Inter active session by school students**	
Live stream at https://www.youtube.com/@EWRGENVIRONMENTALEDUCATIONIISC/streams			

29th December 2022

Date	Time	Session	Venue	Co-ordinators
29-12-2022 **Parallel Session**	**8.30-12. 30** **1.30 – 6. 30**	**School Students Presentations**	**Venue II: Seminar Hall,** 3rd Floor, New Biological Sciences Building	Nagaratna A V M A Khan Sreevidya Shreya M Singh Tulika
		Live stream at https://www.youtube.com/watch?v=yqRnTRRWbRs		
29-12-2022 **Parallel Session**	**8 30 – 10 30**	**UG**	**Venue III: MRDG Seminar Hall, 1st** Floor, New Biological Sciences Building	Aruna H K Manoj Kumar Netravathy K Vrijulal Vinay S Kaushik P M
		Live stream at https://www.youtube.com/watch?v=cCzUk58-ERU		

29-12-2022 Parallel Session	**10.30 – 4.00**	**PG and Research Scholars**	**Venue III: MRDG Seminar Hall, 1st** Floor, New Biological Sciences Building	Durga Madhab Sudarshan Sri Niwas Singh Kaushik P M
		Live stream at https://www.youtube.com/watch?v=cCzUk58-ERU		
29-12-2022 Parallel Session	**4.30 – 6. 30**	**Faculty**	**Venue III: MRDG Seminar Hall, 1st** Floor, New Biological Sciences Building	E V Ramasamy M N V Prasad Aruna H K Kaushik P M
		Live stream at https://www.youtube.com/watch?v=cCzUk58-ERU		

Date	**Time**	**Session**	**Venue**
29-12-2022	**8.30 – 10 30**	**Technical Session 4**	**Venue I: Auditorium,** Ground Floor, New Biological Sciences Building [Near D Gate], IISc campus
	11.00 –1.15	**Technical Session 5**	
	2.00 - 4.00	**Technical Session 6**	
	4.30 – 8.00	**Technical Session 7**	
Live stream at https://www.youtube.com/@EWRGENVIRONMENTALEDUCATIONIISC/streams			

30th December 2022

Date	**Time**	**Session**	**Venue**
30-12-2022	**8.30–11.00**	**Technical Session 8**	**Venue I: Auditorium** **Venue II: Seminar Hall,** 3rd Floor
	11.30–1.15	**Technical Session 9**	
	2.00 - 5 30	**Technical Session 10**	
	5.30 – 6.30	**Cultural Programme**	**Venue I: Auditorium**
	6.30 – 7.30	**Valedictory**	
Live stream at https://www.youtube.com/@EWRGENVIRONMENTALEDUCATIONIISC/streams			

Day 1, WEDNESDAY: 28th December 2022

8:15 am	Registration	
8:30 – 9:00 am	**Environment Education: Biennial Lake Symposiums** Capacity Building Programmes at IISc: Overview - T V Ramachandra Environment Education and Environment Literacy: Need and Opportunities - Medha	
9:00 to 10.30 am - Inaugural Session		
Timings	**Type**	**Speaker**
09:00 - 09:15 am	**Welcome Address**	**Dr. TV Ramachandra** Convener, LAKE 2022
09:15 - 09:30 am	**Inaugural Address**	**Dr. Tejaswini Ananth Kumar** Founder & Managing Trustee, Adamya Chetana
09:30 - 09:45 am	**Guest of Honour**	**Dr. Vijai Krishna R (virtual, online)** Independent Education Management Professional, & Director, Vidyaniketan Public School
09:45 - 10:00 am		**Dr. Harish Krishnamurthy** Chairman - Vagdevi Vilas Institutions, Bengaluru
10:00 - 10:15 am		**Dr. Nagalaxmi B.N.**, Principal, Maharani Lakshmi Ammanni College for Women (**MLAC**)
10: 15 – 10:25 am	**Presidential Address**	**Dr. Rajasekara Murthy,** Emeritus Professor, Environment Canada, Canada
10:25 – 10:30 am		**Vote of thanks**

Tea – 10:30 to 11:00 am

11:00 -12:00 pm	**Keynote Address**	Conservation of Wetlands: Ecosystem-based Adaptation of Climate Change – T V Ramachandra
12:00 – 12:45 pm	**Keynote talk**	Documenting Biodiversity by involving youth at village levels: Opportunities and Challenges - M D Subashchandran

12: 45 – 1:30 pm	**Keynote talk**	Plants, Ecosystems and Climate Change - K Sankara Rao

Lunch - 01:30 - 02:15 pm

Technical Session 1 (02:15 pm to 4.00 pm) Venue: Auditorium, Ground Floor, New Biological Sciences Building Moderators: B M Kumaraswamy, Bharath Setturu			
Timings	**Type**	**Speaker**	**Title**
2.15 – 2.45 pm	**Keynote**	B M Kumaraswamy	Status of Forest Cover in India and Climate Change threats
2.45 – 3.05 pm	Plenary talk	Bharath Setturu	Insights of land use dynamics for conservation of Sambhar Lake
3.05 – 3.25 pm	Oral (online)	Aishwarya, N Bharath, H.A **VIRTUAL- Zoom**	Flood Resilient Scenario Modelling (FReSMo): for assessing coastal flood impact of built infrastructure
3.25 – 3.45 pm	Oral	Samar Singh Virdi	Conservation and sustainable management of Sambhar Lake, a Ramsar Site of International importance
3.45 – 4.00 pm	Oral	Manjunath D	Western Ghats biodiversity spatial information system

Tea – 04:00 to 04:30 pm

Technical Session 2 (4.30 pm to 5.30 pm) Venue: Auditorium, Ground Floor, New Biological Sciences Building Moderators: Upendra Nongthomba, Vinay S			
4.30 – 5.00 pm	**Keynote**	Upendra Nongthomba	Evaluation of cytogenotoxic potential and embryotoxicity of KRS-Cauvery River water in zebrafish (Danio rerio)
5.00 – 5.30 pm	Plenary	Vinay S	Environmental flow assessment in rivers of Karnataka
5.30- 5.45 pm	Oral	Sincy V	Spatial DSS for managing fish resources in Bangalore
5.45 – 6.00 pm	Oral	Asulabha KS	Microalgal SDSS for sustainable management of lakes

Technical Session 3 (6.00 to 7.30 pm) Venue: Auditorium, Ground Floor, New Biological Sciences Building **Moderators:** M D Subash Chandran, Sincy V			
6.00– 6.15 pm	Oral	Abhishek B	Expert system for managing biodiversity
6.15 – 6.30 pm	Oral	Tulika Mondal	Machine Learning based land use classification of heterogenous landscape using Big Data
6.30- 6.45 pm	Oral	Paras Negi	AI based prudent management of natural resources in agrarian landscape
6.45 -7.00 pm	Oral	Prasanna B M	Decentralized Solar power generation: Challenges and opportunities
7.00 – 7.15 pm	Oral	Sara Kunnath	SEEA Protocol for Accounting of Energy Assets
7.15 – 7.30 pm	Oral	Ravishankar Mishra	Plant of Phytogeographic regions of India
7.30 – 7.35 pm	Poster	Kaushik P M	Carbon sequestration potential of wetland
7.35- 7.40 pm	Poster	Vishnu Mukri	Traditional knowledge on medicinal plants in Uttara Kannada district
7.40 – 7.45 pm	Poster	Gayathri Naik	Gonda's of Bhatkal, Uttara Kannada: Socio ecological perspective
7.45 – 7.50 pm	Poster	Srikanth Naik	Ethno ornithological knowledge and uses of birds in the coastal region of Uttara Kannada
7.50 – 8.00 pm		Convenor, Lake 2022	Concluding Remarks of Day 1

Day 2 - 29th December 2022

29th December [8.30 to 10.30 am IST]

Technical Session 4

Moderators: Rajasekara Murthy, Sara Kunnath

Timings	Type	Speaker	Title
8.30 -9.05am	Expert Lecture	Ramachandra Rao (Burlington) **Virtual -Zoom**	Assessing and addressing the water quality in Lake Erie
9.10- 9.45 am	Expert Lecture	Rajasekhara Murthy	North American Great Lakes Water Quality Management
9.50 to 10.30 am	Expert Lecture	Nikolay Filatov (Petrozavodsk) **Virtual -Zoom**	The Present state and changes of Large Lakes of Russia under Climate Warming and Anthropogenic Impact

Tea – 10:30 to 11.00 am [29th December]

Technical session: 5

Moderators: Karthick B, Asulabha K S

11.00 – 11.32 am	Expert Lecture	Shigeki Mayama Tokyo Gakugei University, Japan **Virtual -Zoom**	Taking diatoms to school – a two-decades experience
11.33 – 11.50 am	Invited talk	Mihir Kulkarni CCMB, Hyderabad	Temporary waters: "Hotspecks" of Diversity in the Freshwater Realm
11.51 – 12.08 pm	Invited talk	Vidyadhar Atkore SACON, Coimbatore	Dams and Freshwater fishes

12.09 – 12.26 pm	Invited talk	Biswa Bhusan Mahapatra, NCBS	Invasive freshwater molluscs – Patterns in spreading.
12.27 – 12.44 pm	Invited talk	Girish & Rasika, ATREE and WWF	River Health Assessment - Developing a tool for multi-dimensional hydro-ecological measurements for river systems in India
12.45 – 1.15 pm	Plenary talk	Karthick Balasubramanian, ARI, Pune	Diatoms as an indicator of Myristica swamp conditions in the Western Ghats

Lunch 01:15 - 02:00 pm [29th December]

Technical session: 6 **Moderators: M N V Prasad, Chandan M C**			
2.00 to 2.30 pm	Plenary	M C Chandan	A robust spatial decision support system for combating unplanned growth across selected cities of India
2.30- 3.00 pm	Plenary	E V Ramasamy	Microplastics in the Wetlands and Estuaries of Kerala Coast : Risks and Challenges
3.00 to 3.30 pm	Plenary	Deepika Shetty	Developing sustainable goals in architecture design and its contribution towards water management in built environment
3.30 to 4.00 pm	Plenary	M N V Prasad	Conservation of aquatic resources - Ecosystem-based Adaptation (EbA) of Climate Change for Disaster Risk Reduction (EbA-DRR)

Tea– 04:00 to 04:30 pm

Technical session: 7 [4.30 – 8.00 pm] **Moderators: G R Rao, Prasanna B M**			
4.30- 5.00 pm	Plenary	Akshay Chakravarthy	Impact of Climate Change on Aquatic Arthropods
5.00 – 5.30 pm	Plenary	Sri Niwas Singh	A multi criteria selection in wheat breeding.
5 30 – 6.00 pm	Plenary	G. Ramachandra Rao	An Insight into the world of plant endemics of Western Ghats
6.00 – 6 30 pm	Plenary	Sudarshan P. Bhat	Role of Macrophytes in phytoremediation and phytochemistry
6.30- 7 00 pm	Plenary	Durga Madhav Mahapatra	Bioderivatives for a sustainable bioeconomy

7. 00 – 7.15 pm	Oral	Narasimhaiah N	Dietary composition and feeding habits of fish, *Gerres filamentosus* (Cuvier) from Mangalore Coast, Karnataka, India
7.15 – 7.30 pm	Oral	Manoj Kumar Singh	Nakti nala watershed - a product of Narwa 2019-2020 A GIS based approach for the assessment of work done in 2019-2020
7.30 – 7.45 pm	Oral	Sourosree Lahiri	Environmental and health impacts of microplastics
7.45 – 8 00 pm	Oral	Jyoti Srivastava	Present, past and future distribution of ebony tree species in India: integrating ensemble species distribution modeling and fossil pollen data
		Convenor, Lake 2022	Concluding Remarks of Day 2

Day 3 - 30th December 2022

30th December [8.30 to 10.30 am IST]

Technical Session 8 Moderators: Rejini Simpson, Samar Virdi			
Timings	**Type**	**Speaker**	**Title**
8.30 -9.05 am	Plenary	Krushnamegh Kunte	Butterflies
9.05 – 9.30 am	Plenary	Rejini Simpson	LiFE (Lifestyle for Environment): Low carbon lifestyle
9.30- 10.00 am	Plenary	Surabhi Mehrotra	Climate Resilient Strategies to Manage Socio- Ecological Systems- Wetlands
10.00 – 11.00 am		Teachers from Uttara Kannada, Channagiri	

Tea– 11 am 11 30 am [29th December]

Technical session: 9 [11. 30 – 1.15 pm] [Big data, AI and ML for Environmental Management) Moderators: Uttam Kumar, Abhishek B			
11.30 – 11.45 am	Oral	Anindita Dasgupta	Assessment of changes in LST during the last two decades: urban transformation
11.45- 12.00 pm	Oral	Madhurima Panja **VIRTUAL- Zoom**	Epicasting: An Ensemble Wavelet Neural Network for Forecasting Epidemics)
12.00– 12.15 pm	Oral	Rahisha Thottolil	Cloud Computing for Big Geospatial Data Analysis with Google Earth Engine – Urban Research Applications

12.15 - 12 30 pm	Oral	Tanujit Chakraborty **VIRTUAL- Zoom**	Past, Present and Future of Time Series Forecasting
12.30 -1 15 pm	Plenary	Uttam Kumar	Semi-supervised Tree Canopy Detection and Classification of Plant Disease using Convolutional Neural Network based Transfer Learning Models

Lunch 1: 15 - 02:00 pm [30th December]

Technical session: 10 [2.00 to 3.30 pm]		
Panel discussion 1	Media's role in the prudent management of lakes and green cover	Aksheev Thakur Bosky Khanna Deepika Cariappa Kere Manjunath Siraj Rasheed Kappan
Tea 3.30 – 4.00		

Technical session: 10 [4.00 to 5 30 pm]		
Panel Discussion 2	Problems and challenges of lake conservation and the strategies to mitigate the problem -	Almitra Patel KS Bhat Elangovan K Prabhu Shankar Rai Sonali Singh Jagadish Reddy Vinod Jacob

Cultural Programme [5 30 – 6 30 pm]

Valedictory		
Lake 2022 – Recommendations		
Lake 2022 – Sahyadri Awards Presentations		
06.30 – 07.30 pm	**Chief Guest**	Anandi Subramanian
	Guest of Honors	Aruna H K
		M D Subash Chandran
		M A Khan
		Sreevidya
		B M Kumaraswamy
7.30 – 7.45 pm	Convenor, Lake 2022	Concluding Remarks and Way forward

Lake 2022: - 13th Biennial Lake Symposium

Conservation of Wetlands: Ecosystem-based Adaptation of Climate Change

Date: **28-30th December 2022**

Venue: Auditorium, Ground Floor, New Biological Sciences Building [Near D Gate],
Indian Institute of Science, Bangalore 560012, Phone: +91 080-22933503/22933099
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A symposium focusing on lakes/wetlands, popularly known as "**Lake Symposium**" was initiated by the Energy & Wetlands Research Group at the Centre for Ecological Sciences, Indian Institute of Science, Bangalore in the year 1998. The theme was broadened in 2000 (Lake 2000) with wider participation of education institutions, Governmental and non-governmental organisations, etc. The basic idea of the symposium was to bring out the trends in ecosystem conservation, restoration and management, including the hydrological, bio-physical, people's participation and the role of non-governmental, educational and governmental organizations and the future research needs. **Lake 2022** will be the 13**th**Biennial Lake Conference would focus on "Conservation of Wetlands: Ecosystem-based Adaptation of Climate Change".

Wetlands constitute vital components of the regional hydrological cycle. They are highly productive, support exceptionally large biological diversity, and provide a wide range of ecosystem services such as food, fibre, waste assimilation, water purification, flood mitigation, erosion control, groundwater recharge, microclimate regulation, enhance the aesthetics of the landscape, and support many significant recreational, social and cultural activities, aside from being a part of our cultural heritage. Wetlands play an important role in mitigating climate change adaptation through capturing and storing carbon to reduce atmospheric greenhouse gases (GHG), and providing resilience to hazards such as flooding, storm surge and coastal inundation.

The theme of World Wetlands Day 2022 is "**Wetlands Action for People and Nature"**, highlighting the importance of actions ensuring that wetlands are conserved and sustainably used. This would demonstrate the vital role of wetlands for the future of humanity and specifically their relevance towards achieving the new Sustainable Development Goals. Lake 2022 conference would provide a unique opportunity to increase understanding of the role of ecosystems in sustaining the food, water and human livelihood with the challenges faced by these fragile ecosystems. The deliberation involving all stakeholders would help raise awareness about wetlands' importance and the need to preserve them.

The sustainable development goals have ecological, social and economic aspects for present and future generations with an equitable share of resources. Conservation of natural resources through sustainable ecosystem management and development is the key to our secured future. Sustainable development of a region requires a synoptic ecosystem approach that relates to the dynamics of natural variability and the effects of human interventions on key indicators of biodiversity and productivity. Formulating and implementing action plans that best conserve vital ecosystems require understanding issues, concerns and threats. This requires awareness of the ecosystem function, goods and services among decision-makers and the public at large. Collaborative planning between scientists, policymakers and community members is an essential element of ecosystem-based management. Approaches towards this direction include:

- Fostering participation of all stakeholders to ensure that individuals and organizations are provided an opportunity to participate in the ecosystem conservation activities.
- Recommending policies and actions that can be undertaken to restore, maintain or enhance aquatic and terrestrial resources.

- Recommending policies and action plan towards the conservation and sustainable management of fragile ecosystems such as Western Ghats – water tower and food bowl for peninsular India.
- Nature based solutions to mitigate climate change ranging from the restoration of habitats to water resource management, disaster risk reduction, and green infrastructure—to address societal problems. Nature-based solutions provide essential benefits and services to the community, such as reducing greenhouse gas emissions, securing safe water resources, clean air, and ensuring food security.

Lake 2022 Symposium focussing on Conservation of Wetlands: Ecosystem-based Adaptation of Climate Change (during 28-30th December 2022) provides a unique opportunity to increase understanding of the role of ecosystems in sustaining the food and water with the challenges faced by these fragile ecosystems. The forum would demonstrate the vital role of ecosystems for the future of humanity and specifically their relevance towards achieving the new Sustainable Development Goals.

Lake 2022 conference: Lake 2022 forum would deliberate on nature based solutions through protection, restoration, and sustainably managing ecosystems in ways that increase their resiliency and ability to address those societal challenges, while also safeguarding biodiversity and improving human wellbeing. Lake 2022 participants include all stakeholders (Researchers: 30%, School students and teachers: 20%, college and university students: 20%, NGO's, community representatives: 20%, government officials (local, state and centre): 10%

Lake 2022 would focus not only on updating the current knowledge of the scientific community but also would bring in awareness among students, teachers, practitioners and the public. This would provide a platform for interaction among researchers, policymakers, academics and NGOs and address the issues related to wetlands and biodiversity in an era of climate change. This would help develop a stronger network among experts and institutions to develop efficient strategies for conserving and managing fragile ecosystems. As a part of the conference, it has been decided to have theme-based lead lectures by eminent scholars, paper and poster presentations by researchers, school and college students.

OBJECTIVES

Focus of **Lake 2022** would be (i) assessment of the present status and conservation aspects of ecosystems (terrestrial, aquatic - wetlands, lakes, tanks, ponds, swamps, streams and rivers), (ii) presentation by researchers, practitioners, students of case studies focusing on biodiversity, ecology, present status, threats, conservation measures required, (iii) discussion of current initiatives of conservation and management, (iv) role of education institutions, non-governmental organisations, religious organisations, (v) discussion of people's livelihood and fundamental right towards equitable resource allocation through scientific assessment of ecosystem goods and services, (vi) presentation by students (schools and colleges) based on documentation focusing on wetlands – biodiversity, present status, ecology, conservation and protection needs, (vii) allocation of financial and human resources to conserve and protect ecologically fragile ecosystems, (viii) proposals by students and non-governmental organisations for conservation, protection, restoration and sustainable management of aquatic ecosystems, (ix) discussion on research gaps and activities to be initiated by researchers to evolve appropriate strategies towards conservation of ecosystems in Western Ghats, (x) application of advanced technologies – big data, artificial intelligence (AI), Machine Learning (ML) and Deep Learning techniques for monitoring and sustainable management of ecosystems, (xi) developing SDSS – spatial decision support system for planning and management of ecosystems, and (xii) developing strategies for conservation and sustainable management of aquatic ecosystems in Western Ghats to sustain water, food and human livelihood.

THEMES for Paper Presentation/ Poster in Lake 2022

Papers are invited on the following themes from researchers, faculty from universities, Research Scholars, planners, development managers, economists and social scientists, school (VIII-XIIth students) and college (UG and PG) students and teachers.

1. Ecosystems (wetlands, forests, grasslands, estuaries, etc.)- Structure and functions.
2. Climate change – adaptation and mitigation strategies
3. Nature based solutions to address changes in the climate
4. Application of Geoinformatics in Ecosystems Management - Land use, Land cover dynamics, fragmentation of ecosystems
5. Monitoring of ecosystems – Big Data (Remote Sensing Data), Artificial Intelligence (AI), Machine Learning (ML) and Deep Learning techniques
6. Ecosystem (terrestrial, aquatic – coastal, fresh water) Goods and services.
7. Biodiversity, Hydrology and Ecology of Western Ghats.
8. Aquatic Ecosystems - Food and water security, people's livelihood.
9. Wetlands and swamps: Restoration, Conservation and Management.
10. Carrying capacity of river basins in Western Ghats.
11. Natural capital accounting and Valuation of Ecosystem services.
12. Sacred Groves (*kans, devarakadu*) and Myristica Swamps.
13. Eco-Tourism in Western Ghats and Carbon sequestration.
14. Natural and Anthropogenic disasters.
15. Limnology, aquatic ecology, biodiversity and prospects of bio-monitoring.
16. Pollution –terrestrial and aquatic - Monitoring and Management, waste (solid / liquid) management, bioremediation.
17. Constructed wetlands, bioremediation, phytoremediation
18. Sustainable Agriculture and Organic farming.
19. Coastal ecosystems – Biodiversity, Ecology, Productivity and Livelihood aspects.
20. Prospects of Renewable Energy (solar, biofuel, bioenergy) and Energy Conservation.
21. Environmental Education and Sustainable Development.
22. Environment Ethics and Green Technology; and Environment Literacy.

SCHOOL AND COLLEGE STUDENTS' PARTICIPATION

Orientation (Lake 2022- Pre Conference workshops) are planned in the partner schools for training students and teachers. The session would involve lectures and hands-on sessions (environment monitoring – biotic and abiotic components of an ecosystem). Institutions organizing the pre-conference Lake 2022 workshops (Co-ordinated by Centre for Environment Education (CEE), Bangalore) are:

- Sri Arurovindo Public School, Ulsoor
- BGS National Public School, Hulimavu
- Bangalore Blaze, Nagarabavi
- Ideal International Techno School, Channagiri
- K. K. English School, Varthur
- Poornapramati School, Banashankari
- Vagdevi Vilas Group of Institutions, Bidadi, Martahalli, Varthur, Whitefield
- Vidyaniketan Public School, Ullal
- Vidyanjali Primary and High School, Gottigere

Conservation of Wetlands: Ecosystem-based Adaptation of Climate change

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Abstract

Wetlands constitute the most productive ecosystems with a wide array of goods and services. These ecosystems serve as life support systems; serve as habitats for a variety of organisms including migratory birds for food and shelter. They aid in bioremediation and are hence aptly known as 'kidneys of the landscape'. Major services include flood control, wastewater treatment, arresting sediment load, drinking water, protein production, and more importantly recharging of aquifers apart from aiding as sinks and climate stabilizers. The wetlands provide a low-cost way to treat the community's wastewater, while simultaneously functioning as a wild fauna sanctuary, with public access. These ecosystems are valuable for education and scientific endeavours due to their rich biodiversity. However, post-industrialization and globalization era witnessed a spurt in unplanned developmental activities with senseless urbanisation leading to the degradation and decline of fragile ecosystems. This necessitates the conservation of vital ecosystems through sustainable management tenets, which requires an understanding of the livelihood support of ecosystems. Hence, there is a pressing need to carry out the valuation of the ecosystem services, especially intangible benefits, provided by ecosystems. The value of all ecosystem services, including the degradation costs, and implications of climate change needs to be understood for developing appropriate policies toward the conservation and sustainable use and management of ecosystems. Regional and national accounts need to include measures of resource depletion or their degradation in a measure of the current economic well-being of a population. The existing GDP growth percentages used as yardsticks to measure the development and well-being of citizens in decision-making processes are substantially misleading, as it is based on the market exchange of material well-being, will indicate resource depletion/degradation only through a positive gain in the economy and will not represent the decline in these assets (wealth) at all. Appraisal of ecosystem services (ES) allows for adjusted regional or national accounts which reflect the output of ecosystem services as well as the depletion of natural resources and the degradation costs (externalized costs of the loss of ecosystem services) of ecosystems in economic terms, which will help raise awareness and provide a quantitative tool to evaluate the sustainability of policies toward prudent management and conservation of fragile livelihood supporting ecosystems. The monetary valuation of ecosystem services can help in building a better understanding of their influence on well-being and can further facilitate information-driven decisions and policy reforms that align with the Sustainable Development Goals (SDGs) through the wise use of natural resources. Prudent management of vital ecosystems aid in mitigating the threat of global warming as healthy ecosystems aid in mitigating changes in climate.

Keywords: Wetlands, climate change, adaptation, ecosystem services

Introduction

Wetlands constitute vital components of the regional hydrological cycle. They are highly productive, support exceptionally large biological diversity, and provide a wide range of ecosystem services such as food, fibre, waste assimilation, water purification, flood mitigation, erosion control, groundwater recharge, microclimate regulation, enhance the aesthetics of the landscape, and support many significant recreational, social and cultural activities, aside from being a part of our cultural heritage. It was acknowledged that most urban wetlands are seriously threatened by conversion to non-wetland purposes, encroachment of drainage through landfilling, pollution (discharge of domestic and industrial effluents, carbon sequestration, disposal of solid wastes), hydrological alterations (water withdrawal and inflow changes), and over-exploitation of their natural resources. This results in the loss of biodiversity and disruption of goods and services provided by wetlands. Major implications of unplanned developmental activities are

- **Loss of wetlands and green spaces:** Urbanisation has telling influences on the natural resources such as decline in green spaces (vegetation) including wetlands and / or depleting groundwater table in the rapidly urbanising landscapes such as Bangalore. The region had green cover of 68.2% (in 1973) which has declined to < 3% (in 2021) with an increase in urban area (paved surface) of 1080% with a decline of green cover of 88% and a 79% decline in wetlands (Figure 1). Quantification of a number of trees in the region using high spatial resolution remote sensing data with field census reveals 1.5 million trees and human population is 9.5 million, indicating one tree for seven persons in the city.

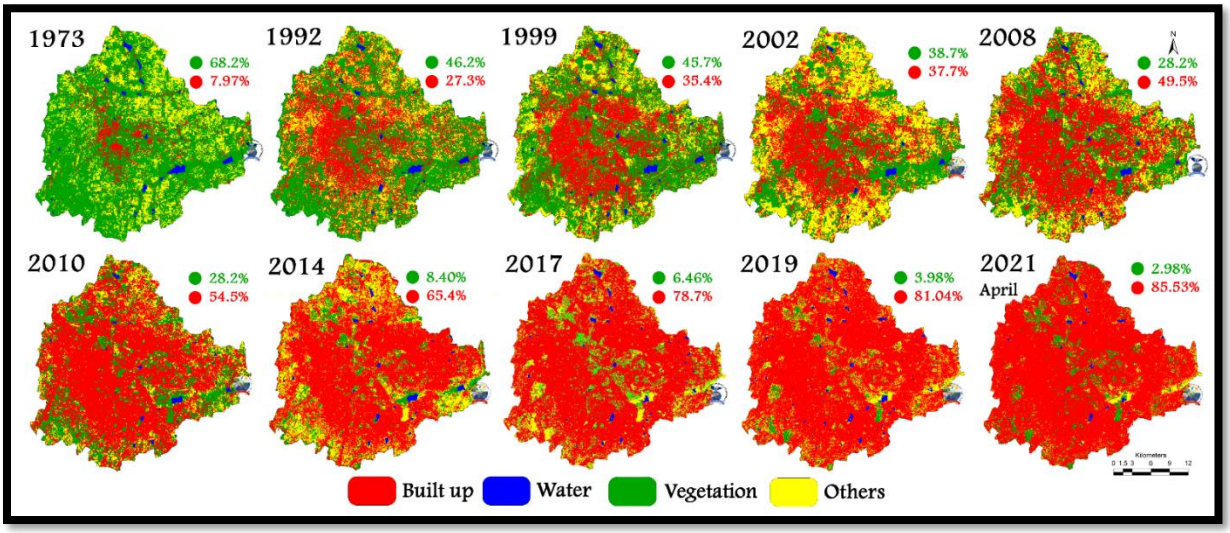

Figure 1: Spatial pattern of landscape dynamics in Bangalore during 1973 to 2021

- **Floods:** Conversion of wetlands to residential layouts has compounded the problem by removing the interconnectivity in undulating terrain. Encroachment of natural drains, alteration of topography involving the construction of high-rise buildings, removal of vegetative cover, and reclamation of wetlands are the prime reasons for frequent flooding even during normal rainfall post-2000. Unplanned urbanisation has drastically altered the drainage characteristics of natural catchments, or drainage areas, by increasing the volume and rate of surface runoff. Drainage systems are unable to cope with

the increased volume of water, and are often blocked due to indiscriminate disposal of solid wastes. Encroachment of wetlands, floodplains, etc. obstructs floodways causing loss of natural flood storage.

Frequent flooding in the city is a consequence of the drastic increase in impervious area and loss of wetlands (and interconnectivity of wetlands) with the high-density urban developments. The uncoordinated pattern of urban growth is attributed to a lack of good governance and decentralized administration, which was evident from the lack of coordination among many Para-state agencies, which has led to unsustainable use of the land and other resources. The mitigation of frequent floods and the associated loss of human life and properties entail the restoration of interconnectivity among wetlands, restoration of wetlands (removal of encroachments), conservation, and sustainable management of wetlands.

- **Decline in groundwater table:** Studies reveal the removal of wetlands has led to the decline in the water table. The water table has declined to 300 m from 28 m over a period of 20 years after the reclamation of the lake with its catchment for commercial activities. In addition, the groundwater table in the intensely urbanized area such as Whitefield, etc. has now dropped to 400 to 500m.
- **Heat island:** Surface and atmospheric temperatures are increased by anthropogenic heat discharge due to energy consumption, increased land surface coverage by artificial materials having high heat capacities and conductivities, and the associated decreases in vegetation and water pervious surfaces, which reduce surface temperature through evapotranspiration.
- **Increased carbon footprint**: Due to the adoption of inappropriate building architecture, the consumption of electricity has increased in certain corporation wards drastically. The building design conducive to tropical climate would have reduced the dependence on electricity. Higher energy consumption, enhanced pollution levels due to the increase of private vehicles, traffic bottlenecks have contributed to carbon emissions significantly. Apart from these, mismanagement of solid and liquid wastes has aggravated the situation.

Lakes or Wetlands provide vital ecosystem services and processes, such as the provision of food (fish, fodder, etc.), groundwater recharge, water purification, remediation, nutrient assimilation, carbon sequestration, moderating micro-climate, habitat for flora and fauna, flood reduction, erosion control, opportunities for education, aesthetics, and recreation (de Groot et al. 2020; Ramachandra et al. 2011, 2019, 2021; Barbier 2013; Costanza et al. 1997). Wetlands help to conserve biodiversity by providing habitat for fish, planktons, aquatic plants, insects, and crustaceans, as well as feeding and resting areas for water birds (Ramachandra et al. 2016). Food chains/food webs describe the structure of communities inhabiting a particular ecosystem, and the associated energy as well as nutrient flows, and the interactions between species (Ramachandra et al. 2005; 2006; 2016). Wetlands aid in removing nutrients like nitrate, phosphate, etc., from water (Ramachandra et al. 2021; Ramachandra et al. 2020a).

The function of the wetland ecosystem is illustrated in figure 1, which includes food production, habitat provision, information provision, and regulation of ecosystem processes. Microalgae are primary producers

that sequester carbon and synthesize food and energy for higher trophic levels (Kulkarni and Ramachandra 2006; Peel et al. 2019). Enhanced oxygen levels on early Earth, triggering aerobic respiration and the evolution of complex multicellular life forms are due to photosynthesis by microalgae (cyanobacteria) and the release of oxygen (Sánchez-Baracaldo and Cardona 2020). Wetlands provide food and shelter for diverse aquatic organisms (zooplankton, fish, and birds), fodder (livestock and other grazers), medicine, water purification/treatment (remediation), and carbon sequestration (Ramachandra et al. 2020b; Ramachandra et al. 2014). Fish store nutrients in their tissues, translocate nutrients, and excrete dietary nutrients in dissolved forms that are readily available to primary producers (Vanni 2002). Fish feeding alters the community structure of phytoplankton, zooplankton, and insects (Griffiths 2006).

Wetlands provide numerous ecosystem services, sustaining the livelihoods of dependent populations with the provisioning, regulating, and cultural services, and hence there is a need to quantify the socio-cultural, ecological, and economic value of wetlands (TEEB 2010) for appropriate management strategies by policymakers, and other stakeholders (figure 2) with incentives, and financial support for conservation. Prudent management with the sustainable use of wetlands would aid in maintaining biodiversity, mitigating pollution, and changes in the climate.

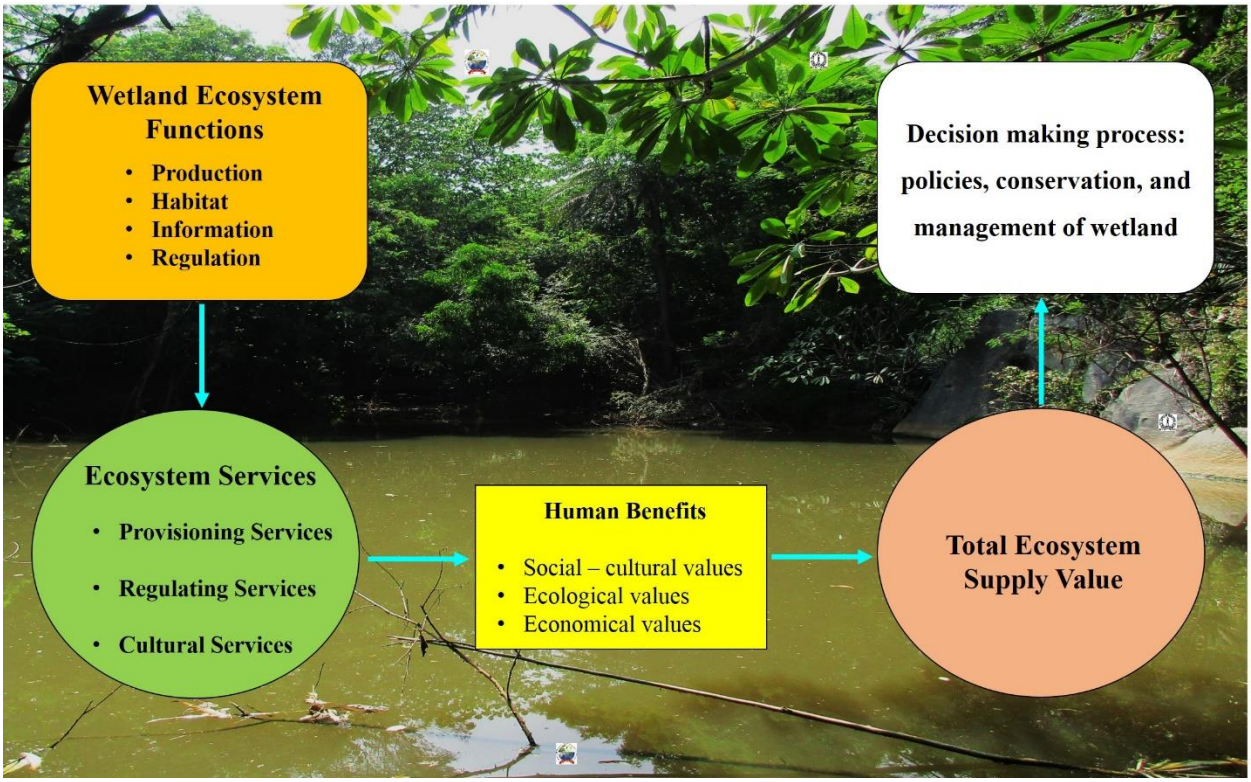

Figure 2: Wetland ecosystem function and service valuation

Figure 3: Ecosystem services from wetlands

Ecosystem services categorized as provisioning services, regulating services, and cultural services are the benefits derived from nature for human well-being (figure 3). Freshwater lakes provide various services supporting the livelihoods of dependent communities, which include the provision of fish (food), fodder (livestock), water (drinking and irrigation), navigation, recreation, and socio-economic development (Najar and Khan 2012), generation of hydropower, etc. (Anshumali and Ramanathan 2007). Recreation services of wetlands are evident as tourism is a major source of income, and employment in Rudrasagar lake (Burman et al. 2007). The wetland ecosystem supply values range from 7670 (Andhra Pradesh), 7689.4 (Gujarat) to 7896.5 (Karnataka) million US$yr^{-1} (Pandey et al. 2004).

The total ecosystem supply value (TESV) is the sum of provisioning, regulating, and cultural services. The value of an asset is determined by estimating the net present value (NPV) based on the stream of income expected to be earned in the future and then discounting the future income back to the present accounting period (SEEA 2021). Valuation of wetland ecosystem services would aid in formulating strategies for wetland conservation to adapt and mitigate changes in the climate, protect biodiversity, and sustainable use of wetland resources. The main objectives of this study were to assess total ecosystem supply value (TESV) and assess the net present value (NPV) of wetlands in Karnataka, India.

Materials and Methods

Study Area: Karnataka State is endowed with a vast inland water spread that includes lakes, tanks, reservoirs, rivers, and ponds. Figure 4 depicts the spatial distribution of wetlands in Karnataka. The state is located at 11°30'N and 18°30'N latitudes, 74°E and 78°30'E longitudes, and is the eighth largest state by area and the ninth largest state by population in India. Karnataka state is surrounded by the Arabian Sea to the west, Goa to the northwest, Maharashtra to the north, Telangana to the northeast, Andhra Pradesh to the east, Tamil Nadu to the southeast, and Kerala to the southwest. The state is divided into 30 districts, with Bengaluru as the capital city. Karnataka has a total land area of 191,967 km^2 (or 5.83 per cent of India's total land area). Rainfall ranges from 500 mm to over 4000 mm. Agumbe in the Sahyadri region receives the second heaviest annual rainfall (7000 mm) in India. Summer temperatures range from 18°C – 40°C, while winter temperatures range from 14°C – 32°C. Ragi, jowar, rice, wheat, sugarcane, coconut, groundnut, and cotton are the major crops grown in Karnataka.

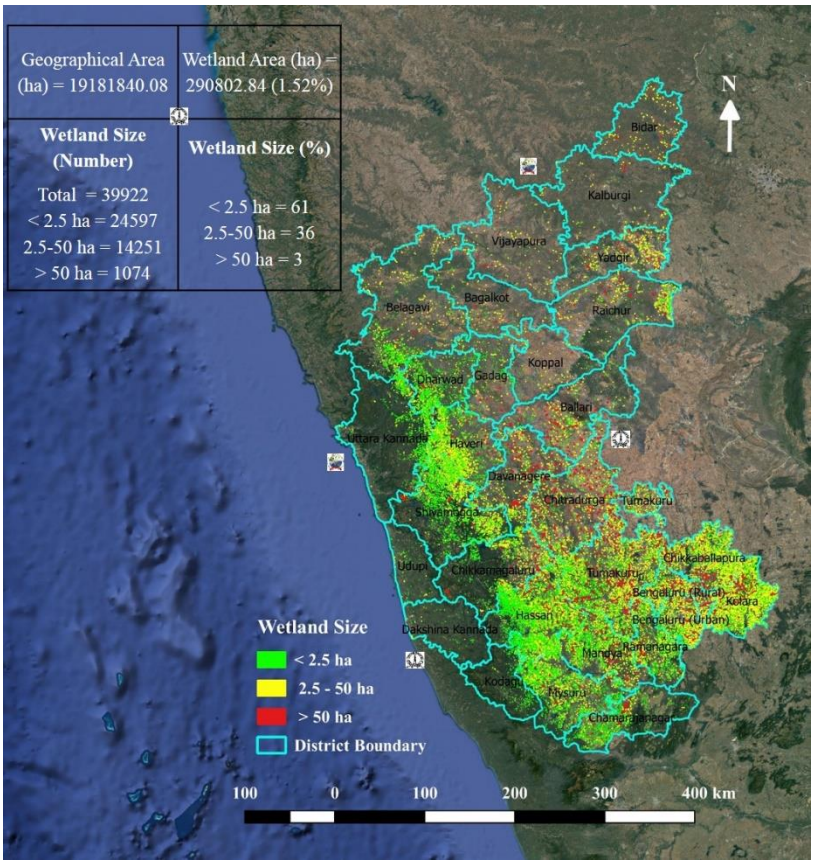

Figure 4: Wetlands of Karnataka, India

The total ecosystem supply value of wetlands in Karnataka was assessed considering (a) provisioning services, (b) regulating services, and (c) cultural services. Ecosystem services are accounted through the (i) residual value method, and (ii) benefit transfer method. Provisioning services of ecosystems are accounted for through the residual value (or resource rent) method. The residual value method has been used to estimate the value of an ecosystem service by taking the gross value of the final marketed good (to which the ecosystem service provides input) and then deducting the cost of all non-ecosystem inputs, including labour, produced assets, and intermediate inputs (SEEA 2021). Benefit transfer involves transferring monetary values of ecosystem services from previous studies or literature that focused on a different region or time period to our area of interest (Ramachandra et al. 2019). Regulating and cultural service values are based on case studies from India, which are compared with the global ecosystem service valuation database (ESVD) [https://www.es-partnership.org/wp-content/uploads/2020/08/ESVD_Global-Update-FINAL-Report-June-2020.pdf] and published literature (of case studies from India) considering GDP (PPP) per capita for India (https://data.worldbank.org/indicator/ NY.GDP.PCAP.PP.CD? locations=IN) and the currency exchange rate (https://www.xe.com/currencyconverter/convert/?Amount=1&From=USD&To =INR).

The provisioning services considered are microalgae, fish, and macrophytes. Microalgae have a relatively shorter cycling period (5–7 days), and the microalgal productivity is 51.1 t/ha/yr. Microalgal biodiesel production will be economically viable with the economic valorization of residual biomass and extraction of value-added products such as glycerol, colloids, etc. (Branco-Vieira et al. 2020; Yang et al. 2012). The total benefit (in Rs/ha/yr) from microalgae was computed by considering biodiesel, glycerol, food/protein, and feed for fish. Microalgae, being producers in the aquatic food chain, sequesters efficiently to the extent of 1.83 kg of carbon dioxide by a kilogram of algae (Chisti 2008). The carbon sequestration service is accounted for by considering the social cost of 80 USD per tonne of carbon dioxide removal (Verma et al. 2014) and molecular weight ratio (1 tC equals 3.67 tCO_2). The total value of carbon sequestration is Rs 234404 tCO_2/ha/yr.

Macrophytes covered 50432.35 ha, which is ~18% of the Karnataka wetland area. Benefit from macrophytes was computed by considering services such as fodder, honey production, food, grazing, and handicrafts. The total value for carbon sequestration by macrophyte is Rs. 311.92 kgCO_2/ha/yr.

Fish is a rich source of easily digestible protein, polyunsaturated fatty acids, vitamins, and minerals for human nutrition (Elaigwu et al. 2019). The average fish catch based on field investigations is 495 kg/ha/yr and benefit (residual value) from fish (as food) is 65 Rs/kg. The data on irrigation (figure 5b) and agricultural crops grown in each district of Karnataka was obtained from government reports (District at a Glance).

The provisioning services of wetlands are calculated by equation (1). The regulating service (*RS*) is calculated by equation (2), and the cultural service (*CS*) is calculated by equation (3). The total ecosystem supply value (*TESV*) is calculated using equation (4), which is the sum of provisioning, regulating, and cultural services. The equation (5) is used to calculate the *NPV* (net present value) of a wetland ecosystem (SEEA 2014, 2021), considering a social discount rate of 3% and the life of an ecosystem asset of 50 years.

$$PS_n = \sum_{i=1}^{10} PS_i \times A_n$$

..... (1)

Where, *PSn* is the total provisioning service district wise. *n* is Karnataka's 1–30 districts, *i* is the various provisioning services (*i* = 1 to 10 services), *An* is the wetland area of each district, but the area is different for the macrophyte (considered macrophyte cover area), irrigation (considered tank irrigated area), and fuelwood service (considered annual fuelwood extraction from 10% of the macrophyte area).

$$RS_n = \sum_{i=1}^{17} RS_i \times A_n$$

..... (2)

$$CS_n = \sum_{i=1}^{7} CS_i \times A_n$$

..... (3)

$$TESV = \sum_{n=1}^{30} PS_n + RS_n + CS_n$$

..... (4)

$$NPV = \sum_{t=1}^{T} \frac{R_t}{(1+r)^t}$$

..... (5)

where, *NPV* = net present value; *R* = net cash flow from an ecosystem in year *t*; *T* = discount period (50 year); and *r* = discount rate (3%). District-wise spatial extent of macrophyte is assessed using remote sensing data (Google Earth) and QGIS open-source GIS for mapping various wetland ecosystem services.

Results and Discussion

Microalgae biomass composed of carbohydrates, lipids, and proteins has been widely used in industries to produce fuel (biodiesel, bioethanol, methane, biobutanol, and biogas), feed (spirulina, and chlorella powder), biofertilizers, and medicines (pharmaceuticals and nutraceuticals). Select microalgal species are rich in proteins and produce proteins of 2.5 to 7.5 tons/ha/yr (Khan et al. 2018al 2018b). The provisioning services provided by microalgae from wetlands accounts to 110467 Rs/ha/yr.

Fisheries sector provides livelihoods, income, and economically nutritious food to the society (Sincy et al. 2018, 2022). Fish compose protein, essential fatty acids, and micronutrients (Fe, Zn, Ca, and vitamin A) and form an important component of the human diet and serve as medicine apart from supporting livelihoods of fishing communities. Major carps such as *Labeo rohita*, *Catla catla*, *Cirrhinus mrigala*, and the exotic carps *Cyprinus carpio*, *Ctenopharyngodon idella*, and *Hypothalmichthys molitrix* with high economic value constitute a vital component of local economy in India (Dasgupta and Panigrahi 2014). Eco-tourism integrates both socio-economic and cultural activities involving fishing activities has been providing recreation and education services that is aiding in the decentralized development (Tursi et al. 2015) based on fish resources. The provisioning service provided by fish from wetlands in Karnataka accounts to 32175 Rs/ha/yr. Fish supports the livelihoods of fishing communities with regular income and employment. The estimate indicates of US$ 158,368, the revenue from fish products at Sundarbans (Islam and Hossain 2017).

Macrophyte provides food, fodder, medicine, and aid in water purification (remediation), carbon sequestration, while providing recreation opportunities (Ramachandra et al. 2018). Macrophyte serve as food for other aquatic organisms, fodder for livestock, medicine for treating animal and human diseases, fiber, green manure, industrial raw materials (manufacture of essential oils), pesticides, and ornamental plants (Zhang et al. 2014). *Alternanthera sessilis*, *Eleocharis dulcis*, and tubers of *Colocasia esculenta* are being used as vegetables, while *Fimbristylis dichotoma*, *Cyperus iria*, and *C. pangorie* are used for making mats (Rao et al. 2008). The ecosystem services provided by diverse species of macrophyte amounts to 11291 Rs/ha/yr.

The benefits provided by wetlands of Karnataka can range from tangible products (such as food, fodder, fuelwood, medicine, and water) to intangible products (such as habitat, climate regulation, flood control, erosion control, water and air quality regulation, recreation, and aesthetics). The spatial analyses of wetlands in Karnataka using remote sensing data, highlight that about 61% of wetlands had an area of <2.5 ha, 36% of wetlands had an area of 2.5 – 50 ha, and 3% of wetlands had an area of >50 ha.

The provisioning, regulating, and cultural services provided by wetlands in Karnataka constitute about 18%, 69%, and 13%, respectively, of the total ecosystem supply value. The provisioning, and regulating services provided by wetlands in Karnataka, which amount to 49.70 and 196.89 billion Rs/yr respectively.

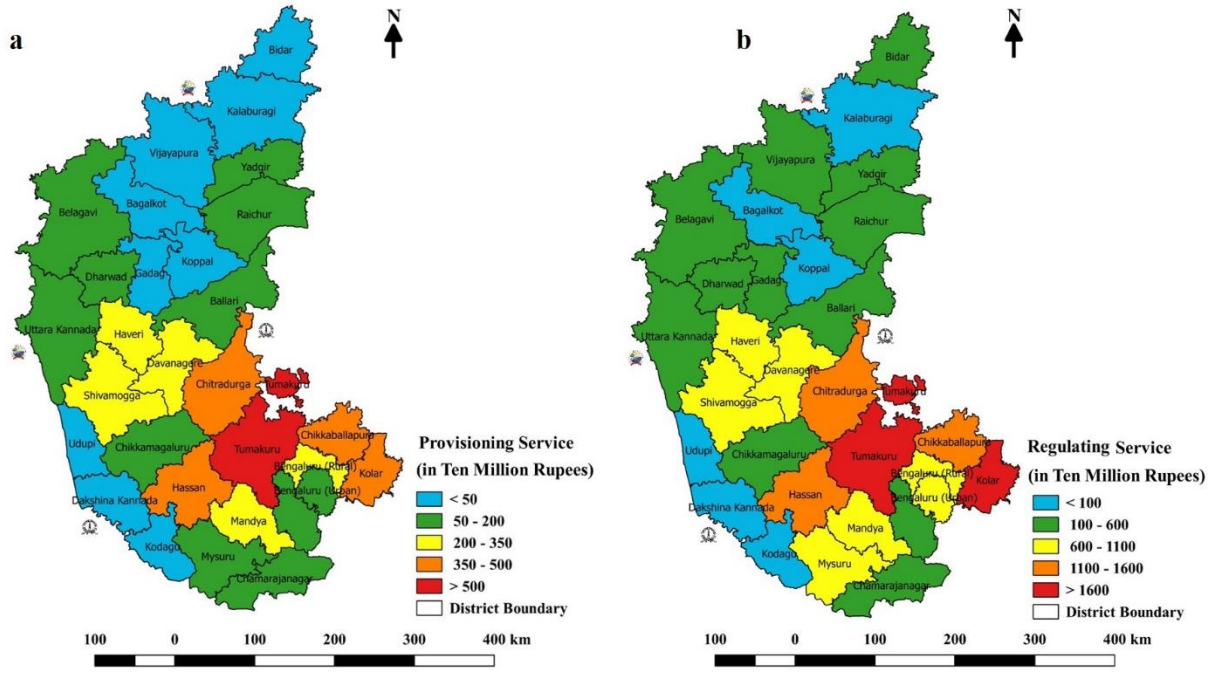

Figure 5: a) Provisioning service and b) Regulating service of wetlands of Karnataka

Recreational services of wetlands include swimming, boating, jogging, gardening, amusement parks, and as picnic spots for scenic beauty. The lakes in Karnataka have cultural significance, for example, Lalbagh lake inside the Lalbagh Botanical Gardens supports a variety of flora and fauna and attracts nature lovers, bird watchers, and tourists. Nagavara lake in Bengaluru has the water-front leisure park, Gardens, adjacent to it. The amusement park for children, and musical fountains, are popular among visitors. Thonnur lake in Mysuru is an attractive spot for bird watching, boating, and swimming. Researchers are attracted to Karanji lake in Mysuru as it has the largest walk-through aviary in India and a butterfly park. The Regional Museum of Natural History on the banks of Karanji lake provides information on the natural environment of South India and nature conservation. Pampa Sarovar is a sacred lake in Koppal district, Karnataka. A special pooja is conducted in the Honnamana kere (Honnama lake) in Kodagu during the Gowri festival. People offer bagina (puja items along with flowers and bangles placed in a bamboo basket) to the lake and pray for good rain. In Karnataka, during Ganesh Chaturthi, Ganesh idols are immersed in *Kalyani* near the lakes. During festivals such as Durga puja, Jagadhatri puja, Lakshmi puja, and Ganesh Chaturthi, visitors perform puja in lakes (Bhattacharya et al. 2014; Bengani et al. 2020).

The cultural services provided by wetlands in Karnataka amount to 37.93 billion Rs/yr and the district-wise share is presented in figure 6. The annual economic value of the cultural service of the Pateira de Fermentelos wetland is estimated at 3087 €/ha/yr (Roebeling et al. 2016). About 90% of people are willing to pay (WTP) for recreation in the Kanibrazan wetland, with an average estimate of 38217 Rials/person (Zarandi et al. 2019).

The cultural services of wetlands are evident from the revenue of US$ 144832 from the Sundarbans from tourism with 96949 native and 3868 foreign tourists (Islam and Hossain 2017).

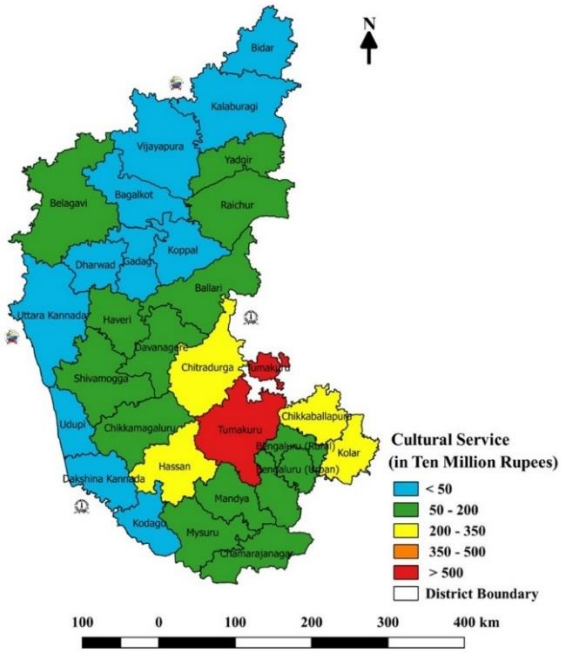

Figure 6: Cultural service of wetlands of Karnataka

The district-wise ecosystem services provided by wetlands, reveal that the Tumakuru district with the larger spatial extent of wetlands, contributes significantly (47,142 million Rs/year) through ecosystem services, followed by Kolar, Chitradurga, Hassan, Chikkaballapura, Mandya, and Shivamogga. The value of provisioning, regulating, and cultural services provided by wetlands in Tumakuru district is 8214, 32641, and 6287 million Rs/yr respectively. Udupi district had the lowest values of 40, 157, and 30 million rupees per year in provisioning, regulating, and cultural services, respectively.

Total ecosystem supply value is the summation of provisioning, regulating, and cultural services. TESV depends on the spatial extent and condition of the ecosystem. The TESV of Karnataka wetlands reveals that Tumakuru district tops among all districts with 47.14 billion Rs/yr of the total 284.52 billion Rs/yr from wetlands in Karnataka (Figure 7).

NPV computed based on the annual flow of TESV shows that the worth of ecosystem assets of wetlands in Karnataka amounts to 7321 billion rupees. NPV ranged between 450 - 650 billion rupees in districts like Chitradurga, Chikkaballapura, Hassan, and Kolar (Figure 7), whereas it ranged between 250 - 450 billion rupees in Davanagere, Haveri, and Shivamogga. Similar studies done across the globe indicate the net present value of revenue (benefits) earned during the last ten years from Sukhna lake in Chandigarh was estimated at

Rs. 451 million (Chaudhry et al. 2013). In the case of Koshi Tappu Wildlife Reserve, the total net benefit value from wetland fodder was estimated at USD 4251,919 (Sharma et al. 2015).

Wetlands are fundamental to the economic, social, and cultural wellbeing of the population in India. Table 1 lists provisioning, regulating, cultural services, TESV, and NPV of wetlands in Karnataka. Wetlands cover an area of 281300 hectares in Karnataka and provide provisioning services worth 1.8 lakh Rs/ha/yr, regulating services worth 7 lakh Rs/ha/yr, and cultural services worth 1.3 lakh Rs/ha/yr. The total ecosystem supply value (TESV) of wetlands in Karnataka amounts to 285 billion Rs/yr (10.1 lakh Rs/ha/yr) and the NPV of wetland assets is about 7321 billion rupees (table 1).

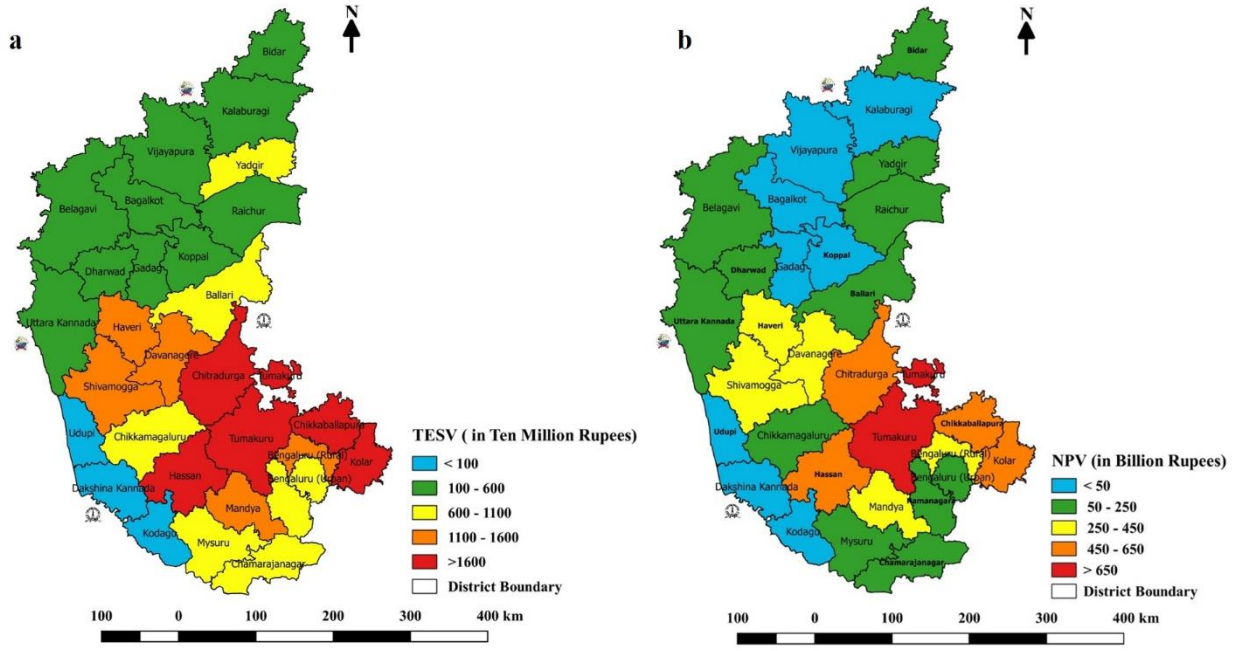

Figure 7: a) TESV and b) NPV of wetlands of Karnataka

Table 1: Total ecosystem value of Karnataka wetlands

Services	Details	
	Wetland: Total area (ha)	281299.5
Provisioning Service	Total Rs/yr (in Billion Rupees)	49.70
	Production Rs/ha/yr (in Lakhs)	1.8
	% distribution	18
Regulating Service	Total Rs/yr (in Billion Rupees)	196.89
	Production Rs/ha/yr (in Lakhs)	7
	% distribution	69

Cultural Service	Total Rs/yr (in Billion Rupees)	37.93
	Production Rs/ha/yr (in Lakhs)	1.3
	% distribution	13
TESV	Total Rs/yr (in Billion Rupees)	284.52
	Production Rs/ha/yr (in Lakhs)	10.1
NPV	NPV in Billion Rupees	7320.6

Conservation and Management of Wetlands: The loss of ecologically sensitive wetlands is due to the uncoordinated pattern of urban growth happening in Bangalore. This is due to a lack of good governance and decentralized administration evident from lack of coordination among many Para-state agencies, which has led to unsustainable use of the land and other resources. Failure to deal with water as a finite resource is leading to the unnecessary destruction of lakes and marshes that provide us with water. This failure in turn is threatening all options for the survival and security of plants, animals, humans, etc. There is an urgent need for:

- **Restoring and conserving the actual source of water -** the water cycle and the natural ecosystems that support it - are the basis for sustainable water management
- **Reducing the environmental degradation that is preventing us from reaching goals** of good public health, food security, and better livelihoods world-wide
- **Improving the human quality of life** that can be achieved in ways while maintaining and enhancing environmental quality
- **Reducing greenhouse gases to avoid the dangerous effects of climate change** is an integral part of protecting freshwater resources and ecosystems.

A comprehensive approach to water resource management is needed to address the myriad water quality problems that exist today from non-point and point sources as well as from catchment degradation. Watershed-based planning and resource management is a strategy for more effective protection and restoration of aquatic ecosystems and for protection of human health. The watershed approach emphasizes all aspects of water quality, including chemical water quality (e.g., toxins and conventional pollutants), physical water quality (e.g., temperature, flow, and circulation), habitat quality (e.g., stream channel morphology, substrate composition, riparian zone characteristics, catchment land cover), and biological health and biodiversity (e.g., species abundance, diversity, and range).

Conclusion

The valuation of ecosystem services of wetland ecosystems, district-wise for Karnataka State, India is implemented as per the validated protocol - System of Environmental Economic Accounting (SEEA, 2021). Services of the ecosystem were quantified by considering only the contribution of the ecosystem to the benefit, through the residual value method by taking the gross value of the final marketed good to which the ecosystem

service provides input and then deducting the cost of all other inputs, including labour, produced assets, and intermediate inputs.

The value of wetland ecosystem services, helps in developing appropriate policies toward the conservation and sustainable management of ecosystems. The value of provisioning, regulating, and cultural services ranged from 4 - 821.4 ten million Rs/yr, 15.7 - 3264.1 ten million Rs/yr, and 3 - 628.7 ten million Rs/yr respectively. Among the districts, the Tumakuru district contributes significantly with TESV of 47.14 billion Rs/yr. TESV of Karnataka wetlands amounts to 285 billion Rs/yr and the NPV is 7321 billion rupees. The valuation of ecosystem services underlines the fact that wetlands are highly productive and economically viable ecosystems, and the accounting of ecosystem services provides crucial information for optimal decision making toward the wise use of wetland resources.

Conservation of wetland ecosystems entails regular monitoring of water quality, recording of aquatic species, regular removal of accumulated silt, maintaining riparian vegetation, prevention of untreated wastewater inflow, regulating the introduction of exotic species, implementation of constructed wetlands and algal pond at inlets for nutrient removal, awareness among stakeholders, including public through regular seminars, workshops, and media, encouraging research on wetlands, adoption of wetlands by the local educational institutions for regular monitoring and environmental education programmes, and constituting a functional working committee of subject experts, local people, and decision makers for regular auditing and to provide valuable inputs to the wetland custodians.

Acknowledgement

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Flood Resilient Scenario Modelling (FReSMo): for assessing coastal flood impact of built infrastructure

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Abstract:

Coastlines have played an instrumental role in the progression of human settlement. However, the rapidly changing climate is foreboding for both coasts and coastal settlements. The rising frequency of coastal extremes, such as flooding from tidal anomalies and storm surges, hampers coastal sustainability, causing rampant damage to the built infrastructure. The loss of residential buildings by the Government of India's National Action Plan for Climate Change (NAPCC) has been cited as one of the prominent impacts of prolonged inundation. During the three successive flood events caused by cyclones Bulbul (2019), Aamphan (2020), and Yaas (2021), India has suffered a loss of about 3.44 million homes in the afflicted district of West Bengal. Regardless of the loss, coastal flood impacts on buildings are rarely prioritised in developing countries due to their resource-intensive nature, the lack of aboriginal damage catalogues or damage records, and discrete behaviour based on building typology, which prevents the adaptation of foreign damage curves on native buildings. Moreover, investing in flood-resilient housing is impracticable without estimating the prevailing cost of flood damage and becomes essential for economic appraisals and optimal resource distribution for Building Back Better (BBB). Hence, this study aims to demonstrate the efficacy of Flood Resilient Scenario Modeling (FReSMo), an unconventional approach to developing pragmatic solutions for flood resilience in developing countries.

The present study investigates the coastal flood risk phenomenon using a three-part mechanism of analysis, comprehension, and a solution-based method. During the analysis phase, the thesis had to identify and comprehend the risk profile of Sagar Island, West Bengal, India. The second part is to understand the flood behaviour of prominent building typologies in Sagar Island through a self-designed multivariate damage matrix using a literature-based approach and a lab-based experiment approach. The third part of the thesis begins by recognising IPCC-defined nature-based solutions as the best possible local adaptation technique for flood-resilient development in developing countries. The findings reveal the dominance of economic and accessibility parameters in defining vulnerability, which will increase further due to changes in climate, population, and landscape dynamics. The flexible multivariate damage model is applied to the damaged structure to interpret the resulting financial loss. The loss estimates are used to conduct a cost-benefit analysis determining the efficacy of nature-based solutions (mangroves) in lowering building vulnerability and preserving coastal sustainability. Changes in climate, population, and landscape dynamics. The flexible multivariate damage model is applied to the damaged structure to interpret the resulting financial loss. The loss estimates are used to conduct a cost-benefit analysis determining the efficacy of Nature Based Solutions (mangroves) in lowering building vulnerability and preserving coastal sustainability.

Keywords: Climate change, Coastal flood risk, Cost-benefit analysis, Flood damage matrix, Flood return period, Nature Based Solution, Sea level rise

Conservation of aquatic resources - Ecosystem-based Adaptation (EbA) of Climate Change for Disaster Risk Reduction (EbA-DRR)

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Abstract

Water plays a critical role in human life and in the operation of all businesses. Thus, water is one of the most significant resources in the world. Water is a carrier of materials and energy. The circular economy (CE) model, which strives to delink economic growth and development from the consumption of finite raw materials also depends on water. In addition to providing a mechanism for transforming growth into a good trend for the environment, economy, and society, the Circular economy model offers a framework that is durable and sustainable for future generations. Due to urbanization and climate change, water is currently very unevenly distributed and its shortage is felt seriously in many parts of the world not only for dirking (domestic use) but also for agriculture. In order to promote resource efficiency, reduce waste generation, and enhance environmental, economic, and social sustainability, the CE must take steps to safeguard water resources, manage them sustainably, and reuse water and water-based resources such as materials and energy.

The UN Sustainable Development Goals 2, 3, 4, 6, 7 and 13-15 SDG and EU Green Deal are inter-connected and super-imposed with the theme of the symposium *"Lake 2022"*. Water shortage and floods are currently posing numerous obstacles for sustainability. The Circular Economy (CE) model's implementation of water and waste water is an ambitious political goal for many nations and areas worldwide. Water as a service, water as a source of energy, and water as a carrier of materials should be integrated across domestic industrial sectors for achieving sustainability.

This talk highlights the significance of water resources to the CE model. The **Hyogo** Framework for Action 2005–2015 **(HFA),** which the **Sendai Framework** has now replaced for Disaster Risk Reduction 2015–2030 **(SFDRR**), identifies Quality education (SDG 4) as key to mitigate the impact of climate change, strengthening sustainable development.

Key words: Water, Circular economy, Hyogo Framework, Sendai Framework, UN-Sustainable Development Goals, EU-Green Deal, Climate action

Assessing and addressing the water quality in Lake Erie

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Lake Erie is a source of drinking water to more than 11 million people and receives millions of gallons of wastewater, provides important species habitat and supports a substantial industrial sector billions of dollars of annual income to tourism, recreational boating, shipping, fisheries, and other industries. These and other key ecosystem services are currently threatened by a significant anthropogenic-induced decline in water quality, manifested by increases in the magnitude, duration, and extent of harmful and nuisance algal blooms and hypoxia. In recognition of the urgent need to arrest this decline and develop a sustained restoration and management programme Canada and the U.S have committed remedial actions. In this talk, I will provide a synthesis of nutrient inputs, impairments by HABs and hypoxia, modelling and Best Management Practices in the watersheds. The results demonstrate that phosphorus reduction is of primary importance, but the effects of climate, nitrogen and other factors should also be considered in the context of adaptive management.

The present status and changes of large lakes in Russia under climate warming and anthropogenic impacts

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This presentation will focus on an assessment of the present state and predict the dynamics of the ecosystems of largest lakes of Russia: Ladoga, Onego and Baikal under climate warming and anthropogenic impacts. Forecasting of the state of the lakes ecosystem in situations of Global Climate Change and active exploitation of its resources (water, biological, energy, recreational, transport) is carried out on a three-dimensional mathematical model of the lake ecosystem, coupled with long term observational data. The prognostic assessments of the seasonal and long-term dynamics of the lake ecosystem performed using the information system serve as the basis for identifying the possible economic, social and cultural consequences of regional and global changes, which is necessary to create a management decision support system.

Keywords: Large Lakes of Russia, ecosystem modeling, lake-watershed system, water resources management, climate and anthropogenic scenarios.

Lake 2022 - 13th Biennial Lake Symposium
Conservation of Wetlands: Ecosystem-based Adaptation of Climate change,
28th -30th December 2022, http://wgbis.ces.iisc.ac.in/energy/lake2022
Venue: Auditorium, New Biological Science Building, Indian Institute of Science
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Machine Learning based Land use classification of heterogenous landscape using Big Data

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Abstract:

Big spatial remote sensing data in different spectral, spatial, temporal, and radiometric resolutions can be acquired, managed and analysed using Geographic Information System by the implementation of various advanced and optimal algorithms and approaches. Machine learning with remote sensing help in analysing landscape dynamics through Big data by automation. The current study shows the application of machine learning algorithm for the analysis of landscape in three different scenarios – forested region (Chikkamagaluru district), agrarian region (Bagalkote district) and urban region (Bangalore Urban district) to prioritize Ecological Fragile Zones (EFRs) based on bio-geo-climatic-social variables. The land use analysis has been done using supervised machine learning-Random Forest algorithm for heterogenous landscapes. Random Forest uses bagging or bootstrap aggregation for accurate classification of data. Landsat temporal data has been used to identify the changes in land use and land cover (LULC) from 1973 to 2022 in different landscapes of Karnataka. Spatiotemporal change in forest structure has been quantified using forest fragmentation indices which showed a decline in natural interior forest cover in the study areas. The cellular Automata Markov model has been applied to simulate the likely changes in LULC based on the present trend. The prediction showed that in business-as-usual scenario the decline of forests and increase in agricultural and horticultural practices with rapid urban sprawl will continue in the future. The landscape model assists to manage and plan for sustainable development in the Ecological Fragile Regions (EFRs) to mitigate the negative impacts on natural resources. The study areas were divided into 5'*5' grids to calculate the Environmental Fragile Regions (EFRs). Grids has been assigned value based on landscape dynamics, ecological, geo-climatic, hydrological, energy availability and social characteristics. The aggregated weightage for each grid is generated and grouped based on mean and standard deviation to determine the various levels of fragility. EFR 1 represents ecologically highly fragile requiring strict conservation measures, EFR 2 is less fragile than EFR 1, except degradation of some forest patches. EFR 3 represents a moderate conservation region, and EFR 4 represents less fragility. Chikkamagalur, Bagalkote and Bangalore Urban district comprises 20%, 4% and 9% under EFR1 category, respectively.

Keywords:

Big data, Machine Learning, Land use Land cover (LULC), Forest Fragmentation, Land use Modelling, Ecological Fragile Regions (EFRs)

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AI based prudent management of Natural Resources in Agrarian Landscape

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Abstract:

Natural Resource Rich Regions **(**NRRRs) are ecologically or economically significant with diverse landscapes with distinguishing biotic and abiotic elements, which are vulnerable to any disturbance by external influences either anthropogenic or natural, and it is challenging to restore to their original state**.** Identification of NRRRs considering spatially ecological, geo-climatic, and social dimensions help in conservation planning and sustainable management of natural resources as per the Biodiversity Act, 2002, Government of India. The anthropogenic land use and land cover (LULC) changes have been the major driver for landscape dynamics. Unplanned and uncontrolled exploitation of natural resources due to industrial developmental activities have escalated rates of LULC changes that led to the degradation of the ecosystem. Spatio-temporal LULC change information provides insights into affecting factors and their impacts on the landscape. The current study has been carried out in three districts of Kalyana Karnataka having different landscapes namely Bidar as rapidly urbanizing, Raichur as agrarian, and Bellary as a heterogeneous landscape. These districts are witnessing drastic growth in rural built-up areas and the expansions of the National Investment & Manufacturing Zone [NIMZ], in response to the State's industrial policy of 2014-19 for industrial development. Supervised machine learning technique - Random Forest (RF) was used to assess land use dynamics. Random forest is an ensemble of decision trees maintaining multi-variance and minimizes the correlation among decision trees, in addition, it is less sensitive to noise and reduction of training. Modeling of likely land use aided in the identification of ecologically fragile areas. CA-Markov model is a dynamic model for predicting LULC changes and can simulate long-term predictions of spatial variation of complex patterns. The current study suggests that there is a need to establish robust systems to frame effective policy and make interventions for the conservation and restoration of natural resources.

Keywords: Land use dynamics, supervised learning, Machine learning, Random Forest.

SEEA Protocol for Energy Asset Accounting

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Abstract

SEEA –Energy is a conceptual framework adopted by the United Nations Statistical Commission in 2012 as the international statistical standard for environmental-economic accounts developed from the SEEA Central framework. This is an accounting approach, which categorically records the stocks and flows of energy within the territory of reference and analyses of the role of energy within the economy. The energy accounts in SEEA comprises of three types of accounts, namely Physical supply and use tables, Monetary supply and use tables and Asset accounts. This accounts the energy-related activities within the environment and provides a structure for compiling and presenting all energy flows that enter and are used within the economy and leave the national economy of a country for a period of time and it finally quantifies the balance. The energy in the state of Karnataka state has a total installed capacity of 31,393 MW and the main energy users of the state are the domestic sector which consumes 8158 Million Units, which accounts for 19% of its energy production, commercial sector usage of power is 5394 Million Units, which accounts for 13% of energy use. The industrial sector accounts for 9221 Million Units, which is 22% of the generated power and agricultural sector accounts for the maximum use of power in Karnataka with 15,613 Million units which account for 37% of its generated power. However, there is an accelerated momentum towards Renewable energy enhancement in the state. The Ministry of New and Renewable Energy has ranked Karnataka as the state with fourth highest capacity addition of Renewable energy in the country with 15, 856 MW of installed capacity. The state has ambitious developmental plans with 611 new projects amounting to 91016 crores. The energy requirement for this expansion will have to come from Renewable Energy to base its development on sustainable means.

Key words: Sustainable Development. Renewable Energy. Asset Accounting. Economic Development. Environmental Management

An insight into the world of plant endemics in Central Western Ghats

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Species richness and endemism are two key attributes of biodiversity that reflect the complexity and uniqueness of natural ecosystems. Myers *et al*., (2000) strongly favor identification and prioritization of `hotspots', or areas featuring exceptional concentrations of endemic species and experiencing exceptional loss of habitat. In order to understand the forest population dynamics in relation to endemism, 116 forest transects from Uttara Kannada district were analyzed for evergreenness, endemism and other important ecological parameters. Using these results percentage distribution maps was prepared. Transects were also subjected to Pearson's correlation and Regression analysis to measure the vegetation relationship between evergreenness and endemism and other vegetation parameters for developing conservation priorities transect-wise. It is evident from the correlation matrix that the highest correlation (0.89) was

between '% endemism' and '% evergreenness'. Results shows that the evergreenness of forests, which goes in harmony with endemism, plays a very crucial role for the entire forest and linked ecosystems in the Western Ghats, as landscape elements play decisive role in distribution of terrestrial and aquatic organisms making untrammelled nature a holistic system

Evaluation of cytogenotoxic potential and embryotoxicity of KRS Cauvery River water in zebrafish (*Danio rerio*)

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Abstract In the Cauvery River (CR), indiscriminate waste discharge causes unexplained skeletal deformity in some fish species in the water. To investigate this phenomenon, we analyzed the biological, physical, and chemical parameters present in the water and then evaluated the toxicity effects on the zebrafish (*Danio rerio*) model. The zebrafish were treated with KRS-CR water samples collected from three stations (fast-flowing water [X], slow-flowing [Y], and stagnant [Z] water), before and after filtration. Firstly, we detected microscopic organisms (MO) such as Cyclops, Daphnia, Spirogyra, Spirochaeta, and total coliform (Escherichia coli), which are bioindicators of water pollution present in the samples. All physicochemical parameters analyzed, including heavy metals before and after filtration of the water with Millipore filter paper (0.45 µm), were within the acceptable limits set by standard organizations, except for decreased dissolved oxygen (DO), and increased biochemical oxygen demand (BOD), and chemical oxygen demand (COD), which are indicators of hypoxic water conditions, as well as the presence of microplastics (polybutene (< 15 µm), polyisobutene (≤ 20 µm), and polymethylpentene (≤3 mm)) and cyclohexyl in CR water samples. Zebrafish embryos treated with the water samples, both before and after filtration, exert the same cytogenotoxic effects by inducing increased reactive oxygen species (ROS) production, which triggers subcellular organelle dysfunctions, DNA damage, apoptosis, pericardial edema, skeletal deformities, and increased mortality. As a result, we observed that both water samples and zebrafish larvae had significantly less oxygen using SEM and EDS. Our findings show that KRS-CR water can induce cytogenotoxic and embryotoxic defects in zebrafish due to hypoxic water conditions triggered by the microplastic influx. Among the three types of microplastics (MPs) observed, we discovered that the concentration of polyisobutylene (PIB) (< 10 µg/mL) was higher than that of the other MPs particles identified in the CR. Zebrafish larvae exposed to various concentrations of polyisobutylene microplastics (PIB-MP) showed reduced swimming and hyperactivity, delayed hatching, increased ROS, changes in mRNA levels of genes (*mnsod, cu/znsod, gsr*, and *gstp1*) encoding antioxidant proteins, skeletal deformity, and increased mortality. The present study would provide valuable insights for health hazard evaluation and future river water treatment strategies.

Ecosystem services quantification through big spatial data, machine learning and InVEST Model

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Abstract:

Global warming and climate change have become evident with anthropogenic pressure on the natural environment due to the incessant burning of fossil fuel, increased industrial activities, and higher deforestation and degradation. The carbon content in the atmosphere is aggravating greenhouse gas contents in the atmosphere and causing abrupt changes in the climate. Forests are immense repositories of carbon from the atmosphere, thereby significantly balancing the Carbon cycle (C-cycle) by storing enormous quantities of carbon captured as above ground, below ground and Soil Organic Carbon (SOC). The global sinks of carbon, such as forests, soil, and ocean, are getting affected by unpredicted land use land cover changes (LULC) and its associated emissions. Machine learning and Artificial Intelligence techniques are assisting in exploring big spatial data to account for the spatiotemporal land use changes. Karnataka state of union India has good forest cover and holds the responsibility of capturing large quantum of carbon. The large scale LULC changes in the form of unplanned developmental activities are affecting its sequestration potential. In this regard, the Invest 3.7 Carbon model has been used to assess the temporal change in carbon capture by forests of Karnataka. The Invest model takes the land use map and associated carbon values in Mg or tons per hectare to extrapolate for entire regions. The research also tries to capture likely carbon capture for the year 2033 through the input of the LULC model results. The carbon model summarises the loss from 1985 to 2019. The total sequestration in 1985 shows 1137.97 Tg, which has reduced to 831.53 by 2019, which further depicts that loss may reach 818.57 Tg by 2033. The anthropogenic pressures across the state are the causal factors for the loss. The reduction in the green cover depreciates the carbon sequestration potential. The likely loss of 13 Tg carbon is noticed from 2019 to 2033. Awareness is crucial for conservation, identifying opportunities to reduce emissions and finding alternatives to ineffective management. The increased plantation and reduced deforestation activities associated with modified harvest systems can be considered a potential approach for carbon reduction and sequestration.

Keywords: InVEST, Carbon Sequestration, SEEA, LULC, Ecosystem Services.

Conservation and Sustainable Management of Sambhar Lake, a Ramsar Site of International Importance

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Abstract

Sambhar Lake is a Ramsar site located in Rajasthan, it is one of the most frequented wetlands in the country and is visited by thousands of migratory birds both nationally and internationally. Given the ecological significance of the region, this study is an environmental assessment to understand the existing conditions of the lake and its catchment in the context of natural resources and richness of biodiversity. A comprehensive assessment of various parameters is carried out, including but not limited to, extensive literature reviews, documentation of geographic and biological characteristics of the wetland, digitization of lake boundary, catchment area and other affecting factors, spatio-temporal analysis of water spread and documentation of biodiversity existing in the region. Total bird species, IUCN status of visiting birds, historic population patterns, migratory paths, factors affecting bird populations have also been analysed. Further, the study proposes recommendations and suggestions to maintain and improve the ecological health of the wetland and mitigate the potential contemporary as well as future anthropogenic damages.

Integration of Indigenous Low Carbon Technologies with Novel Low Energy Mass Housing in Ladakh (U.T.)

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Abstract:

Great Himalayan range with regions namely, Jammu & Kashmir, Ladakh and high altitude parts of north eastern states inherently experience high solar exposure, cold, arid climate and significantly challenging geography. With a scarcity of affordable public housing projects in these regions a grid enabled low energy residential prototype is proposed having the capability to operate on nearly zero consumption of heating and cooling energy with the application of indigenous and contemporary energy efficient passive design techniques. Preliminary study, development of design and reading of simulation results were applied for the performance and benefit analysis of the low energy building prototype. Analysis of the climatic zone further classified and narrowed the design criterion by confirming upon beneficial architectural components proven

to be energy efficient. These architectural components include, optimization of direct solar gain and orientation of building envelope, modified Trombe wall system, traditional sunrooms, solar chimney with openable vents, efficient spatial planning and compliance of relevant parameters such as window-wall-ratio (WWR). The proposed low energy housing for the economically weaker section is estimated to save nearly 50% of active fuel-based household heating energy. Site has been planned in such a way that about 100% of required electricity can be generated from onsite renewable energy for the proposed infrastructure, it is proven more beneficial if additional electricity is generated to offset the power supply and result in lower or subsidized electricity bills. Design is compliant to different codes relevant to energy conservation and low-income housing with an embodied carbon of about 1.2 kgCO2/m2 per dwelling unit giving 'A' grade in cradle to gate impacts. The findings and performance of this prototype can serve as a guideline for energy efficient design in low-income group housing situated in severe cold and arid regions of India such as Ladakh (U.T.).

Decentralized Solar power generation: Challenges and opportunities

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Abstract

Solar power generation taking the major role in power generation from the renewable energy because of its decentralized nature and abundant availability of sunlight. Economically efficient, environmental friendly solar energy harnessing through the Photovoltaic cells are dominant among all other technologies and also taking major portion in large scale deployment of solar power plant. Although solar power plant is very helpful to achieve the Net zero carbon emission goal of the country, that also facing many challenges. Knowing the Potential of the solar insolation and Photovoltaic power generation of the region needed for development of the power plant. Understanding of the environmental implications of solar power plant are very much required to make solar power more reliable. The current study focus on solar Potential of the region, possible temperature variation because of installed PV panels, also depicts the area identification for the deployment of large scale solar plants considering the ecology and biodiversity of the region.

Keywords: Large scale PV power plant, solar potential, temperature

Environmental and Health Impacts of Microplastics

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Amongst the 17 Sustainable Development Goals (SDGs) prioritised by the United Nations, SDG 12 talks about responsible consumption and production, to improve climate action in SDG 13, life on water (SDG 14), and life on earth (SDG 15). Therefore, it's crucial to safeguard and maintain our land and water by minimising the magnitude of impacts as consequent our consumption.

Ever since the 1950s, plastic has become an integral part of our daily life starting from clothes, coatings, transportation, and cleaning supplies as its cheap, strong, light, and pliable nature. However, the intangible drawbacks of plastics are becoming more and more obvious. Plastic leaks in large amounts into rivers and seas, having a negative impact on marine ecosystems and related economic activity. Plastic residues come in various shapes and sizes, from massive, readily recognisable objects to tiny, microscopic particles. Additionally, macroplastics undergo photodegradation, under UV radiation or as a result of abrasion during production, usage, or maintenance, such as the erosion of tyres during use or the abrasion of synthetic fabrics while washing to form microplastics. Especially, during the COVID-19 pandemic, wherein the majority of the world's population was dependent on online shopping apart from the excessive usage masks and PPE kits – which has magnified the intangible impacts of microplastics on a different level altogether in every sphere of our lives.

This study serves as a comprehensively reviews the sources, pathways and sinks of primary and secondary microplastics in terrestrial and marine environment, human health and wildlife while discussing the certain solutions to reduce their impacts.

Keywords

Sustainable Development Goals, Microplastics, Sources, Pathways, Sinks

Introduction

As the name suggests, microplastics are minute pieces of plastic. They are officially described as plastics with a diameter of less than five millimetres (0.2 inches) (United Nations Environment Programme), which is smaller than the typical pearl used in jewellery. Microplastics may be divided into two groups: primary and secondary. Microfibers shed from clothes and other fabrics, such as fishing nets, as well as microscopic particles made for commercial purpose, such as those found in cosmetics, are the two main types of microplastics. Particles known as secondary microplastics are produced when bigger plastic objects, such as water bottles, break down. The sun's rays and ocean waves are the key environmental variables that contribute to this disintegration.

Like plastic goods of any size, the issue with microplastics is that they do not easily decompose into harmless components. Plastics can take hundreds or even thousands of years to disintegrate, and while they do so, they cause significant environmental damage. Microplastics can be seen on beaches as minute pieces of coloured plastic in the sand. Marine creatures frequently absorb microplastic contamination in the waters.

While some of this environmental contamination is the consequence of littering, the majority is due to storms, water runoff, and winds that transport plastic—both whole items and microplastics—into our seas. The main source of secondary plastics in the environment is single-use plastics, which are products made of plastic that are intended to be used just once before being thrown, such straws.

Plankton to whales, as well as commercial seafood and even drinking water, have been shown to contain microplastics. Unbelievably, conventional water treatment systems cannot completely eliminate all residues of microplastics. Microplastics in the water can combine with other dangerous compounds before being consumed by marine creatures, which only serves to aggravate matters further.

Microplastics

Unintended repercussions of technology are common. A new kind of pollutant has been produced as a result of technological advancements in production and our poor recycling practises. It endangers our ecology despite frequently being concealed from view. Microplastics are tiny pieces of plastic, measuring 5 millimetres or less, that are either created artificially for use in goods or are left behind after polymer-based garbage degrades in the environment. Microplastics have been discovered in both marine and land life by researchers. In addition to salt, sugar, beer, alcohol, and honey, it also gets into the food chain. Rainfall and

Primary Sources of Microplastics: Small plastic particles, or primary microplastics, are directly discharged into the environment. These are purposefully created particles, similar to those that may be found in several consumer and industrial goods. Microplastics have been utilised as abrasives in cosmetics. When exposed to our environment, bulky plastic trash like bottles and bags breaks down into tiny plastic fragments, creating secondary microplastics. Primary microplastics are created by manufacturers because of the distinct physical and chemical characteristics produced by their tiny size. These characteristics include abrasiveness, stiffness, and durability. Its attributes are influenced by its composition, size, density, and form. Microplastics are used by scientists in a variety of industries, including agriculture, medicines, wastewater treatment, construction, detergents, paints/coatings/inks, personal care, industrial abrasives, and cosmetics. However, these particles frequently find up in our seas and other places after weathering, degrading, or being abraded by environmental or physical phenomena. Synthetic fabrics, city dust, tyres, road markings, marine coatings, personal care items, and manufactured plastic pellets are also sources of microplastics. Most of the major sources of microplastics in the ocean are common consumer goods. Plastic fragments less than 5 millimetres in size are referred to as microplastics.

Secondary sources of Microplastics: In the water, microplastics are becoming more and more prevalent. The UN estimates that there may be 51 trillion microplastic particles in the ocean, 500 times more than there are stars in the entire galaxy. Marine creatures have the potential to consume microplastics prevalent in the ocean. The plastic then gathers, and through the food chain, it may end up in people. They have been discovered in several foods and beverages, including as beer, honey, and tap water. It should come as no surprise that plastic fragments have also lately been found in human faeces.

Plastics frequently include additives, such as stabilisers or flame-retardants, and other potentially dangerous chemical compounds that may be damaging to the animal or person swallowing them. The effect on human health is as of yet unclear.

The Sources to sink approach was studied on a global scale in both terrestrial and marine ecosystem and implications on human health. However, the participants of the online survey were from India expect two participants from abroad.

A comprehensive literature review was conducted on the existing research on Microplastics in India and abroad. Over 200 research papers were review so as to understand the probable sources, pathways, sinks, implications of Microplastics in different Environments and Human Health. In order, to fulfil the aims and objectives of the study. An online survey via google forms was also conducted to understand and build general awareness of local people.

Society has become increasingly reliant on plastics since commercial production began in about 1950. Their versatility, stability, light weight, and low production costs have fueled global demand. Most plastics are initially used and discarded on land. Nonetheless, the amount of microplastics in some oceanic compartments is predicted to double by 2030. To solve this global problem, we must understand plastic composition, physical forms, uses, transport, and fragmentation into microplastics (and nanoplastics). Plastic debris/microplastics arise from land disposal, wastewater treatment, tire wear, paint failure, textile washing, and at-sea losses. Riverine and atmospheric transport, storm water, and disasters facilitate releases. In surface waters plastics/microplastics weather, biofoul, aggregate, and sink, are ingested by organisms and redistributed by currents. Ocean sediments are likely the ultimate destination. Plastics release additives, concentrate environmental contaminants, and serve as substrates for biofilms, including exotic and pathogenic species. Microplastic abundance increases as fragment size decreases, as does the proportion of organisms capable of ingesting them. Particles <20 μm may penetrate cell membranes, exacerbating risks. Exposure can compromise feeding, metabolic processes, reproduction, and behavior. But more investigation is required to draw definitive conclusions. Human ingestion of contaminated seafood and water is a concern. Microplastics indoors present yet uncharacterized risks, magnified by the time we spend inside (>90%) and the abundance of polymeric products therein.

Scientific challenges include improving microplastic sampling and characterization approaches, understanding long-term behavior, additive bioavailability, and organismal and ecosystem health risks. Solutions include improving globally based pollution prevention, developing degradable polymers and

additives, and reducing consumption and expanding plastic reuse. Microplastics (1 to 5,000 microparticles) captured widespread attention after reports detailed massive "garbage patches" in the world's great ocean gyres. Concern followed over possible negative impacts on marine life. While plastic wastes in the environment are truly a global and multimedia issue, popular press and scientific attention have predominantly been "oceancentric" (e.g., Cole et al., 2011). Like climate change and persistent organic pollutants, plastic debris exemplifies our capacity to alter the environment on a global scale. Villarrubia Gómez et al. (2018) argued that marine plastic contamination is irreversible and globally ubiquitous, and therefore meets two of the three conditions for a chemical pollution planetary boundary threat.

The third condition is demonstrated by widespread ecological disruption. The investigation of the possibility of such disruption has only recently begun but will become more critical as plastic contamination rises. Indeed, Koelmans et al. (2017) recently argued that it is time to move beyond conjecture and proposed a framework for evaluating the toxicological risks of microplastics. Microplastics are found in diverse forms, including spheres, fragments, and fibers. Most (with the exception of intentionally manufactured microbeads) arise from the deterioration of larger plastics (macroplastics). Microplastics fragment into ever-smaller debris over time, eventually becoming nanoplastics (1 m; Lambert & Wagner, 2016; Hartmann et al., 2019). Hence, microplastics are largely a transitional state between macrodebris and nanomaterials. Besseling et al. (2018) estimated that fragmentation of spherical microplastics could generate >1014 times greater numbers of nanoparticles. To understand microplastic sources, fate, and consequences, one must consider the continuum, from plastic products and debris to microplastics and nanoplastics. Despite growing attention, the actual amounts of plastic in environmental compartments (terrestrial, marine, freshwater, and atmospheric) and their ecological significance are still unclear.

The Nature of Plastics and Microplastics

While the public often assumes that all plastics are compositionally the same and thus behave analogously in the environment, this is not the case. To understand the behavior, fate, and consequences of microplastics, we must first consider their composition and diversity. Identification of microplastics in the environment presents a multidimensional challenge that is yet unmet. Their complexity parallels that of naturally occurring, particulate organic matter (Hoellein et al., 2019). Plastics (and thus microplastics) vary in chemical composition, physical form, size, texture, and shape. These characteristics evolve while in use and after discard. Intentionally manufactured microplastics, designated primary microplastics, include microbeads in personal care products and industrial abrasives for delicate surfaces.

Uses and Properties of Plastics

Due to their attributes, synthetic polymers have supplanted many naturally derived materials in modern society (Lebreton & Andrady, 2019). Applications include single-use food and beverage containers, thermal insulation, home and workplace furnishings, electrical and electronic devices, vehicle interiors, toys, fabrics, surface coatings, and even medical devices (e.g., artificial joints, incubators, intravenous (IV) fluid bags, and drug delivery devices).

Weathering and Degradation of Plastics

Plastics are vulnerable to weathering to varying degrees. Chemical oxidation of the polymer as a result of exposure to sunlight is often the most impactful (Andrady, 2015). As noted above, additives may reduce such degradation. Photooxidation is most rapid at the water surface, on beaches, and in exposed terrestrial scenarios, negligible if shielded in aquatic sediments, soil, or landfills.

Microplastics in the Indoor and Terrestrial Environment

Residents of developed countries spend >90% of their lives indoors (Bernstein et al., 2008), and homes and workplaces are increasingly airtight and insulated with additive-treated insulation such as polystyrene. Consequently, our exposure to microplastics from inhalation and dust ingestion indoors may have toxicological consequences, but scant research exists on the subject. In one of the few published studies, Dris et al. (2017) reported indoor air concentrations of microfibers of between 1.0 and 60.0 fibers m−3, exceeding outdoor levels (0.3 to 1.5 fibers m−3). Indoor microfibers consisted of 67% natural or hybrid materials (primarily cellulose fibers, acetate cellulose, or keratinous wool). The remaining fibers were wholly synthetic polymers, dominated by polypropylene (Dris et al., 2016).

Terrestrial Inputs of Microplastics to the Oceans

Plastics are manufactured, used, and predominantly first disposed of on, or into, soils. Plastics at the soil surface are subjected to greater UV exposure, abrasion, and temperatures than water-immersed materials (Ng et al., 2018). Upon entering soils, microplastics can penetrate vertically via water infiltration (O'Connor et al., 2019), facilitated by wet/dry weather cycles or tilling (Rillig, Ingraffia, et al., 2017) and by the actions of soil organisms (Rillig, Ziersch, et al., 2017).

Landfills and Dumps

Most plastics are disposed of in landfills in developed countries. These vary from secure, lined, and covered facilities to open trash piles that are later abandoned. However, even developed countries have had issues with off-site losses or mismanaged waste.

Tire Wear

Another source of microplastics to terrestrial ecosystems is from vehicle tire wear. Modern tires contain fillers (e.g., carbon black), additives, metallic and polymeric fibers, and natural and synthetic rubbers (primarily butadiene and styrene-butadiene polymers).

Paint and Coatings

Paints and surface coatings often contain polymers. Painted surfaces include structures, roadway markings, and vessels and are subject to weathering. Abrasive blasting (occasionally using microbeads) prior to repainting of surfaces will also generate microparticles. Paint often contain metal-based pigments (e.g., Cu and Zn).

Microplastics From Clothes Washing

Habib et al. (1998) was among the first to suggest synthetic fibers, originating from textile washing, might be useful tracers of wastewater effluents and land-applied biosolids. Due to differences in media sampled and analytical methods, researchers do not yet agree on which microplastic types are most dominant in the environment. However, the International Union for the Conservation of Nature ranked releases from the laundry of synthetic textiles first, contributing 35% of the world ocean's microplastic burden (Boucher & Friot, 2017).

Wastewater Treatment

Industrial and domestic wastewaters contain microplastics and polymer additives derived from consumer products (Schreder & La Guardia, 2014). In affluent countries, wastewaters and storm water runoff from urban areas are typically routed to centralized treatment facilities. The treated effluents are eventually discharged to receiving waters. Some effluents, however, particularly in arid areas, are redirected for irrigation.

Direct Releases to Surface Waters

Plastics may enter surface waters directly via fishing and aquaculture, intentional disposal from vessels, and storm-related debris. Nets, lines, floats, and traps may contain plastics and synthetic fibers.

Results from Online Survey

The results of the online survey reveal that though citizens are aware of the harmful effect of microplastics to a certain degree. The question is its just ease of developed unsustainable habits which result in the current massive generation of microplastics.

Discussion of plausible solutions

Since the production and consumption both happen on land. It is important that these measures are brought on land. Immediate reforms from the packaging industries to the reformed psychological consciousness in the general habit patterns in the common citizens of India. The type of material used by the industries must to be change to bio-degradable products like neem-coated materials. Invention and Innovation in this current urgency of climate impacts along with ground work implementation through awareness programs, engaging with stakeholders and bringing change at the grassroot level is the only solution. There also has to be constant monitoring at block levels of every neighbourhood via volunteers or appointed locals who are given incentives for doing the same.

Conclusions

Microplastics are a transitory state existing between plastic products/macrodebris and nanoplastics. The perception that all plastics are inert and compositionally identical is incorrect. To resolve critical questions and mitigate possible impacts, plastic manufacturers, aquatic and terrestrial and atmospheric scientists, health care specialists, waste and chemical engineers, economists, regulators, and others must collaborate and better

understand the composition and nature of plastic products, including additives. The complexity of microplastics becomes far more convoluted once they enter, intermingle, and weather in the environment.

Technology to enable Resilient Riverine Ecosystems- Case study of Garanihalla Watershed

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Abstract

Ecosystem-level management remains a very useful, valid scientific concept with very little realization of its practice worldwide. Recent advances in Technology can be a great enabler for Resilient Ecosystem management. We discuss it further through a proposed Action Research project of Garanihalla watershed in the Vedavati Riverine Ecosystem of semiarid south Karnataka. We do not claim to have either complete solutions or cover all components required, our effort is to distinguish what are possible through a smart synthesis of existing Technologies, detail out areas for Action Research and further work on it through collaboration with multiple stakeholders. For resilience component, we focus on Livelihoods and Natural resources and present a few use cases of Technology use.

The highest priority in a semi-arid region is Water resources particularly ground water. Sustainable use of this invisible common pool resource is a worldwide challenge. At the project site, in a classic case of 'Tragedy of the Commons' scarcity has only spurred further overuse amongst private borewell owners.

A breakthrough Technology innovation of SMART bore well pumps can provide 'Win Win' solution for Sustainable use. The water output from borewells increase/decrease to adapt to varying supply in the Aquifers that are the source for borewells. It uses a Variable Frequency Drive (VFD) to replace the conventional starter of the Bore well and are equipped with Realtime measurement of water level, water discharge of the bore well. It further serves as a digital platform to connect several IOT devices in ten kilometer radius through multiple connectivity options and provides a gateway to the cloud. AI powered system intelligence regulates the discharge from submersible pump to match with the aquifer supply.

Wins to the farmer include preventing drying up borewells in summer, overuse from other borewells, and higher discharge during periods of abundant supply. All were achieved with the same submersible pump installed. They can adapt and validate the benefits of direct bore well recharge. Additional benefits include preventing motor burnouts, low discharge due to low voltage, plug and play provision of alternate power from solar panels.

Wins for sustainability are – Reduction of overuse during low groundwater levels; Real-time data on water levels and borewell discharge; validation of impact benefits from different recharge options. Each such installation creates a network in a large area that enables the plug and play of several IOT devices. Using this, we can measure other components of the water use like rainfall, evaporation, soil moisture, and stream flow with appropriate sensors and acquire real-time data. The solution is affordable, rugged and ready for on-field deployment. Other Technology use cases we consider are -a) Impact evidence guided site selection for groundwater recharge; b) Climate knowledge-based guidance for resilient farming system; c) AI driven automated irrigation system to increase water use efficiency; d) Shift from area based high value crop/tree insurance to individual claims by using novel Drone technology; e) Tech enabled Fodder and Disease management for Sheep and Goat grazers; f) Carbon credit payments for Trees on farm and public lands; g) Tech enabled real time Monitoring of Government and NGO projects and validation of their impact.

Taking diatoms to schools for changing water stewardship: a two-decades experience

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Diatoms are one of the most diversely evolved organisms in aquatic environments and have been used as bioindicators for water monitoring around the world. In the past, many Japanese reivers were seriously polluted caused by rapid development of economy and industry. We have overcome such a situation by various efforts, but today many countries are still suffered from similar pollution. I have been involved in educational outreach efforts using diatoms in schools to promote students' awareness of water environment and encourage their action for its restoration. In 2001, My research group began to develop an educational simulator, SimRiver, for understanding the relationship between the anthropogenic effects to river water quality and the specie component of diatom communities. The program of the simulator has been improved by feedbacks from users every year. According to the river basin created by a setting of environmental factors, such as land use, population, sewage treatment plant, and season, SimRiver calculates water quality and generates a virtual slide of the diatom community corresponding to the water quality caused by the setting. As SimRiver can generate various diatom communities, its combination with real diatom specimens collected from rivers as well as riverine phots or videos from the past and the present led students to easily understand changing of river environment, which took for a long period of time actually. Furthermore, the comparison of diatoms between the countries with different statuses of development fostered the students' mind of the cleaning river and global cooperation.

Temporary waters: "Hotspecks" of Diversity in the Freshwater Realm

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Despite occupying less than 1% of the earth's surface, freshwater ecosystems support more than 10% of its biodiversity. Among the many taxa inhabiting these habitats, I will draw attention to the largely unseen and unnoticed ones—the invertebrates. Many of these organisms are small, often microscopic and abundant in these freshwaters, sustaining their ecological functions. Often large, perennial habitats (lakes, rivers) have received more attention, while the rich biodiversity of smaller, temporary habitats (ponds, pools) goes largely unnoticed. Renewed interest for these habitats across the globe has highlighted their unique diversity, which is mainly shaped by the characteristic environment. In India, we lack baseline data on the diversity of many of these organisms, largely due to limited exploration and taxonomic expertise. Focusing on some micro-invertebrate groups, I will briefly outline the unique ecology of seasonal habitats, their biodiversity and the threats they face in the Western Ghats. Lastly, I will also highlight the potential of some of these taxa for biomonitoring.

Quantifying fish assemblage patterns in a free-flowing and the dammed river of Western Ghats, India

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Currently the state of freshwater biodiversity on earth is disheartening. A significant proportion of freshwater diversity is declining due to human activities such as habitat fragmentation, dams, pollution and invasive species. Tropical rivers not only harbours one of the highest fish diversities but also support a significant population of fisher communities. I compared fish assemblage patterns across 23 segments between two rivers from 2019 to 2020 in Karnataka state of the central Western Ghats in India. Aghanashini is one of the free-flowing rivers while Sharavathi is dammed river. Fish diversity was highest in Aghanashini (63) than Sharavathi river (41). Similarly, fish abundance was significantly higher in Aghanashini *i. e.* 2444 (71%) than Sharavathi 944 (28%). Some of the key fish guilds such as water column position-based guilds, flow dependent guilds, and feeding guilds differed between these two rivers due to river habitat, water chemistry and flow regulation. Some of the Western Ghats endemic-habitat specialist and flow dependent species such as *Hypselobarbus curmuc*a, *H. jerdoni*, and *H. kolus*, were exclusively restricted to headwaters of Aghanashini than Sharavathi largely due to hydrologically less modified habitat conditions. Flow regulation due to dam in Sharavathi has affected crucial habitats thereby leading to disappearance of such endemic and habitat species. To restore endemic fish diversity of Sharavathi, it is important to maintain flow downstream of *the* Gerusoppa dam especially during the lean season. Future studies should focus on quantifying the relationship between flow regime and fish diversity including key fish guilds. This will enhance our knowledge ecohydrology in the country.

Lakes to Everywhere: A curious case of freshwater mollusc invasion

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Molluscs are the second one-biggest and species invertebrate phylum after Arthropoda. There are round 7000 freshwater molluscs that play a number one position inside the surroundings. Although those freshwater species are very restricted of their habitats, however, due to the growth in globalisation, exchange and shipping, freshwater molluscs get introduced to new environments, and come to be intricate to the native biodiversity and also person. Our study shows that there are globally 28 freshwater invasive molluscs, which reportedly cause extreme issues to the native communities, which include monetary loss, agriculture and others. The foremost pathways of introduction for the freshwater molluscs are discovered to be unintentional/unintended (e.g., hitchhikers with macrophytes, ballast water, aquarium waste disposal) and pet alternate. The species occurrence data is collated from open-source database such as Global Biodiversity Information Facility (GBIF), iNaturalist, and also from the published and grey literature. The species

distribution model shows Europe, South America and Eastern North America because the most prone areas. Niche dynamics analysis shows 14 species with lower and 9 species with excessive niche overlap throughout the native and added levels. *Corbicula fluminea* and *Physella acuta* comply with niche conservatism.

River Health Assessment - Developing a tool for multi-dimensional hydro-ecological measurements for river systems in India

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River systems are complex ecohydrological systems with a historical significance for human civilization. While there is a growing understanding of the ecosystem services they provide, the impacts of human influence on these dynamic systems are poorly understood. There is a need for a comprehensive measure of assessing the health of rivers and the effects of anthropogenic influence on rivers. River Health Assessments or RHAs are a potential tool to monitor and guide protection, restoration and management of river systems. As a tool, RHA is still in its developmental stages in the country. Most RHA studies in India have been based on a few water quality parameters. At the Freshwater Ecology and Ecosystem Services working group in ATREE, as a part of a project in collaboration with WWF, India, we have been developing a field based, multi-dimensional and comprehensive measure of river health, and conducting the field work in the rivers Moyar, Bhavani and Noyyal in Tamil Nadu. Our RHA includes multiple parameters and indicators of river health, including water quality measures, ecological and biodiversity indicators like freshwater fish, macroinvertebrate and diatoms' compositions, and catchment and bank characteristics. In our talk, I will present results, insights and takeaways for this multidimensional index that we have developed in the context of biomonitoring as a growing field.

Insights into diatom diversity of *Myristica* swamps from the Western Ghats, India

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The Western Ghats, one of the global biodiversity hot spots, is home to one of the rare and threatened ecosystems, Myristica swamps. In the present study, we attempted to explore the diatom community structure from this unique ecosystem. These swamps are characterized by low conductivity, low pH, and low nutrient values, and they are a treasure trove for the enormous endemic biota. A total of 20 diatom samples, along with all environmental variables, were examined for taxonomic analyses using light (LM) and scanning electron microscopy (SEM) across the central Western Ghats. Analysis revealed a total of 99 species of diatoms belonging to 27 genera across the 17 sites, from which 51 diatom species were endemic to this unique acidic environment and can be putative novel species. Overall, the dominant diatom genera inside the swamps included, *Gomphonema* (18.1%), *Eunotia* (11.1%), *Navicula* (10.1%), *Pinnularia* (8%), *Frustulia* (7%), *Achnanthidium* (6%), *Neidium* (6%), and *Planothidium* (4%). The diatom assemblages were dominated by species like *Eunotia rhomboidea* Hustedt, *Ulnaria ulna* (Nitzsch) Compère, *Navicula nielsfogedii* J.C.Taylor & C.Cocquyt, *Navicula obtecta* I.Jüttner & E.J.Cox, *Cymbopleura* sp., *Gomphonema insularum* Kociolek, J.B.Woodward & C.Graeff, *Achnanthidium minutissimum* Czarnecki, *Eunotia incisa* W.Smith ex W.Gregory, *Navicula globulifera* var. *robusta* Hustedt, *Frustulia crassinervia* Lange-Bertalot & Krammer, and *Brachysira neoexilis* Lange-Bertalot. Further, the study also found many new species belonging to the genera *Eunotia*, *Frustulia*, *Gomphonema*, *Navicula*, *Pinnularia*, and *Neidium*. The results confirm the high biodiversity and endemicity inside these swamps. Further, the study aims to document all these taxa in a monograph, which can be used as a regional database for taxonomic guidance and identification purposes.

Keywords: The Western Ghats, Myristica swamps, Diatoms, Diversity, Environment

Developing Sustainable Goals in Architecture Design and its Contribution towards Water Management in Built Environment

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Architects work toward the provision of the spaces required to support human activity and development objectives. Prehistorically, design was to provide shelter from the elements and security from wild animals for communal life. The drive to build bigger, taller, faster has become the goal for contemporary buildings, made possible by technological innovations and advancements. On a global scale, we are currently dealing with several habitat-related issues, like a lack of potable water, pollution of the soil, air, and water, a decline in biodiversity, unpredictable climate change, frequent natural disasters like landslides and flooding, and the effects of urban heat islands. If we want to promote sustainable growth, our goals for the built environment must shift.

34 per cent of the total energy used is used by the building industry, while 20 per cent is used by transportation. Therefore, there would be a substantial positive impact on the problems impacting both our ecosystem and the human population if we could address the needs for energy conservation and natural resource management in the built environment. The design should consider reducing consumption, changing resource use, identifying potential threats to the ecosystem, and adapting to the natural environment. People's total quality of life, including their health and wellbeing, should be improved by design. It is crucial to keep in mind the maintenance of eco-sensitive zones for resource conservation and to recognize breeding regions, among other things, while discussing the nutrient cycle and ecosystem preservation. Water management includes preserving surface water bodies and their water sources, increasing the management of rainwater and groundwater recharge, and enhancing vegetation, particularly tree cover. The built environment will be more practical if environmental concerns are connected to people's social and economic needs. The architectural design addresses a variety of sustainable design goals. The examples will demonstrate how to map such objectives and give supporting information. Examples of small-scale architectural approaches to waste management, energy savings, and open space development will be discussed. Sector-level planning to demonstrate efficient blue-green infrastructure will be shown. Including sustainable goals in environmental design also addresses disaster management objectives, as will be demonstrated.

Keyword: sustainable design goals (SDG), sustainable development, water resource management.

A multi-criteria selection in wheat breeding

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Selection is an integral part of life. Wherever there is an option, there is a selection. Selection is either natural, as practised by nature, so to say, or artificial, as practised by man. Artificial selection, by human beings, is largely subjective and hence varies from person to person. Of course there are objective ways of selection and the whole field of decision support system, plant breeding and animal breeding etc. are very much objective in their approaches. In pursuit of selecting desirable plant types the ideal plant types or crop ideotypes were suggested by plant breeders. On the similar line this paper gives an example of a very objective and effective method of varietal selection in wheat (*Triticum aestivum* L. em. Thell.). This approach could be applied at any level like global level to a particular farmer family level. However, as the number of varieties being tested, replications and trial locations increase, the power of this procedure is realized in plant breeding. Let us try to understand it with the help of a suitable example in wheat. Forty varieties evaluated on eleven parameters would be subjected to normalized cumulative ranks analysis to select top ten good performers. The selected varieties would be recommended to farmers for cultivation in this area.

Forty wheat varieties were evaluated on 11 parameters in three replications and the average values are given in table 1. Since various parameters are not of same dimensions, their data were transformed by ranking. The ranking was done as per desirability of selection criteria. Selection criteria can be changed to select a different kind of crop idiotype just by changing the sort order in ranking. Here in this particular case the suitable varieties being looked would have more test weight, spike weight, yield per plot, spikes per square meter, effective tillers, plant height, yield per hectare, biological yield per plant and should be early flowering, small flag leaf area and resistant to Karnal bunt. Table 2 gives the ranks, cumulative ranks and normalized cumulative ranks of 40 genotypes tested and studied by two students on 11 parameters as: 1. test weight or 1000 seed weight in grammes, 2. ten spikes' weight, 3. yield/ plot, 4. spikes/ m^2, 5. effective tillers, 6. plant height, 7. yield/ ha, 8. biological yield/ plant, 9. days to 50% flowering (abbreviated as D2-50%F), 10. flag leaf area (calculated as length x width x 0.75) and 11. Karnal Bunt infestation percentage. On sorting table 2 on the basis of CR or NCR in increasing order, table 3 is obtained. Table 1 & 2 could be merged by concatenating the average values and their respective ranks as given in table 4. Again table 4 could be sorted on CR or NCR in increasing order to get table 5. This single table is enough for poster presentation to sum up the findings of such experiments. However, everything has to be explained in detail so as to comprehend the power of this selection technique. The procedure is carried out in two steps: 1. Calculation of ranks of each genotype and summing the ranks to find cumulative rank, and 2. Normalizing the cumulative ranks by minimum value and finding out a preferred list of genotypes by sorting the normalized cumulative ranks. The two steps could be easily understood by the following two formulae: 1. $CR = \sum_{i=1}^{n} Ri$ and 2. $NCR = CR/CR_{min}$, where, CR = cumulative rank; NCR = normalized cumulative rank; R = Rank; n =

number of parameters/characters evaluated. A single line formula could also be written as NCR = $(\sum_{i=1}^{n} Ri)/(\sum_{i=1}^{n} Ri)min$. Values of NCR would range from one to CR_{max}/CR_{min}. NCR value of one would show the best genotype and the maximum value would show the worst genotype. The range would be an indicator of diversity. Many papers (Singh 2017; Singh et al. 2018; Singh and Tiwari 2020; Yadav et al. 2020; Singh and Kant 2022; Kumar et al. 2022) and a large number of postgraduate theses have already been written using normalized cumulative ranks for varietal selection and many other aspects of plant breeding. Table 1 gives the average values of three replications. A sharp human mind with an excellent memory power could comprehend each data point of this table and draw inferences. This is an exaggeration as all humans do not understand mathematics and fear big numbers. That is why the ranking is better than any other data transformation techniques especially for such situations like selecting desirable plant varieties.

Table 2 gives the (transformed) ranking data as well as cumulative ranks and normalized cumulative ranks of respective varieties. A sharp human mind could find better varieties from CR or NCR values from table 2. However, table 2 data could be sorted on CR or NCR values in increasing order so as to get a preference order of varieties. This could be further simplified by numbering which is even more comprehensible to farmers for whom this whole experiment/exercise is intended to. Large tables pose problems during presentation. Therefore, top few varieties could be shown along with a few lowermost ones and missing the middle data-set would solve the problem. The results and conclusions in this experiment and analysis are **relative** and multi-location trials may give a little bit different results compared to single location trials. This would be a pointer to genotype environment interaction.

The mean test weight of 40 evaluated genotypes is 41.259 with standard error of 0.61484. The average values of three replications ranged from 34.33 to 56.67. It is desirable to have higher test weight as it would come from bold, plump and well-matured filled grains. Similarly, ten spikes' weight and yield per plot are expected to be high in desirable varieties. Spikes per square meter is an agronomic trait that could be handled in two ways by managing seed rate and tillering abilities of varieties. The highest test-weight (56.67) has come from CRD Gehun 1 (Table 1). However, CRD Gehun 1 is showing first rank in five parameters (1, 5, 6, 8 and 9). It is last in spikes/m^2. Spikes/m^2 is an agronomic trait that can be managed by increasing seed rate and increasing tillering capacity. Thus performance of CRD Gehun 1 could be further improved by increasing seed rate and reducing flag leaf area.

Table 1. Average values of three replications

S.N.	Variety↓ Sort Order→	Test Weight	10 Spikes' Weight	Yield/ plot	Spikes/ m^2	Effective Tillers	Plant Height	Yield/ ha	Biological Yield/ Plant	D2-50%F	Flag Leaf Area	Karnal Bunt
		0	0	0	0	0	0	0	0	1	1	1
1	HPST-16-17-07	41.33	24.67	2.01	529.67	4.47	110.2	25.17	17.6	83	34.76	13.33
2	HPST-16-17-15	35.33	28.67	1.75	429	4.53	104.53	21.83	21.33	83	43.97	3.67
3	HPST-16-17-16	39.33	30	1.92	569.67	4.8	109.13	23.96	20.53	83	31.27	5
4	BHU-25	40	33.33	2.38	629.67	5.33	93.17	29.71	24.67	84	29.86	8
5	BHU-31	42.67	34.67	2.51	536.67	4.4	94.33	31.33	17.33	85.67	36.79	9
6	ZINCOL	36.67	31.33	1.56	439	3.73	103.93	19.46	17.87	91	32.01	6.67
7	ANKUR	40.67	30	1.72	451	4.53	105.9	21.46	19.73	87	34.72	4.67
8	PBW-Zn 1	38.67	27.33	1.88	464.33	4.53	105.43	23.5	18.4	83	38.91	18.33
9	WB-02	38	25.33	1.67	684.33	4.4	98.3	20.92	17.2	83	37.21	10
10	HPAN-101	44	24	2.22	552	5.2	104.77	27.71	28.13	87	33.85	7.67
11	HPAN-147	46	26	1.16	589.67	4.47	90.69	14.54	17.87	91	38.49	70.33
12	HPAN-164	35.33	25.33	1.92	586	3.73	102.2	23.96	19.07	87	36.6	7.33
13	HPAN-42	38	29.33	2.77	486.67	4.47	103.8	34.63	16.47	85	53.03	10.33
14	HPAN-57	43.33	28.67	1.83	559.33	4.6	99.9	22.82	21.87	83	34.99	7.33
15	HPAN-65	36.67	32.67	2.8	485	4.33	104.5	35	20.8	86	40.77	21
16	HPAN-111	42	24	2.31	506.33	5.53	101.03	28.88	22	87	40.14	16.67
17	HPAN-127	43.33	27.33	2.27	553.33	4.4	99.7	28.33	19.2	87	40	9
18	CRD Gehu 1	56.67	29.33	1.69	272.67	7.93	112.53	21.15	45.6	79	61.06	8
19	PBW-677	42.67	26.67	2.94	480.33	5.33	102.23	36.75	21.6	87	41.91	6
20	HD-2967	40	27.33	2.13	433	5	95.6	26.67	17.73	87	39.65	32.67
21	HD3271	40.67	30.67	2.13	570.33	5.87	97.97	26.63	28.13	84.67	49.87	3.33
22	HPAN153	41.67	26	1.68	420.33	6.47	99.93	21.04	28.93	84.67	51.93	0
23	HPAN163	38.67	23.33	2.39	531	6.07	99.34	29.83	17.47	88.67	39.37	6.33
24	HPAN165	45.33	28.67	2.01	385	5.73	111.23	25.17	23.07	86	51.26	9.67
25	HPAN196	43.67	28.67	2.12	517.67	5.33	107.83	26.46	19.87	86	46.7	5
26	HPYT409	40	28	2.21	518.33	4.2	100	27.63	15.87	84.67	48.57	0
27	HPYT418	41.67	24.67	2.04	402.67	4.73	98.67	25.46	16.8	82	52.05	1.33
28	HPYT424	41.33	25.33	2.46	497.33	5.93	99.9	30.75	23.73	87.33	49.05	11.33
29	HPYT426	44.67	30.67	2.19	422	6	100.37	27.33	23.6	87.33	57.5	11.33
30	HPYT441	38.67	26.67	1.84	520	5.27	102.2	23.04	18.93	86.67	42.9	3.33
31	HPYT443	45.33	22	2.14	427.33	6.53	101.73	26.75	22.67	85.33	46.27	9
32	HPYT446	46.33	14	1.55	448.33	5.6	101.23	19.33	22.13	86	35.95	30
33	HPYT474	43.67	23.33	2.41	513.67	5.2	101.73	30.13	19.2	86	35.84	3.33
34	HPYT480	41.67	26	2.57	460.33	4.33	106.87	32.08	20.13	80	55.26	11
35	HPYT489	37.67	22.67	1.28	507	5.33	106.8	16	18.67	82.67	51.51	0
36	HPYT490	34.33	24.67	2.04	579.67	4.8	100.3	25.54	19.73	90	50.06	0
37	HPAW152	42	29.33	2.15	552	4.73	108.97	26.83	21.33	84.67	50.49	5.67
38	HD3117	40.67	30	2.45	525.67	6.2	110.7	30.67	29.47	83.33	46.74	3
39	CSW18	40	32.67	1.39	446.33	5.2	112.4	17.42	24.27	89.33	59.84	3.33
40	HD3226	41.67	28.67	1.61	591.33	5.2	105.3	20.17	23.73	88.67	64.49	3.33

Table 2. Ranks, cumulative ranks and normalized cumulative ranks based on table 1.

S.N.	Variety↓	Test Weight	10 Spike Weight	Yield/ plot	Spikes/ m2	Effective Tillers	Plant Height	Yield/ Ha	Biological Yield/	D2-50%F	Flag Leaf Area	Karnal Bunt	CR	NCR
	Sort Order→	0	0	0	0	0	0	0	0	1	1	1		
1	HPST-16-17-07	20	31	23	15	30	5	23	34	5	6	34	226	2.02
2	HPST-16-17-15	38	14	30	34	27	15	30	17	5	22	12	244	2.18
3	HPST-16-17-16	29	8	25	8	22	6	25	20	5	2	14	164	1.46
4	BHU-25	25	2	10	2	12	39	10	6	12	1	23	142	1.27
5	BHU-31	12	1	5	13	33	38	5	36	19	11	25	198	1.77
6	ZINCOL	36	5	36	32	39	17	36	31	39	3	19	293	2.62
7	ANKUR	22	8	31	29	27	11	31	23	26	5	13	226	2.02
8	PBW-Zn 1	30	20	27	27	27	12	27	30	5	14	36	255	2.28
9	WB-02	33	28	34	1	33	35	34	37	5	12	29	281	2.51
10	HPAN-101	7	34	13	11	17	14	13	4	26	4	22	165	1.47
11	HPAN-147	3	25	40	4	30	40	40	31	39	13	40	305	2.72
12	HPAN-164	38	28	25	5	39	20	25	27	26	10	20	263	2.35
13	HPAN-42	33	11	3	24	30	18	3	39	17	35	30	243	2.17
14	HPAN-57	10	14	29	9	26	30	29	15	5	7	20	194	1.73
15	HPAN-65	36	3	2	25	36	16	2	19	20	19	37	215	1.92
16	HPAN-111	14	34	11	22	11	25	11	14	26	18	35	221	1.97
17	HPAN-127	10	20	12	10	33	32	12	25	26	17	25	222	1.98
18	CRD Gehu 1	1	11	32	40	1	1	32	1	1	39	23	182	1.63
19	PBW-677	12	23	1	26	12	19	1	16	26	20	17	173	1.54
20	HD-2967	25	20	18	33	21	37	18	33	26	16	39	286	2.55
21	HD3271	22	6	18	7	8	36	19	4	13	28	7	168	1.5
22	HPAN153	16	25	33	37	3	29	33	3	13	33	1	226	2.02
23	HPAN163	30	36	9	14	5	33	9	35	35	15	18	239	2.13
24	HPAN165	4	14	23	39	9	3	23	11	20	31	28	205	1.83
25	HPAN196	8	14	20	19	12	8	20	22	20	24	14	181	1.62
26	HPYT409	25	19	14	18	38	28	14	40	13	26	1	236	2.11
27	HPYT418	16	31	21	38	24	34	22	38	3	34	5	266	2.38
28	HPYT424	20	28	6	23	7	30	6	8	33	27	32	220	1.96
29	HPYT426	6	6	15	36	6	26	15	10	33	37	32	222	1.98
30	HPYT441	30	23	28	17	16	20	28	28	25	21	7	243	2.17
31	HPYT443	4	39	17	35	2	22	17	12	18	23	25	214	1.91
32	HPYT446	2	40	37	30	10	24	37	13	20	9	38	260	2.32
33	HPYT474	8	36	8	20	17	22	8	25	20	8	7	179	1.6
34	HPYT480	16	25	4	28	36	9	4	21	2	36	31	212	1.89
35	HPYT489	35	38	39	21	12	10	39	29	4	32	1	260	2.32
36	HPYT490	40	31	21	6	22	27	21	23	38	29	1	259	2.31
37	HPAW152	14	11	16	11	24	7	16	17	13	30	16	175	1.56
38	HD3117	22	8	7	16	4	4	7	2	11	25	6	112	1
39	CSW18	25	3	38	31	17	2	38	7	37	38	7	243	2.17
40	HD3226	16	14	35	3	17	13	35	8	35	40	7	223	1.99

Ten spikes' weight is a reproductive and desirable character and hence it has to be selected for higher values. It should be considered along with higher harvest index. However, harvest index is not a parameter in this experiment. BHU-31 is ranking first in ten spikes' weight (Table 2) with its value 34.67. Yield per plot is a super character like yield per hectare. It depends on many other yield contributing traits. PBW-677 is ranking first in yield per plot as well as yield per hectare (Table 2). Looking at correlation coefficient data (Table 7), there is almost a perfect positive correlation between yield per plot and yield per hectare (r = 0.999975 which is near about 1). It is quite expected as yield per hectare is derived from yield per plot only.

Therefore, one of these parameters (yield per hectare) could be left in initial yield trials and may be considered in large-scale final trials where trials are conducted on large plots of many hectares. This gives a case of feature reduction to simplify the varietal selection process. Spikes/meter square is an agronomic trait and optimum values for each wheat variety may have to be worked out by agronomic trials and maintained by seed rate and tillering capacity. Moreover, ecological laws of density dependence and inverse square law would work in their limits.

Table 3. Same as table 2 but sorted on CR or NCR.

S.N.	Variety↓	Test Weight	10 Spike Weight	Yield/ plot	Spikes/ m2	Effective Tillers	Plant Height	Yield/ Ha	Biological Yield/ Plant	D2-50%F	Flag Leaf Area	Karnal Bunt	CR	NCR
	Sort Order→	0	0	0	0	0	0	0	0	1	1	1		
1	HD3117	22	8	7	16	4	4	7	2	11	25	6	112	1
2	BHU-25	25	2	10	2	12	39	10	6	12	1	23	142	1.27
3	HPST-16-17-16	29	8	25	8	22	6	25	20	5	2	14	164	1.46
4	HPAN-101	7	34	13	11	17	14	13	4	26	4	22	165	1.47
5	HD3271	22	6	18	7	8	36	19	4	13	28	7	168	1.5
6	PBW-677	12	23	1	26	12	19	1	16	26	20	17	173	1.54
7	HPAW152	14	11	16	11	24	7	16	17	13	30	16	175	1.56
8	HPYT474	8	36	8	20	17	22	8	25	20	8	7	179	1.6
9	HPAN196	8	14	20	19	12	8	20	22	20	24	14	181	1.62
10	CRD Gehu 1	1	11	32	40	1	1	32	1	1	39	23	182	1.63
11	HPAN-57	10	14	29	9	26	30	29	15	5	7	20	194	1.73
12	BHU-31	12	1	5	13	33	38	5	36	19	11	25	198	1.77
13	HPAN165	4	14	23	39	9	3	23	11	20	31	28	205	1.83
14	HPYT480	16	25	4	28	36	9	4	21	2	36	31	212	1.89
15	HPYT443	4	39	17	35	2	22	17	12	18	23	25	214	1.91
16	HPAN-65	36	3	2	25	36	16	2	19	20	19	37	215	1.92
17	HPYT424	20	28	6	23	7	30	6	8	33	27	32	220	1.96
18	HPAN-111	14	34	11	22	11	25	11	14	26	18	35	221	1.97
19	HPAN-127	10	20	12	10	33	32	12	25	26	17	25	222	1.98
20	HPYT426	6	6	15	36	6	26	15	10	33	37	32	222	1.98
21	HD3226	16	14	35	3	17	13	35	8	35	40	7	223	1.99
22	HPST-16-17-07	20	31	23	15	30	5	23	34	5	6	34	226	2.02
23	ANKUR	22	8	31	29	27	11	31	23	26	5	13	226	2.02
24	HPAN153	16	25	33	37	3	29	33	3	13	33	1	226	2.02
25	HPYT409	25	19	14	18	38	28	14	40	13	26	1	236	2.11
26	HPAN163	30	36	9	14	5	33	9	35	35	15	18	239	2.13
27	HPAN-42	33	11	3	24	30	18	3	39	17	35	30	243	2.17
28	HPYT441	30	23	28	17	16	20	28	28	25	21	7	243	2.17
29	CSW18	25	3	38	31	17	2	38	7	37	38	7	243	2.17
30	HPST-16-17-15	38	14	30	34	27	15	30	17	5	22	12	244	2.18
31	PBW-Zn 1	30	20	27	27	27	12	27	30	5	14	36	255	2.28
32	HPYT490	40	31	21	6	22	27	21	23	38	29	1	259	2.31
33	HPYT446	2	40	37	30	10	24	37	13	20	9	38	260	2.32
34	HPYT489	35	38	39	21	12	10	39	29	4	32	1	260	2.32
35	HPAN-164	38	28	25	5	39	20	25	27	26	10	20	263	2.35
36	HPYT418	16	31	21	38	24	34	22	38	3	34	5	266	2.38
37	WB-02	33	28	34	1	33	35	34	37	5	12	29	281	2.51
38	HD-2967	25	20	18	33	21	37	18	33	26	16	39	286	2.55
39	ZINCOL	36	5	36	32	39	17	36	31	39	3	19	293	2.62
40	HPAN-147	3	25	40	4	30	40	40	31	39	13	40	305	2.72

Although the present data show that CRD Gehun 1 is ranking first (Table 2) in effective tillers, yet a lot of variation has been noticed in populations of CRD Gehun 1. This may be due to a sampling bias otherwise zero-tillering plants are common features of CRD Gehun 1's population. In fact, one should select for zero to one or two effective tillers in successive generations to develop CRD Gehun 1's derived pure lines for 0, 1 and 2 tillers respectively. The seed rates will have to be increased for better yields. The spike length in uniculm, single tiller to 2 tiller decreases progressively. Hence, better yields could be obtained by developing 0, 1, 2 tiller purelines. The idea for higher plant height is that it would give higher biological yields. If it is allocated more towards grains then higher yields may result. More biomass is being allocated towards sterile glumes (glume 1, glume 2), lemma and palea. PBW-677 is on first rank on both yield / ha and yield per plot. Therefore, it would be worthwhile to include it in crossing with other potential varieties. CRD Gehun 1 is giving highest biological yield per plant. Therefore, it would be worthwhile to develop this variety into a high harvest-index variety. Early flowering and early maturing characters are aimed at developing early varieties. CRD Gehun 1 is the earliest. BHU-25 has the smallest flag leaf area followed by HPST 16-17-16. Therefore, these two varieties could be crossed to potential varieties with large flag leaf area for reducing flag leaf area.

Karnal Bunt: Four varieties namely, HPAN153, HPYT409, HPYT489 & HPYT490 are showing zero per cent Karnal Bunt infestation *i.e.*, complete resistance. Karnal Bunt is new to this area but out of 40 screened varieties, only four are resistant. Rest 36 varieties are susceptible showing 1.33% to 70.33% infestation. Karnal Bunt appears when March month receives rains especially during flowering of wheat. Thus there is an ecological/environmental predisposition in the expression of Karnal Bunt in this region. To adopt climate smart agriculture, we will have to grow resistant to low-infested varieties like HPAN153, HPYT409, HPYT489, HPYT490 (zero per cent infestation) and HPYT418 (1.33% infestation). Otherwise, we will have to eat Karnal Bunt-infested wheat. This is a caution/alarm signal for scientists and governments alike. On overall consideration the top ten varieties evident from table 3 and/or 5 are HD3117, BHU-25, HPST-16-17-16, HPAN-101, HD3271, PBW-677, HPAW152, HPYT474, HPAN196 and CRD Gehu 1. None of these varieties are completely resistant to Karnal Bunt. Karnal Bunt infestation level in these varieties is ranging from 3 to 8%. From this data set, gene pyramiding can be planned with top ten varieties. Karnal Bunt resistance should be transferred from resistant varieties to top varieties by backcrossing.

Table 6: Correlation coefficient data.

	Test Weight	10 Spikes' Weight	Yield/ plot	Spikes/ m^2	Effective Tillers	Plant Height	Yield/ ha	Biological Yield/ Plant	D2-50%F	Flag Leaf Area	Karnal Bunt
Test Weight	1										
10 Spikes' Weight	-0.125	1									
Yield/ plot	-0.074	0.178	1								
Spikes/ m^2	-0.436	0.026	0.046	1							
Effective Tillers	0.62	-0.158	-0.002	-0.443	1						
Plant Height	0.121	0.097	-0.091	-0.381	0.182	1					
Yield/ ha	-0.074	0.178	0.999975	0.046	0.000369	-0.09	1				
Biological Yield/ Plant	0.616	0.131	-0.083	-0.392	0.771	0.344	-0.082	1			
D2-50%F	-0.234	-0.001	-0.105	0.219	-0.191	-0.304	-0.105	-0.303	1		
Flag Leaf Area	0.23	0.107	-0.066	-0.4	0.425	0.343	-0.064	0.376	-0.128	1	
Karnal Bunt	0.24	-0.183	-0.2	0.05	-0.129	-0.397	-0.199	-0.151	0.278	-0.251	1

Table 7: Descriptive statistics.

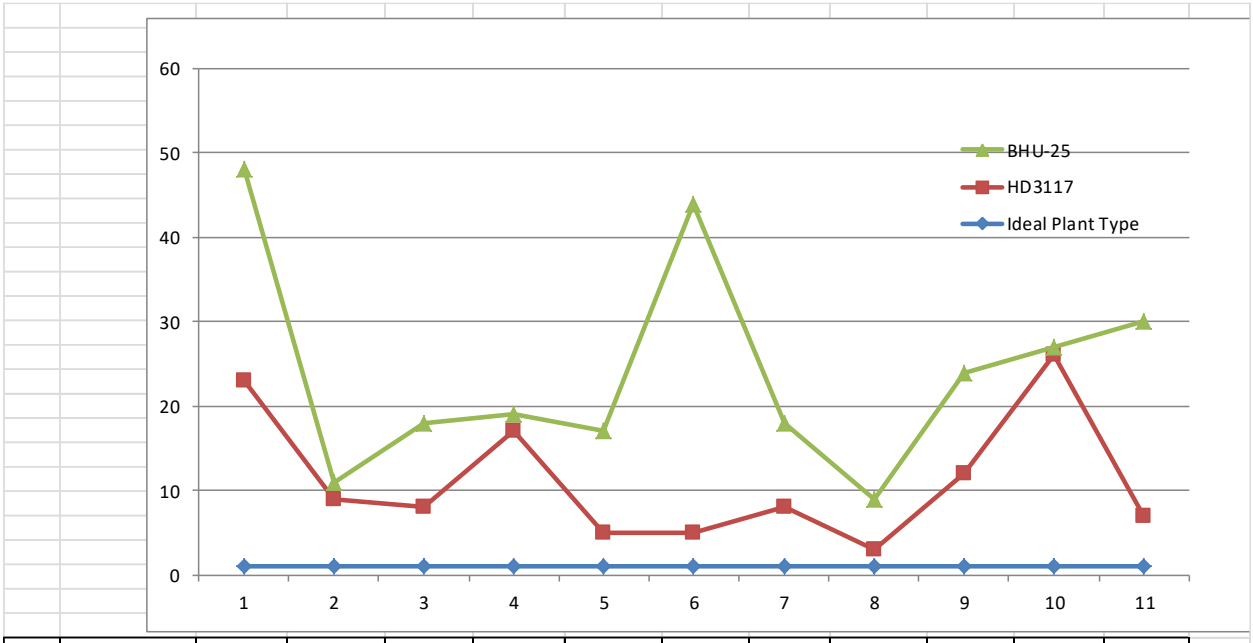
Descriptive Statistics	Test Weight	10 Spikes' Weight	Yield/ plot	Spikes/ m^2	Effective Tillers	Plant Height	Yield/ ha	Biological Yield/ Plant	D2-50%F	Flag Leaf Area	Karnal Bunt
Mean	41.259	27.30025	2.0525	501.8498	5.11075	102.8835	25.651	21.56825	85.567	44.141	9.88275
Standard Error	0.61484	0.593443	0.064726	11.99508	0.132481	0.818371	0.807911	0.825844	0.424177	1.399916	1.921353
Median	41.33	27.33	2.08	510.335	5.1	102.2	26	20.33	86	42.405	7.33
Mode	40	28.67	2.01	552	5.33	102.2	25.17	21.33	87	#N/A	3.33
Standard Deviation	3.888589	3.753262	0.409363	75.86357	0.837883	5.175836	5.109675	5.223099	2.682732	8.853846	12.15171
Sample Variance	15.12112	14.08698	0.167578	5755.281	0.702048	26.78927	26.10878	27.28076	7.197052	78.39058	147.664
Kurtosis	5.209947	2.806986	-0.21659	1.19418	1.912224	-0.17527	-0.215	10.76788	0.168314	-0.65954	15.77413
Skewness	1.385657	-0.87506	-0.01353	-0.35095	1.027344	-0.05055	-0.00852	2.72888	-0.127	0.423513	3.550976
Range	22.34	20.67	1.78	411.66	4.2	21.84	22.21	29.73	12	34.63	70.33
Minimum	34.33	14	1.16	272.67	3.73	90.69	14.54	15.87	79	29.86	0
Maximum	56.67	34.67	2.94	684.33	7.93	112.53	36.75	45.6	91	64.49	70.33
Sum	1650.36	1092.01	82.1	20073.99	204.43	4115.34	1026.04	862.73	3422.68	1765.64	395.31
Count	40	40	40	40	40	40	40	40	40	40	40
Confidence Level(95.0%)	1.243631	1.200351	0.130921	24.26235	0.267968	1.655313	1.634154	1.670428	0.857979	2.831597	3.886304

Top two selected varieties were also graphically compared with the ideal plant type (crop ideotype) as shown in Figure 1. This is an indication of further scope for improvement in top selected varieties. From same data set the information about desirable gene sources are also obtained. For example, in this paper, the best performer variety HD3117 has scope for further improvement in test weight and flag leaf area. Test weight of HD3117 (ranking 22) could be further improved by crossing it with CRD Gehun 1 (ranking 1). Similarly, the flag leaf area of HD3117 (ranking 25) could be further improved by crossing it with BHU-25 (ranking 1). In

fact, the top few, say five or ten, varieties should be crossed together in full or half diallel in hope of getting transgressive segregants, combination breeding or gene pyramiding.

Conclusions

Based on critical examination of 11 parameters of 40 wheat varieties it could be safely concluded that top five-ten varieties along with four Karnal Bunt resistant varieties could be recommended for cultivation by farmers of this area. If meteorological department predicts rains during anthesis, then resistant varieties must be given priority



S.N.	Variety↓	Test Weight	10 Spike Weight	Yield/ plot	Spikes/ m2	Effective Tillers	Plant Height	Yield/ Ha	Biological Yield/ Plant	D2-50%F	Flag Leaf Area	Karnal Bunt
	Ideal Plant Type	1	1	1	1	1	1	1	1	1	1	1
1	HD3117	22	8	7	16	4	4	7	2	11	25	6
2	BHU-25	25	2	10	2	12	39	10	6	12	1	23

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Semi-supervised Tree Canopy Detection and Classification of Plant Disease using Convolutional Neural Network based Transfer Learning Models

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Abstract

With the ever growing demand of increasing population and exploitation of natural resources, deforestation has become evident in most parts of the world causing detrimental effects on the environment. Therefore, inventory and management of trees and forest in urban/rural areas are of utmost importance to maintain a sustainable balance in the ecosystem.

In this context, unmanned aerial vehicle (UAV) based remote sensing of different land cover and land use have garnered a lot of attention. UAVs have applications in weather monitoring, precision agriculture, orchard management, etc. Now, it is possible to detect and monitor trees from their canopy with the availability of high spatial resolution images acquired from cameras mounted on UAV. Tree canopy detection and counting has been important in orchard and forest management, forest surveys and inventory, monitoring tree health, tree counting and so on.

Previous studies have focused on using deep neural networks for detecting tree canopy and in a few cases, they have been successful in delineating the tree canopy masks. However, creating training samples of masks by annotation is an extremely demanding task for two important reasons. Firstly, due to the absolute volume of data required for deep neural networks and the effort required for creating labelled masks through bounding boxes can be manifold. Secondly, resolution of the UAV images and irregular shapes of the tree canopies make it difficult to hand draw the masks around the canopies. Here, we will discuss a two stage semi-supervised approach for detecting the tree canopy. The first stage entails detection of tree canopy through bounding boxes using RetinaNet, and the second step delineates the tree canopy masks using thresholded ExGI (excess green index), neural networks with back propagation, and SLIC (simple linear iterative clustering). The results revealed a MAP (mean average precision) of 90% for tree canopy detection and 65% accuracy for the tree canopy extraction.

As an unfavorable effect of climate change, wide scale prevalence of diseases in agricultural crops have also affected both the production quality and quantity of agricultural products at local to regional scale. More

often than not, the diseases remain unidentified causing anguish to the farmers while threatening national food security. In order to circumvent this problem, early diagnosis of diseases using a fast and reliable method is beneficial. Plant disease identification from images captured by digital cameras is an area of active research. Use of various machine learning algorithms for plant disease classification and the evolution of deep convolutional neural network (CNN) based architectures have further improved the plant disease classification accuracy. In this framework, an automated computer vision-based plant disease detection and classification scheme from plant and leaf's photographs is highly desirable. Although, there exist a few techniques currently used in an adhoc approach for plant disease detection and classification, a systematic study to evaluate their usage and efficacy on actual plant data has largely remained unexplored. Second part of the talk will focus on evaluating various CNN based state-of-the-art transfer learning architectures like GoogLeNet, AlexNet, VGG16 and ResNet50V2 models for plant disease detection and classification. The models were tested on popular publicly available three plant disease benchmark database such as PlantVillage dataset, New Plant Disease dataset and Plant Pathology dataset. The evaluation results revealed that VGG16 outperformed all other architectures.

Keywords: Tree canopy, UAV images, object detection, clustering, image segmentation**,** plant disease, plant pathology, disease detection, transfer learning, CNN.

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Past, Present and Future of Time Series Forecasting

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Abstract

The ability to forecast the future, from weather patterns to disease propagation is essential to our modern lives. In fact, humans have always sought to know their own future. How do humans attempt to see the future and how have statistical and machine learning methods changed over the centuries?. After a quick go through from the very ancient forecasting techniques to modern forecasting tools, we will discuss about our recent work on forecasting models, ranging from classical methods and neural network approaches. Figure below shows the time series forecasting models from different areas.

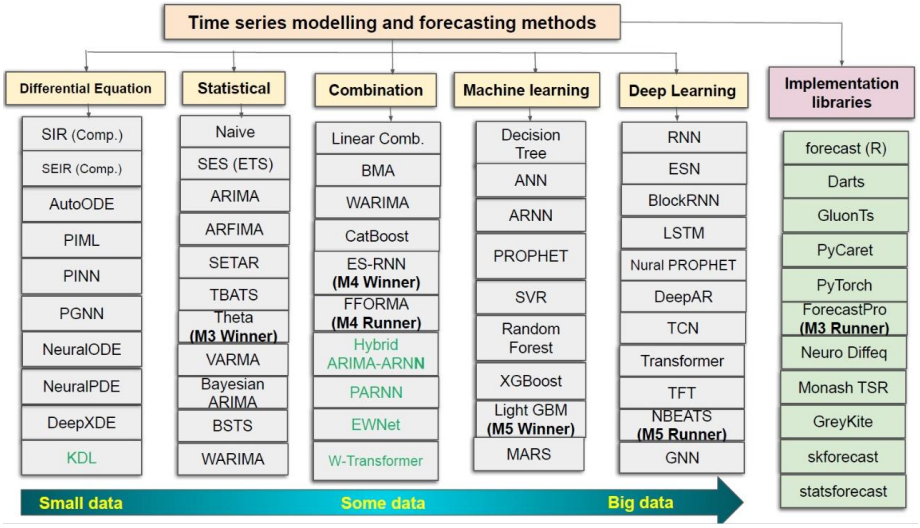

Figure: Time series forecasting models.

Impact of Increased Urbanisation on Land Surface Temperature: A Case Study of Bangalore

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Abstract

21st century is also called as urban century (UN-habitat, 2008) and a majority of the global population have considered cities as their home. Global population will continue to grow and become ever more urbanised during the next three decades. Rapid urbanisation brings about numerous changes in the structure and functioning of landscape. At present more than 50% of the population live in urban areas while in 1900's only 13% of the population lived in cities. Rapid urbanisation with the changes in land use patterns has resulted in the human induced urban heat island (UHI). UHI is a well-known phenomenon in which urban environments retain more heat than nearby rural environments effecting the urban population. City-heat interacts with rising summer temperatures and heat-waves, placing additional pressure on infrastructure. The impact of urbanisation on land surface temperature and local environment is a concern. There are evidences that the average temperature of the earth is rising because of increased urbanization and land use changes. This study attempts to understand the effect of Land Use Land Cover (LULC) changes on surface temperature. Landsat 5 TM and Landsat 8 images with a resolution of 30 m were obtained from USGS (United States Geological Survey) for the year of 2000, 2007, 2014, 2019, 2020 and 2021. Land Surface Temperature (LST) of Bangalore was derived using band 10.

Land Surface Temperature (LST) has increased over time but during lock down which started form March 2021 and continued during the pandemic, when the majority of the anthropogenic activities were at halt, the LST was also low (in March 2021, January 2021) when compared with the previous years. During 2000 to 2020 (March) where development and expansion of the city were taking place, the drastic rise in the temperature can be observed. City has unplanned growth towards its periphery where the temperature is also more than the central region. In 2021 (January and March) was assessed for the impact of lockdown as compared to the other years where the environmental degradation appears to be the least. Seasonal analysis of the year 2020 was performed where Normalized Difference Vegetation Index (NDVI) and Normalized Difference Built-up Index (NDBI) were computed from the spectral bands and their correlation with LST were determined. NDVI and LST showed a negative correlation of -0.32 and -0.11 for March and November 2020 respectively. In case of built-up, LST showed high correlation of 0.63 in March and relatively low value of 0.28 in November 2020. The results showed that the effect of UHI (urban heat island) is more in summer than in winters.

Keywords: Urban Heat Island, Land Surface Temperature, Normalized Difference Vegetation Index, Normalized Difference Built-up Index, Land Use Land Cover

Introduction

Today majority of the global population are living in the cities [1]. In the next decade, global population will continue to grow and will become even more urbanized. Bangalore is India's

third largest city in terms of population where considerable amount of land cover/land-use changes have occurred due to urban expansion. To cater to the needs of growing population there has been overutilization of natural resources. Exhaustion of these resources has resulted in environmental deterioration giving rise to a larger problem of climate change at a local and regional level.

Absorption of incoming heat coming from the sun and re-radiation from the dark surfaces interacting with the rising summer temperatures result in heat-waves that create "Urban Heat Islands (UHI)" effect leading to climate change [2]. In cities, impervious surfaces like buildings that have increased at the expense of natural permeable cover and other land use classes are the causes of UHI. To study these changes, Earth observation from remote sensing technology have played a significant role in accessing human-environmental interactions required for environmental decision and policy formulations [3]. There have been studies to explore the relationship between UHI and various urban land uses. Relationships were analyzed between UHI effect and land use/cover type using Landsat-7 ETM+, Landsat-8 OLI and various other remotely sensed data [4]. However, the impact of urban expansion on the temperature, local and regional climate, air and water quality, vegetation, etc. needs to be studied and analyzed. In this paper, the distribution and extent of land surface temperature (LST) and its various zones are studied for Bangalore City.

Problem Statement

Increased urbanization has resulted in decrease of soft and permeable surfaces leading to changes in LULC (Land Use Land Cover) . Urban Heat Island (UHI) which is referred as occurrence of higher temperature in cities or metropolitan areas can be monitored with the help of RS satellites that have thermal scanners, and are used to gather data for land surface temperature (LST) of the entire area. Therefore, understanding the effects of landscape pattern on UHI is important for improving the ecology and sustainability of cities.

As urban expansion is mainly governed by urban policies, urban planning should give more significance to tree canopy increase. Therefore, analyzing UHI effect is essential for developing mitigation strategy. The objectives of this paper are:

i.) Compute time series LST maps of Bangalore.
ii.) To analyze the impacts of seasonal changes on LST.
iii.) To examine temperature changes during lockdown.

Study Area

Bangalore is a metropolitan city situated in the state of Karnataka, India (Figure 1). Bangalore is known as Silicon Valley of India, this city was well known for its favorable climate. Presence of a large number of water bodies and vegetation made it a city of lakes. As Bangalore became more urbanized, a large number of water bodies disappeared and consequently vegetation also decreased over the years [5].

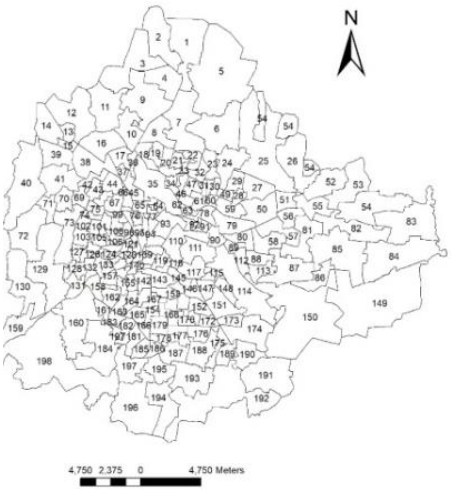

Figure 1. Ward level map of Greater Bangalore.

IV. MATERIALS AND METHODS

Landsat 5 TM and Landsat 8 images with a resolution of 30 m were obtained from USGS (United States Geological Survey) for the year of 2000, 2007, 2014, 2019, 2020 and 2021. Land Surface Temperature (LST) of Bangalore was derived using band 10.

A. Three phases– The entire study was divided into three phases where in the first phase the temperature difference of (2000-2007) was analyzed, second phase (2007-2014) and third phase (2014-2021) was examined. The change of temperature in the study area was examined by creating different temperature zones. The temperature zones can be differentiated from low to high categorizing different areas of the city making it possible to identify the areas which needs more attention when compared to others.

B. Generation of LST map–UHI analysis of the study area was done by deriving LST maps that were generated using Landsat-8 Thermal band from April 2021 dataset.

(i) Spectral Radiance: LST values were derived using the LANDSAT-8 Data Users Handbook (Department of the Interior USGS, 2019) [6]. The digital numbers (DN) of the pixels of the imagery were converted to Spectral Radiance (L_λ) as follows:

$$L_\lambda = M_L Q_{cal} + A_L \qquad (1)$$

where, Q_{cal} is the DN and M_L and A_L are the rescaling coefficients obtained from the metadata of respective satellite data.

(ii) Calculation of Emissivity: Emissivity was computed using Proportional Vegetation (Pv) which is the vegetation proportion.

$$\varepsilon = 0.004P_v + 0.986 \qquad (2)$$

Pv is computed as

$$P_v = \left(\frac{NDVI - NDVI_{min}}{NDVI_{max} - NDVI_{min}}\right)^2 \qquad (3)$$

where, $NDVI_{min}$ is normally the value of water or bare soil and $NDVI_{max}$ is the value corresponding to dense vegetation.

(iii) LST Computation: Brightness Temperature (T(k)) was calculated from the obtained $L_\lambda$in equation (1), where L_λ is the spectral radiance.

$$T(k) = \frac{k_2}{\ln\left(\frac{k_1}{L_\lambda}+1\right)} - 273.15 \qquad (4)$$

The calibration constants k_1 and $k_2$were obtained from the metadata of the satellite. Absolute zero -273.15°was added to the above equation to obtain results in ° Celsius. LST was computed as:

$$LST = T(K)/[1+(\lambda * Ts/hc) * \ln(\varepsilon)] \qquad (5)$$

where, T is the derived brightness temperature, λ = wavelength of emitted radiance, s = Boltzmann constant and c = velocity of light.

C. NDBI calculation : NDBI is used to measure the intensity of imperviousness using satellite data [7]. It highlights the impervious areas distribution where there is a higher reflectance in the shortwave infrared band compared to the near-infrared band. NDBI is calculated as:

$$NDBI = \frac{\rho_{SWIR} - \rho_{NIR}}{\rho_{SWIR} + \rho_{NIR}} \qquad (6)$$

Results and Discussion

LST of the different years for both the seasons were analyzed for BBMP boundary of Bangalore. The results were divided into three sections: (i) **Phase I** to observe where the major changes that have taken place from year 2000-2007, (ii) **Phase II** captures the changes between year 2007-2014, (iii) **Phase III** examines the change during year 2014-2021. Figure 2, 3, 4 and 5 shows the changes in the LST during different years analyzed. Figure 3 and 5 shows LST images of year 2019 and 2020 which further helps in showcasing the drastic change that can be seen in LST during 2021 in both the seasons. These changes captures the effect of lockdown

that started during end of March 2020 where the country experienced shut down of economic activities due to widespread pandemic that started around the world.

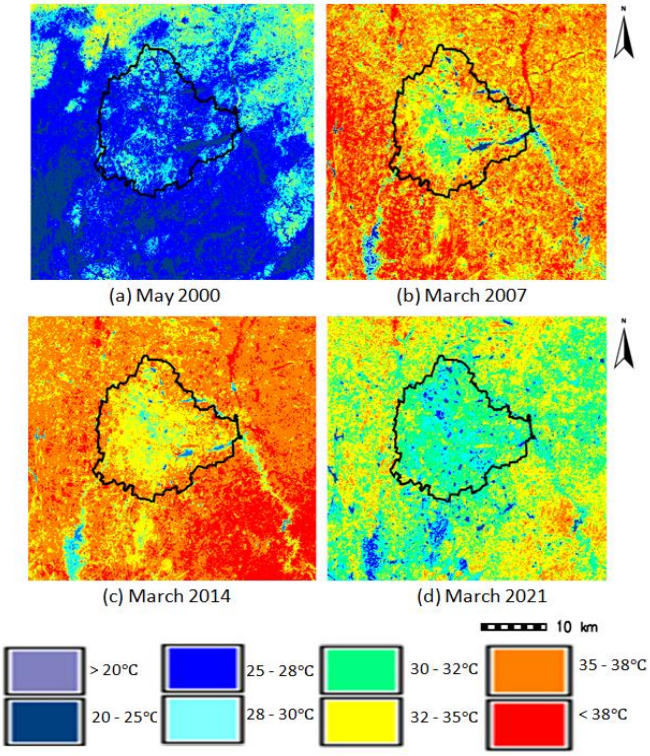

Figure 2: Land Surface Temperature (LST) of Bangalore during summer in the year (a) 2000, (b) 2007, (c) 2014 (d) 2021

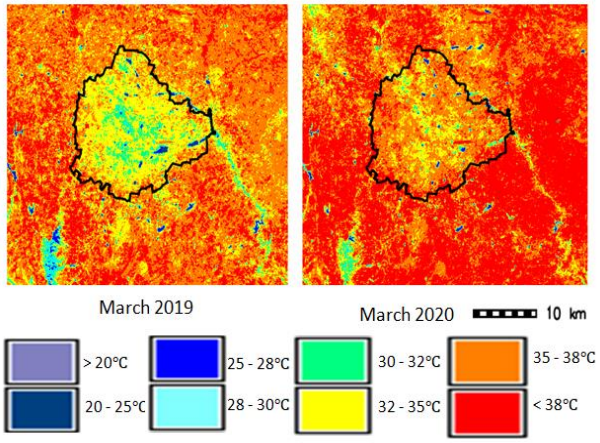

Figure 3: Land Surface Temperature (LST) of Bangalore during summer in the year (a) 2019, (b) 2020

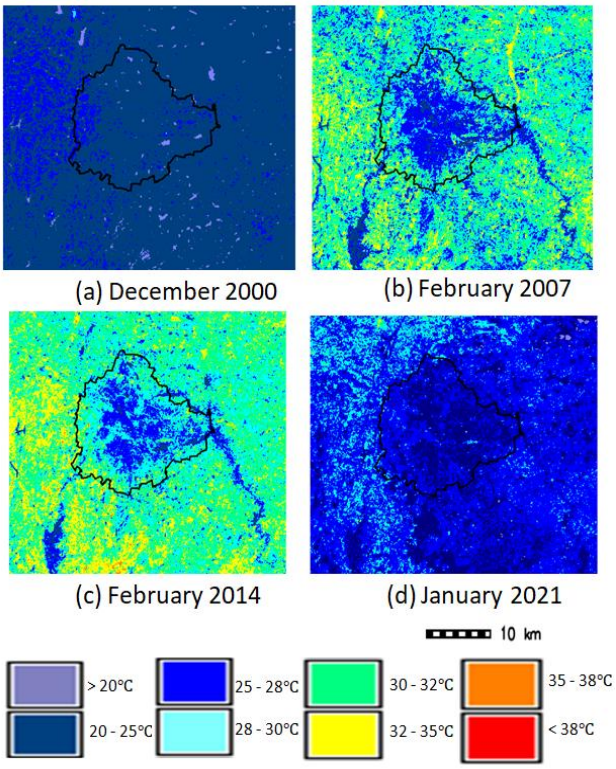

Figure 4: Land Surface Temperature (LST) of Bangalore during winter in the year (a) 2000, (b) 2007, (c) 2014, (d) 2021

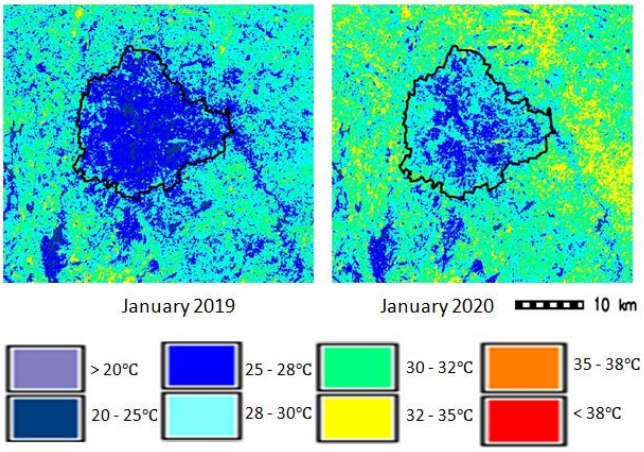

Figure 5: Land Surface Temperature (LST) of Bangalore during winter in the year (a) 2019, (b) 2020

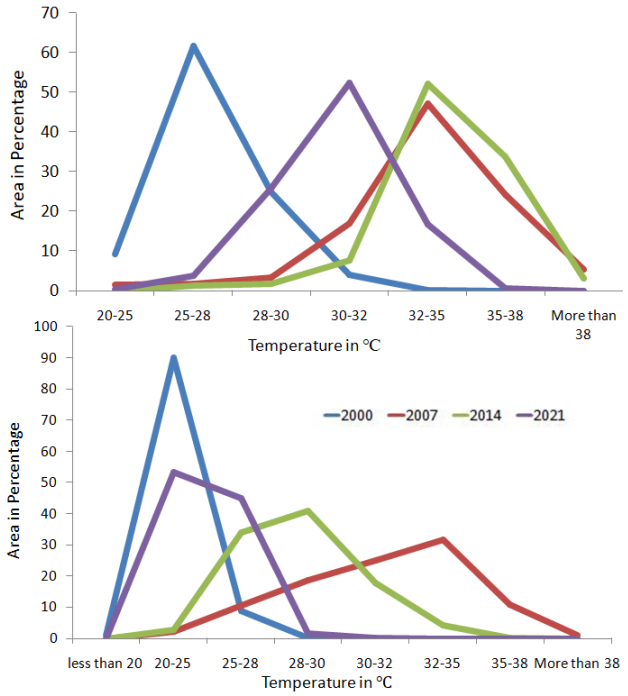

Figure 6: Percentage area of various temperature zones assessed during four years of study (2000, 2007, 2014, and 2021) within the BBMP boundary.

(i) LST change in phase I (2000-2007)

In the year 2000, during summer season 61.76 % of the BBMP area of Bangalore (shown as black boundary in the figures) was in a temperature zone in between 25-28℃ which was quite pleasant, while it drastically decreased to 1.67% in 2007. 16.92% of the area was in between 30-32℃ in 2007, while it was only 4% in the year 2000. The cooler temperature zones were undergoing transition into hotter zones from 2000-2007. In year 2000 during winters, 90.14 % of the area was between 20-25℃ temperature range which was left to only 2.07% in 2007.

(ii) LST change in phase II (2007-2014)

During summer season, 52.2 % of the BBMP area in the year 2014 was in the temperature range in between 32-35℃, while it was 47.14 % in 2007. 29.53% of the area was in higher temperature zones in 2007 which further got increased to 36.94% in the year 2014. During winter, in the year 2007, 18.62 % of the area was between 28-30℃ temperature range which increased to 41.07% in 2014(Figure 6).

(iii) LST change in phase III (2014-2021)

LST of 2021 shows a drastic change compared to the earlier years. Lockdown started from March 2020 throughout the country due to the pandemic, where Bangalore also underwent a major shut down. Therefore during March 2021 the temperature is comparatively cooler which can be observed in Figure 2 (d). During winter in the year January 2021, 53.44% of the BBMP area was under 20-25℃ temperature range.

Figure 7 shows correlation analysis performed considering 1447 points corresponding to LST, NDBI and NDVI from the study area. Result showed high correlation in the month of March (0.63) and relatively low in November (0.28) between LST and NDBI. Increase in the built-up index values also showed corresponding increase in LST which confirmed that the impact of UHI is more in summer season as correlation is high for March.

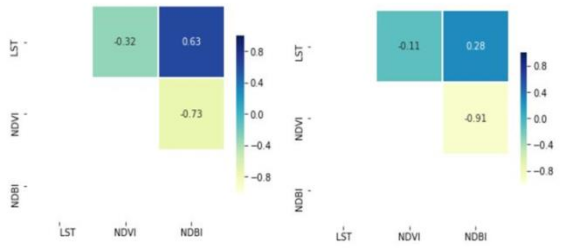

Figure 7: Correlation matrix between LST, NDVI and NDBI for summer and winters 2020.

Conclusion and Recommendations

LST maps showed that central region of the city with lower temperature that can be related to a comparatively higher vegetation cover. Fast paced urbanization further exacerbated urban temperature with increased amount of impervious surfaces, decrease in vegetation cover and open grounds, and waste, heat emission from various sources like industries, vehicles, etc. However due to absence of emissions during lockdown the temperature during both the seasons in the year 2021 showed a relative pleasant temperature. Due to major shut down of the city the changes are visible making the year 2021 as an exceptional case where temperature drop can be seen.

Therefore from the present study it can be concluded that anthropogenic Green House Gas (GHG) emissions have increased and are now higher than ever before. This has led to atmospheric concentrations of carbon dioxide, methane and nitrous oxide that are unprecedented. Besides land use land cover changes, surface properties, local climatic conditions, season, size of the city (population and area), and emissions due to pollution gives rise to anthropogenic heat influencing the UHI intensity of the city. Anthropogenic GHG emissions are mainly driven by population size, economic activity, lifestyle, energy use, land use patterns, technology and climate policy, which should be considered during urban planning.

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Epicasting: An Ensemble Wavelet Neural Network for Forecasting Epidemics

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Abstract
Infectious diseases, caused by microorganisms, remain among the top contributors to morbidity and mortality on a global level, among which many diseases produce epidemic waves of infection, severely distressing the healthcare systems. The unavailability of specific drugs and ready-to-use vaccines to prevent most of these epidemics makes the situation worse. These force public health officials and policymakers to rely on early warning systems generated by reliable and accurate forecasts of epidemics [1]. Alongside the significant health hazards, the untimely outbreak of these epidemics has led to the mass destruction of limited resources and the collapse of economy. This problem is pivotal in developing countries, hence early knowledge of epidemic timing, intensity, and mortality rates are crucial in designing countermeasures to reduce the impact of such cumbersome outbreaks. The need for generating reliable forecasts to mitigate the impacts of epidemics has led to growing interest among researchers in the centuries-old field of epidemiological modelling [2]. The epidemiological models (we will refer these as epicasters) can be used for

nowcasting as well as forecasting the total number of confirmed cases, number of hospitalizations, or number of deaths. These varied forecasts generated by the epicasters have become an immediate choice of stakeholders in tailoring countermeasures, such as vaccination campaigns, staff scheduling, and resource allocation to efficiently tackle the situation at hand, which could translate to reductions in the impact of a disease [3, 4]. Within the scope of epidemiological forecasting various deterministic approaches have been developed (e.g., SIR model) [5]. Despite their vast applicability, these models are more suitable for understanding the disease dynamics rather than nowcasting and forecasting (we refer to them as epicasting). To overcome the limited predictability of these mechanistic approaches, there have been several attempts to mitigate the severity of infectious disease dynamics using statistical frameworks [6]. While the statistical models focus on parametric methods to predict epidemic outbreaks, machine learning and deep learning models generate the forecast in a data-driven approach [7]. Recently with the increasing data availability and computation power, machine learning and deep learning architectures have become a vital part of epidemic forecasting and are widely used as individual forecasters or in a hybridized environment [3]. Albeit the applicability of the statistical models for epicasting, these approaches impose certain restrictions on the data characteristics (e.g, linearity, non-stationarity) prior to their application. Since, real-world epidemic datasets exhibit complex non-linear characteristics owing to the changing climatic and demographic conditions, pre-processing these epidemic datasets into simpler parts has often led to satisfactory forecasts [8]. To overcome this problem, wavelet transform has been considered an efficient mathematical tool for the past three decades [9, 10]. Previous studies have utilized a discrete wavelet transform (DWT) for extracting signal from the noise by decomposing the series into high-frequency (details) and low-frequency (smooth) filters. However, the restriction on the signal length to be an exact power of 2 imposed by the DWT approach has led to the development of its maximal overlapping version (MODWT) [9]. The MODWT approach has similar properties as that of the DWT, but it is free from the limitations of DWT. Moreover, the MODWT approach provides increased resolution for noisy data and unlike DWT it retains the length of each decomposed series as that of the original series. Applications of MODWT-based neural networks have been demonstrated in various fields such as predicting electricity price [11] and generating weather forecasts [12] among many others. However, these wavelet neural networks have fewer applications in epidemiological forecasting. Moreover, the ambiguity of the structure of the wavelet neural network and lack of theoretical properties like asymptotic stationarity makes the forecasts unstable and unreliable. To address this concern we attempt to develop a novel MODWT-based ensemble wavelet neural network (EWNet) architecture for epicasting the short, medium, and long-term infectious disease dynamics that are more reliable than the state-of-the-art statistical, machine learning, and deep learning frameworks. EWNet is first built theoretically with the help of the MODWT algorithm combined with auto-regressive neural networks in an ensemble setup and further used to solve the epicasting problem. More precisely, our proposed EWNet modelinitially decomposes the epidemic datasets into a number of “details” (describing high-frequency variations at a particular time scale) and “smooth” (describing low-frequency variations) using a MODWT-based multi-resolution decomposition. In the subsequent step, EWNet models the “details” and “smooth” segments of the data with a series of autoregressive feedforward neural networks having pre-defined architecture specified based on theoretical properties of the model including asymptotic

stationarity, ergodicity, irreducibility, and learning stability. Finally, an ensemble approach is applied using an inverse MODWT transformation to ensure the reduction of bias in the overall forecast. The proposed EWNet model is specially designed for handling nonlinear, non-stationarity and long-range dependency of real-world epidemic datasets. Moreover, the solid mathematical properties utilized in developing this model make it more explainable and reliable than modern deep-learning techniques. In addition, the model does not have growing variance over time and exhibits better long-range forecastability for epidemic datasets. From a practitioner's viewpoint, we extensively study the global characteristics of fifteen real-world infectious disease datasets covering influenza, malaria, dengue, and hepatitis B from different regions. We demonstrate the epicasting ability of the proposed EWNet model on all the fifteen epidemic datasets by a rolling window approach having three test horizons - short, medium, and long-term and measure their performance using four accuracy metrics. The efficacy of the proposed model w.r.t. sixteen state-of-the-art forecasters ranging from traditional time series models to the most recent deep learning algorithms demonstrated its generalizability. We show that our proposal can generate a better long-term forecast and can outperform the majority of these forecasters on average. Moreover, the robustness of the forecast generated by our proposed EWNet method is also validated using a non-parametric statistical test. *Keywords:* Wavelet methods, epidemiology, neural networks, time series forecasting.

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Cloud Computing for Big Geospatial Data Analysis with Google Earth Engine – Urban Research Applications

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Abstract

Over the past few years, Big data analysis has drawn attention in various disciplines, such as data science, socio-economic studies, natural resource management, disaster management, and Earth sciences. The enormous amount of existing geospatial data, variety of data sources and data types, and the growing diversity and accessibility well defines the Big data. In geospatial big data analysis, cloud-based platforms are commonly used because it presents cloud storage for storing big data with accessible scalability [1]. There are various cloud computing platforms for geo-big data processing such as Amazon Web Services (AWS) launched in 2006, Azure created by Microsoft (2010), IBM cloud computing (2011), and Google Earth Engine (2011).

Recently, Google Earth Engine (GEE) has drawn great attention in the remote sensing big data processing spotlight and most researchers tend to use GEE to get access to broad satellite imagery archives and geospatial datasets. GEE platform is for large-scale Earth Observatory data processing and analysis [2]. The free GEE tool provides access to multi-source spatial datasets and it also provides access to a large volume of publicly available satellite imagery and other derived products (normalized difference vegetation index (NDVI), land use land cover maps, digital elevation models, and soil moisture, population, global water surface and so on) for studying the field of Earth science. GEE can access high-speed parallel processing and apply machine learning (ML) algorithms using Google's computational infrastructure. The GEE Application Programming Interfaces (APIs) with development environments make it easy to work on Google cloud with the support of coding languages such as JavaScript and Python. GEE is also a powerful image analysis tool because it has a very user-friendly Graphical User Interface (GUI) to begin exploring and analysing spatial data. Thus, GEE code editor enable users to find, analyse and visualize global geospatial data in significant ways without any supercomputers or specialized coding expertise. In addition, users can upload their own spatial data sets and even share scripts with other users for free, thereby promoting knowledge exchange [3]. As a geospatial processing platform, its ability to analyse global data rapidly lends itself to be an invaluable tool for studying many applications in the spatial data science domain. This paper reviews recent applications of GEE in geoscience and it also includes explanations of how Earth Engine can be utilized in urban mapping studies with a case study of Bangalore City.

It is widely agreed today that urbanization has imposed too much stress on the Earth's surface. Hence identifying and mapping builtup area is essential for realizing the spatial distribution of

the human settlement and for planning developmental activities with the aid of from remote sensing data [4-7]. The geographical distribution of publications in GEE showed a broad spectrum of applications in the Earth sciences at both regional and global scales. However, the availability of GEE platform and its impact on urban studies have not been carefully explored in the Indian context. Therefore, a thorough understanding of the spatial distribution of urban landscape in Indian cities and urban land area expansion needs to be analysed using GEE tool. Multispectral satellite imagery with medium spatial resolution, particularly Landsat series data with an archive exceeding 40 years, have been extensively used for land change detection analysis and derived satellite image products have been used for various environmental applications since 2016 [1].

Kumar and Mutanga [3] presented the first review of the applications of GEE platform and investigated whether researchers in developing countries were making use of the GEE platform. The literature review focused on which dataset and algorithms were more frequently used for urban mapping studies at a global scale and found that a vast range of the research were conducted in high-income countries. Dandan et. al., [8] used GEE to extract the spatiotemporal pattern of urban dynamics for a long time series over 30 years (1987 to 2017). Additionally, spatio-temporal Land Use Land Cover (LULC) analysis for urban and wetland classes of two regions in Singapore were explored using GEE [9]. Naime Celik [10] provided details about identifying urban land cover change detection using GEE and Binary Random Forest (RF) classification to discriminate newly builtup and excavated areas. In another study, an automatic urban growth mapping was also developed by Miyazaki et. al., [11]. Freely available remote sensing data with medium resolution (Landsat and Sentinel-1, 2 satellite) sensors have been utilized for urban resource management, urban planning and spatial mapping. Thus, GEE has become one of the most capable platforms for geospatial and big data analysis and the results of literature promise that GEE can support substantive progress on global challenges involving the process of geospatial big data. However, GEE has some limitations, it does not include any neural network-based models, and users train and run neural networks and even deep neural network (DNN) algorithms in Google Colab with data from GEE [1].

In this research, we propose an effective method for mapping urban areas from multi-temporal satellite data in GEE platform. The main objectives of this study are: (1) To map accurate urban builtup land area to quantify the change in urban areas at ward level and perform a ward wise inter-comparison of urban growth, (2) Assess the area of human settlements in and around Bangalore City that do not have access to electricity.

The literature review demonstrated that optical imagery was useful across many applications including urban land area mapping. First, we look at how GEE can be used to quantify urban areas in Bangalore City from Sentinel-2A imagery (launched in 2015) through Random Forest algorithms using per-pixel supervised image classification method. Multi-temporal data of the year 2018 and 2020 were used to quantify the urban land use changes. More than 700 ground training samples were collected for each class for the two years separately to classify the land

areas. Percentage of builtup area were calculated and analyzed ward-wise to understand the urban dynamism. Results showed that overall classification accuracy of more than 92% were achieved for both the years. Urban builtup area has increased rapidly at the cost of significant reduction in waterbody and vegetation, and impacted the quality of urban environment. Significant increase in urban builtup were observed in several wards such as Dodda Bidarakallu (Fig. 1), Kodigehalli, Sanjaya Nagar, Hemmigepura, Shettihalli, Kengeri, Chokkasandra and Uttarahalli while other wards also showed rise in builtup area wise urban proportion. On an average, 87% of the 198 wards have observed an increase in the percentage of builtup area. (Rahisha and Uttam, 2022 [12]). Results were validated by observing those changed spots in Google Earth images.

Fig. 1. Changes observed through Google Earth images in Dodda Bidarakallu ward between the year 2018 and 2020.

Second part of this study assessed the human settlements without access to electricity for areas in and around Bangalore City. Accurate information about the human settlement without electricity is essential for monitoring the areas deprived of electricity and to end the darkness. We used multimodal and multi-resolution data of the year 2019 with 27 layers such as Landsat-8 OLI bands, Sentinel-1 C Band (SAR data) with VV and VH polarization, spectral indices (EVI, NDVI, MNDWI, NDBI, NDMI, BSI, SAVI, IBI, BuEI and SoEI), Texture parameters (DISS, Entropy and Angular Second Moment), Topological data (slope and elevation), and land surface temperature to detect land use land cover map with urban builtup, vegetation, water, and barren land classes with a spatial resolution of 30 m using object-based Random Forest algorithm. All the analyses were carried out on GEE platform to overcome the computational limitations. Classified image and the night-time light data from VIIRS are shown in Figure 2.

Overall, 39 experiments on classification were carried out with various combinations of feature vectors to obtain the most accurate land use map with 4 classes. Composite of Landsat bands and advantages of other spectral indices with thresholds rendered the highest classification accuracy of 93.49%. The final mapping results of human settlement without electricity was obtained by comparing binary classified maps with resampled VIIRS night-time light imagery. Figure 3 correspond to areas like Kansawadi, Shimpadipura and Avverahalli in Bangaore City and Poojaridoddi and Jeemangalam in Tamil are the areas deprived of electricity. The results

revealed that the total area of human settlements without electricity in and around Bangalore City is approximately 36.57 sq. km. accounting for 6.2% of the total study area [13].

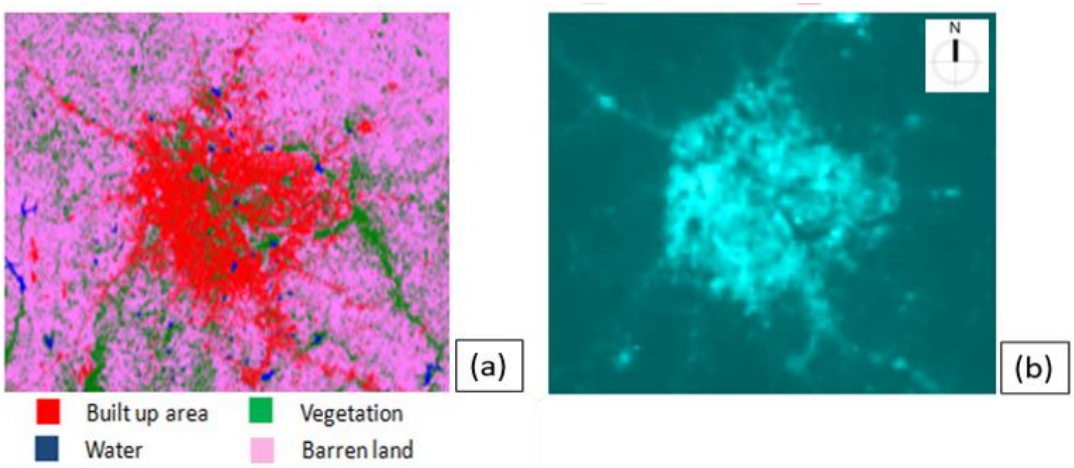

Figure 2: (a) Classified image of Bangalore City, and (b) VIIRS night-time light data.

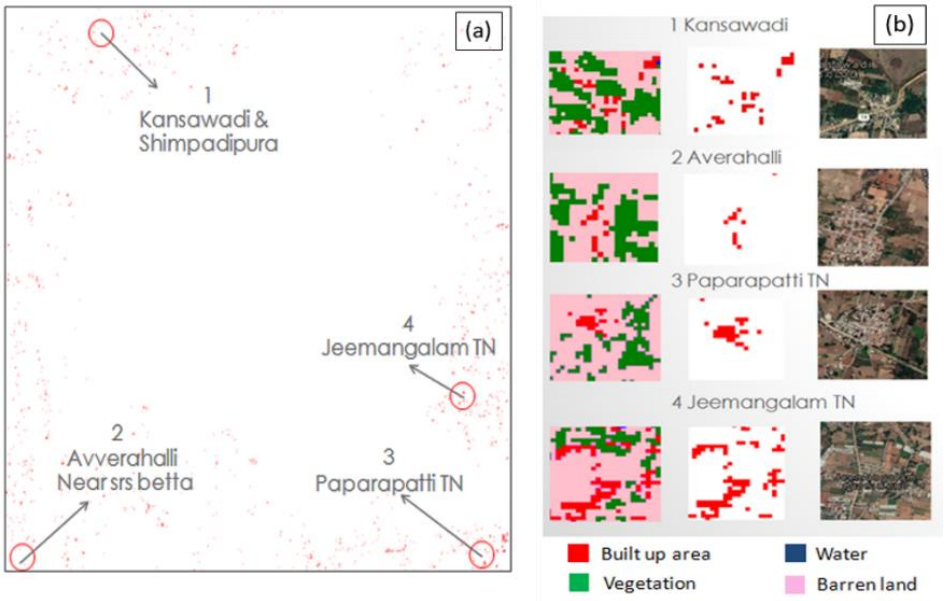

Figure 3: (a) Four identified human settlements (1, 2, 3, and 4 marked in the image) without electricity, (b) Zoomed view of the settlements and their corresponding Google Earth images. (TN is Tamil Nadu).

GEE has played a vital role in conducting geo-big data analysis for a variety of remote sensing applications across the world over the last 10 years. In this work, part 1 demonstrated the use of remote sensing dataset and functions available in Earth Engine to classify builtup area and non-builtup areas in Bangalore city at ward level. In particular, we used optical imagery time series as inputs, extracted features from the time series dataset, generated labels, and predicted builtup area with a Random Forest classifier. Second part of our research involved quantifying the area of human settlements in and around Bangalore City that do not have access to

electricity. Remote sensing data and GEE platform is apt to understand and resolve many more aspects of urbanization challenges.

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Present, past and future distribution of ebony tree species in india: integrating ensemble species distribution modeling and fossil pollen data

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ABSTRACT

The current study uses an ensemble modelling to map the suitable habitat zones of *D. melanoxylon* for the past i.e., Last Glacial Maximum (~22,000 yrs BP) and Middle Holocene (~6000 yrs BP), current and future climate change scenarios (2050s and 2070s) for RCP 2.6 and 8.5 across the Indian subcontinent. The best suitable habitat for *D. melanoxylon* has been observed in Western, Southern and Central region of Indian subcontinent. The future projection for the year 2050 and 2070 under RCP 2.6 and 8.5 shows significant decrease in habitat suitability in the Western, Southern and Central India region. We used current occurrence and fossil pollen data of *D. melanoxylon* to validate the model projections. The distribution models complement the fossil pollen records of *D. melanoxylon* for the Last Glacial Maximum (LGM) and Middle Holocene (MH) and hindcast the prevalence of the species in Western Ghats, Nilgiris and Telangana Plateau (for LGM) and the entire Karnataka state and Nilgiri hills (for MH). By 2050 and 2070, a decline in extremely suitable habitat from the current range by 1.70% and 1.74% respectively has been estimated under RCP 8.5 i.e., the highest greenhouse gas emission scenario. The main cause of decreased habitat suitability is the predicted seasonal temperature and precipitation variations. Mean annual temperature (33.9%) significantly affected the distribution shift of *D. melanoxylon* along with isothermality (24.3%) and mean temperature of wettest quarter (19.1%). Our results provide useful information for establishment of conservation strategies to conserve and save the *D. melanoxylon* from the effects of future climate change.

Keywords: *Diospyros melanoxylon*, ensemble SDM, Indian subcontinent, suitable habitat, fossil pollen, Last Glacial Maximum, Middle Holocene

Groundwater composition near a lake abutting MSW landfill site

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Abstract

The only planet on which life is supported is Earth, thanks to water. Groundwater use has rapidly increased, which has resulted in several new issues, admittedly, overuse leading to quality degradation, seasonal variations in the water table that influence shallow wells, and, contamination. The present paper presents findings on the groundwater composition near a lake located in a contamination-prone zone abutting a municipal solid waste plant which was once an open landfill site. Thirty-three groundwater samples were collected near Anchepalya lake and the Doddabidarakallu MSW plant. Samples were tested for physiochemical parameters and heavy metals as per Standard Methods of testing water and wastewater. Data were analyzed concerning BIS and WHO standards and

their hydro-chemical facies were determined by using a Piper diagram. All the samples were exceeding the acceptable limits of drinking water specifications. Nearly 9% of samples had higher electrical conductivity (>2500µs/cm), not suitable for irrigation purposes also. It is opined that there is a need to prevent future contamination to save, safeguard and, manage water for long-term usage. We cannot be selfish and deplete the environment without caring for it.

Dietery composition and feeding habits of fish, *Gerres filamentous* (Cuvier) from Mangalore Coast,Karantaka, India.

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Abstract:

Diet composition of the fish indicates many important ecological factors that include behaviour, condition, habitat, energy intake, interactions between the species etc. The silver biddies, *G. filamentous* is important in commercial value. It finds a place in the market in diversified forms. Presently, it has a great demand in local areas. Exploratory survey conducted by Department of Fisheries, India has indicated that 0.07 lakh tonnes of gerreids were captured in Karnataka coast during 2019-2020. Thus, in the light of its importance, the present study was aimed at investigating dietary and feeding habits of *G. filamentosus* from Nethravthi-Gurupur estuaries of Mangalore coast. Both qualitative and quantitative analyses were carried out to study the feeding habits of *G.filamentosus* during July, 2009-June, 2011 for two years period.

Gut content analysis showed that in both sexes have different compositions of diet been found. They were amphipods, copepods, isopods, crustaceans & its appendages, prawn and its remains, crab and its remains, gastropods, bivalve larvae and shells, polychaetes, semi-digested matter, fish & its remains, setae, plant matter, diatoms, sand grains, sponge spicules, foraminifera and other items. Further analysis revealed that, in all the size groups starting from 8-9 cm to 28-29 cm during July, 2009-June, 2010, food items were found in different proportions during first year and in all the size groups starting from 7-8 cm to 29-30 cm for the food items during second year period food items were found to be same as the previous year.

The percentage occurrence of food items in the stomach contents in both the sexes of *G. filamentosus* were found to vary with months considerably. During July, 2009-June, 2011, the highest percentage of food items was polychaetes in both the sexes, whereas the lowest percentage was sponge spicules in both the sexes.*G. filamentosus* is a omnivorous species feeding on free swimming organisms near to the bottom and directly to the bottom. The presence of sand grains, detritus, benthic organisms in the stomach of *G. filamentosus* indicate that they browse at water bottom for food.

Key words: *Gerres fialmentosus*, Gut content analysis, Diet composition, Magalore Coast.

Evaluation of phytochemicals and validation of antioxidant potential of wild *solanum* species from Mysore district, Karnataka, India

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ABSTRACT

Solanum species are nutritional enriched group of plants recognized for high medicinal value in Angiosperm family. This diverse taxon comprises more than 2,300 species and great deal of studies support the economic importance of these species. However, limited studies have been done on the wild species. Intention of the study was to explore wild species of *Solanaceae* family for their antioxidant properties. Ten species growing in and around Mysuru district, Karnataka, India were screened and phytochemicals from selected species viz *Solanum seaforthianum, S. sisymbriifolium, S. diphyllum* and *S. anguivi* were obtained by soxhlet extraction using methanol, chloroform and water. Total reducing potential and four radical scavenging assays (DPPH, ABTS, H2O2 and NO) were performed and compared with total phenols and flavonoid content. Comparatively, aqueous extract of *S. anguivi* was having high phenol (1.55 mg GAE/g) and flavonoid content (96.91 mg QE/g), consequently it displayed maximum reducing potential activity (64.09 mg AAE/g). With respect to radical scavenging efficiency, although concentration-dependent rise in the activity was detected in all species but significant variation ($p<0.05$) was noticed depending on the plant species and extraction solvent used. DPPH and H_2O_2 scavenging was higher in *S. sisymbriifolium*in methanol (97.98%) and chloroform extract (88.85%). *S. diphyllum*displayed more ABTS scavenging efficiency (86.21%) with EC_{50} value of 6.2 mg/ml and *S. anguivi* scavenged NO more efficiently with EC_{50} value of 7 mg/ml. The present finding supports the ethno-pharmaceutical properties of selected plants and highlight their possible application in neutralizing free radicals and consequently managing oxidative stress related chronic diseases.

Key words: *Solanum* sp., Antioxidant, DPPH, ABTS, Scavenging, Phenols

Study on seasonal diversity of zooplankton of Chikkere water body in relation to water quality

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ABSTRACT:

The present study deals with the Zooplankton diversity on Chikkere water body of Sira town. Surface water samples were collected from four selected stations at monthly intervals from January 2021 to December 2021 in Chikkere water body. Analysis of physico – chemical parameters were done and the results revealed that most of the physico – chemical parameters were recorded within the permissible limits. Zooplankton belonging to four different groups

were identified of which Rotifers formed the bulk with **47.82**% fallowed by Cladocera **26.1% and Copepods 17.39%** A total of **23 species** of fishes under five genera belonging to five families.

Key words: Physico-chemical**,** Water quality, Zooplankton, Diversity, Chikkere water body.

Sustainable Agriculture by Value Addition to Bio Wastes

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ABSTRACT

Sustainable future depends on the management of natural resources without wasting immediately. Every product has its own life cycle. The ultimate fate of the residues depends on how efficiently it can be utilized again without discarding. The management of wastes again putting back into the loop is the basis of bio economy. The materials are recirculating in nature. The hazardous particles when enters any natural component disturbs the whole ecosystem. Over utilization of chemicals in agriculture depleting the soil quality for last decades. The only solution is the organic cultivation. The world is moving towards organic farming for health, society, economic, environmental benefits. The government across the world directing policies to adopt organic methods for production. Various technologies are developed for organic fertilizers production. One of such biotechnology is vermicomposting with the help of ecological engineer earthworms. Vermicomposting is one of the green technologies with zero waste and emission. On the other hand, economically feasible and socially acceptable. Vermicompost is produced by various bio wastes. The bio wastes have huge bioconversion potential to produce green manure. The nutrients are recycled without disturbing the balance by the application of organic fertilizers to soil and plant growth. In the current study the value of organic farming in every context is analyzed and case studies related to benefits of organic farming is elaborated. The technological aspects of vermicomposting are explained. Highlights on the resource management for bio economy and use of agricultural wastes for vermicompost production is documented.

Key words: Sustainability; Organic farming; Vermicomposting; Bio economy; Bio wastes.

Threats on aquatic ecosystem- mitigation and conservation strategies.

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ABSTRACT:

The immense value of ecosystem service provided by freshwater bodies is incomputable. However, the productivity and biodiversity of freshwater bodies are undergoing degradation as a result of climate- and anthropogenic-induced changes worldwide. There is substantial evidence showing how many freshwater fishes, amphibians, mammals, and reptiles are at risk of extinction. Based on available data the threats can be categorized as existing and emerging. With this categorization, the problems associated with conservation and their solutions vary from one type to another. The mitigation strategies like sewage treatment, use of algicides, use of GIS technology, etc need to be used. The major stakeholders in the conservation are local people, local government bodies, NGOs, and the government. By considering all this there is a need for tailor-made strategies with a combination of traditional and scientific reasoning to conserve the freshwater ecosystem.

A study on foraging behavior of black kites (*Milvusmigrans govinda*) ATA meat market of Mysuru, Karnataka

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ABSTRACT

The Black Kite (*Milvus migrans*) is one of the most successful and abundant birds of prey in the world. They mostly inhabit the cities because of their high adaptability and plenty of food resources. Large number of Black Kites forage on offal with House Crows (*Corvus splendens*) in the meat markets and garbage dumps of many Indian cities. The objective of the current study was to observe the foraging behavior of Black Kites at the meat market which is in the heart of the Mysuru city in Karnataka. The study was carried out from April to August 2022 on biweekly basis from 8:00h to 10:00h by following the standard methods. This meat market has become a foraging spot for Black Kites in particular and other Urban faunal groups like Crows, Sparrows and Feral dogs

are also seen foraging with the Black Kites. Different episodes related to the foraging behavior of Black Kites were documented with the aid of camera (Samsung Galaxy A71; 64.0 MP) for further analysis. Cordial sharing of resources and habitat was also documented. The interesting results during the study were abundance of different birds along with Black Kites, the different fauna present in the meat market, perching objects of Black Kites and the preferred offal parts of chicken and fish meat by Black Kite at Devaraja meat market of Mysuru. Thus, this pioneer study to assess the offal consumption by Black Kites showcases a positive human-wildlife interaction which aids in the promotion and development of conservation strategies related to Black Kites at several natural urban landscapes such as Mysuru by providing the foraging grounds like Devaraja Market.

Key words: *Milvus migrans govinda*, Accipitridae, Foraging behavior, Devaraja market, Mysuru.

Evaluation of phytochemicals and validation of antioxidant potential of wild *Solanum* Species from Mysore District, Karnataka, India

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ABSTRACT

Solanum species are nutritional enriched group of plants recognized for high medicinal value in Angiosperm family. This diverse taxon comprises more than 2,300 species and great deal of studies support the economic importance of these species. However, limited studies have been done on the wild species. Intention of the study was to explore wild species of *Solanaceae* family for their antioxidant properties. Ten species growing in and around Mysuru district, Karnataka, India were screened and phytochemicals from selected species viz *Solanum seaforthianum, S. sisymbriifolium, S. diphyllum* and *S. anguivi* were obtained by soxhlet extraction using methanol, chloroform and water. Total reducing potential and four radical scavenging assays (DPPH, ABTS, H2O2 and NO) were performed and compared with total phenols and flavonoid content. Comparatively, aqueous extract of *S. anguivi* was having high phenol (1.55 mg GAE/g) and flavonoid content (96.91 mg QE/g), consequently it displayed maximum reducing potential activity (64.09 mg AAE/g). With respect to radical scavenging efficiency, although concentration-dependent rise in the activity was detected in all species but significant variation ($p<0.05$) was noticed depending on the plant species and extraction solvent used. DPPH and H_2O_2 scavenging was higher in *S. sisymbriifolium*in methanol (97.98%) and chloroform extract (88.85%). *S. diphyllum*displayed more ABTS scavenging efficiency (86.21%) with EC_{50} value of 6.2 mg/ml and *S. anguivi* scavenged NO more efficiently with EC_{50} value of 7 mg/ml. The present finding supports the ethno-pharmaceutical properties of selected plants and highlight their possible application in neutralizing free radicals and consequently managing oxidative stress related chronic diseases.

Key words: *Solanum* sp., Antioxidant, DPPH, ABTS, Scavenging, Phenols

A study on the avifaunal diversity at Karanji Lake, Mysuru, Karnataka

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ABSTRACT

Birds are important ecological indicators. Field study was conducted to record Avifaunal diversity at Karanji Lake, Mysuru, Karnataka. Birds were recorded during April 2021 to March 2022 on bimonthly basis. The Line Transect Method (LTM) and Point Count Method (PCM) were employed as per the standard methods. Identification using standard field guides and Photographs captured using digital Camera (Nikon D70; 21.0 Megapixels). The recorded data was compiled using appropriate statistical tools. Total 94 different bird species were recorded belonging to 16 orders and 47 families. Highest number of birds was represented by Order Passeriformes with 23 families and Family Ardeidae was dominating with 8 species. Based on IUCN Status the documented birds were classified into Least Concerned and Near Threatened categories contributing 95.7% and 4.3% respectievely. Further, these birds were grouped into omnivorous (33%), insectivorous (27.6%), carnivorous (23.4%), Piscivorous (7.4%), Frugivorous (3.2%), Nectarivores (2.1%), Grainivorous (2.1%) and Herbivorous (1.1%) on feeding habits criteria. The different diversity indices values revealed the occurrence of good number of bird species supported with existing vegetation from the study area. Thus, the present study on Avifaunal diversity would help understand for conservation of birds at the Karanji Lake, Mysuru in future, which is important from biodiversity perspective.

Key Words: Avifaunal Diversity, Passeriformes, Ardeidae, IUCN Status, Karanji Lake, Mysuru.

Assessment of diversity of stingless bees in Southern Karnataka through morphometric analysis

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Abstract

The present investigation was carried out to assess the diversity of stingless bees in Southern Karnataka through morphometric analysis. Stingless bee samples were collected from 40 different locations of Southern Karnataka. A total of 18 different morphometric parameters including Total body length, No. of hamuli, Pro thoracic leg length, Mesothoracic leg length, Metathoracic leg length etc of the collected bee samples were

measured with 10 replications from each of the locations. The collected bee samples were preserved in 70% ethanol. The morphometric measurements were done using a binocular microscope. These morphometric values were also assessed through principal component analysis. Using all the 18 morphological characters a Scree plot was constructed. PCA concentrated variability in 8 components. Pearson correlation significance showed that the correlations were significant at the levels 0.01 and 0.05. Total variance explained 60% of variance in this study. Morphometric analysis revealed that the bees collected from different regions of Southern Karnataka did not vary much except for the body colour and size. However, there is no difference observed in number of hamuli (5) irrespective of the district from which bees were collected. Earlier biometric investigations especially in India were based on few morphological characters and lacked proper statistical analysis of data. Even in Karnataka we find contrasting differences in morphology, nesting habitats and behaviour between species nonetheless there are very less studies about the morphometry of stingless bees, therefore the present investigation was planned with the following objectives.

Key words: Stingless bees, Morphometry, Principal Component Analysis, Scree Plot, Pearson Correlation Significance.

Organic farming and their products: practice and perception

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ABSTRACT

Increase in population directly influences the need for more quantity of food. Use of chemicals for agriculture has led to many problems related to both environment and health. Organic farming is such a farming method where strictly no chemicals are used and agriculture is done in a friendly way towards environment. This study helps to know about the organic farming practices among people belonging to farming background and also the knowledge about organic farming and its products among people belonging to non-farming background. The study collected primary data about awareness of organic products and results indicate that people are not completely aware about organic farming and benefits of their products. There is a need to spread awareness among people about this farming method. Also, concern of non-availability of organic products should be addressed. The availability of organic products in local markets, and grocery shops has to be increased so that people can benefit out of it.

Prioritising ecologically sensitive burrowing meso fauna in correlation with mangrove regeneration for effective conservation in the biodiversity of Sundarban

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ABSTRACT:

The relative roles of river, atmospheric and tidal forcing on estuarine sea level variability are a matter of concern in today's research world and thus, are being examined thoroughly especially in deltaic estuarine wetlands. The deltaic landscape contains vegetated marshes, tidal flats, circuitous channels and other features that frictionally dissipate waves propagating through the system. Direct forcing by local wind stress over the surface of the estuary is minimal, owing to the lack of significant fetch due to landscape features of the estuary. In West Bengal, Bakkhali sea beach and Henry's Island alongside, exhibits one of such deltaic estuarine ecosystems along with remarkable regeneration patches of mangroves, the unique feature of haline soil of Sundarbans. The existing diversity of burrowing meso faunal community is observed to play a significant role in their distribution, that is at a regular interval with the regenerating mangrove patches. So, through this study we have tried to light on the characteristics of burrowing meso fauna, their striking distribution in correlation to the regeneration of very important mangrove community at Bakkhali (a deltaic estuary) and Henry's Island. The findings make a compelling economic case for protecting and restoring mangroves as a risk reduction strategy. Studies like these are important to demonstrate the value of natural climate solutions to encourage investment in nature along our shorelines.

Qualitative analysis of aerosols and air quality during the pre-monsoon season for the cities of Delhi, Mumbai, Bengaluru and Chennai over the past five years (2018-22) using merra-2 and ground based data.

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Abstract

Air pollution has emerged as one of the major problems in the major cities of India, especially in the recent decades. The rapid urbanization has played a huge role in this. All four cities of Delhi, Mumbai, Bengaluru and Chennai have a higher aerosol and AQI level than desirable. Air pollution in all four cities needs to be curbed in order to minimize health issues. The nationwide lockdown of 2020 had a significant impact on the air quality of all four cities. Post 2020, air aerosol amounts have increased in all four cities and 2022 had the highest amount. Delhi is the most polluted of all four cities.

Keywords: Air pollution, Aerosol Optical Depth, Air Quality Index

Faunal diversity of Ishwaramangala

Poornaprajna

Abstract:

The faunal diversity study includes classes- Pisces, Amphibians, Reptiles, Aves and Mammals under vertebrates and Arthropoda, Mollusca and Annelida etc. Western ghats is one of the world's ten "hottest biodiversity hotspots." On the outskirts of Western ghats, in an area of 4 acres of organic cultivation, in Ishwaramangala, of Puttur taluk, Dakshina Kannada district in Karnataka, a few among above mentioned classes which were spotted are considered. An observation of Birds, frogs, snakes, spiders, insects in general and Butterflies in particular along with their larval hostplants, lifecycle, and behaviours like courtship, egg laying, mudpuddling are documented. Initially started photographing out of curiosity to know more about the beautiful creatures in my native place and later started documenting scientifically which ended up with the collection of more than 80 species of butterflies, more than 30 species of birds, more than 20 species of spiders, 8 species of frogs, 7 species of snakes and some insects and still counting. Different species were identified based on photographs with the help of experts and some field guides.This observation was made during leisure time apart from academics during lockdown period.

Effect of construction work on water percolation ability of soil in different areas of Bengaluru

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Abstract

The foundational substrate on which life first appears is soil. It sustains lifeforms. The deterioration in physical, chemical, and biological properties of soil is known as soil degradation. Half of the world's soil is already damaged as a result of ongoing deforestation, urbanization, industrial pollution, overgrazing, and unsustainable agriculture methods. This loss puts at risk the quality and availability of food, water security, biodiversity, increases the danger of a change in the climate, and can result in loss of livelihood. Construction of buildings and other structures can also result in soil pollution. Cement, which is one of the major material used for construction, are often carried by wind and travel to other parts of the city or state, increasing pollution of nearby and other areas also. Cement dust can directly alter the pH level (alkalization) and also alters the chemical composition of soils and their physical properties. In this paper, we check the water retention capacity of soil in the areas where construction work is going on either in form of building or road (concrete road construction) in and around Malleshwaram, Bengaluru. We calculate the percolation rate of water in soil in trees on the sidewalk and trees near parks or lakes.

Key words: Soil pollution, Construction work, Cement, Water Percolation

Cell phone towers effect on birds in our environment

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Mobile phones have become an inseparable part of our lives and so are the phone towers, but these towers are equally dangerous and life threatening to many organisms specifically of the birds. Recent studies have established the effects of electromagnetic radiation (EMR) from the cell phones on birds.The EMR damages adult bird skull, birds eggs, and the developing embryos. The radiofrequency waves from the towers disturbs the earth's magnetic field, which the birds utilize for their navigation. A short-time exposure to EMR disturbs and confuses the bird thereby affecting their navigation capability during migrations. This article explores the effects of EMR on bird diversity in some of the major phone towers installed in and around Bengaluru. During the survey period, fewer species of birds were observed at the selected sites. The number of birds recorded within 300m radius of mobile tower was comparatively less than that found outside 300m radius which reveals that birds are affected more within this range. Moreover the birds commonly found within 300m radius were Myna, Rock Pigeon, Eagle, Crow. Based on the current available data it can be stated that the EMR emitted from cell phone towers affect the bird biodiversity. Further research is very essential to explore more connection between EMR and their hazardous effects on birds to save and protect the avian species.

Key words: Mobile Phone tower, EMR, Bird biodiversity, Bengaluru

Tree poisoning in and around Bengaluru: A survey

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Abstract

Tree poisoning is the *practice of poisoning trees* by injecting poisonous toxic chemical substances *and leaving them standing to rot on the landscape.* It can be done intentionally or accidentally. A poisoned tree's individual parts would have adverse consequences such as roots, fruits, berries, stem, leaves etc. Poisoning trees by drilling holes, injecting poison with syringes, acids etc. The toxic chemicals affect all the parts of trees and kills each one of them slowly. It may also effect other soil organisms and the soil quality as well which gets contaminated by toxic substances. Internally there will be destruction in the annual ring system by affecting the xylem and pholem leading to change in color of the bark revealing that the tree is poisoned. Relevant photographs and videos were taken in areas like Malleshwaram, Nagarbhavi and other localities of Bengaluru. Documents and also certain articles regarding the same are taken for consideration. Hence it was concluded that tree poisoning is occurring very frequently and has become a man made disaster to nature which needs to looked in very quickly as possible and to come up with strict protocols for people who are practicing it.

Nature based solutions to address changes in the climate - in rural and urban Karnataka

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ABSTRACT: This paper analyzes reasons and solutions for the inadequate implementation and development of Nature Based Solutions and how nature based solutions can effectively aid in urban and rural areas of Karnataka to sustain the biodiversity and mitigate climate change. Research articles and case studies were reviewed, and it was observed that, it is essential to produce firm evidences regarding Nature Based Solutions for further actions. Agroforestry, Blue, Green and Grey infrastructure are efficient and cost-effective nature based solutions to tackle crop loss, drought, heavy rainfall and urban heat stress due to climate change. In conclusion, we need to spread awareness about the urgency of the situation, educate the respective persons about these various methods, strategically plan actions for both long-term and short-term, policies to be strict and have a backup plan on hand when an abrupt obstacle arises, to work on economic values bring in as many as stakeholders to monitor and communicate with the communities needed and to have trust and proper communication between the beneficiaries (public), benefactors(public and Government) and stakeholders or NGOs.

When plants Glow

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ABSTRACT:-

It is so interesting for all of us to know that tobacco plants also emit light when a gene of fireflies is replaced in it. Fireflies are nocturnal, harmless, non-poisonous soft-bodied beetles, which are light-emitting. The luciferin gene is responsible for bioluminescence. It synthesizes an enzyme luciferase that is a catalyst in fireflies which produces light. Autoluminiscent plants were created either by transplanting the DNA segment responsible for bioluminescence in plants (e.g. tobacco) which started to behave in a different way to light up itself; or were created by injecting the chemical that is produced and used by fireflies in emanating their characteristic light into the leaves of a watercress plant and this led it to give off a dim light for about four hours. The vital vision is just to make sure that the plant gets enough light even in the dark like a glowing lamp, also this can help in photosynthesis of new and young baby plants. The light also to know that it is produced by energy metabolism. These fireflies also light up not just the plants but the whole forest. These bioluminiscent plants could soon be a natural alternative to electric street lighting.

How do people cut the edge of the milk packet?: A Survey

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Milk is one of the important proteins included in the diet. It is one of the major supplements consumed by all over the country. According to the survey conducted, it is estimated that over 203 million metric tons of milk is consumed in India on a daily basis. Milk is packed in a plastic material named as polyethylene tertraphthalate (PET). It is generally observed that milk packet ends are cut during emptying packets. But this may be considered fatal as the small piece may go as plastic waste and may not be recycled. An effort to do a survey on how many people have made this practice was done in the college. Over 250 milk packets were collected by the students and physical examination was done to check the packets. The results were tabulated. Later awareness was done about the same.

A survey on the nailing and pinning of tress in Malleshwaram 18th cross

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Abstract

Trees are one of the key factors that play a vital role in the environment. Its role being numerous is one of the major parts of the biodiversity. Anthropogenic activities are the main reason for the decline of trees at present. According to the survey total number of trees in Bengaluru is 14,78,412. BBMP receives thousands of applications to uproot the trees from various sectors for various reasons. Nailing & pinning the trees are one of the most devastating issues in the present days. It makes the trees open for infection. It eventually weakens the tissue of the trees. An effort was made to check the number of trees nailed & pinned was done in and around Malleshwaram 18th cross. Around 250 trees were checked by physical examination for the number of nails and pins stuck in each tree and data was formulated.

Key Words: Nailing, Pinning, Trees, Physical examination.

Effect of three plant extracts on the Sitophilus oryzae, the stored pest of rice.

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Rice is one of the staple foods of many people in our country. Rice is one among those crops that cannot be stored for long time due to the infestation of pest. Along with post harvesting loss there is loss during storage. Many methods of prevention of pests have come up recently. In this experiment plant based extracts have been used to control the infestation. Three plants extract, both direct and dried method was used with 10 adults in each replica. Mortality of insects were checked every 24 hrs for 7 days. The results were tabulated to check the plant extract that was highly effective.

Key Words: Plant extracts, Pest, Storage, Mortality

Constructed wetlands, bioremediation, phytoremediation

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ABSTRACT

The dramatic increase of population all over the world is creating two major problems with water supply. The first one is an increase in water demand while the second one is a sharp increase in the amount of waste water. To overcome these challenges constructed wetlands, bioremediation and phytoremediation are some of the sustainable methodologies. By the use of these methods contaminants such as wastewater, fossil fuels, semi-solid effluents and the increase and decrease of metal availability in the soil can be treated effectively. Low concentrations of recalcitrant pollutants in farming or industrial runoff to highly poisonous and hazardous radioactive contaminants can be converted into usable water by eco-friendly means.

Microorganisms are utilized to enhance the treatment of waste water due to their metabolic biochemical pathways such as nitrification, denitrification etc. Plants through photosynthesis extract chemicals from the soil and deposit above the ground part of their bodies, or convert them into less toxic forms. They absorb ionic compounds at low concentrations through their roots. This synergistic action between plant root systems and microorganisms remove or convert toxic substances in soil or water cost efficiently. Thus improving the economy of developing countries.

Keywords: Population, Constructed wetlands, Bioremediation Phytoremediation Contaminants, Pollutants, Wastewater, Micro-organisms, Nitrification, Denitrification, Plants

Survey report on avian fauna in four regions of Bengaluru

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Abstract

Birds are the most important part of the food chain which plays a vital role in balancing our ecosystems. Bengaluru has a wide variety of bird species of which some of them are indigenous (native) and some of them are migratory species. The early morning bird watch, survey of the species richness in the particular area (Yelahanka- GKVK campus, Allalasandra lake, Vidyaranyapura, Mahalakshmi layout) helped us to understand the various aspects about the species variety as well as their behavioural changes due to the ever-changing environmental conditions. The careful watch has been carried out to understand and analyse the aspects related to bird diversity in the concerned area. Terrestrial avian communities are considered or known to be the best indicator of an active and functional ecosystem in the urban areas which in turn can be easily protected than the other biotic aspects of the environment. This study selected various places of Bengaluru as the survey area. The results have been deduced based on the survey conducted in some particular areas of Bengaluru.

Keywords: Bird Biodiversity, Bengaluru Urban, GKVK campus, Allalasandra lake, Vidyaranyapura, Mahalakshmi layout

Monitoring of ecosytems – big data (remote sensing), artificial intelligence, machine learning and deep learning techniques

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ABSTRACT

With the technology of sensor, RFID and GPS, many researches are recently being carried out on monitoring animal behavior and interactions with the environment. The proposal system can provide real – time animal situation information such as current location, body temperature and pictures. The tracking of animals based on its movements like migration or search for food etc. Next, we design the implement a prototype of the proposed animal situation tracking system. The research consists of 4 phases of methodology, approach to research questions, generations of model via machine learning, development of mobile application where generated model was integrated. This system is now used to track the movement of system is now used to track the movement of stray dogs by the above methodology

Biodiversity of snakes in South-Western Ghats

(Note on: Study of snakes in Karnataka)

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ABSTRACT

Western ghats are comfortable beds for a number of reptile species,the fascinating facts and their feature of being endemic to a specific forest gave us the zeal to study about the snake fauna of South Indian forest

Anaimalai-Palani Hill; complex with a rich tapestry of habitats and landscape features, the Palani Hills has many species endemic to the place and many elegant ones.

Agumbe rainforest;the hidden gem of Western Ghats has rich diversity of elegant reptiles for the,Trimeresurus and lots more of the same species.

Nallamala Hills; provides a visual treat for herpetologists, and the forest has welcomed many new species in recent years.A snake named after the forest itself !.

Munnar: with unique species being endemic to Munnar the region is considered an abode for herpetologists, there are red list status species also.

Mhadei forest provides attractive glance of venomous and non-venomous snakes including 'big four' Indian venomous snakes!

Reason for them being endemic to that particular forest is a fascinating fact to the question why, which would be discussed in the paper along with all the species endemic to the forests.

Keywords: endemic, snakes, forest, diversity.

Ants and their Nests: Survey report on ants nest biodiversity

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Maharani lakshmi Ammanni College for Women Autonomous, Malleshwaram 18th cross Bangalore
[2] – Corresponding Author**:** chayadevika96@gmail.com bhavya@mlacw.edu.in

ABSTRACT

In social insects, nests are very important structures built to provide a protected microhabitat for development, food storage and the places where most interactions between all members of a colony occur. Ants are highly diverse group of insects .The study of ants nest is fascinating. Considering that nature of habitat is an important aspect of ants nest, subterranean and arboreal nest were studied. The study showed the nature of nest and habitat of ant species – *Oecophylla smaragdina, Camponotus spp.,*

Dinoponera gigantea, Crematogaster brunnea and Pogonomyrmex badius.The size and shape of the nest varies they are elliptical ranges to half meter in length, horizontal upto 800 cm^3 ,round/ oval,narrower,and helical respectively. The three ant species *Oecophylla smaragdina, Camponotus spp.* and *Crematogaster brunnea* are arboreal and make their nest on trees only either by weaving together leaves of the host plant using the silk produced by their larvae or by other means. Ant species *Dinoponera gigantea* and *Pogonomyrmex badius* are subterranean which make their nest under the ground.

Keywords: subterranean, arboreal, microhabitat.

Avian Diversity in Ashwathnagar

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Ashwathnagar area is located in the northern part of Bangalore. In this paper two areas of Ashwathnagar are taken into consideration, one is the Dollar's Colony of Ashwathnagar and the other one is near KEB layout of Ashwatnagar (in the outskirts) to study bird diversity in these localities. Both the places are situated hardly one kilometre apart from each other but there is a good difference in the vegetation of the two areas and thereby the availability and diversity of birds in the two areas. More varieties of birds are observed in one of the areas. This paper strikes to provide the information on how this difference in bird diversity is related to the vegetation of the area and what are some of the bird species spotted in these area by bird watching. Efforts are also made to observe the eating habits of these birds in order to identify the type of trees or vegetation to which these birds are attracted the most.

Keywords: Avian diversity , Bangalore, Ashwathnagar, Vegetation and Feeding habit.

Composter prototype for biowaste processing by Black Solder fly (*Hermetia illucens*)

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Abstract

Urban solid waste management has become a matter of importance due to rapid urbanization and population. Many ways of combating this issue has been addressed by waste experts worldwide by developing sustainable methods of managing the municipal waste. In this context recycling of organic waste material (biowaste) has not yet gained momentum even though it constitutes major parts of all municipal waste generated. Conversion of organic waste can

reduce threats to public health and environment. One of the approaches of biowaste conversion is by using insect larvae. One of them is Black Soldier Fly (BSF), Hermetia illucens. Harvested BSF larvae can also be used as a source of protein for animal feed (poultry). A unique method of treating organic waste is employing insects which is gaining popularity as it has various advantages over conventional methods. Installation costs are low and conversion of biowaste is high. The insects used in bioconversion can also be used as source of protein. However, certain conditions have to provided and taken are of such as feed components, proper temperature, humidity and suitable environment for the insects to survive and live. Among the insects, black soldier fly (Hermetia illucens) larvae (BSFL) is gaining significant attention, as it very efficiently converts organic waste into useful bio products A composter prototype is designed by investigators to convert the biowaste by BSFL. These larvae will be used to decompose more organic waste or processed as animal feed, used in poultry.

Butterflies and Plants

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Abstract

Jaya Prakash Narayan (JP) Park, is a Botanical Garden cum park located in North West Bengaluru. Surrounded by greenery, this park is known to promote the importance of verdure in our lives. Along with trees and plants come flowers and along with flowers come pollinators. One of the chief pollinators in JP park are various species of butterflies. They are seen in the park at various times of the day and sometimes also near their favorite flowering plants. This paper contributes to how the diversity butterflies is vital in nature and the common species found in the park. Attempts have been made to understand the behavioral patterns and flight timings of these butterflies and the predators that endanger them.

Solid Waste management by designing plastic bed

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Plastic has contaminated possible sources and its rampant usage and improper way of disposal has turned to be a global threat. Out of a huge bulk of plastic waste, only a fraction of it is recycled. Recent research findings reported traces of microplastic in human blood thus raising questions about safety usage of platic and ill effects on health of organisms. Inspite of this kind of awareness, the use of plastic has become inevitable and its impact on the environment has posed major challenge for existence of living beings on earth. In this context making of plastic

bed can be one of the effective ways for safe use of plastic. This has both advantages and disadvantages too, but can find a solution to reduce pollution created by plastic. This effort will decrease the harsh effect of plastic on ecosystems and help us to take a step towards conservation of environment.

Sustainable agriculture and organic farming

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Indian agriculture economy is increased from traditional agriculture in 1950's to highly capital intensive sector in 2020's. Agriculture has diversely expanded to crops like horticulture, floriculture, medicinal and all allied activities. Thus the scale of production has increased as the demand grown. Now the point of convergence is to prevent crop wastage and improve the use of resources. The wastage issue arises due to lack of transportation facilities, fall in the price, hazardous situation like covid19, Case – thousands of liters of milk wasted in Belagavi as it could not be distributed. Cold storage is one such method to prevent crop wastage.

Cold storage is effective space for bulk handling perishable goods, especially fruits and vegetables and dairy products between production and marketing, used to preserve such commodities in fresh state by controlling various gases, maintaining adequate temperature and humidity within the storage system.

Cold storage has the potential to transform agriculture, making it sustainable and profitable for even small holder farmers. This method of storing fruits and vegetables is not far reaching the farmers. Infact, state and central schemes to boost the network of cold storage facilities can play a major role in improving farmer's income and prevent crop wastage.

Keywords; Indian agriculture, food production, cold storage, crop wastage, farmers income

Agriculture sustainability and organic farming

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Continued interest in defining and developing sustainable agriculture and food systems reflects that the present global food system is far from ideal. While intensive production forms give high yields, they often come with significant externalities in terms of pollution, overuse of resources and destruction of critical natural capital. And, still large populations lack food security. However, there are large differences in terms of farming systems and geographical areas as regards which problems are most severe, and many important initiatives in intensively farmed areas as well as in extensive agriculture seek to improve farming systems. One such approach is organic agriculture, which is defined by the International umbrella organisation . Organic agriculture is a production system that sustains the health of soils, ecosystems and people. It relies on ecological processes, biodiversity and cycles adapted to local conditions, rather than the use of inputs with adverse effects. Organic agriculture combines tradition, innovation and science to benefit the shared environment and promote fair relationships and a good quality of life for all involved. The paper will focus primarily on sustainable agriculture using different organic farming methods.

Aquatic ecosystem

Pooja.E

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Abstract

Aquatic ecosystems support a substantial source of the earth's biological diversity. They are an essential reservoir and share an enormous proportion of earth's biological productivity. Both aquatic resources and its biodiversity are interrelated to each other and they perform a myriad of functions and are valuable and essential for the sustainability of biotic communities. Aquatic biodiversity in both freshwater and marine environments are under continuous decline because of overexploitation of species, introduced exotic plant or animal, pollution sources from cities, industries and agricultural zones, loss and changes in ecological niche. Their conservation and management in the form of bio reserve points and bioregional management and worldwide monitoring are needed for the protection of the aquatic biodiversity. This review is presenting information on biodiversity in aquatic habitats and their resources, in marine and fresh water ecosystems, their importance conservation and restoration mechanisms.

Medicinal recycling

Pushpa R[1], Shreeja P[2], Chandana M[3], Bhavya B*

Abstract

Weeds are basically considered as one of the unwanted plants is classified as threats as they reduce the growth of a plant, by consuming its nutrients. The present project aims at collecting the information of weeds which have medicinal properties. This lessens the fact of considering weeds as waste and can be modified them as medicine which cures disease. The weeds act like magical healer and the usage of them can help us economically and protecting our environment.

KEY WORDS: Weeds, Medicinal property.

Analysis of water samples of three lakes in Bengaluru

Kusuma RC[1], Likitha ND[2], Bhavya B*

Abstract:

Lakes are large inland bodies of fresh or salt water. They are good aquatic ecosystem providing a lot of benefits to human beings and to animal life. Lakes are really beneficial to all life. In the present project the quality of water is described depending on the physical, chemical, and biological characteristics of water. The water sample is collected from the three lakes of

Bengaluru namely Hessarghatta lake, Binnamangala lake, and Sankey tank. The water sample is tested for PH, colour, amount of oxygen dissolved, salinity, chlorinity and temperature.
Key words: Lake, Salinity, Chlorinity, dissolved oxygen, PH

Microbial assessment of Sankey lake water

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ABSTRACT

Lakes occupy such a small fraction of the landscape belies their importance as environmental systems and resources for human use. While accounting for only 3% of the Earth's surface, lakes and ponds are vital habitats, and provide essential resources for a wide range of species, including humans. They have intrinsic ecological and environmental values. The quality of water is analyzed on the different parameters like pH, turbidity, BOD, and microbiological assessment (MPN). Most Probable Number technique is a method for estimating the number of bacteria in a food or water sample. Test was carried out to determine the colony forming unit (cfu/ml) through Standard Plate Count(SPC). The quality of the water mainly depends on the Coliforms thriving in the water body, hence, to differentiate between the lactose fermenting and non-lactose fermenting microorganisms the water sample was plated on the EMB **(Eosin-Methylene** blue**).** The microbial test is done on the water sample to detect enteric pathogens. Based on the colony forming unit the number of bacteria was counted. (Cfu/ml). Gram +ve short rods, Gram –ve rods, Gram –ve pleomorphic rods, Gram +ve cocci, Gram +ve rods, Gram +ve rods in chain are the bacterial cultures found in the water sample. Fungal staining was performed, tease mount method with lacto phenol cotton blue stain. The fungal species such as *Aspergillus niger, Trichoderma spp, Fusarium spp, Yeast* were observed**.** The study suggests that careful monitoring of lake water by performing continues analysis on a regular basis will we helpful to protect the water resources and will also help in checking the impurities. This will be helpful in creating awareness among the people who reside near the lakes to save the quality of water and also keeping the environment clean.
Key words: **BOD, Colony forming unit, Coliforms. Water quality.**

Registration before 15 December 2022

LAKE 2022: Conservation of Wetlands: Ecosystem-based Adaptation of Climate Change

[THE 13TH BIENNIAL LAKE SYMPOSIUM]

Date: **28-30th December 2022**

Venue: Auditorium, Ground Floor, New Biological Sciences Building [Near D Gate], **Indian Institute of Science, Bangalore** 560012, Phone: +91 080-22933503/22933099

Symposium Web: **http:**//wgbis.ces.iisc.ernet.in/energy

E Mail: energy.ces@iisc.ac.in; lake2022.iisc@gmail.com

Organised by	
Energy and Wetlands Research Group [http://wgbis.ces.iisc.ernet.in/energy], **Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012**	
Centre For Environment Education, Bangalore	Energy &Urban Research Group, RCGSIDM, IIT-Kharagpur
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Adamya Chetana, Bangalore	Alva's Education Foundation (R) Moodbidri
Bangalore Blaze Girls High School	Vagdevi Vilas Institutions, Bangalore
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K.K. High School, Varthur, Bangalore	Vidyanjali Primary and High School
Supported by	
ENVIS Division, The Ministry for Environment, Forests and Climate Change, Government of India	

Lake 2022 - 13th Biennial Lake Symposium

Conservation of Wetlands: Ecosystem-based Adaptation of Climate change,
28th -30th December 2022

Introduction: A symposium focusing on lakes/wetlands, popularly known as "**Lake Symposium**" was initiated by the Energy & Wetlands Research Group at the Centre for Ecological Sciences, Indian Institute of Science, Bangalore in the year 1998. The theme was broadened in 2000 (Lake 2000) with wider participation of education institutions, Governmental and non-governmental organisations, etc. The basic idea of the symposium was to bring out the trends in ecosystem conservation, restoration and management, including the hydrological, bio-physical, people's participation and the role of non-governmental, educational and governmental organizations and the future research needs. **Lake 2022** will be the 13**th**Biennial Lake Conference would focus on "Conservation of Wetlands: Ecosystem-based Adaptation of Climate Change".

Wetlands constitute vital components of the regional hydrological cycle. They are highly productive, support exceptionally large biological diversity, and provide a wide range of ecosystem services such as food, fibre, waste assimilation, water purification, flood mitigation, erosion control, groundwater recharge, microclimate regulation, enhance the aesthetics of the landscape, and support many significant recreational, social and cultural activities, aside from being a part of our cultural heritage. Wetlands play an important role in mitigating climate change adaptation through capturing and storing carbon to reduce atmospheric greenhouse gases (GHG), and providing resilience to hazards such as flooding, storm surge and coastal inundation.

The theme of World Wetlands Day 2022 is "**Wetlands Action for People and Nature"**, highlighting the importance of actions ensuring that wetlands are conserved and sustainably used. This would demonstrate the vital role of wetlands for the future of humanity and specifically their relevance towards achieving the new Sustainable Development Goals. Lake 2022 conference would provide a unique opportunity to increase understanding of the role of ecosystems in sustaining the food, water and human livelihood with the challenges faced by these fragile ecosystems. The deliberation involving all stakeholders would help raise awareness about wetlands' importance and the need to preserve them.

The sustainable development goals have ecological, social and economic aspects for present and future generations with an equitable share of resources. Conservation of natural resources through sustainable ecosystem management and development is the key to our secured future. Sustainable development of a region requires a synoptic ecosystem approach that relates to the dynamics of natural variability and the effects of human interventions on key indicators of biodiversity and productivity. Formulating and implementing action plans that best conserve vital ecosystems require understanding issues, concerns and threats. This requires awareness of the ecosystem function, goods and services among decision-makers and the public at large. Collaborative planning between scientists, policymakers and community members is an essential element of ecosystem-based management. Approaches towards this direction include:

- Fostering participation of all stakeholders to ensure that individuals and organizations are provided an opportunity to participate in the ecosystem conservation activities.
- Recommending policies and actions that can be undertaken to restore, maintain or enhance aquatic and terrestrial resources.
- Recommending policies and action plan towards the conservation and sustainable management of fragile ecosystems such as Western Ghats – water tower and food bowl for peninsular India.
- Nature based solutions to mitigate climate change ranging from the restoration of habitats to water resource management, disaster risk reduction, and green infrastructure—to address societal problems. Nature-based solutions provide essential benefits and services to the community, such as reducing greenhouse gas emissions, securing safe water resources, clean air, and ensuring food security.

SCOPE

Lake 2022 Symposium focussing on Conservation of Wetlands: Ecosystem-based Adaptation of Climate Change (during 28-30th December 2022) provides a unique opportunity to increase understanding of the role of ecosystems in sustaining the food and water with the challenges faced by these fragile ecosystems. The forum would demonstrate the vital role of ecosystems for the future of humanity and specifically their relevance towards achieving the new Sustainable Development Goals.

Lake 2022 conference: Lake 2022 forum would deliberate on nature based solutions through protection, restoration, and sustainably managing ecosystems in ways that increase their resiliency and ability to address those societal challenges, while also safeguarding biodiversity and improving human wellbeing. Lake 2022 participants include all stakeholders (Researchers: 30%, School students and teachers: 20%, college and university students: 20%, NGO's, community representatives: 20%, government officials (local, state and centre): 10%

Lake 2022 would focus not only on updating the current knowledge of the scientific community but also would bring in awareness among students, teachers, practitioners and the public. This would provide a platform for interaction among researchers, policymakers, academics and NGOs and address the issues related to wetlands and biodiversity in an era of climate change. This would help develop a stronger network among experts and institutions to develop efficient strategies for conserving and managing fragile ecosystems. As a part of the conference, it has been decided to have theme-based lead lectures by eminent scholars, paper and poster presentations by researchers, school and college students.

OBJECTIVES

Focus of **Lake 2022** would be (i) assessment of the present status and conservation aspects of ecosystems (terrestrial, aquatic - wetlands, lakes, tanks, ponds, swamps, streams and rivers), (ii) presentation by researchers, practitioners, students of case studies focusing on biodiversity, ecology, present status, threats, conservation measures required, (iii) discussion of current initiatives of conservation and management, (iv) role of education institutions, non-governmental organisations, religious organisations, (v) discussion of people's livelihood and fundamental right towards equitable resource allocation through scientific assessment of ecosystem goods and services, (vi) presentation by students (schools and colleges) based on documentation focusing on wetlands – biodiversity, present status, ecology, conservation and protection needs, (vii) allocation of financial and human resources to conserve and protect ecologically fragile ecosystems, (viii) proposals by students and non-governmental organisations for conservation, protection, restoration and sustainable management of aquatic ecosystems, (ix) discussion on research gaps and activities to be initiated by researchers to evolve appropriate strategies towards conservation of ecosystems in Western Ghats, (x) application of advanced technologies – big data, artificial intelligence (AI), Machine Learning (ML) and Deep Learning techniques for monitoring and sustainable management of ecosystems, (xi) developing SDSS – spatial decision support system for planning and management of ecosystems, and (xii) developing strategies for conservation and sustainable management of aquatic ecosystems in Western Ghats to sustain water, food and human livelihood.

THEMES for Paper Presentation/ Poster in Lake 2022

Papers are invited on the following themes from researchers, faculty from universities, Research Scholars, planners, development managers, economists and social scientists, school (VIII-XIIth students) and college (UG and PG) students and teachers.

1. Ecosystems (wetlands, forests, grasslands, estuaries, etc.)- Structure and functions.
2. Climate change – adaptation and mitigation strategies
3. Nature based solutions to address changes in the climate
4. Application of Geoinformatics in Ecosystems Management - Land use, Land cover dynamics, fragmentation of ecosystems
5. Monitoring of ecosystems – Big Data (Remote Sensing Data), Artificial Intelligence (AI), Machine Learning (ML) and Deep Learning techniques
6. Ecosystem (terrestrial, aquatic – coastal, fresh water) Goods and services.
7. Biodiversity, Hydrology and Ecology of Western Ghats.
8. Aquatic Ecosystems - Food and water security, people's livelihood.
9. Wetlands and swamps: Restoration, Conservation and Management.
10. Carrying capacity of river basins in Western Ghats.
11. Natural capital accounting and Valuation of Ecosystem services.
12. Sacred Groves (*kans, devarakadu*) and Myristica Swamps.
13. Eco-Tourism in Western Ghats and Carbon sequestration.
14. Natural and Anthropogenic disasters.
15. Limnology, aquatic ecology, biodiversity and prospects of bio-monitoring.
16. Pollution –terrestrial and aquatic - Monitoring and Management, waste (solid / liquid) management, bioremediation.
17. Constructed wetlands, bioremediation, phytoremediation
18. Sustainable Agriculture and Organic farming.
19. Coastal ecosystems – Biodiversity, Ecology, Productivity and Livelihood aspects.
20. Prospects of Renewable Energy (solar, biofuel, bioenergy) and Energy Conservation.
21. Environmental Education and Sustainable Development.
22. Environment Ethics and Green Technology; and Environment Literacy.

SCHOOL AND COLLEGE STUDENTS' PARTICIPATION

Orientation (Lake 2022- Pre Conference workshops) are planned in the partner schools for training students and teachers. The session would involve lectures and hands-on sessions (environment monitoring – biotic and abiotic components of an ecosystem). Institutions organizing the pre-conference Lake 2022 workshops (Co-ordinated by Centre for Environment Education (CEE), Bangalore) are:

- Sri Arurovindo Public School, Ulsoor
- BGS National Public School, Hulimavu
- Bangalore Blaze, Nagarabavi
- Ideal International Techno School, Channagiri
- K. K. English School, Varthur
- Poornapramati School, Banashankari
- Vagdevi Vilas Group of Institutions, Bidadi, Martahalli, Varthur, Whitefield
- Vidyaniketan Public School, Ullal
- Vidyanjali Primary and High School, Gottigere

AWARDS: There are **three awards in the students and teachers' category**— High School (VIII, IX, X); College (PUC, UG, PG) and Teachers (school and college). Awards for the best paper presentation would include a Certificate and a Memento. The best posters would be similarly awarded.

Lake 2022 Symposium: Programme Details

Dates	Time	Session	Venue
28-12- 2022	9 – 10 30 AM	Inauguration of Lake 2022	Auditorium
	11-12 PM	Keynote address	
	12- 1 30 noon	Plenary Lectures (Invited) – 2 lectures of 30 min each	
	2 30- 4 pm	Technical Session 1 – Presentations by young Researchers	
	4 30 – 6 pm	Technical Session 2 – Presentations by senior Researchers	
	2 30- 6 pm	Johny Biosphere session – Interactive session with school students	Open-Auditorium
29-12- 2022	9 – 10 30 AM	Technical sessions – 3, 4 and 5, Presentations by school students (urban)	Parallel sessions – lecture halls (3)
	11-12 PM	Technical sessions – 3, 4 and 5, Presentations by school students (rural)	
	12- 1 30 noon	Technical sessions – 6, 7 and 8, Presentations by college students	
	2 30- 4 pm	Technical sessions – 9, 10 and 11, Presentations by Research Scholars	
	4 30 – 6 pm	Technical sessions 12: Poster session – presentations and evaluations	
	7 to 8 30 pm	Cultural programme	Auditorium
30-12-2022	9 -10 30 PM	Technical sessions – 13 and 14, Presentations by teachers (school and college), Faculty from Universities	Auditorium
	11- 1 30 PM	Technical Session 15: Plenary Lectures– Climate Change (invited)	
	2 30- 4 pm	Panel discussion – finalising recommendations of the Lake 2022 forum	
	4 30 – 5 30 pm	Cultural programme – by students	
	6 – 7 30 pm	Valedictory Programme – prize distribution, Finalising recommendations of Lake 2022	
31-12-2022	9-12 30 pm	Field Ecology – nearby ecosystems (lakes, forests)	

LAKE 2022 - Organising Committee:

T. V. Ramachandra, CES	Rejini Simpson, CEE, Bangalore
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Vijaikrishna R, Vidyaniketan Public School,	M. R. Pranesh and C J Jagadeesha, KERF, Bangalore
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Uma Mohan, Auro Mirra International School	Col C.P. Muthanna, Kodagu Model Forest Trust

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Call for papers

Call for Scientific Papers: Delegates interested in presenting papers as oral or poster need to submit the scientific paper as per the guidelines given below.

Guidelines for Paper Preparation: The full text paper (e-version preferably in a CD and one hard copy) formatted to A4 (210 mm x 297 mm) size, after having been scrutinized and accepted, will be printed as received, by offset process. Therefore, the text of the paper in English must confirm strictly to the following requirements and be free from errors.

Template as per: http://wgbis.ces.iisc.ernet.in/energy/lake2022/proceedings.php

Top/bottom margin	**25 mm (on first page 35 mm)**
Left/right margin	25 mm (all pages)
Typing area	160 mm x 247 mm (including folio), single space single column
Total pages	8 -10 pages including figures, tables, photographs, references etc., if any.
Font type	Times New Roman/Arial
Title	14 point BOLD CAPITALS
Author's Name	**12 point Bold** Upper-Lower (Do not prefix name with/Ms./Dr./Prof.)
Affiliation (designation, organisation and place)	*11 point italics*
E Mail ID, Telephone number and Mobile	11 point
Organisation web URL	11 point
Main headings	10 point **BOLD CAPITALS**
Subheadings	10 point **Bold Upper-Lower**
Text	10 point normal
Print	Laser Print or letter quality

The paper title, name(s) of author(s), affiliation and address, center justified, should be typed in a space of 50 mm from the top margin on the first page. The paper should begin with a synopsis of not more than 200 words describing the aim(s) of the work, methods, results obtained and conclusions. Type the headings, subheadings and paragraphs aligned with the left-hand margin (Align Left). Text justified on both sides is preferred. Use double space between paragraphs, and between section headings/subheadings and paragraphs. Do not number paragraphs, but number section and sub-sectional headings except synopsis, in conformity with established convention. The manuscript should be prepared by using MS Word (suitable for Windows). Figures should be drawn in black Indian Ink on translucent paper or acetate material (Gateway Tissue) with lettering of appropriate size using stencils. The figures should be placed nearest to the first reference in the text. Photographs on glossy paper may be included, if necessary. The authors must send brief bio-data (100 words) and the recommendations that they would like to be considered as a part of the conference based on their presentations.

Posters: Size A 0 and template as per
http://wgbis.ces.iisc.ernet.in/energy/lake2022/posters/poster_template.pdf

EXHIBITION STALL

An exhibition of software and hardware related to the Environmental technologies, Restoration and Monitoring technologies, Water quality analysis, Geographic Information System (GIS), Global Positioning System (GPS), Remote sensing, Image processing and Cartography, as well as products and services of other organizations and agencies working in the area related to the theme of the conference, will be organised. Organisations / Agencies can participate in the exhibition on payment of fee of INR 25,000. Registered agencies would be allowed to make 10 minutes presentation. Interested agencies may contact the Lake 2022 secretariat and remit the fee through DD drawn in favor of ***"Lake 2022 Symposium,* Indian Institute of Science"** payable at Bangalore.

REGISTRATION FEE**

- Delegates: Rs. 3,000/-, Accompanying person: Rs. 1500/-
- Research Scholars and University faculty: Rs. 3,000/- (mandatory to attend all days)
- **Masters students**: INR 1500/- (mandatory to attend all days)
- **UG students**: INR 1000/- (mandatory to attend all days)
- Representatives from NGO: Rs. 5,000/ -, Industry:15.000/-, Govt Agency: 5,000/-
- School and PU students: The organizing committee has decided to waive registration fee to school students and teachers **whose papers are accepted for presentation in the technical session**.

Registration fee to be paid either through Demand draft be drawn in favour of the "Lake 2022, Indian Institute of Science", payable at Bangalore or wire transfer **A/C 10270575339, IFSC Code SBIN0002215**, State Bank of India, Indian Institute of Science Branch, Bangalore 560012. DD to be sent along with duly filled in registration form.

**Registered Participants (Mandatory to attend all three days) will get the certificate on the concluding day of the conference.

The registration fee would include registration kit, working lunch and tea during the symposium. Accompanying person will have access to all technical sessions and hospitality as per delegates except registration kit.

ACCOMMODATION

- Key speakers and invited delegates would be accommodated on the campus
- Delegates whose paper is accepted for the technical session will be accommodated on the campus on a first come, first serve basis.
- Participants requiring accommodation must mention the requirement in the registration form and be arranged in the student hostel / nearby hotels. Room rent is required to be paid by the delegates as per the tariff in the respective hotel (Rs. /person/day – non AC room and Rs /person/day for AC room). Accommodation will be arranged on a payment basis upon the request from the delegates.

EXPECTED OUTCOME

- Fostering participation of all stakeholders to ensure that individuals and organizations are provided an opportunity to participate in the development of aquatic resources – lakes conservation activities;
- Encouraging intergovernmental initiatives through partnerships between communities and non-profit organizations;
- Identifying significant natural, recreational, economic, cultural, scenic resources and aquatic ecosystem values; Identifying potential threats to aquatic resources and values;

  Recommending policies and actions that can be undertaken to restore, maintain or enhance aquatic and terrestrial resources.

DATES TO REMEMBER

Registration [Submission of Registration form]	**15 December 2022**
Participants presenting papers/posters -Submission of scientific papers (full length / extended abstract), posters with the Registration Form (with the registration fee, depending on the category) –	30th **November** 2022
Review of Papers and posters by the committee	5th **December** 2022
Final submission of the revised manuscript (based on review)	5th **December 2022**
Notification of Acceptance of Papers (on web)	10th **December 2022**
Lake 2022 Conference	**28-30th December 2022**

Paper Acceptance details at:

http://ces.iisc.ernet.in/energy

E Mail: energy.ces@iisc.ac.in; lake2022.iisc@gmail.com

Address for Communication

Dr. T.V. Ramachandra

Convenor, Lake 2022 Conference

Energy and Wetlands Research Group, TE 15,

Centre for Ecological Sciences, Third Floor, E wing,

New Bioscience Building, [Near D Gate],

Indian Institute of Science, Bangalore 560012

Phone: 91-080-22933099/2293 3503 (extn. 101/107)

E mail: tvr@iisc.ac.in,

energy.ces@iisc.ac.in

Lake2022.iisc@gmail.com

Conference Web: http://ces.iisc.ernet.in/energy

Energy & Wetlands Research Group, CES, Indian Institute of Science, Bengaluru

The Energy and Wetlands Research Group at the Centre for Ecological Sciences (CES), is actively involved in studies and training on issues related to the environment, water resources, energy, ecology, wetlands, geographic information systems, environmental impact assessment and natural resource management. The Centre for Ecological Sciences, founded in 1983 with the support of the Ministry of Environment, Forests and Climate Change (MoEFCC), offers exciting research opportunities in various areas in ecology. Over the past 40 years, CES have instilled a tradition of rigorous enquiry in diverse areas of ecology, evolution and behavior. The projects of CES are often integrative which uses multiple approaches, from theoretical and laboratory studies to field-based research, to explore the research questions. A number of CES research areas are breaking new ground in ecology while others have significant roles in conservation. Details at http://wgbis.ces.iisc.ernet.in/energy

https://www.researchgate.net/profile/T_V_Ramachandra/publications
https://scholar.google.co.in/citations?user=Woh1fa8AAAAJ&hl=en

Indian Institute of Science (http:/iisc.ac.in)

The Indian Institute of Science (IISc) was founded in 1909 as a result of the joint efforts of Jamsetji Nusserwanji Tata, the Government of India, and the Maharaja of Mysore. In 1886, Jamsetji Tata conceived of a university of science that will work for the benefit of India, and in 1898 created an endowment for establishing such an institution. Over the last 112 years, IISc has become India's premier institute for advanced scientific and technological research and education. Its mandate is "to provide for advanced instruction and to conduct original investigations in all branches of knowledge as are likely to promote the material and industrial welfare of India." In keeping with this guiding principle, the Institute has strived to foster a balance between the pursuit of basic knowledge and applying its research for industrial and social benefit. IISc's research output is diverse, interdisciplinary and cuts across traditional boundaries. The Institute has over 42 academic departments and centres that come under six divisions. It also places equal emphasis on student learning, with about 4000 students pursuing several postgraduate and PhD programmes, as well as a dedicated four-year undergraduate programme aimed at providing research-oriented training for young students in the basic sciences.

Centre for Environment Education (CEE), Bangalore

Centre for Environment Education (CEE) Ahmedabad was established as a Centre of Excellence under the Ministry of Environment, Forest and Climate Change, Govt. of India, working in the field of Environmental Education and Education for Sustainable Development. CEE develops innovative programmes and educational material and builds capacity in the field of Education for Sustainable Development (ESD). It is committed to ensure that Environmental Education (EE) leads to action for sustainable development. It undertakes field projects that demonstrate and validate the role education can play in sustainable development. CEE South is the southern regional office of the centre looking after the projects in the states of Karnataka, Tamil Nadu, Telangana, Andhra Pradesh, Kerala and UTs of Andaman & Nicobar, Puducherry and Lakshadweep Islands on implementation of the awareness and action programmes related to environment and development issues through innovative methodologies and approaches. Email: ceesouth@ceeindia.org

Lake 2022 - 13th Biennial Lake Symposium

Conservation of Wetlands: Ecosystem-based Adaptation of Climate change

28th -30th December 2022,

Venue: Auditorium, Ground Floor, Bioscience Building [Near D Gate],
INDIAN INSTITUTE OF SCIENCE, Bangalore 560012

Registration form (to be sent by 15 November 2022)				
1	Name			PHOTOGRAPH
	Aadhar Number			
2	E mail			
3	Mobile			
4	Phone			
5	Fax			
6	Designation			
7	Department			
8	Institution			
9	Organisation Address			
10	Correspondence Address			
12	Presenting -	Paper		poster
13	Title (paper / poster)			
	If Yes, Title of the paper /Poster			
	Enclosed: Abstract / Paper (e–version and hard copy): (Please ensure CD is virus free)			
	e-version of the Abstract and paper be sent to: **energy.ces@iisc.ac.in; lake2022.iisc@gmail.com**			
14	Registration fee	Amount:	DD No:	Date:
	Bank			
	Wire Transfer	Amount:	UTR No:	Date:
15	Accommodation	Required		YES / NO
	Accommodation Charges	Amount:	DD No:	Date:
	Bank			
	Wire Transfer	Amount:	UTR No:	Date:
16	Travel Details	Arrival		Date & time
		Departure		Date & time

(All fields must be filled) *DD in favour of '**Lake Symposium, Indian Institute of Science**'

Signature of Participant
Place:_____ ____Date:_____

Signature of HOD/Principal (in case of students)
Organisation:

Organised by

Energy and Wetlands Research Group [http://wgbis.ces.iisc.ernet.in/energy],
Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560012

Centre For Environment Education, Bangalore	Energy &Urban Research Group, RCGSIDM, IIT-Kharagpur
Karnataka Environment Research Foundation	Department of Civil Engg., S R University, Warangal
Adamya Chetana, Bangalore	Maharani Lakshmi Ammanni College for Women (**MLAC**)
Bangalore Blaze Girls High School	Vagdevi Vilas Institutions, Bangalore
BGS National Public School, Bangalore	Vidyaniketan Public School, Ullal, Bangalore
K.K. High School, Varthur, Bangalore	Vidyanjali Primary and High School

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