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IIT Tirupati Navavishkār I-Hub Foundation

Souvenir

International Conference
on
GeoAI and Smart Mapping for a Sustainable Tomorrow

GIS Day - 2025

19th November, 2025

Technically Co-Sponsored by

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Organized by

Department of Civil Engineering
Centre for Data Science and Machine Learning
School of Engineering & Technology
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5th International GIS Day

GeoAI and Smart Mapping for a Sustainable Tomorrow

Centurion University
Shaping Lives...
Empowering Communities...

19th November 2025

Editors

Dr. Rajib Kumar Majhi

Dr. Abhishek Das

Dr. Prafulla Kumar Panda

Prof. Bikram Narayan

Organized by

Department of Civil Engineering

Centre of Excellence, Data Science & Machine Learning

In association with

School of Engineering and Technology

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Preface

The Fifth International Hybrid Poster/Paper Presentation on GIS Day 2025, organized by the Department of Civil Engineering and the Centre for Data Science & Machine Learning of Centurion University of Technology & Management (CUTM), Odisha, and supported by Esri India Pvt. Ltd., PanAsian IP Services Pvt. Ltd., and Kalinga Consult & Engineers Pvt. Ltd., continues to serve as an annual global platform for scientists, researchers, academicians, practicing engineers, and students focusing on the latest innovations and applied research in Geographical Information Systems (GIS), Remote Sensing, Artificial Intelligence (AI), and Smart Mapping technologies.

Centurion University of Technology & Management, established in 2010 as Odisha's first multi-sector private university, continues its mission to "Shape Lives and Empower Communities" by promoting education, research, and innovation that generate wealth and livelihood opportunities for underprivileged communities. Esri, the world leader in GIS software founded in 1969 in the USA, provides technology deployed across 350,000 organizations worldwide. Kalinga konsult is offering a wide range of professional services in design, planning, and project management, and PanAsian IP Services Pvt. Ltd., an expert in intellectual property management, extend valuable support to this initiative.

It is our proud privilege to welcome all participants to this globally recognized event. This year, more than 190 abstracts were received from around the world, and after a rigorous review process, 75 high-quality abstracts have been accepted for presentation.

The GIS Day 2025 Proceedings include peer-reviewed abstracts and research outputs covering a broad spectrum of topics such as GeoAI applications, spatial data analytics, climate mapping, remote sensing integration, machine learning in geospatial modeling, and other innovations aimed at promoting sustainability and resilience.

We are delighted to present this Souvenir Volume, containing abstracts of the keynote lectures, invited talks, and technical papers selected for presentation during this year's celebration. We extend our heartfelt gratitude to the Advisory Committee, Organizing Committee, reviewers, authors, student volunteers, and our industry collaborators for their continuous guidance and contributions.

We sincerely thank Centurion University of Technology & Management, Esri India Pvt. Ltd., Kalinga konsult Pvt. Ltd., and PanAsian IP Services Pvt. Ltd. for their generous support and encouragement. We are confident that the deliberations and discussions during GIS Day 2025 will foster meaningful collaborations, inspire innovation, and strengthen the global geospatial community.

We look forward to fruitful interactions and knowledge sharing at this year's GIS Day 2025 international conference on "GeoAI and Smart Mapping for a Sustainable Tomorrow."

- Editors

Souvenir Messages

Prof. (Dr.) Mukti Kanta Mishra
President, CUTM

Centurion University of Technology and Management, Odisha, India

Message

Geospatial technology today stands at the forefront of digital transformation, driving innovation across sectors and shaping how societies respond to global challenges. The fusion of Geographic Information Systems (GIS) with Artificial Intelligence (AI) has opened unprecedented opportunities to analyze, predict, and visualize complex spatial phenomena—empowering decision-makers to design smarter, safer, and more sustainable communities.

At Centurion University of Technology and Management (CUTM), we recognize GIS as more than a mapping tool—it is a bridge between data and action, technology and humanity. Since 2021, our annual GIS Day celebration has evolved into a global academic platform, fostering research collaboration and nurturing future-ready professionals equipped to harness the power of GeoAI for societal transformation.

I take immense pride in the Department of Civil Engineering and the Centre for Data Science and Machine Learning, in association with the School of Engineering and Technology, for organizing the International Conference on GIS Day 2025 in collaboration with Esri India Pvt. Ltd. for the fifth consecutive year. This hybrid poster and paper presentation exemplifies CUTM's unwavering commitment to experiential learning, interdisciplinary innovation, and sustainable development.

As GIS Day continues to be celebrated by premier institutions worldwide, I extend my heartfelt wishes to all organizers, participants, and partners. May this year's celebration further strengthen our mission to create a smarter, geospatially empowered, and sustainable tomorrow.

Mukti Kanta Mishra

Prof. D. N. Rao
Vice-President, CUTM

Centurion University of Technology and Management, Odisha, India

Message

I am pleased to know that the Department of Civil Engineering and the Centre for Data Science and Machine Learning, in collaboration with Esri India Pvt. Ltd., are organizing the International Conference on GIS Day 2025 at Centurion University of Technology and Management, Paralakhemundi, Odisha, on 19th November 2025, marking the fifth consecutive year of this remarkable initiative.

This year's theme, "GeoAI and Smart Mapping for a Sustainable Tomorrow," beautifully captures the transformative potential of combining Geospatial Technology with Artificial Intelligence to address critical global challenges such as climate change, urban sustainability, and resource management. Such initiatives strengthen our university's vision of promoting interdisciplinary research, innovation, and technology-driven education that directly benefits society.

Over the years, GIS Day at CUTM has evolved into a platform of international repute, encouraging students, researchers, and professionals to explore the power of location intelligence and smart mapping. I deeply appreciate the consistent efforts of the organizing teams for nurturing a GIS-driven mindset among young learners and fostering collaborations that extend beyond academic boundaries.

I extend my heartfelt congratulations and best wishes to the organizers, participants, and partners of GIS Day 2025. May this year's celebration inspire many more milestones in the journey toward a sustainable and geospatially empowered future.

D. N. Rao

Prof. (Dr.) Supriya Pattanayak
Vice-Chancellor, CUTM

Centurion University of Technology and Management, Odisha, India

Message

It gives me immense pleasure to convey this message for the Souvenir being published on the occasion of the International Conference on GIS Day 2025, organized at Centurion University of Technology and Management, Paralakhemundi, Odisha, on 19th November 2025, marking the fifth successful edition of this prestigious event. I extend my heartfelt appreciation to the Department of Civil Engineering and the Centre for Data Science & Machine Learning for jointly organizing this international conference in collaboration with Esri India Pvt. Ltd. Their continued dedication to promoting geospatial awareness and technological innovation reflects the university's commitment to interdisciplinary research, societal advancement, and sustainable development.

This year's theme, "GeoAI and Smart Mapping for a Sustainable Tomorrow," aptly emphasizes the convergence of Artificial Intelligence and Geospatial Technologies—two powerful tools that are reshaping how we analyze, visualize, and respond to global challenges. The inclusion of expert lectures, paper and poster presentations, and interactive sessions featuring eminent speakers from India and abroad provides an exceptional platform for our students, faculty members, and professionals to learn, collaborate, and innovate. I commend the organizing team for their consistent excellence and for transforming GIS Day at CUTM into an internationally recognized platform for knowledge exchange and innovation. I am confident that GIS Day 2025 will once again inspire new ideas, foster meaningful collaborations, and strengthen CUTM's mission of creating a technologically empowered and sustainable future.

Supriya Pattanayak

Prof. (Dr.) Biswajit Mishra
Pro Vice-Chancellor, CUTM

Centurion University of Technology and Management, Odisha, India

Centurion University
Shaping Lives... Empowering Communities...

Message

Warm greetings and best wishes to all participants, delegates, and organizers of the International Conference on GIS Day 2025, hosted by the School of Engineering and Technology, Department of Civil Engineering, and the Centre of Excellence in Data Science and Machine Learning, Centurion University, Paralakhemundi Campus.

Centurion University takes pride in celebrating GIS Day since 2021, reinforcing its commitment to interdisciplinary learning and innovation in Geospatial Science and Technology. Over the years, this event has evolved into a vibrant platform for research exchange and technological exploration addressing challenges in sustainability and spatial intelligence.

The theme, "GeoAI and Smart Mapping for a Sustainable Tomorrow," reflects the convergence of Artificial Intelligence and Geospatial Science — redefining how we visualize, analyze, and manage Earth's resources. GeoAI enables intelligent solutions for urban planning, climate resilience, agriculture, disaster management, and sustainable infrastructure.

Aligned with the University's vision of "Shaping Lives and Empowering Communities through Experiential Learning and Applied Research," GIS Day 2025 fosters collaboration among global experts, researchers, and innovators. I commend the organizers for their dedication and extend my best wishes for a successful conference that inspires innovation, partnerships, and progress toward a smarter and more sustainable world.

Biswajit Mishra

Dr. Anita Patra
Registrar, CUTM

Centurion University of Technology and Management, Odisha, India

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Message

Dear Students,

Greetings on the occasion of GIS Day!

Geographic Information Systems (GIS) have emerged as a transformative tool in understanding our world through spatial thinking, data visualization, and evidence-based decision-making. On this day, we celebrate the power of GIS and technology in addressing some of the most pressing global challenges — from sustainable resource management and urban planning to climate resilience and disaster response.

As students, I encourage you to explore the possibilities that GIS offers — not only as a technology but as a way of thinking critically about the world around us. The ability to analyze, interpret, and visualize spatial data will continue to be an invaluable skill in research, policy, and professional practice across disciplines.

At Centurion we have already been into GIS as a field of Domain and Research (and interdisciplinary) for our students and faculty. Let us use this opportunity to reaffirm our commitment to innovation, sustainability, and informed action for a better and more connected world.

Anita Patra

(Anita Patra)

Prof. (Dr.) Prafulla K. Panda
Convener, GIS Day 2025
Dean, SoET, PKD, CUTM

Centurion University of Technology and Management, Odisha, India

Message

It gives me immense pleasure to share that the Department of Civil Engineering and the Centre for Data Science and Machine Learning of Centurion University of Technology and Management are celebrating the 5th International GIS Day on November 19, 2025, with the theme "GeoAI and Smart Mapping for a Sustainable Tomorrow." This flagship event continues to serve as a dynamic platform for fostering innovation and collaboration in Geographical Information Systems (GIS), Remote Sensing, and Artificial Intelligence applications. Since its inception in 2021, GIS Day at Centurion University has evolved into a vibrant international event attracting the participation of eminent scientists, academicians, and professionals from India and abroad. Each year, the event has grown in scale, enthusiasm, and intellectual exchange, offering students and researchers valuable exposure to cutting-edge technologies. This year, we are proud to have received more than 190 abstracts, out of which 75 outstanding research papers and posters have been shortlisted for presentation. This remarkable response reflects the expanding interest and academic depth in GIS and related technologies.

I extend my sincere gratitude to all members of the organizing committee for their dedication and teamwork in making this event a success. I am confident that the deliberations during GIS Day 2025 will inspire innovative ideas and promote sustainable geospatial solutions.

Happy GIS Day!

(Prafulla Kumar Panda)

Dr. Rajib Kumar Majhi
Co-Convener, GIS Day 2025
HoD, Civil Engineering, CUTM

Centurion University of Technology and Management, Odisha, India

Message

It is my pleasure to greet all participants, researchers, and guests on the occasion of International GIS Day 2025, themed "GeoAI and Smart Mapping for a Sustainable Tomorrow."

The Department of Civil Engineering, in association with the Centre for Data Science and Machine Learning, began celebrating GIS Day in 2021, marking our first proud participation—and we were honored to be recognized as the National Winner that year. Since then, this event has grown into a prestigious platform, drawing renowned academicians, scientists, and professionals from across the nation and abroad who share their insights on the ever-evolving field of Geographical Information Systems (GIS) and its allied technologies. Each year, the excitement and scale of this celebration have expanded tremendously, with enthusiastic participation from students and scholars alike. This year, we received more than 190 abstracts, out of which 75 high-quality research contributions have been shortlisted for presentation—reflecting the global relevance and diversity of the topics discussed.

I extend my heartfelt gratitude to the Management of Centurion University for their constant encouragement, and to all members of the organizing committee for their tireless efforts in making this event a success. I am confident that GIS Day 2025 will continue to inspire innovation, collaboration, and knowledge sharing among the geospatial community.

Best wishes for a grand success to GIS Day 2025!

Rajib Kumar Majhi

Dr. Abhishek Das
Co-Convener, GIS Day 2025
Assistant Professor, CUTM

Centurion University of Technology and Management, Odisha, India

Message

It gives me immense pleasure to present this souvenir for the GIS Day celebrations, an event dedicated to showcasing the transformative potential of Geographic Information Systems in addressing real-world challenges. The conference brought together students, researchers, faculty, and industry experts to explore how geospatial thinking continues to shape sustainable development, resource management, and informed decision-making.

A special highlight of this event is the significant contribution of the Centre for Data Science and Machine Learning, whose expertise has strengthened the analytical foundation of GIS applications. By integrating AI-driven modelling, spatial data analytics, and machine learning approaches, the Centre has expanded the horizons of what GIS can achieve. Its interdisciplinary research initiatives and innovation-driven environment have empowered participants to understand geographical patterns more deeply and transform raw spatial data into actionable insights. The Centre's active involvement in this celebration underscores its vision of merging data intelligence with geospatial technologies to build smarter, more resilient communities.

I extend my heartfelt appreciation to all speakers, participants, collaborators, and volunteers for their dedication in making this event a success. As this souvenir captures the essence of our shared learning and collaboration, I hope it inspires continued exploration, innovation, and growth in the fields of GIS and data science.

Abhishek Das

Prof. (Dr.) Sujata Chakravarty
CEO, Data Science & Machine Learning

Centurion University of Technology and Management, Odisha, India

Message

It gives me immense pleasure to welcome all participants, distinguished guests, experts, and young researchers to the upcoming International Conference on GeoAI and Smart Mapping for a Sustainable Tomorrow – GIS Day 2025, which will be held on 19th November. This event is jointly organized by the Department of Civil Engineering and the Data Science & Machine Learning Research Centre, reflecting our commitment to advancing research, innovation, and societal impact.

The convergence of Geospatial Technologies and Artificial Intelligence is transforming the way we understand our environment, manage resources, and plan for the future. GeoAI has the potential to support sustainable development, enhance disaster resilience, optimize urban planning, and strengthen decision-making at every level. Through this conference, we aim to bring together bright minds to share ideas, present breakthroughs, and inspire new collaborations.

I extend my heartfelt thanks to the organizing team, our invited speakers, industry partners, and all contributors who are working tirelessly to make this event meaningful and successful. I am confident that the discussions and insights that will emerge on 19th November will pave the way for innovative solutions that benefit society and the environment.

My best wishes to all participants for a productive and enriching experience.

(Sujata Chakravarty)

Dr. Roshan K. Srivastav
Project Director, IIT Tirupati Navavishkar I-Hub Foundation-cum-Head, Geo-Intelligence and Applications Laboratory

Indian Institute of Technology, Tirupati, Andhrapradesh, India

Message

It gives me immense pleasure to be a part of the International Conference on GIS Day 2025 at Centurion University of Technology and Management, themed "GeoAI and Smart Mapping for a Sustainable Tomorrow."

Geospatial technologies today form the foundation of our nation's digital transformation—enabling data-driven governance, sustainable urban planning, precision agriculture, disaster management, and environmental resilience. As we move towards Viksit Bharat 2047, the integration of GIS with Artificial Intelligence (GeoAI), the Internet of Things (IoT), and Digital Twin technologies will define how we manage our natural and built environments with precision and foresight.

The future belongs to those who can think spatially. Therefore, embedding GIS education across disciplines—from engineering and environmental sciences to economics and policy—is no longer optional but essential. Building capacity in spatial data analytics will empower our youth to tackle complex societal challenges and create innovative solutions for public good.

GIS Day 2025 stands as a powerful reminder of our collective responsibility to nurture spatial thinking and promote geospatial literacy across all sectors of society. It symbolizes collaboration, innovation, and awareness—celebrating how mapping and GeoAI can lead us toward a more informed, sustainable, and equitable future. Let this day inspire students, researchers, and professionals alike to use geospatial intelligence as a force for positive global change.

Roshan K. Srivastav

Shri Suresh Kumar Pattanaik
DDSC-cum-Project Director

Watershed Department, Gajapati,
Odisha, Government of Odisha

Message

It gives me great pleasure to convey my best wishes to Centurion University of Technology and Management, Paralakhemundi Campus, for organizing the International GIS Day 2025 on the theme "GeoAI and Smart Mapping for a Sustainable Tomorrow." This annual celebration has become a remarkable platform for students, researchers, and professionals to exchange ideas and showcase innovative applications of Geographical Information Systems (GIS), Remote Sensing, and Artificial Intelligence in promoting sustainable development.

Over the years, GIS technology has proven to be a transformative tool in natural resource management, watershed planning, and climate resilience. Its integration with artificial intelligence and machine learning offers enormous potential for accurate mapping, predictive modeling, and decision-making, which are vital for efficient management of land and water resources.

I am glad to note that Centurion University has been consistently organizing GIS Day since 2021, encouraging young minds to explore technological innovations for real-world challenges. The participation of experts from across the country and abroad, along with the submission of over 190 research abstracts this year, reflects the growing importance of this initiative.

I extend my hearty congratulations to the organizers and wish GIS Day 2025 a grand success. May this event continue to inspire collaborative efforts toward a smarter and sustainable future.

Suresh Kumar Pattanaik

Prof. (Dr.) P. Raja
Principal Scientist (Retd.), IISWC-ICAR

Centurion University of Technology and Management, Odisha, India

Message

I am delighted that the Department of Civil Engineering and the Centre of Excellence in Data Science and Machine Learning, School of Engineering and Technology, Centurion University of Technology and Management, Paralakhemundi Campus, are organizing the International Conference on GIS Day 2025 on 19th November, 2025, with the theme "GeoAI and Smart Mapping for a Sustainable Tomorrow." This initiative continues the University's commitment to promote innovative applications of Geospatial Technologies for sustainable and resilient development.

The integration of Geographic Information Systems (GIS) with Artificial Intelligence (AI) and Machine Learning (ML) has opened new frontiers in environmental research, particularly in understanding and modeling greenhouse gas (GHG) fluxes—a key driver of climate change. Advanced geospatial analytics and intelligent modeling now allow us to visualize and predict climate patterns, assess vulnerabilities, and support data-driven decision-making for climate resilience. It is essential to develop and employ such an advanced tools to scale up our understanding from localized studies to landscape and regional levels, enabling the translation of scientific insights into actionable policies. The convergence of GeoAI, remote sensing, and spatial data science thus holds immense potential to address pressing global challenges in climate change, natural resource management, and sustainable infrastructure development.

I extend my heartfelt appreciation to the organizers, contributors, and industry collaborators for their efforts in creating this valuable platform for knowledge exchange and collaboration. My best wishes for the grand success of GIS Day 2025.

Happy GIS Day!

(P. Raja)

Dr. M. L. Narasimham
Retd Professor of Civil Engg., Andhra University, Vishakhapatnam

Centurion University
Shaping Lives...
Empowering Communities...

Expert Member, State Committee on Dam Safety, Govt of Andhra Pradesh

Message

I am delighted to note that the Department of Civil Engineering, School of Engineering and Technology Science and Centre for Data & Machine Learning is organizing the 5th International GIS Day on November 19th, 2025, with the support of Esri Pvt. Ltd. and GTIDS Pvt. Ltd., in association with the, School of Agriculture and Bioengineering, and M.S. Swaminathan School of Agriculture. It gives me immense pleasure to extend my heartfelt greetings on this occasion. With over five decades of experience in water resources engineering, I have witnessed how the integration of geospatial technologies has transformed the way we plan, develop and manage our natural resources. Conferences of this nature are vital platforms where professionals, researchers and administrators converge to exchange views on the state- of- the - art of spatial data analysis and modelling.

In the field of engineering particularly in water resources management, such discussions help to refine our collective understanding of resource behaviour, environmental impact and risk patterns. They enable the formulation of informed blueprints for sustainable development, infrastructure resilience and disaster risk mitigation. I sincerely hope that the deliberations of this conference will inspire innovative geospatial practices that guide the path toward a secure and sustainable water future.

Wishing the organizers every success in this grand event. Happy GIS Day!

(M. L. Narasimham)

Prof. (Dr.) C. R. Rao
Professor, Emeritus, CUTM

Centurion University of Technology and Management, Odisha, India

Message

On the occasion of 5th International GIS Day on 19th November 2025, I convey my hearty greetings to the organizing team and participants for celebrating the day and for their dedicated work in extending the applications of this knowledge to several practical uses. I sincerely hope that CUTM will achieve recognition for its untiring work from national and international agencies in the near future.

Happy GIS Day!!!

Prof. C. R. Rao

Dr. Joseph J. Kerski
Geographer – Education Manager, Esri

Esri International Court
Broomfield CO 80021-3200 USA

Message

I would like to express my gratitude to Centurion University of Technology and Management, Odisha, and Dr. Prafulla Panda and his team for inviting me to share my hands-on experience regarding the advancements in GIS and its diverse applications in the global context. Centurion University's core mission is to "Shape Lives and Empower Communities," focusing on creating wealth and livelihood opportunities for the underprivileged. What sets CUTM apart is its unique approach to integrating higher education with skill development across various economic sectors.

The GIS Day team from CUTM was honored as the winner for organizing this major event in 2021, which featured a poster presentation and expert talks from renowned professionals, including myself.

I extend my best wishes to the team for another successful GIS Day 2025. May this year's event be just as remarkable!

Dr. Joseph J. Kerski

Agendra Kumar
Managing Director, Esri

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10th Floor, Max Towers,
Sector - 16B, Noida, Uttar
Pradesh, India - 201301

Message

Centurion University of Technology & Management is a leading institution in Odisha to offer master's program in Geoinformatics. Esri India is honoured to partner with CUTM for GIS Day which is being celebrated on 19th November 2025. The themes selected for the poster competition are very inspiring. Dept. of Civil Engineering and Centre for Data Science & Machine Learning have together taken this initiative to organize GIS Day 2025 at such a large scale. GIS Day is celebrated every year for professionals to share their work and learn from each other. Adoption of GIS in India has gone up very significantly in last couple of years. GIS is supporting many new applications and is also leveraging data science and AI/ML for getting a better understanding of the world around us. It is important for students to learn GIS techniques as it offers tremendous employment opportunities as GIS professionals as well as users of GIS applications.

My compliments to CUTM – Dept. of Civil Engg. and Centre for Data Science, and all the delegates and participants on this occasion.

Happy GIS Day!!!

Agendra Kumar

Kalinga Konsult & Engineers

Innovate. Elevate. Dominate.

Bhubaneswar, Odisha

Message

It is a privilege for Kalinga Konsult & Engineers to extend warm greetings to Centurion University of Technology and Management, Paralakhemundi Campus, on the occasion of International GIS Day 2025, themed *"GeoAI and Smart Mapping for a Sustainable Tomorrow."*

As a multidisciplinary civil engineering consultancy based in Bhubaneswar, Kalinga Konsult & Engineers has always emphasized the integration of geospatial intelligence, advanced surveying technologies, and sustainable design principles in modern infrastructure development. Our services—ranging from aerial and LiDAR surveys, geotechnical investigations, and hydrological studies to BIM and CAD-based project design and management—reflect our commitment to precision, innovation, and sustainability

We are delighted to witness how GIS Day has evolved into a vibrant platform connecting academia, industry, and research. The overwhelming response of over 190 abstracts received this year demonstrates the growing enthusiasm among young engineers and scientists toward geospatial technologies and AI-driven applications.

We appreciate the efforts of Centurion University in nurturing talent and promoting interdisciplinary collaboration. On this proud occasion, Kalinga Konsult & Engineers conveys heartfelt congratulations to the organizers and participants. We firmly believe that initiatives like GIS Day will continue to inspire the next generation of innovators and contribute meaningfully to the vision of a smarter, sustainable, and data-driven future for our nation.

Panasian IP Services Panasian IP Services Attorneys-at-Law New Delhi, India

Message

It is with great pleasure that PanAsia IP Services Pvt. Ltd. extends heartfelt congratulations to Centurion University of Technology and Management, Paralakhemundi Campus, on organizing the International GIS Day 2025 with the theme *"GeoAI and Smart Mapping for a Sustainable Tomorrow."*

As a leading organization specializing in intellectual property protection, technology transfer, and innovation management, PanAsia IP Services is committed to fostering collaborations between academia, industry, and research organizations. We strongly believe that intellectual property plays a pivotal role in translating technological innovations—such as those emerging from GIS, Remote Sensing, and GeoAI—into tangible societal and environmental benefits.

The celebration of GIS Day serves as a vital platform for exchanging ideas and showcasing technological advances that address critical global challenges. It is inspiring to witness Centurion University's continued success since its first GIS Day celebration in 2021, and its growth into an international hub for knowledge sharing and applied geospatial research.

We are particularly delighted to learn that this year's event received over 190 abstracts, with 80 high-quality studies selected for presentation, reflecting a strong global participation.

PanAsia IP Services commends the efforts of the organizers and participants for their dedication to innovation and sustainable development. We extend our best wishes for the grand success of GIS Day 2025 and look forward to continued collaboration in advancing technology-driven progress.

Organizing Committee

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Keynote Abstracts

From Data to Decisions: Shaping a Spatially Intelligent Future

Roshan K. Srivastav
Project Director, IIT Tirupati Navavishkar I-Hub Foundation
Head, Geo-Intelligence and Applications Laboratory (Geo-Intel Lab), IIT Tirupati

Abstract

The convergence of Geospatial Intelligence (GeoAI) and Smart Mapping is redefining the way we understand, plan, and sustain our world. By integrating satellite data, IoT sensors, and AI-driven analytics, GeoAI transforms spatial information into real-time, actionable intelligence — empowering data-driven decisions in agriculture, water management, urban resilience, and climate adaptation. Smart Mapping enables the creation of digital twins that simulate complex systems, allowing predictive insights for resource efficiency and sustainability. As nations strive toward sustainable growth, GeoAI emerges as the digital backbone for environmental stewardship, infrastructure planning, and inclusive governance. India's emphasis on open geospatial data, indigenous innovation, and the integration of AI with mapping technologies positions it to lead globally in this transformation.

At the forefront of these national efforts, the Geospatial Intelligence and Applications Laboratory (Geo-Intel Lab) at IIT Tirupati Navavishkar I-Hub Foundation is fostering innovation, training, and technology platforms that align with India's vision of Viksit Bharat 2047, where spatial intelligence powers sustainable and equitable development. This keynote explores how the synergy between GeoAI and Smart Mapping is creating pathways toward a smarter, resilient, and sustainable tomorrow.

Keywords: Geospatial Intelligence (GeoAI), Smart Mapping, Digital Twins, Viksit Bharat 2047, and Sustainable Growth

GIS based Multi - Criteria Decision Making Models for Assessing Coastal Vulnerability

M. L. Narasimham
Retd Professor of Civil Engg., Andhra University, Visakhapatnam
Govt of Andhra Pradesh

Abstract

Multi-Criteria Decision Making (MCDM) methods, integrated with Geographic Information Systems (GIS), offer a structured framework to assess coastal vulnerability by quantitatively evaluating key spatial variables. These approaches allow simultaneous consideration of diverse criteria and sub-criteria, each influencing the vulnerability of coastal zones in distinct ways. The integration of MCDM and GIS provides an objective approach for analyzing and visualizing the effects of key vulnerability factors, supporting region-specific coastal risk planning and parameter-based vulnerability delineation.

In this paper the importance of MCDM techniques is presented along with an information on its applications in the field of water resources. A brief mention of the basic methodology of most commonly used MCDM methods (AHP method, TOPSIS method and Fuzzy Logic Integration approach) is presented to give an insight on their applicability. The factors that influence the coastal stability are identified in two categories viz., Physical factors and Socio-economic parameters. The physical factors include coastal geomorphology, shoreline change rate, coastal slope, tidal range, significant and wave height, The socio-economic factors are population density and land use add further granularity to the evaluation.

MCDM - GIS integration framework for computing the Coastal Vulnerability Index (CVI) is presented along with an information on the sources of data corresponding to the parameters that enable to compute the CVI. Three case studies including the one which is currently under progress is presented in detail. The following are the case studies discussed in this paper:

1) Coast Of South Carolina, USA
2) Kozhikode Coast, Kerala and
3) Coastal Stretch of Kakinada District, Andhra Pradesh

For each of the case the parameters considered, the series of layers developed and their integration for arriving at the CVI of the study are discussed along with individual CVI maps for those coastal belts.

Keywords: Coastal Vulnerability Index, GIS, MCDM, AHP, Shoreline Change, Coastal Slope, Tidal Range, Spatial Analysis

GIS Applications

Tourism-Led Urban–Rural Interface Planning for Raimona National Park, Assam: Ecological Zoning, Community Livelihoods, and Low-Impact Destination Design

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Abstract

Raimona National Park, declared in 2021, lies in the westernmost part of Assam within the Bodoland Territorial Region (BTR), forming part of the Indo-Bhutan landscape that connects with Bhutan's Phibsoo Wildlife Sanctuary and West Bengal's Buxa Tiger Reserve. This strategic location positions Raimona at a tri-junction of ecological and socio-cultural exchange, while its proximity to Kokrajhar (35 km), Bongaigaon (65 km), Alipurduar (90 km), and Gelephu in Bhutan (25 km) makes it a potential gateway for cross-border eco-tourism. The park, home to rich flora and fauna including golden langurs, elephants, and hornbills, offers significant opportunities for conservation-linked development. This study investigates how Geographic Information Systems (GIS) can be applied to structure a tourism-led planning framework for the urban–rural interface of Raimona National Park. By integrating satellite imagery, protected area boundaries, and OpenStreetMap road networks, the research develops a zoning framework that differentiates between core conservation zones, buffer regions, and potential eco-tourism areas. Spatial analysis of accessibility corridors highlights key connectivity routes from nearby towns and state highways to the park entrance, identifying gaps in last-mile road infrastructure. Beyond physical planning, the study incorporates community livelihood mapping, focusing on fringe villages such as Kachugaon, Rhaijuli, and Saralpara. Local opportunities in homestays, handicrafts, cultural tourism, and guided forest treks are spatially linked to eco-tourism zones, ensuring equitable distribution of tourism benefits. The GIS-based approach also provides insights into minimizing ecological impacts by guiding the siting of visitor facilities, entry points, and interpretation centers. The outcome is a GIS-supported urban–rural interface model that balances ecological sensitivity with livelihood needs, promoting Raimona as a low-impact, sustainable tourism destination. The proposed model not only strengthens regional connectivity within Assam and BTR but also enhances Raimona's role in the transboundary conservation landscape shared with Bhutan and West Bengal.

The findings highlight the transformative role of GIS as a decision-support system in protected area tourism planning. By visualizing ecological zones, infrastructure gaps, and community assets in an integrated framework, GIS enables policymakers, planners, and local stakeholders to jointly design development strategies that conserve biodiversity while empowering communities. This approach is replicable for other emerging protected areas in Northeast India, positioning tourism as a bridge between conservation and development.

Keywords: Raimona National Park, GIS, Tourism Planning, Urban–Rural Interface, Ecological Zoning, Community Livelihoods, Bodoland Territorial Region

Resilient Infrastructure Planning through 3D GIS and Real-Time Simulations

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Abstract

Integrating geospatial digital twins with simulation modeling is changing how we operate. This new technology helps in planning, monitoring, and optimizing natural and built environments. A geospatial digital twin is a dynamic, data-driven replica of real-world systems. It is created using Geographic Information Systems, LiDAR, remote sensing, and IoT sensor networks. Unlike static 3D models, these twins continually evolve in near real-time. This allows for predictive simulations and decision-making across various fields.

This paper outlines a framework to develop geospatial digital twins based on 3D GIS, BIM, and real-time sensor feeds for sustainable infrastructure planning. Simulation models within the twins enable stakeholders to compare flood risk maps, optimize traffic flow, monitor energy efficiency, and assess climate adaptation measures. In addition to immersive visualization with "what-if" simulation features, these systems give urban planners, policymakers, and engineers the chance to model risks, cut costs, and build resilience.

Case studies demonstrate how geospatial digital twins streamline asset management, improve disaster response, and promote sustainable urban development. With increasing climate variability and urban pressures, simulation modeling in a geospatial context becomes essential for supporting UN Sustainable Development Goals and creating future-ready cities.

Keywords: Geospatial Digital Twin, Simulation Modeling, 3D GIS, BIM Integration, Climate Resilience, Smart Cities, Sustainable Infrastructure, IoT-enabled Monitoring

Geospatial Intelligence for Smart Urban Mobility and Transport Systems

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Abstract

Urban transport systems are crucial for economic growth. Rapid urbanization has led to traffic congestion on one side and pollution on the other. This results in poor management of mobility. When GIS joins forces with artificial intelligence, IoT, and real-time data, they create a strong foundation for smart mobility solutions. This combination allows for predictive analytics, better routing, and sustainable transport planning.

This paper suggests a GIS-based framework for smart mobility. It shows applications in real-time trafficmonitoring, smart publictransport routing, EVinfrastructureplanning, and accident hotspot prediction. GeoAI models use spatial and temporal analytics to predict travel demand patterns, optimize multimodal transport networks, and improve last-mile connectivity. Depending on the decisions that need to be made, dynamic decision-making happens through IoT sensor integration with GIS dashboards. Simulation models allow for exploring "what-if" scenarios, such as new road layouts or changes in traffic policy.

Case studies demonstrate how the smart mobility system affects traffic efficiency, reduces emissions, and enhances safety. These benefits help combat climate change and improve citizens' well-being. Therefore, this study concludes that transport analytics supported by GIS is essential for creating sustainable, fair, and future-ready urban mobility systems to meet SDG 11: Sustainable Cities and Communities.

Keywords: GIS, Smart Mobility, Urban Transport Systems, GeoAI, IoT, Traffic Forecasting, Sustainable Cities, SDG 11

Flood-Prone Area Prediction using GeoAI and GIS for Sustainable Disaster Management

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Abstract

Floods are among the most frequent and devastating natural disasters, causing significant loss of life, property, and infrastructure. Identifying and mapping flood-prone areas in advance is essential for effective disaster preparedness and sustainable urban planning. This study aims to develop a GeoAI-based predictive model to identify flood-vulnerable zones by integrating geospatial data with machine learning techniques. The proposed approach utilizes satellite imagery, rainfall records, land-use/land-cover data, and digital elevation models (DEM) within a GIS environment. Machine learning algorithms such as Random Forest will be applied to analyze spatial and environmental factors influencing flood occurrence and generate susceptibility maps. The resulting flood risk maps will support authorities in planning early warning systems, evacuation routes, and resilient infrastructure development. By combining GeoAI with GIS-based spatial analysis, this study demonstrates a simple yet effective framework for proactive disaster risk reduction. The outcomes are expected to contribute to building climate-resilient communities and advancing sustainable disaster management practices.

Keywords: GeoAI, Flood Susceptibility Mapping, Machine Learning, GIS, Disaster Risk Reduction

Spatio -Temporal variation of rainfall over Odisha

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Abstract

The study on Spatio-Temporal Variation of Rainfall over Odisha analyzes the changing patterns of rainfall distribution across different regions and time periods of the state. Odisha, located on the eastern coast of India, experiences significant variability in rainfall due to its diverse topography and monsoon influence. Using long-term rainfall data from meteorological stations and satellite-derived datasets, the study evaluates seasonal, annual, and decadal rainfall trends. Spatial interpolation techniques in GIS are applied to map the variation and identify rainfall zones. The analysis reveals that coastal districts receive higher and more consistent rainfall, while interior and western parts exhibit greater fluctuations and frequent drought occurrences. A declining trend in monsoon rainfall is observed in certain regions, indicating possible climate change impacts. The findings highlight the importance of spatial rainfall assessment for effective water resource management, agricultural planning, and disaster mitigation in Odisha.

Keywords: Spatio-temporal Analysis, Rainfall Variation, GIS, Climate Change, Water Resource Management.

Urban Sprawl Analysis Using Geospatial Approach-A Case Study of Paralakhemundi Municipality, Odisha, India

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Abstract

Urban sprawl, the unplanned and uncontrolled expansion of urban areas, poses significant challenges to sustainable development and environmental management. This study utilizes Geospatial Technology and Remote Sensing (RS) to analyse the patterns and dynamics of urban sprawl in Paralakhemundi Municipality, Odisha, India over the past two decades.

Satellite imagery from multiple time periods was processed and analysed using GIS-based classification techniques to detect changes in land use and land cover (LULC). The findings reveal a notable increase in built-up areas, particularly along transportation corridors and peripheral zones, highlighting the pressure of urban growth on natural and agricultural lands.

This case study emphasizes the effectiveness of GIS and RS tools in urban planning and monitoring, offering crucial insights for policymakers and local authorities to promote sustainable urban development. The study demonstrates how geospatial approaches can support informed decision-making in managing urbanization in small to mid-sized towns like Paralakhemundi.

Keywords: Urban Sprawl, Geospatial Technology, Remote Sensing (RS), Land Use and Land Cover (LULC), Sustainable Urban Development

GIS-Enabled Smart Mobility: Advancing Sustainable Urban Transport Systems

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Abstract

Rapid urbanization and the growing number of vehicles have made mobility management one of the most pressing challenges for modern cities. Efficient and sustainable transport systems are vital to minimizing congestion, reducing energy consumption, and curbing environmental pollution. Urban planners are now increasingly turning to advanced spatial technologies to address these complex issues. This paper explores how Geographic Information Systems (GIS) can enhance smart mobility planning and urban transport management. GIS enables the integration of spatial data, IoT sensors, and GPS tracking to analyze traffic flow, identify bottlenecks, and assess accessibility across diverse urban zones. Through spatial analysis and real-time mapping, GIS helps authorities visualize mobility patterns, plan multimodal connectivity, and make data-driven infrastructure decisions. The study highlights how GIS-based transport models can improve route optimization, enhance road safety, reduce travel time, and encourage the adoption of electric and public transport options. Moreover, GIS supports sustainable urban development by enabling predictive analysis for future transport demands and facilitating effective policy formulation. Ultimately, GIS acts as a powerful decision-support tool for developing smart, resilient, and environmentally responsible cities that prioritize both mobility efficiency and citizens' quality of life.

Keywords: GIS, Smart Mobility, Urban Transport, Spatial Analysis, Sustainable Cities, Intelligent Transport Systems.

Mapping of Land Use and Land Cover in Ponda Taluka for Sustainable Urban Planning

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Abstract

Urban planning is crucial as most regions are experiencing a rapid rise in urbanization. Although urbanization drives higher economic activity, scarce resources and limited land necessitate strategic control of urban expansion. Urban expansion in Goa, particularly in Ponda Taluka, has intensified following the 2018 policy amendment under Section 16B, which permitted the conversion of orchard lands into settlement zones. This regulatory change has accelerated unregulated spatial transformation, leading to the rapid growth of built-up areas at the expense of agricultural and vegetated lands. This study analyzes the spatio-temporal transformation of Land Use and Land Cover (LULC) in Ponda Taluka, Goa, with a focus on sustainable urban planning. Over the past three decades, Ponda has witnessed substantial shifts in land-use patterns driven by rapid urbanization, infrastructural development, and policy changes. The analysis employs satellite imagery from the Landsat series for the years 1991, 2013, 2018, and 2021. Supervised classification was performed using the Maximum Likelihood Algorithm (MLA) in GIS software. LULC was classified into five major categories: built-up areas, agriculture, vegetation, water bodies, and barren land. Accuracy assessments, including confusion matrices and Kappa coefficients, were conducted to validate the classification results. Findings reveal a threefold increase in built-up areas, rising from 7% in 1991 to approximately 22% in 2021, underscoring the rapid pace of urban transformation in the region.

Keywords: Urbanization, Land Use and Land Cover (LULC), Ponda Taluka, GIS and Remote Sensing, Sustainable Urban Planning

Landslide Hazard Zonation Using GIS And Remote Sensing

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Abstract

Landslides are among the most destructive natural hazards, causing significant loss of life, property damage, and environmental degradation. Effective identification and mapping of landslide-prone areas are essential for disaster management and land-use planning. This study focuses on Landslide Hazard Zonation (LHZ) using Geographic Information System (GIS) and Remote Sensing (RS) techniques. Various thematic layers such as slope, aspect, elevation, lithology, land use/land cover, rainfall, and drainage density were prepared and integrated within a GIS environment. Weighted overlay and analytical hierarchy process (AHP) methods were applied to evaluate the relative contribution of each factor to landslide susceptibility. The resulting zonation map categorizes the area into low, moderate, high, and very high hazard zones. The findings demonstrate that GIS and remote sensing are powerful tools for spatial analysis and provide a scientific basis for mitigating landslide risks and supporting sustainable development in vulnerable regions.

Keywords: Landslide, Natural Hazard, Environmental Damage, Disaster Management, Land Use/Land Cover

An Optimized YOLO–OpenCV Framework for Automated Flood Detection Using Remote Sensing Imagery

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Abstract

Flood is one of the most destructive natural calamities, often disturbing human being's life, destroying many lives and homes and make effect on local environment or ecosystem. Before time flood detection is playing a vital role in order to prevent this natural disaster like flood. This research come with an automated flood detection Frame work, which usually merge YOLO (you look only once) Deep Learning Model with image processing capability of OpenCV. The Model examine or analyze satellite images gathered from Open remote sensing sources like Sentinel, Google Earth etc. to recognize and map flooded regions. The Presented methodology offers YOLOv8 to distinct land and water area precisely, even in complicated environmental situations. OpenCV is used for preprocessing of an image and enhancing visualization using bound box which helps to improve the accuracy and efficiency of flood detection. Examined result data shows that model achieve high precision while developing low computational or operational cost which makes it suitable for monitoring of real time flood detection and making emergency response. The research study reveals that how GeoAI combining with deep learning model can buildup disaster management which leads to reduce the risks. Spatial analytics fusion and image recognition based on neural network provide an effective data driven solution helps for environmental monitoring, overall, the YOLO-OpenCV framework leads to climate resilience.

Keywords: YOLO, OpenCV, Flood Detection, Remote Sensing, Deep Learning, GeoAI, Climate Resilience, Disaster Management

Enhancing Community Resilience through Integrated Disaster Risk Reduction and Early Warning Frameworks

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Abstract

Disaster Risk Reduction (DRR) and Early Warning Systems (EWS) are essential components of sustainable development and community resilience, particularly in regions highly exposed to natural hazards such as floods, storms, and tsunamis. Disaster risks stem from the complex interaction between physical hazards and the vulnerability and exposure of human populations, infrastructure, and ecosystems. Understanding these relationships is fundamental to designing strategies that effectively minimize disaster impacts. An effective EWS provides timely and accurate information that enables communities and authorities to take preventive and responsive measures before a disaster occurs. However, many developing countries continue to face challenges in implementing and operating comprehensive warning systems due to limited resources, lack of awareness, and inadequate coordination among agencies. The devastating 2004 Indian Ocean tsunami highlighted the consequences of these gaps, where thousands of lives could have been saved through timely warnings and community preparedness. Modern EWS frameworks now integrate four key components: risk knowledge, monitoring and forecasting, communication and dissemination, and response capability. When all these elements function cohesively, EWS can substantially reduce disaster risks, strengthen preparedness, and build the resilience of at-risk populations. This research emphasizes the need for people-centered, technology-driven, and action-oriented early warning systems that are accessible, understandable, and usable at all community levels. Strengthening DRR frameworks through integrated EWS approaches is crucial for minimizing disaster-induced losses and promoting adaptive, resilient societies.

Keywords: Disaster Risk Reduction (DRR); Early Warning Systems (EWS); Natural Hazards; Risk Management; Sustainable Development.

Integrated Geospatial AI Agent Framework for Precision Agriculture Decision Support System

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Abstract

As food security becomes a pressing issue worldwide and the consequences of climate change keep getting worse, it is evident that traditional farming methods cannot satisfy the demands of modern agriculture anymore. This research is reshaping the landscape with the Integrated Geospatial AI Agent Framework for Precision Agriculture Decision Support System—a revolutionary platform programmed to change farmers' decision-making processes radically. The system, by fusing geospatial technologies with machine learning, creates a smart agricultural ecosystem that can scan and analyse 3000 geospatial data points relating to 54 environmental variables. This framework operates six different agricultural objectives simultaneously: monitoring water stress, detecting diseases, assessing soil health, optimizing irrigation, managing nitrogen, and forecasting crop yield, all by a single, integrated platform. The system put forward exhibits exemplary effectiveness as it attains 98.67% accuracy in water stress detection, 97% accuracy with a 94% F1-score for disease detection and complete accuracy for irrigation recommendations. Besides, the models for soil health monitoring, nitrogen management, and crop yield prediction have achieved R^2 values of 0.9608, 0.9997, and 0.9355, respectively, indicating their robust predictive capabilities. This multi-objective geospatial strategy with a strong point in the elimination of fragmented tools by providing local, data-driven insights that can be adjusted to different environmental conditions is what makes it different. By integrating GIS technology with Random Forest algorithms, the framework not only contributes to increased productivity but also, by maintaining soil quality, biodiversity, and water resources, serves as a vehicle for the implementation of global Sustainable Development Goals (SDGs), thus ensuring environmental sustainability.

Keywords: Precision agriculture, Geospatial AI, Machine learning, Decision support system, Sustainable development

Mapping of Groundwater Potential Zones in Vaishali District, Bihar Using Arc GIS

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Abstract

The study on mapping groundwater potential zones in Vaishali District, Bihar was done using remote sensing and GIS. Satellite data (SRTM, Landsat) and maps of geology, slope, soil, land use, rainfall, and drainage were used to find areas suitable for groundwater. Each layer was given a weight, and a weighted overlay method was applied to prepare the final map. The district was divided into Very High, High, Moderate, and Low groundwater potential zones. Flat areas with alluvial soil and low slope showed high groundwater potential, while hilly or built-up areas showed low potential. This study helps in water resource planning, well site selection, and recharge management. It shows that GIS and remote sensing are useful and low-cost tools for groundwater studies.

Keywords: Groundwater, GIS, Remote sensing, Vaishali, SRTM, Rainfall, Thematic maps.

Average Annual Rainfall Mapping for Supaul District Bihar in Arc GIS

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Abstract

This study presents an analysis of the average annual rainfall patterns in Supaul district, Bihar, with the objective of mapping spatial and temporal variations to support agricultural planning and water resource management. Supaul, located in the flood-prone Kosi region, experiences highly variable monsoonal rainfall that significantly affects local livelihoods. Using rainfall data collected over the past two decades from the India Meteorological Department (IMD) and local weather stations, this research employs Geographic Information System (GIS) tools to create a detailed rainfall distribution map for the district. The analysis reveals that while the district receives an average annual rainfall of approximately 1100–1300 mm, the distribution is uneven, with southern regions generally receiving less rainfall compared to northern parts closer to the Kosi river. The findings can help policymakers and farmers adopt region-specific strategies for crop selection, irrigation planning, and flood management. This mapping also provides a baseline for climate change impact assessments in the region.

Keywords: Supaul District Bihar Average Annual Rainfall Rainfall Mapping Geographic Information System (GIS) Monsoon Spatial Distribution

A Review on Landscape Ecology

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Abstract

Landscape ecology deals with the spatial structure, internal functions and the relationship between the various parts of the landscape. The complex of landscape processes represents a gamut of interacting variables of geology, soils, vegetation and climate. Landscapes are repositories of the history of changes and constructing a framework of event stratigraphy demands collection of varied information stored therein. As like as trees indicate the changes in tropical forest ecosystems, the abiotic geomorphological features can serve as robust indicators of landscape level change dynamics. The GIS integrated remote sensing technology and data have been proved to be of immense application in geomorphology including terrain modelling and analysis. This fulfils the crucial ambition within landscape ecology to improve understandings of the interactions between natural environments and human societies in landscapes. This has led to 'land system mapping' and 'ecological land classification' being described in literatures spreading the importance of landscape ecology in modern society with accelerated primary native ecosystem conversion and degradation in the earth. The integrated landscape planning requires balancing multiples ofsuch ecosystemtypes. Species distribution models use predictors and result in probability levels of species distribution in landscapes, regions, and continents. Environmental gradients across landscapes play crucial role in the plant species distribution and considered as key factors in the physiognomy (structure) of plant communities. Debates on ecology and biogeography have focused on factors controlling regional variation in species richness. Out of the generally observed patterns viz. a monotonic decrease in species richness with increasing elevation and a hump-shaped relationship with a peak in species richness at intermediate elevations, the latter is common in both tropical and non-tropical biomes. India has a rich biodiversity due to its geodiversity in terms of geography, climate and geological entities. The first national level mapping of forest cover of India was carried out using remote sensing during 1983. Subsequently, the Forest Survey of India (FSI) has been mapping the forest cover biennially. This is useful for land reclamation and geo-environmental planning and management. The present study addresses the UN Sustainable Development Goal No. 3, 9, 11, 13, 14 and 15.

Key Words: Landscape, Terrain modelling, Ecological land classification

Geospatial Analysis of Urban Sprawl and Land Use Dynamics in Paralakhemundi Municipality, Odisha

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Abstract

Urban sprawl, the unplanned and uncontrolled expansion of urban areas, poses significant challenges to sustainable development and environmental management. This study utilizes Geospatial Technology and Remote Sensing (RS) to analyse the patterns and dynamics of urban sprawl in Parlakhemundi Municipality, Odisha, India over the past two decades. Satellite imagery from multiple time periods was processed and analysed using GIS-based classification techniques to detect changes in land use and land cover (LULC). The findings reveal a notable increase in built-up areas, particularly along transportation corridors and peripheral zones, highlighting the pressure of urban growth on natural and agricultural lands. This case study emphasizes the effectiveness of GIS and RS tools in urban planning and monitoring, offering crucial insights for policymakers and local authorities to promote sustainable urban development. The study demonstrates how geospatial approaches can support informed decision-making in managing urbanization in small to mid-sized towns like Paralakhemundi.

Keywords: Urban sprawl, Geospatial technology, Remote sensing, Land use and land cover (LULC), Sustainable urban development

Land used and Land cover using GIS and RS Begusarai

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Abstract

Land Use and Land Cover (LULC) analysis plays an important role in understanding the relationship between human activities and the natural environment. This study uses Geographic Information System (GIS) and Remote Sensing (RS) techniques to identify, classify, and analyze different land use and land cover types in a selected region. Satellite imagery and spatial data were processed and analyzed to detect changes over time, including agricultural expansion, urban growth, water bodies, and forest cover. The integration of GIS and RS provides accurate, efficient, and up-to-date information for environmental management and planning. The results help in assessing the impact of land use changes on natural resources and support sustainable development strategies.

Keywords: Land Use, Land Cover, GIS, Remote Sensing, Satellite Imagery, Spatial Analysis, Urbanization, Environmental Monitoring, Change Detection, Sustainable Development

Development of Drainage Diversion System in Mineral Exploration Activity Zone using Spatial Engineering Methodology for Baphlimali Bauxite Mines

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Abstract

This study emphasizes the minimisation of environmental effects like sedimentation, water pollution, and land degradation, through the development of drainage diversion system for the Baphlimali Bauxite Mines. The data collection on land use, mining activity, and environmental compliance was done and GIS based geospatial analysis was performed to evaluate the land-use changes, hydrological impacts of the mine area in its vicinity to ascertain the conformity with environmental regulations. The infrastructure evaluations for studying the efficacy of mitigating structures including drains and settling ponds was also part of the methodical approach. The results expose significant changes in land use pattern; agricultural land and scrub woodlands which are the most influenced elements. The compliance assessments revealed compliance percentage of 50% indicating partial adherence to environmental protections act particularly for groundwater monitoring. the infrastructure studies, revealed that concrete drains and parapet walls showed more efficiency, while settling ponds were rather successful in reducing sedimentation. Environmental monitoring showed improvements in dissolved oxygen levels; still, continuous problems with turbidity exists. The paper underscores the need for improved mitigation infrastructure, enhanced enforcement of environmental laws, and targeted interventions aiming at long-term sustainability in mining activities.

Keywords: Environmental Management, Geospatial Analysis, Mining Impacts, Sustainability Evaluation, Compliance Assessment

Smart Infrastructure Planning with GIS and AI

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Abstract

The objective of this project is to implement a simple, data-driven framework for Smart Infrastructure Planning by integrating Geographic Information Systems (GIS) with basic Artificial Intelligence (AI) techniques. The focus is on ensuring equitable distribution and optimal placement of a specific public amenity (e.g., public transit stops, recycling centers, or charging stations) within an urban environment. Traditional planning often relies on generalized metrics, leading to potentially underserved or over-saturated areas. Our methodology leverages the inherent spatial analysis capabilities of GIS to compile and preprocess crucial datasets, including high-resolution population density maps, existing infrastructure locations, and relevant socioeconomic factors. This spatial data forms the foundation for the "Smart" component. We then employ straightforward AI/Machine Learning methods, primarily spatial regression and clustering algorithms. Spatial clustering is used to objectively identify neighborhoods that exhibit high demand (high population density) but have poor service coverage (long distance to the nearest existing amenity). A basic suitability model is then trained using linear regression to predict the optimal sites for new installations based on minimizing travel time and maximizing neighborhood accessibility. The final output is a high-priority suitability map generated within the GIS environment, clearly ranking potential locations. This project demonstrates how simple GeoAI can move infrastructure decisions beyond intuition, providing municipal planners with a transparent, cost-effective, and equity-focused tool for sustainable urban development.

Keywords: Smart Infrastructure Planning, Geographic Information Systems (GIS), Artificial Intelligence (AI), Spatial Analysis, Sustainable Urban Development

A GeoAI-Driven Framework for Road Damage Detection using AI and GIS

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Abstract

Roads are very important for travel and daily life, but when they get damaged, it causes accidents, traffic jams, and vehicle problems. In many cities, people still check road conditions manually, which takes a lot of time and is not always correct. To solve this problem, our project "Road Damage Detection using AI and GIS" will help to automatically find and report road damages. In this project, we are using Artificial Intelligence (AI) to detect cracks, potholes, and other damages from road images or videos taken by cameras or drones. The AI model, made with tools like Python, TensorFlow, OpenCV, and TFLite, will identify damaged areas. After that, GIS (Geographic Information System) will be used to show the exact location of those damaged areas on a digital map. This will help government authorities to quickly see which roads need repair and plan maintenance work in a better way. It will save time, reduce manual work, and make roads safer for everyone. In the future, this system can also be used to check other infrastructure like bridges and footpaths. Our main goal is to use technology to build smart and safe cities where road problems can be detected early and solved faster.

Keywords: Road Damage Detection, Artificial Intelligence (AI), Geographic Information System (GIS), Deep Learning, Smart City Planning

Integrated Hydrological Modeling Approach for Scenario Generation toward Sustainable Water Management in the Tel River Basin

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Abstract

The Tel River Basin in western Odisha, a crucial tributary of the Mahanadi, faces rising pressures from agricultural intensification, variable water resources, and evolving land use patterns. To assess hydrological dynamics and support integrated water management, the SWAT+ model was deployed, with careful calibration at Kantamal and Kesinga gauges using a 15-year record (2000–2015) and the DDS algorithm. Calibration delivered strong Nash–Sutcliffe Efficiency (NSE) of 0.80 for Kantamal and high performance at Kesinga; validation for 2015–2020 confirmed robustness (NSE 0.78, 0.76).

A global sensitivity analysis identified the percolation coefficient as the most influential parameter (sensitivity 0.76) for subsurface flow, followed by deep aquifer bottom depth (0.10), shallow yield (0.06), soil water capacity (0.01), and curve number (0.004). Canopy leaf area and soil hydraulic conductivity also affected runoff and evapotranspiration, while baseflow and initial water table depth played a minimal role. These results reveal that soil-plant-aquifer interactions are pivotal for accurate water balance modeling and guide further data refinement.

Scenario simulations assessed interventions to improve water use efficiency, change cropping patterns, and enhance groundwater recharge. Model projections show increased water use efficiency and groundwater recharge both support baseflows and environmental flows, while crop diversification reduces overall water demand and improves reliability of streamflow. These results directly inform policy efforts such as PMKSY, Atal Bhujal Yojana, and the REWARD program, enabling climate-resilient, sustainable watershed strategies for the region. The Tel River Basin model offers a robust decision-support platform for optimizing water resource management under changing conditions.

Keywords: Integrated hydrological modelling, DDS algorithm, water use efficiency, groundwater recharge, cropping pattern, environmental flow

Smart Water Resource Management through GeoAI

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Abstract

The increasing demand for clean and sustainable water resources has become one of the most pressing global challenges of the 21st century. The integration of Geospatial Artificial Intelligence (GeoAI) provides an innovative approach to manage water resources more efficiently and intelligently. The study, "Smart Water Resources Management through GeoAI", explores how the fusion of geospatial technologies – such as remote sensing, GIS and satellite data – with artificial intelligence techniques could revolutionize water monitoring, distribution and conservation. GeoAI enables real-time analysis of spatial and temporal data, which supports predictive modeling to predict rainfall patterns, groundwater depletion and flooding. Machine learning algorithms process vast environmental datasets to detect water quality issues, optimize irrigation systems, and identify areas vulnerable to drought or pollution. By automating data collection and analysis, GeoAI facilitates better decision making for policy makers and engineers in achieving sustainable water governance. The integration of cloud computing and IoT sensors further increases data accessibility and accuracy, allowing dynamic and adaptive water management strategies. Ultimately, GeoAI-powered smart water management promotes sustainability, resilience, and equitable distribution of water resources while addressing the growing challenges of climate change and population growth. This interdisciplinary approach combines environmental science, data analysis and engineering to ensure long-term water security.

Keywords: GeoAI, Smart Water Management, Remote Sensing, GIS, Artificial Intelligence, Sustainable Water Resources

A Hybrid CNN–RNN Framework for Landslide Risk Mapping from Satellite Imagery and Environmental Factors

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Abstract

Landslides are among the most devastating natural disasters, often triggered by complex interactions between geological, hydrological, and meteorological factors. This study proposes a deep learning–based framework for satellite image analysis to predict landslide-prone regions with enhanced accuracy. The model integrates multispectral and high-resolution satellite imagery with environmental variables such as rainfall intensity and soil tightness to improve early detection. Convolutional Neural Networks (CNNs) are employed to automatically extract spatial and spectral features from satellite data, while temporal rainfall trends are incorporated through Recurrent Neural Networks (RNNs) to model time-dependent variations influencing slope stability. Soil compactness or tightness, derived from ground-based or remote sensing measurements, is included as a key predictor to assess vulnerability under varying moisture conditions. The fusion of these multimodal inputs enables the system to capture both surface patterns and subsurface stability indicators that traditional statistical models often overlook. The proposed approach aims to generate probabilistic risk maps identifying zones of potential failure before the occurrence of actual landslides. Experimental results using historical satellite datasets and regional rainfall records demonstrate that the hybrid CNN–RNN model achieves higher prediction accuracy compared to conventional threshold-based or regression techniques. This research highlights the significant role of deep learning in integrating satellite imagery, rainfall data, and soil properties for proactive landslide risk management and disaster mitigation planning.

Keywords: Landslide prediction, satellite imagery, Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), disaster risk management.

Energy and Emission Efficiency of Diesel and Electric Pumps for Groundwater Irrigation in Nayagarh District, Odisha

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Abstract

Groundwater is the principal source of irrigation in Nayagarh district, Odisha, where seasonal fluctuations strongly influence irrigation demand and energy use. This study assesses the efficiency of diesel and electric pumps for groundwater extraction using block-level data from the 6th Minor Irrigation Census. Pre-monsoon water depths range from 5.75 m bgl in Gania to 9.08 m bgl in Ranapur, with Ranapur, Nayagarh, and Nuagaon showing high seasonal fluctuations indicative of intensive groundwater use. Agriculture covers 74% of the district's land, largely under kharif crops dependent on groundwater. Pump capacity varies by hydrogeological setting and smaller horsepower pumps are common in Gania and Odagaon with shallow aquifers, while higher horsepower pumps are used in Bhapur, Khandapada, and Ranapur due to deeper water tables. Energy and emission efficiency were estimated for shallow, medium, and deep tubewells across blocks. Ranapur emerged as the most energy- and emission-intensive block, with diesel pumps consuming up to 0.048 kWh/m³ and emitting 0.128 kg CO_2/m³. Nayagarh block was most efficient for tubewells, while Gania performed best for dug wells. Overall, diesel pumps produced 3–4 times more CO_2 than electric pumps. Results suggest that replacing diesel with electric or solar pumps, combined with micro-irrigation, could substantially reduce emissions. Targeted interventions are needed in hotspots such as Ranapur and Bhapur, while efficient practices in Nayagarh and Gania provide scalable models for sustainable groundwater use.

Keywords: Groundwater extraction, Energy consumption, Carbon-CO_2 emissions, Diesel vs. electric pumps, Agricultural electrification.

Integrated Hydrological Modelling Approach for Scenario Generation toward Sustainable Water Management in the Tel River Basin

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Abstract

The Tel River Basin in western Odisha, a vital tributary of the Mahanadi River, is experiencing growing challenges due to agricultural intensification, fluctuating water resources, and changing land use patterns. To evaluate the basin's hydrological dynamics and promote sustainable water management, the SWAT+ model was employed and calibrated at the Kantamal and Kesinga gauging stations using a 15-year dataset (2000–2015) with the DDS algorithm. Model calibration demonstrated excellent performance with Nash–Sutcliffe Efficiency (NSE) values of 0.80 at Kantamal and 0.76 at Kesinga, while validation (2015–2020) yielded similarly robust results (NSE 0.78 and 0.76). Global sensitivity analysis identified the percolation coefficient as the most influential parameter (sensitivity 0.76) affecting subsurface flow, followed by deep aquifer bottom depth (0.10), shallow yield (0.06), soil water capacity (0.01), and curve number (0.004). Parameters such as canopy leaf area and soil hydraulic conductivity also influenced runoff and evapotranspiration, whereas baseflow and initial water table depth played minor roles. These findings highlight the critical role of soil–plant–aquifer interactions in water balance modelling and underscore the need for refined data inputs. Scenario-based simulations further assessed strategies to enhance water use efficiency, modify cropping patterns, and increase groundwater recharge. Results indicated that improved water use efficiency and groundwater recharge substantially bolster baseflows and environmental flow regimes, while crop diversification reduces water demand and enhances streamflow reliability.

Keywords: Integrated hydrological modelling, DDS algorithm, water use efficiency, groundwater recharge, cropping pattern, environmental flow.

Role of GeoAI in Disaster Mitigation and Management

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Abstract

GeoAI (Geospatial Artificial Intelligence) represents a transformative convergence of Artificial Intelligence (AI), Machine Learning (ML), and Geographic Information Systems (GIS) that is redefining the landscape of disaster mitigation and management. Through intelligent integration of satellite imagery, remote sensing, and advanced spatial analytics, GeoAI empowers authorities to predict, monitor, and respond to both natural and anthropogenic disasters with unprecedented precision and speed. By identifying vulnerable zones, assessing real-time risk exposure, and forecasting the probability of events such as floods, earthquakes, cyclones, and landslides, GeoAI facilitates proactive mitigation strategies. During emergency phases, it enables automated mapping, real-time surveillance, and damage assessment that drive swift evacuations and efficient allocation of resources. Post-disaster, GeoAI continues to support recovery operations by analyzing the spatial extent of damage, prioritizing rehabilitation, and strengthening long-term resilience planning. Its capability to process and interpret massive geospatial datasets bridges the gap between data science and decision-making, helping governments and organizations develop smarter, sustainable, and disaster-resilient communities. Ultimately, GeoAI emerges not merely as a technological advancement but as a strategic enabler of global safety, sustainability, and resilience in the face of evolving environmental challenges.

Keywords: GeoAI, Disaster Management, Artificial Intelligence, GIS, Machine Learning, Sustainable Development.

Remote Sensing Applications

SAM-Guided Automated Pipeline for Land Cover Change Detection

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Abstract

Land cover change detection plays an essential role in understanding how the Earth's surface is being altered over time. Land cover change detection offers key information on environmental dynamics, urbanization, deforestation, agricultural change, and natural resource management. Detection of these changes is especially critical in the contexts of climate change, biodiversity conservation, and sustainable development, where precise and timely information is necessary to inform decision-making. With the advent of the sudden increase in multitemporal and high-resolution satellite data, there exists a demand for accurate, automated, and scalable approaches with the capability of detecting and analysing land cover changes across large geographical areas over time. This research work presents a Segment Anything Model (SAM) -based automated pipeline for land cover change detection from multitemporal satellite images. The pipeline utilizes the SAM, a state-of-the-art deep learning model for image segmentation applicable in diverse settings. In this methodology, SAM is utilized to segment satellite images into useful land cover classes like forest, water, agriculture, and urban areas, which in turn are used to build the framework for change detection and quantification. The process is formulated as an end-to-end system composed of data preprocessing, SAM-segmentation, temporal feature extraction, and automatic change detection.

The products of the pipeline consist of high-resolution change maps, visual overlays, and statistical overviews that emphasize the spatial extent as well as intensity of land cover changes. The outputs contain actionable information that can be utilized for environmental monitoring, disaster management, sustainable land-use planning, and policy formulation. In summary, the presented framework presents a scalable, precise, and flexible solution for long-term Earth observation studies.

Keywords: Segment Anything Model, Land Cover Change Detection, Multitemporal satellite images, Image Segmentation, Environmental Monitoring, Change Detection

Automated GLOF System: Fusing Satellite Imagery and AI for Lake Detection and Breach Risk Forecasting in Mountain Regions

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Abstract

Glacial Lake Outburst Floods (GLOFs) are sudden and destructive hazards that occur when moraine- or ice-dammed lakes fail, releasing large volumes of water downstream. These events pose severe risks to mountain communities, infrastructure, and ecosystems. With the increasing impacts of climate change and glacier retreat, the frequency and scale of GLOFs are expected to rise, creating a pressing need for systematic monitoring and early warning systems. Current manual or semi-automated approaches are often limited by cloud cover, sparse in-situ measurements, and region-specific applicability. This project develops an automated system that combines remote sensing, machine learning, and time-series analysis to detect and forecast GLOF risks. Lake detection integrates optical data (Sentinel-2, Landsat) with radar imagery (Sentinel-1) to ensure robustness under variable conditions. Segmentation networks such as U-Net and YOLOv5-Seg are employed to delineate lake boundaries, which are then vectorized to generate temporal records of lake area, shoreline dynamics, and expansion rates. These are complemented by DEM-derived morphometric features (e.g., rim height, slope, estimated volume) and climate anomaly indicators (rainfall, temperature). Forecasting employs sequence models (LSTM, Transformer), survival analysis networks, and ensemble learning. A hybrid design integrates morpho dynamic susceptibility indices with learned temporal dependencies, addressing the scarcity of historical breach events. Model performance is evaluated using spatio-temporal holdouts and region-transfer tests, with accuracy measured by IoU, F1-score, ROC-AUC, C-index, and predictive lead time. The system generates per-lake risk assessments, reporting breach probabilities, time windows, and uncertainty intervals. By fusing multi-source Earth observation data with advanced forecasting models, this framework supports scalable early warning systems in high-risk mountain regions.

Keywords: Glacial Lake Outburst Floods (GLOFs), Satellite Imagery Fusion (Sentinel-1 & Sentinel-2, Landsat), Deep Learning Segmentation (U-Net, YOLOv5-Seg), Digital Elevation Model (DEM), Breach Risk Forecasting, Sequence Models (LSTM, Transformer), Early Warning System

Remote Sensing and Deep Learning for Climate Resilience

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Abstract

Climate-induced disasters such as floods, droughts, and heatwaves continue to intensify, creating severe challenges for ecosystems, infrastructure, and human well-being. While recent advances in remote sensing and deep learning have significantly improved climate hazard prediction, existing approaches often emphasize model accuracy without addressing broader challenges of scalability, interpretability, and integration with socio-economic realities. This paper proposes a conceptual framework that advances climate resilience by combining multi-source remote sensing data with deep learning architectures. Specifically, spatio-temporal models such as CNN-LSTM and ConvLSTM are employed for hazard forecasting, segmentation networks such as U-Net and SegNet are applied for vulnerability mapping, and ensemble approaches including CNN-LSTM-XGBoost are explored for uncertainty reduction. Furthermore, explainable AI (XAI) techniques such as Grad-CAM and SHAP are incorporated to ensure that model outputs are transparent, interpretable, and actionable for policymakers and communities. Unlike existing methods, the framework emphasizes the integration of socio-economic indicators with environmental variables to provide holistic risk assessments.

The contribution of this paper is: People today face increasing risks from floods, droughts, and heatwaves, but existing prediction systems are often limited in accuracy, transparency, and practical usefulness. I wrote this paper to propose a framework that combines remote sensing, deep learning, and socio-economic data to create more reliable, interpretable, and actionable climate risk assessments. The goal is to provide better early warnings and support policymakers and communities in building stronger climate resilience.

Keywords: Climate Resilience, Climate-Induced Disasters, Remote Sensing, Deep Learning, Spatio-Temporal Models, Vulnerability Mapping, Explainable AI (XAI), Risk Assessment

Remote Sensing and Deep Learning for Climate Resilience

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Abstract

Climate change poses unprecedented risks to ecosystems, infrastructure, and human livelihoods, demanding innovative approaches to enhance resilience. Monitoring environmental changes including droughts, floods, wildfires, deforestation, and urban heat islands is made possible by remote sensing, which provides large-scale, continuous, and multi-temporal measurements of the Earth's surface and atmosphere. However, extracting useful knowledge from these enormous datasets requires powerful analytical approaches. Deep learning has evolved as an effective technique for modeling complicated spatial-temporal patterns, improving prediction accuracy, and enhancing decision-making. Convolutional neural networks (CNNs) are commonly used for land-use and flood mapping, recurrent models like LSTMs help forecast extreme occurrences, and generative models help restore missing climate data. The integration of remote sensing and deep learning improves early warning systems, risk assessment, ecosystem monitoring, and infrastructure development, ultimately enhancing climate resilience. Despite challenges such as data gaps, processing demands, and interpretability, breakthroughs in multi-source data fusion, explainable AI, and real-time monitoring show promise for reducing the science-policy distinction. The combination of remote sensing and deep learning provides a transformative approach toward proactive climate adaptation and sustainable development.

Keywords: Remote Sensing, Deep Learning, Climate Resilience, Spatio-temporal Modeling, Sustainable Development

Satellite-driven Geo-AI Analytics for Land Price Prediction in India's Dynamic Markets- A New Era in Urban Planning

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Abstract

Land prices in India have experienced a significant escalation in recent years, shaped by spatial location, infrastructure quality, and socio-economic dynamics. Critical drivers include proximity to major transport links, planned development areas, new infrastructure corridors, and access to amenities, all contributing to intense competition for land in urban centres, yet lacking a consistent, objective mechanism for land valuation, leading to information asymmetry and speculative pricing. This research proposes an integrated Geographic Information System (GIS) and Artificial Intelligence (AI) framework to address the limitations of traditional valuation methods, which are often subjective, time-consuming, and prone to bias. The study incorporated Sentinel satellite data for land use and land cover (LULC) classification, leveraging its high-resolution multi-spectral imagery to analyze land use patterns across the study area. GIS tools are employed for spatial pre-processing, enabling the extraction of location-based features such as distance to urban centres, road connectivity, and land cover types. These features are integrated with non-spatial attributes like property size, zoning regulations, and demographic indicators. The Analytic Hierarchy Process (AHP) within a GIS framework is implemented to model and assess these factors, providing a traditional, multi-criteria decision-making approach. However, the results obtained showed that AHP's reliance on subjective weight assignments and limited capacity for handling large, heterogeneous datasets reduces its predictive accuracy, particularly for dynamic real estate markets. To overcome these limitations, this study integrated advanced machine learning techniques, specifically the Random Forest algorithm, to develop a robust predictive model for land price estimation. The Random Forest approach enhanced objectivity by automatically learning relationships from historical transaction data and spatial attributes, accommodating non-linear interactions and improving generalization across diverse urban hubs.

The results contributed to transforming how cities forecast and manage urban expansion, population density shifts, and land use planning. Thus, the research presented a transformative opportunity for land price analysis in India, offering a scalable, objective, and accurate alternative to conventional appraisal methods. By harnessing spatial intelligence and machine learning, this research aims to establish a standardized valuation framework that promotes market transparency, supports equitable development, and informs evidence-based policy decisions in the rapidly evolving Indian real estate sector.

The significance of this study extends beyond real estate forecasting, aligning directly with several Sustainable Development Goals (SDGs), including SDG 11 (Sustainable Cities and Communities) by promoting informed urban planning, SDG 9 (Industry, Innovation, and Infrastructure) through data-driven infrastructure development, and SDG 1 (No Poverty) by supporting equitable land valuation and policy formulation. Moreover, the predictive framework offers actionable insights for urban development authorities, municipal corporations, and revenue departments, facilitating transparent taxation, effective zoning, and efficient resource allocation.

Keywords: Land Prices, Synthetic Aperture Radar (SAR), Geospatial-machine learning (Geo-ML) techniques, Real Estate Sector, and predictive analytics.

Mineral Resource Mapping of Mayurbhanj District, Odisha Using GEE

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Abstract

Mayurbhanj District, Odisha's largest (10,418 km²), hosts diverse mineral resources within its Precambrian geological framework, including the Simlipal Hill Range and Singhbhum Shear Zone. This abstract summarizes mineral mapping efforts leveraging Google Earth Engine (GEE), integrating satellite imagery, geospatial datasets, and machine learning to delineate metallic and non-metallic deposits as of 2025. GEE's cloud-based platform facilitated analysis of Landsat-8/9, Sentinel-2, and ASTER imagery, combined with geophysical (gravity-magnetic) and geochemical data from the Geological Survey of India (GSI) and Odisha Directorate of Mines, to map key minerals with high accuracy.

Key Minerals and Spatial Distribution: Iron Ore, Manganese, Gold, Others: Minor bauxite, chromite, and limestone

Keywords: Minerals in Mayurbhanj District, Mineral Mapping, Google Earth Engine (GEE), Satellite Imagery, Machine Learning

Estimating Carbon Stock

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Abstract

The study focuses on quantifying the total carbon stock stored in vegetation and soil within the Paralakhemundi region of Gajapati district, Odisha, India. Located in the Eastern Ghats, this hilly and forested landscape serves as an ideal site for assessing terrestrial carbon dynamics. The objective of the research is to estimate carbon storage across different land use and vegetation types using field-based biomass measurements, remote sensing data, and allometric models. Satellite imagery, point and area data, and land cover maps were integrated within a GIS framework to classify vegetation strata and estimate above-ground biomass (AGB), below-ground biomass (BGB), and soil organic carbon (SOC). Biomass estimation was performed using species-specific and generalized allometric equations derived from diameter at breast height (DBH) and tree height data. The results indicate a total carbon stock of approximately 152.5 Mg C/ha, comprising 85.6 Mg C/ha from AGB, 20.5 Mg C/ha from BGB, 42.3 Mg C/ha from SOC, and 4.1 Mg C/ha from litter and deadwood. The dense forest zones demonstrated the highest carbon storage, functioning as major carbon sinks, whereas degraded and agricultural areas showed lower carbon content. This study highlights the effectiveness of integrating remote sensing and field-based approaches for accurate carbon assessment. The findings contribute valuable insights for sustainable land management, forest conservation, and climate change mitigation strategies, aligning with national and global carbon accounting frameworks.

Keywords: Carbon Stock Estimation, Remote Sensing, Above-Ground Biomass (AGB), Soil Organic Carbon (SOC), Climate Change Mitigation

Climate Change Impact Assessment on Water System

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Abstract

Climate change poses significant challenges to water systems globally, affecting water availability, quality, and distribution. This study assesses the potential impacts of climate change on a selected water system by analyzing variations in temperature, precipitation patterns, and extreme weather events. Using hydrological modeling and climate projection scenarios (e.g., RCP 4.5 and RCP 8.5), the research evaluates future water flow regimes, reservoir reliability, groundwater recharge, and risks of flooding and drought. Results indicate a marked increase in seasonal variability, reduced water availability during dry periods, and heightened vulnerability of both surface and groundwater resources. These findings underscore the urgent need for adaptive water management strategies that incorporate climate resilience, sustainable usage, and integrated resource planning. The study provides a foundation for policymakers and water managers to develop targeted interventions that ensure long-term water security in the face of a changing climate.

Keywords: Climate Change, Hydrological Modeling, Water Availability, Groundwater Recharge, Adaptive Water Management

Monitoring Air Pollution through Satellite Imagery

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Abstract

Air pollution has become one of the most critical environmental issues affecting human health, climate, and ecosystem stability. Traditional ground-based monitoring stations provide accurate data but are limited in spatial coverage and costly to maintain. To overcome these limitations, satellite-based remote sensing has emerged as a powerful tool for monitoring air pollution over large geographic areas in real time. This study focuses on the use of satellite imagery to assess and analyze air quality parameters such as particulate matter (PM2.5 and PM10), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), and carbon monoxide (CO). By integrating data from satellite sensors like MODIS, Sentinel-5P, and Landsat with Geographic Information System (GIS) techniques, spatial and temporal variations in air pollution can be effectively mapped and visualized. Machine learning and GeoAI algorithms can further enhance the accuracy of pollution prediction and trend analysis. The findings from such monitoring systems help policymakers identify pollution hotspots, design mitigation strategies, and evaluate the effectiveness of environmental policies. The study highlights the importance of satellite remote sensing as a cost-effective, eficient, and scalable solution for continuous air quality assessment. This approach not only supports sustainable urban development but also contributes to achieving the United Nations Sustainable Development Goals (SDGs), particularly those related to health, clean air, and climate action.

Keywords: Air pollution, Satellite remote sensing, Geographic Information System (GIS), Machine learning, Air quality monitoring

Climate Change Impact Assessment on Water System

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Abstract

Climate change poses significant challenges to water systems globally, affecting water availability, quality, and distribution. This study assesses the potential impacts of climate change on a selected water system by analyzing variations in temperature, precipitation patterns, and extreme weather events. Using hydrological modelling and climate projection scenarios (e.g., RCP 4.5 and RCP 8.5), the research evaluates future water flow regimes, reservoir reliability, groundwater recharge, and risks of flooding and drought. Results indicate a marked increase in seasonal variability, reduced water availability during dry periods, and heightened vulnerability of both surface and groundwater resources. These findings underscore the urgent need for adaptive water management strategies that incorporate climate resilience, sustainable usage, and integrated resource planning. The study provides a foundation for policymakers and water managers to develop targeted interventions that ensure long-term water security in the face of a changing climate.

Keywords: Climate change, Hydrological modelling, Water availability, Climate resilience, Adaptive water management

Remote Sensing and Deep Learning for Climate Resilience

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Abstract

The problem of climate resilience is an urgent area of concern worldwide because of the severe threat of climate change to the ecosystem as well as human livelihood and socioeconomic stability. Recent advancements in deep learning and remote sensing can now provide more accurate monitoring, forecasting, and control of hazards related to climate. This paper researches the utilization of deep learning algorithms in conjunction with satellite remote sensing in order to assess environmental changes and predict climate susceptibility. The patterns of the key environmental indicators, including land surface temperature, vegetation index and soil moisture, are extracted using multi-temporal and multi-spectral images of the Sentinel and MODIS satellites. Whereas, long short-term memory (LSTM) networks analyze the time-related patterns to forecast the location of the disasters caused by climate such as heatwave, flood, and drought, the convolutional neural networks (CNNs) are applied to identify the locations in terms of spatial patterns in these data. GIS-based resilience maps are employed to illustrate final products, imply high risk areas and convey valuable information to stakeholders and policy makers. The integration of GeoAI methods avails a sound model of focused disaster reductions, climate-resilient development and planning and sustainable resource control. Altogether, the given work can prove that the combination of the latest machine learning methods and data obtained in the context of the remote sensing of the environment can benefit the climate intelligence greatly, enabling a more timely, efficient, and informed approach to the increasing issues of climate change.

Keywords: GeoAI, GIS Mapping, Climate Resilience, Deep Learning, Remote Sensing, Environmental Monitoring

Satellite- Based Detection of N_2O using Sentinel-5P, GOSAT, OCO

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Abstract

Satellites such as Sentinel-5P**,** GOSAT, and OCO play a crucial role in monitoring greenhouse gases like Nitrous Oxide (N_2O)**,** a potent contributor to climate change and ozone layer depletion. These satellites are equipped with advanced spectrometers and sensors that measure the absorption and reflection of sunlight by atmospheric gases across different wavelengths. By analyzing these spectral signatures, scientists can accurately quantify N_2O concentrations and identify their spatial and temporal variations. The data obtained from these observations provide critical insights into emission sources, including agricultural activities, industrial processes, and natural phenomena such as soil microbial activity. Furthermore, satellite-based detection offers continuous, high-resolution global coverage that is impossible to achieve through ground-based monitoring alone. This capability enables real-time tracking of pollution patterns, facilitates climate modelling, and supports international environmental agreements aimed at reducing greenhouse gas emissions. The integration of satellite data with machine learning and geospatial analysis tools further enhances the precision of emission mapping and trend prediction. Such comprehensive monitoring helps policymakers design evidence-based climate strategies, ensuring sustainable management of natural resources. Overall, the use of space-based remote sensing for greenhouse gas detection represents a transformative approach to understanding and mitigating the impacts of climate change on a global scale.

Keywords: Nitrous Oxide (N_2O), Greenhouse Gas, Satellite Remote Sensing, Sentinel-5P, TROPOMI, GOSAT, TANSO-FTS, OCO

Disaster Risk Reduction (DRR) and Early Warning Systems (EWS) for Hazard Management

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Abstract

Disaster Risk Reduction (DRR) and Early Warning Systems (EWS) play a crucial role in minimizing the impacts of natural and human-induced hazards. DRR focuses on identifying, assessing, and reducing the risks of disasters through systematic efforts that enhance community resilience and preparedness. It involves strategies such as risk assessment, capacity building, sustainable development planning, and the integration of disaster management into policy frameworks. On the other hand, Early Warning Systems are designed to detect potential hazards and provide timely, reliable, and actionable information to communities and authorities before a disaster occurs. Effective EWS consist of four key components: risk knowledge, monitoring and warning services, dissemination and communication, and response capability. The combination of DRR and EWS ensures that societies are not only warned about impending disasters but are also equipped to respond effectively, reducing loss of life, property damage, and economic disruption. Technological advancements, such as the use of remote sensing, Geographic Information Systems (GIS), and real-time data analysis, have significantly improved the accuracy and speed of early warnings. However, challenges remain in ensuring community participation, accessibility, and communication across diverse regions. Strengthening institutional coordination, public awareness, and local-level preparedness are essential to build a culture of safety and resilience. Therefore, the integration of DRR and EWS into national and local disaster management frameworks is vital for achieving sustainable development and safeguarding lives and livelihoods against future hazards.

Keywords: Disaster Risk Reduction (DRR), Early Warning Systems (EWS), Community Resilience, Risk Assessment, and Technological Advancements

Enhancing Disaster Preparedness Through Synergized DRR and Early Warning Mechanisms

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Abstract

Disaster Risk Reduction (DRR) and Early Warning Systems (EWS) play a crucial role in minimizing the impacts of natural and human-induced hazards. DRR focuses on identifying, assessing, and reducing the risks of disasters through systematic efforts that enhance community resilience and preparedness. It involves strategies such as risk assessment, capacity building, sustainable development planning, and the integration of disaster management into policy frameworks. On the other hand, Early Warning Systems are designed to detect potential hazards and provide timely, reliable, and actionable information to communities and authorities before a disaster occurs. Effective EWS consist of four key components: risk knowledge, monitoring and warning services, dissemination and communication, and response capability. The combination of DRR and EWS ensures that societies are not only warned about impending disasters but are also equipped to respond effectively, reducing loss of life, property damage, and economic disruption. Technological advancements, such as the use of remote sensing, Geographic Information Systems (GIS), and real-time data analysis, have significantly improved the accuracy and speed of early warnings. However, challenges remain in ensuring community participation, accessibility, and communication across diverse regions. Strengthening institutional coordination, public awareness, and local-level preparedness are essential to build a culture of safety and resilience. Therefore, the integration of DRR and EWS into national and local disaster management frameworks is vital for achieving sustainable development and safeguarding lives and livelihoods against future hazards.

Keywords: Disaster Risk Reduction (DRR), Early Warning Systems (EWS), Community Resilience, Geographic Information Systems (GIS), Sustainable Development

Climate Resilience and Sustainable Water Management Strategies for Nashik District

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Abstract

The effects of climate change, such as unpredictable rainfall patterns, rising temperatures, and falling groundwater levels, are making it more difficult for the Nashik District The solutions needed to improve climate resilience and guarantee sustainable water management in the area are examined in this study. In order to pinpoint important problems, including over-extraction, ineffective irrigation techniques, and insufficient watershed protection, the study combines hydrological data, climatic changes, and regional water-use patterns. The district can attain long-term water security by combining conventional and contemporary strategies, such as integrated water resource management, watershed management, micro-irrigation, and rainwater collection. For the purpose of developing adaptive capability and advanced sustainable water systems, the article highlights the importance of technological innovation, legislative assistance, and community involvement. The results of this study could help shape district-level action plans that support the more general goals of climate resilience and sustainable development.

Keywords: Climate resilience, sustainable water management, groundwater depletion, rainwater harvesting, watershed management, climate change adaptation, irrigation efficiency, integrated water resources management.

Real-Time Road Damage Detection and Smart Mapping using UAVs

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Abstract

Maintaining the integrity of road networks is a critical component of sustainable urban development and community safety, directly aligning with SDG 11 (Sustainable Cities and Communities). However, traditional manual inspection methods are resource-intensive, slow, and often subjective. This paper presents a novel GeoAI framework designed to automate the identification and mapping of road surface damage, such as potholes and cracks, in real-time. Our methodology leverages a lightweight, high-performance YOLOv8 object detection model. This model was trained on a comprehensive, annotated dataset to accurately identify distinct "damage" areas. We propose a data acquisition workflow utilizing Unmanned Aerial Vehicles (UAVs) equipped with high-resolution cameras, which can autonomously survey road networks far more efficiently than ground crews. As the UAV captures geospatial video data, frames are streamed to a backend API. This high-throughput server, built with FastAPI and running the exported ONNX model, performs real-time inference. Detections are filtered using Non-Maximum Suppression (NMS) to ensure accuracy. Crucially, every positively identified damage instance is geotagged with its precise GPS coordinates and saved to a centralized database, along with its confidence score and a timestamp. This data populates a dynamic, web-based dashboard featuring an interactive map. This "smart map" provides a near-instantaneous, verifiable visualization of infrastructure health, empowering municipal authorities to move from reactive to predictive maintenance. By accurately mapping damage hotspots, our GeoAI solution enables efficient resource allocation, enhances public safety, and contributes to the development of more resilient and sustainable smart infrastructure.

Keywords: GeoAI, road surface damage detection, YOLOv8, Unmanned Aerial Vehicles (UAVs), smart infrastructure.

Remote Sensing-Based Plastic Waste Detection in Water Bodies using GeoAI

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Abstract

Plastic pollution in rivers, lakes, and oceans has become one of the most serious environmental issues of our time. Large amounts of plastic waste float on the surface of water bodies, harming marine life and disrupting aquatic ecosystems. Traditional methods of tracking and cleaning up this waste are mostly manual and limited to small areas, making them slow and inefficient. This project introduces an intelligent way to detect and map floating plastic waste using satellite and drone imagery combined with Artificial Intelligence (AI). By applying Convolutional Neural Networks (CNNs) to high-resolution remote sensing images, the system can automatically identify areas where plastic debris is present on the water surface. The model learns the unique color and texture patterns of plastics compared to water or vegetation, allowing accurate detection even across large regions. Once identified, these locations are plotted on GIS maps to highlight pollution hotspots. This spatial mapping helps us understand where plastic tends to accumulate — often near cities, river mouths, or industrial zones — and why. The results can help governments, environmental organizations, and local communities plan more focused cleanup drives and take preventive actions. Overall, this project shows how combining AI and geospatial technology can make environmental monitoring faster, smarter, and more affordable. It aims to support cleaner waterways, healthier ecosystems, and progress toward global sustainability goals such as SDG 6 (Clean Water) and SDG 14 (Life Below Water).

Keywords: Plastic pollution, remote sensing, Convolutional Neural Networks (CNNs), GIS mapping, environmental monitoring.

Disaster Risk Reduction and Early Warning System

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Abstract

Disaster Risk Reduction (DRR) and Early Warning Systems (EWS) play a crucial role in minimizing the adverse impacts of natural and human-induced disasters. DRR focuses on identifying, assessing, and reducing the risks associated with hazards through sustainable development, preparedness, and mitigation measures. Early Warning Systems, as an integral part of DRR, provide timely and accurate information that enables individuals, communities, and authorities to take preventive action before disasters strike. Effective EWS involves four key elements: risk knowledge, monitoring and forecasting, communication and dissemination, and response capability. The integration of modern technologies such as satellite monitoring, remote sensing, and artificial intelligence has enhanced the efficiency of disaster forecasting and management. Strengthening community awareness, institutional coordination, and infrastructure resilience are essential for reducing vulnerability and building a culture of safety. This paper highlights the importance of combining technology, policy, and community participation to create a comprehensive approach for disaster preparedness and risk reduction.

Keywords: Disaster Risk Reduction (DRR), Early Warning Systems (EWS), remote sensing, artificial intelligence, community resilience.

AI & ML Applications

GeoAI-Driven GIS Approach for Assessing Climate Change Impacts on Water Resources

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Abstract

Climate change has emerged as a critical challenge impacting the availability, distribution, and quality of global water resources. Rising temperatures, irregular rainfall patterns, and extreme weather events pose serious risks to irrigation systems, groundwater recharge, and overall water sustainability. This paper aims to assess the impact of climate change on water systems using an integrated approach of Geographic Information Systems (GIS), Remote Sensing, and GeoAI-based predictive modeling. Satellite datasets, rainfall records, and hydrological parameters are analyzed to detect spatio-temporal variations in water bodies, surface runoff, and drought-prone areas. Machine learning and deep learning techniques are applied to predict future water stress scenarios under different climate change projections. The study emphasizes mapping vulnerable zones and developing early warning systems for floods and droughts. By integrating GeoAI with traditional hydrological analysis, this research highlights sustainable solutions for water management, particularly in agricultural and semi-urban regions. The outcomes will support policymakers, engineers, and researchers in planning adaptive measures to mitigate the adverse effects of climate change on water resources. Overall, the work demonstrates how geospatial intelligence can ensure sustainable water management and resilience against climate uncertainties.

Keywords: Climate Change, Water Resources, GeoAI, Remote Sensing, Sustainable Water Management

Predictive GeoAI with Socio-Economic Data Integration for Sustainable Resource Management

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Abstract

Global sustainability challenges encompassing climate resilience, resource management, and urban development necessitate intelligent frameworks that integrate data analytics with artificial intelligence. This study presents a Predictive GeoAI and Smart Resource Analytics Framework to enhance sustainable planning through structured dataset integration and socio-economic indicators, moving beyond conventional imagery-based methods. The framework aggregates diverse datasets—such as census data, demographic and economic profiles, land-use statistics, agricultural outputs, environmental indices, and climate records—to build a robust geospatial knowledge base. Advanced machine learning models, including XGBoost and Random Forest, are utilized for high-performance predictive modeling of socio-economic and resource utilization patterns, while LSTM networks capture spatio-temporal dependencies in resource demand forecasting. Additionally, Graph Neural Networks (GNNs) are applied to model complex interrelations among spatially connected socio-economic entities. Based on these predictive insights, prescriptive analytics employing optimization and decision-support systems are used to recommend strategies for equitable resource allocation and sustainable policy formulation. A case study on urban water management validates the framework's applicability, predicting scarcity zones and proposing conservation measures through integrated socio-economic and environmental data. The results demonstrate that the proposed ML-driven framework outperforms traditional regression methods in terms of accuracy, robustness, and interpretability. Incorporating smart mapping visualizations further aids policymakers in identifying high-risk and priority areas. By emphasizing structured socio-economic data over imagery-based inputs, this work positions GeoAI as a transformative tool for sustainable resource management, aligning with the United Nations Sustainable Development Goals (SDGs).

Keywords: GeoAI (Geospatial Artificial Intelligence), Sustainability, Predictive Analytics, Socio-economic Indicators, Resource Management

The possible advancement of AI-Based RealTime Wildfire Detection Systems in Similipal Biosphere Reserve using Image processing and Geo-Spatial Technologies

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Abstract

According to the data available in the FSI (Forest Survey of India), the state of Odisha has recorded 2nd highest numbers of wildfire incidents in the year 2024-25. The FSI has lunched the Forest Fire Alert System-3.0 in the year 2019. FSI utilizes MODIS (Moderate Resolution Imaging Spectroradiometer) and VIIRS (Visible Infrared Imaging Radiometer Suite) for fire alerts. However, the VIIRS is most sensitive one and reports higher numbers of fire incidents as compared to MODIS. Similarly, we can find an increasing pattern in fire incidents from the month of January to May in most of the region. In this paper, we have analyzed the fire incidence reported from the Similipal Biosphere Reserve which is the one of the 12 Indian biospheres recognized by UNESCO. Recently, Similipal was in the lime light and grab the attention of many environmentalists and leaders throughout the globe due to the massive wild fire spanning across the 25% of the reserve area. The illegal poaching activities were also reported from the buffer area of the reserve. The cater all these the government of Odisha has tried to setup the ground elevated towers where the AI cameras were installed to detect both poaching activities and fire incidents. Our work includes the analysis of significant causes behind the wildfire in Similipal and the recent remedial steps of the government to mitigate these challenges. We have also discussed the possibilities of adoption of Machine Learning and Image processing techniques not only to predict the wildfire in advance but also to prevent the anthropological activity causing wild fire. In this paper, we have utilized the machine learning algorithms that includes DBSCAN clustering algorithm, K-Mean clustering algorithm. Both of these algorithms are the unsupervised machine learning algorithm generally used in datamining to make clusters. Here we have utilized these algorithms over the Sentinel-2 MSI data to predict the vulnerable spots within the region of Similipal biosphere reserve. Similarly, to prevent the anthropological causes of wild fire we have proposed a CNN (Convolutional Neural Network) based object detection technique. Here we have utilized the concept of transfer learning and used the ResNet-50 instead of building the CNN from scratch. Our proposed Model is therefore addressing the wild fire detection from the prospective of Geospatial based detection techniques and Image processing-based techniques.

Keywords: Sentinel-2; Clustering algorithm; Transfer Learning; Similipal Biosphere reserve; CNN.

Outcome-Driven Predictive Analytics Integrated With CA–Markov for Modeling Bidirectional Urban Growth in Salem and its Periphery, India

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Abstract

Outcome-Driven Predictive Analytics (ODPA) is introduced as a novel framework that leverages observable outcomes as surrogate variables in place of traditional causative factors. In this study, ODPA is integrated into the Cellular Automata Markov (CA–Markov) model to predict urban sprawl in Salem and its peripheral region, Tamil Nadu. Using outcomes of sprawl -*pattern*, *intensity*, and *direction*, as driver variables, ODPA enables robust prediction in limited-data scenarios. The ODPA-driven CA–Markov model achieved strong performance, with only 9.01% deviation between predicted and actual built-up areas. To assess growth dynamics, a comparative study was undertaken between a simulated scenario of unidirectional growth and a Business-as-Usual (BAU) scenario of bidirectional growth. The simulated scenario exaggerated infill and core densification, showing Salem expanding predominantly toward Omalur and Vazhapadi, with conurbation projected by 2100. Conversely, the BAU bidirectional scenario captured highway-oriented sprawl, more rapid growth in peripheral towns such as Sankari, and indicated a Salem–Omalur conurbation by 2050. These results demonstrate the strength of ODPA in reproducing spatial heterogeneity and realistic growth trajectories. By explicitly incorporating neighbouring towns and bidirectional dynamics, ODPA provides a more comprehensive framework for regional urban growth prediction. This work highlights ODPA's potential as both a methodological innovation and a practical tool for urban planning in data-scarce environments.

Keywords: Urbanisation, Direction, Pattern, Intensity, CA Markov, Predictive Modelling

Geo-AI-Based Prediction of Water-Stress-Induced Geopolitical Conflicts in Transboundary River Basins

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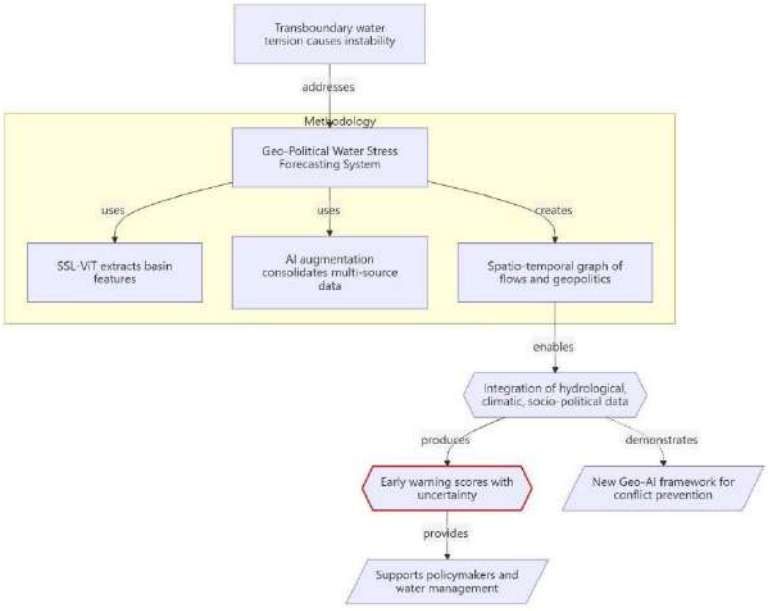
Abstract

Transboundary water tension is being increasingly realized as a force for geopolitical instability, but predictive frameworks so far seldom draw on hydrological, climatic, and political aspects. This project introduces a Geo-Political Water Stress Forecasting System that uses Geo-AI methods to predict conflict threats due to water tension in transboundary river basins. Self-Supervised Learning using Vision Transformers (SSL-ViT) is utilized to retrieve basin-scale features like rainfall anomalies, reservoir behaviour, and land-cover changes from satellite imagery. In parallel, AI augmentation consolidates multi-source data, such as hydrological observations, dam infrastructure data, and governance scores, compensating for missing or sparse data. The system creates a Spatio-temporal graph of upstream–downstream flows and geopolitical linkages to support sophisticated predictive modelling of water-stress-driven conflicts. Through the integration of hydrological, climatic, and socio-political predictors, the system offers early warning scores with uncertainty estimates, providing actionable information to policymakers and global water management institutions. Future extensions involve incorporating other climate projections, scaling to multiple watersheds, and improving predictability using multi-modal fusion models. Generally, the system illustrates a new Geo-AI-driven framework for managing water resources, promoting transboundary cooperation, and preventing geopolitics-based conflict risk.

Keywords: Geo-AI, Water Stress Forecasting, Remote Sensing, AI Enhancement, SSL-ViT, Geospatial-Temporal Modelling, Geopolitical Risk, Conflict Prediction, Transboundary River Basins, Sustainable Development Goals (SDGs)



GeoAI-Driven Approaches for Resilient Coastal and Riverine Infrastructure

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Abstract

New methods may need to change for better use in today's urban areas. There is a greater focus on managing urban growth, which may also involve improving infrastructure and the quality of public life. GeoAI could significantly impact the predictive analytics side of urban planning. Essentially, GeoAI combines GIS with AI, ML, and DL. It uses spatial data from satellites, LiDAR, IoT sensors, and social media to help cities foresee challenges, create future models, and develop policies based on solid data. The study shows that GeoAI can be used for predicting trafic and energy use, determining air quality, and modeling land-use changes over time and space. Pre-trained AI models can automatically extract features from images. The rule-based TextSAM tool transforms unstructured citizen reports into urban insights using NLP terminology. Integrated dashboards and simulation environments allow stakeholders to explore "what-if" scenarios, such as assessing the impact of new infrastructure, zoning policies, or climate adaptation measures. By applying predictive intelligence at the city level, GeoAI helps planners and policymakers create urban systems that are sustainable, inclusive, and resilient. This paper argues that GeoAI is more than just a technology upgrade; it is essential for effective governance and for achieving the SDGs in rapidly growing urban areas.

Keywords: GeoAI, Predictive Urban Analytics, Smart Cities, Spatio-Temporal Modeling, Trafic Forecasting, Sustainable Governance, SDGs

RGB Image Analysis using Machine Learning

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Abstract

RGB image analysis in conjunction with machine learning provides a quick, non-destructive method of crop observation and assessment of treatments. In this experiment, a field experiment of 21 plots was prepared, which were grouped into 3 replications and 7 treatments and each treatment replicated across replications. Details of only the first row of plots (7 treatments) were chosen for detailed analysis. Plot images were analyzed and mean Red, Green, and Blue (RGB) values extracted and compared across treatments. Out of analyzed plots, plot-to-plot variations were recorded in red (62.4–93.2), green (84.7–114.2), and blue (39.1–46.3) channels and indicated that variations occurred in terms of canopy light intensity and general plant health. Green channel values that are commonly correlated to chlorophyll content were further employed to estimate N levels across treatments. Plot 4 recorded a maximum green value (114.2) and Plot2 minimum (84.7) indicating that the variations in N-response occurred among treatments. These findings show that image analysis-based on RGB provides an efficient method of quantification of colour indices that could be correlated to physiological plant traits. Coupling machine learning models to such RGB data could additionally allow automated classification of treatment manifestations, N status prediction, as well as decision aiding in precision farming. This work showcases potential of low-cost computational images methods to allow large-scale real-time crop monitoring.

Keywords: RGB image analysis, Machine learning, Crop monitoring, Precision agriculture, Chlorophyll content, Nitrogen estimation, Canopy color indices, Plant health assessment, Non-destructive analysis, Digital image processing.

GeoAI for Cyclone Preparedness and Disaster Risk Reduction in Coastal Odisha

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Abstract

Odisha is highly vulnerable to recurring cyclones and floods, resulting in significant loss of life and damage to infrastructure. Although agencies such as the India Meteorological Department (IMD) and the Odisha Disaster Rapid Action Force (ODRAF) provide cyclone tracking and early warnings, existing systems often lack localized precision and real-time adaptability. This study proposes an enhanced GeoAI-based predictive framework designed to strengthen disaster preparedness and community resilience. The framework integrates historical cyclone tracks, rainfall records, terrain characteristics, and population density data to generate hyper-local flood and wind risk maps. Using advanced machine learning and GIS-based analysis, ward- and village-level hazard maps will be developed to guide targeted evacuation and resource deployment. In addition, the proposed decision-support system introduces innovative features such as real-time shelter occupancy monitoring to prevent overcrowding, AI-optimized evacuation routing that dynamically adjusts to road blockages or damages, and community-level alert dissemination through SMS, WhatsApp, and IVR systems in regional languages. By bridging predictive analytics with participatory communication tools, this framework transitions from generalized warnings to actionable, location-specific strategies. The resulting GeoAI model aims to enhance the efficiency of disaster response, optimize resource utilization, and minimize casualties. Overall, the study contributes to establishing a smart, resilient disaster management ecosystem that complements existing government initiatives and promotes sustainable climate resilience in Odisha.

Keywords: GeoAI, Disaster Management, Flood and Cyclone Risk Mapping, GIS, Climate Resilience

A Comprehensive Review on Grade Prediction of Complex ores with Deep Learning

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Abstract

Accurate ore grade estimation is a cornerstone of sustainable mineral resource management, yet conventional approaches such as kriging, regression, and interpolation often fall short when confronted with the high-dimensional, heterogeneous, and non-linear characteristics of complex ore deposits. These limitations hinder real-time decision-making, increase operational costs, and exacerbate environmental impacts. In recent years, deep learning (DL), a powerful branch of artificial intelligence (AI), has emerged as a transformative tool in mining engineering and geosciences, offering enhanced capabilities for predicting ore grades by learning complex patterns from large, noisy, and multi-source datasets. This review paper synthesizes the current progress in applying DL models—such as Deep Neural Networks (DNNs), Convolutional Neural Networks (CNNs), and Recurrent Neural Networks (RNNs)—to ore grade prediction using diverse inputs including drill core logs, hyperspectral imagery, geochemical assays, and sensor-based measurements. Studies demonstrate that CNNs effectively analyze image-based geological data, while RNNs, particularly Long Short-Term Memory (LSTM) networks, capture temporal dependencies in real-time sensor streams. Hybrid architectures, integrating CNNs and LSTMs, further improve multi-source data fusion, enabling robust modeling of complex mineralogical variations. Despite these advances, challenges remain. Data scarcity and imbalance due to costly sampling often led to biased datasets and model overfitting. Model interpretability continues to be a barrier, as DL systems function as “black boxes,” limiting trust and practical adoption in mining operations. Moreover, geological heterogeneity restricts model transferability across different ore deposits, underscoring the need for adaptive methods like transfer learning and domain adaptation.Future directions emphasize explainable AI (XAI) to enhance model transparency, transfer learning for cross-site generalization, and generative models such as GANs for synthetic data augmentation. Collectively, these innovations promise to integrate DL into intelligent mine planning and real-time mineral processing, supporting more accurate, cost-effective, and environmentally sustainable mining practices.

Keywords: ore grade; deep learning; Hybrid architecture; complex ore; explainable AI.

Harnessing GeoAI for Smarter and Sustainable Cities

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Abstract

Rapid urban growth has created several challenges in city planning, transportation, resource management, and environmental protection. To overcome these issues, new technologies are being used to make cities smarter and more sustainable. One such innovative technology is GeoAI, which combines Geographic Information Systems (GIS) and Artificial Intelligence (AI) to collect, analyse, and interpret spatial data. GeoAI helps in studying satellite images, digital maps, and sensor data to identify patterns in traffic, land use, air quality, and population density. It also uses machine learning techniques to predict future urban problems such as flooding, heat islands, and overcrowding. These predictions help planners and policymakers take preventive actions instead of reacting after problems occur. GeoAI plays an important role in improving infrastructure, saving resources, and protecting the environment. By transforming large amounts of spatial data into meaningful insights, GeoAI supports sustainable urban development and enhances the quality of life for citizens. Overall, GeoAI for predictive urban analytics provides a smart and scientific way to build cities that are more resilient, efficient, and well-prepared for the challenges of the future.

Keywords: GeoAI, GIS, Artificial Intelligence, Urban Planning, Predictive Analytics, Smart Cities, Sustainability

An Optimized YOLO–OpenCV Framework for Automated Flood Detection Using Remote Sensing Imagery

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Abstract

Flood is one of the most destructive natural calamities, often disturbing human being's life, destroying many lives and homes and make effect on local environment or ecosystem. Before time flood detection is playing a vital role in order to prevent this natural disaster like flood. This research come with an automated flood detection Frame work, which usually merge YOLO (you look only once) Deep Learning Model with image processing capability of OpenCV. The Model examine or analyze satellite images gathered from Open remote sensing sources like Sentinel, Google Earth etc. to recognize and map flooded regions. The Presented methodology offers YOLOv8 to distinct land and water area precisely, even in complicated environmental situations. OpenCV is used for preprocessing of an image and enhancing visualization using bound box which helps to improve the accuracy and efficiency of flood detection. Examined result data shows that model achieve high precision while developing low computational or operational cost which makes it suitable for monitoring of real time flood detection and making emergency response. The research study reveals that how GeoAI combining with deep learning model can buildup disaster management which leads to reduce the risks. Spatial analytics fusion and image recognition based on neural network provide an effective data driven solution helps for environmental monitoring, overall, the YOLO-OpenCV framework leads to climate resilience.

Keywords: YOLO, OpenCV, Flood Detection, Remote Sensing, Deep Learning, GeoAI, Climate Resilience, Disaster Management

GeoAI for Predictive Urban Analysis

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Abstract

GeoAI, the convergence of Geographic Information Systems (GIS) and Artificial Intelligence (AI), represents a powerful paradigm for predictive urban analysis. With cities generating unprecedented volumes of spatial and temporal data, GeoAI enables the extraction of actionable insights for urban sustainability, resilience, and planning. Using machine learning, deep learning, and spatial statistics, GeoAI predicts land-use transitions, traffic patterns, environmental hazards, and socio-economic shifts. These predictive capabilities assist policymakers and planners in optimizing infrastructure, reducing congestion, and mitigating climate-related risks. The integration of spatial data from remote sensing, IoT devices, and urban databases empowers GeoAI to generate fine-grained predictions. Through convolutional neural networks and graph-based learning, GeoAI captures spatial dependencies and urban morphologies, enabling near real-time forecasting. Case studies across smart cities demonstrate GeoAI's effectiveness in urban heat mapping, flood prediction, and mobility optimization. Moreover, explainable AI frameworks enhance interpretability and public trust in AI-driven decision systems. Despite its immense potential, challenges persist in ensuring data privacy, reducing model bias, and achieving interoperability across diverse spatial datasets. Advancements in cloud computing, edge AI, and federated learning are progressively overcoming these barriers. Future research in GeoAI is expected to emphasize ethical governance, open data ecosystems, and multi-agent simulations for urban futures. Ultimately, GeoAI transforms traditional urban analytics into a predictive, adaptive, and sustainable science for the next generation of smart cities.

Keywords: GeoAI, Urban analytics, Machine learning, Smart cities, Predictive modelling

Deforestation Analysis of Begusarai Districtusing GIS and Remote Sensing

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Abstract

Deforestation is a big problem that harms the environment, especially in growing areas like Begusarai, Bihar. This study uses tools called Geographic Information Systems (GIS) and Remote Sensing (RS) to check how forests and green areas have changed over the last 20 years. We used satellite images from different years to see how much green cover has been lost. We also used NDVI (Normalized Difference Vegetation Index) a method to measure the health of plants, to find where deforestation is happening the most. The results show that many trees and green spaces have been lost because of city growth, farming, and building roads and houses. This loss of green areas can cause pollution, warmer temperatures, and fewer animals living in the area. The study shows that GIS and RS are useful tools to watch these changes and can help the government make better plans to protect the environment and manage growth in Begusarai.

Keywords: Deforestation, Begusarai, GIS, RS, NDVI, Forest cover change, Urban expansion, Land use change, Environmental impact, Vegetation monitoring

GeoAI-Driven Predictive Analytics for Sustainable Urban Growth and Smart City Planning

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Abstract

The fast and uncontrolled urban growth is an important challenge to the sustainable development, infrastructure planning and management of resources in contemporary cities. According to these understanding, the traditional urban forecasting approaches cannot be used efficiently to deal with such dynamic and diverse spatial data from different sources. This study introduces a GeoAI-driven predictive analytics platform which combines GIS, remote sensing to model and predict urban growth. The suggested system makes use of urban infrastructure datasets, demographic information, and satellite imagery to forecast changes in land use, population density, and mobility over time. While machine learning methods like Random Forest and Gradient Boosting forecast urban growth and service accessibility, deep learning models, such as Convolutional Neural Networks (CNNs), are used for land-cover classification. Policymakers can identify growth hotspots and model development scenarios thanks to the data's visualization through an interactive geospatial dashboard. According to preliminary tests on publicly available urban datasets, the GeoAI model outperforms conventional statistical models in terms of prediction accuracy by more than 20%. The system encourages data-driven governance and sustainable urban development by offering a clever decision-support tool for smart city planning.

Keywords: GeoAI, Predictive Analytics, Urban Planning, Remote Sensing, Deep Learning, Smart Cities, GIS.

Quantum Unsupervised Segmentation (Q-Seg): Quantum-Driven Advances in Geospatial Intelligence for Sustainable Development Goals

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Abstract

The integration of quantum computing into geospatial analytics marks a significant leap in sustainable development research and practical monitoring. Quantum Unsupervised Segmentation (Q-Seg) represents an emerging computational paradigm that leverages quantum annealing for unsupervised satellite image segmentation. This research paper explores how Q-Seg converts pixel-level segmentation into a graph-based optimization task solvable through existing quantum architectures such as the D-Wave Advantage system. By assimilating spectral and spatial data, Q-Seg provides robust segmentation performance, overcoming the limitations of supervised deep learning that require extensive labeled datasets. The approach enables rapid, accurate environmental analysis, essential for monitoring floods, deforestation, and other Sustainable Development Goal (SDG) indicators. The study compares Q-Seg's efficiency and scalability with classical optimizers and evaluates its deployment potential in real-time operational environments. Results indicate that quantum annealing-driven segmentation offers a promising path toward data-efficient, adaptive, and sustainable geospatial intelligence.

Keywords: Quantum Computing, Geospatial Analytics, Quantum Annealing, Satellite Image Segmentation, Sustainable Development

A GeoAI-Driven Framework for Sustainable Water Resource Management and Climate Resilience

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Abstract

Water scarcity, pollution, and unplanned urbanization have emerged as major global challenges threatening ecosystems and human well-being. Traditional water management systems often lack real-time insights and spatial precision. This study proposes a GeoAI-driven framework integrating Geographic Information Systems (GIS), remote sensing, and Artificial Intelligence (AI) to monitor, predict, and sustainably manage water resources. The framework utilizes satellite-based remote sensing data, geospatial datasets, and machine learning algorithms—such as Random Forest and Convolutional Neural Networks (CNNs)—to analyze temporal hydrological variations and optimize water resource allocation. Spatial parameters like rainfall variability, land use, and groundwater levels are modeled within a GeoAI-enabled GIS environment to produce smart maps for drought prediction, water stress analysis, and watershed planning. Experimental results demonstrate that the GeoAI-based model significantly enhances prediction accuracy for drought-prone and water-stressed regions. Real-time monitoring of surface and subsurface water conditions allows early detection of potential crises. The intelligent mapping system offers actionable insights for policymakers, improving water distribution, flood prevention, and sustainable resource management. This research underscores the transformative role of GeoAI in promoting climate-resilient, data-driven water governance, supporting UN SDG 6 (Clean Water and Sanitation) and SDG 13 (Climate Action) through predictive analytics and optimized resource utilization.

Keywords: GeoAI, Water Resource Management, Remote Sensing, Geographic Information Systems (GIS), Sustainable Development

Land Cover Classification Using Deep Learning and Remote Sensing Imagery

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Abstract

The integration of remote sensing and artificial intelligence has opened new frontiers in Earth observation and environmental monitoring. This project presents a deep learning–based land cover classification framework using the FLAIR-INC dataset and a Feature Pyramid Network (FPN) with a ResNet-34 encoder. High-resolution satellite imagery serves as input to automatically identify and classify diverse land cover types such as urban areas, water bodies, forests, and agricultural regions. The model leverages semantic segmentation to generate detailed maps that highlight spatial patterns of land use and surface change. By accurately distinguishing between natural and man-made features, this approach supports urban planning, ecosystem monitoring, and climate resilience assessment. The outputs enable better understanding of human–environment interactions and can assist policymakers in managing sustainable land resources. This research demonstrates the potential of Deep Learning and Remote Sensing as powerful tools for building climate-resilient and sustainable communities through data-driven geographic intelligence.

Keywords: Deep Learning, Remote Sensing, Land Cover Classification, Semantic Segmentation, Climate Resilience

GeoAI-Driven Framework for Predictive Coastal Resilience and Risk Mapping

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Abstract

Coastal zones are among the most dynamic and fragile ecosystems, increasingly imperiled by anthropogenic pressures, which are further accelerated by climate change. The presented study proposes a cutting-edge GeoAI-based framework that synergistically integrates multi-temporal remote sensing datasets, digital elevation models, and socio-environmental indicators toward the scientific delineation and quantification of coastal vulnerability. Using CNN and multi-criteria spatial analysis in a geospatial environment, the model automatically identifies and classifies the high-risk zones under the influence of sea-level rise, shoreline retreat, storm surges, and land-use transitions. The workflow includes data acquisition from Sentinel and Landsat satellites, topographic normalization through SRTM-derived elevation grids, and derivation of indices such as NDVI, NDWI, and LST to capture ecological and hydrological dynamics. TheAIcomponent avails itself of asupervised deep learning segmentation technique to identify physical degradation patterns, later combined with socio-economic layers using a weighted GIS overlay to compute a comprehensive Coastal Vulnerability Index (CVI). The validation against historical cyclone and inundation records attests to the superior predictive capacity and spatial robustness of the proposed framework. The resultant vulnerability maps provide scientifically grounded decisional support for infrastructure planning on resilient coasts, disaster risk mitigation, and adaptive governance of coastlines while setting a replicable paradigm for sustainable management of coastlines worldwide.

Keywords: GeoAI, Coastal Vulnerability, Remote Sensing, Climate Resilience, Deep Learning, GIS, Environmental Modeling

Leveraging GeoAI and Big Data Analytics to Monitor Urban Green Space Accessibility for Sustainable Cities (SDG 11)

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Abstract

The United Nations' Sustainable Development Goal 11 (SDG 11) calls for making cities inclusive, safe, resilient, and sustainable. A key challenge in achieving this goal is the dynamic and accurate monitoring of urban indicators, such as universal access to safe and inclusive green spaces. Traditional survey-based methods are often slow, expensive, and lack scalability. This study presents a robust framework that leverages big geospatial data and GeoAI to automate the mapping and accessibility analysis of urban green infrastructure. Our approach integrates high-resolution satellite imagery with volunteered geographic information (VGI) to create a comprehensive dataset. We employ a deep learning-based semantic segmentation model to achieve precise delineation of parks and vegetated areas. Subsequently, network analysis is performed to assess green space accessibility across various socioeconomic districts. Our preliminary results demonstrate that this GeoAI-driven methodology can identify green spaces with high accuracy and reveal critical disparities in accessibility, providing actionable intelligence for city planners. This research showcases how big geospatial data analytics can directly support evidence-based policymaking, helping to build more equitable and sustainable cities in line with the conference's vision for a "Sustainable Tomorrow".

Keywords: Sustainable Development Goal 11 (SDG 11), GeoAI, Urban Green Infrastructure, Semantic Segmentation, Accessibility Analysis

Project Tsukinome: An AI-Driven Behavioral Simulation Framework for Emergent Societal Evolution in Virtual Environments

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Abstract

Project Tsukinome is an experimental simulation that explores the emergence of sentient behaviour, social evolution and artificial sentient intelligence within a virtual environment. Drawing conceptual inspiration from John B. Calhoun's Universe 25 experiment, the project examines how Npc's evolve in behaviour, cognition, and social interactions and organization under rules of the world *Manthsala.* Set within the world, the system models a dynamic ecosystem populated by 20Npc's with various personality and behavioural architecture driven and upgraded by needs such and daily activities also their personality and moral deviations, reflecting both cooperation and decay to simulate real world patterns. Technically using Unity with Ai systems like PCG, decision Tree, Memory, mood and unscripted interaction system using LLm's makes for a Life like scenario. A custom 4 minutes day/night cycle with day, month, year and season and weather system and dna based evolution for bridging the gap between real life and virtual world. Project Tsukinome aims for a digital mirror for observing human-like creatures their daily lives evolution, collapse and consciousness emergence within an artificial virtual society which in reality does not exist.

Keywords: Manthsala, Vr, LLM. PCG, Memory based decision Making, Npc, Humans, Behavioural Arctitecture, Autonomus Agents, Mutation, Digital Consciousness.

HADES: Human Autonomous Detection and Engagement System for Tactical Aerial Reconnaissance

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Abstract

The rapid advancement of Unmanned Aerial Vehicles (UAVs) and computer vision has unlocked new possibilities in surveillance, disaster response, and human activity monitoring. However, recognizing human actions from aerial imagery remains challenging due to small object sizes, complex backgrounds, and varying camera perspectives. This project aims to implement YOLOv11, a state-of-the-art real-time object detection model, to identify and classify human actions from aerial images derived from the Okutama-Action dataset. Instead of processing continuous video streams, the dataset's video frames are converted into annotated static images, enabling efficient model training and evaluation without temporal dependencies. Each image captures individuals performing activities such as walking, running, sitting, and carrying objects from drone-mounted cameras at different altitudes and angles. By training YOLOv11 on these labeled aerial images, the model learns to detect and classify multiple human actions simultaneously with high precision and real-time performance. This work demonstrates how advanced deep learning architectures can be effectively applied to UAV-based human behavior analysis using still imagery, paving the way for intelligent surveillance, autonomous monitoring, and search-and-rescue applications.

Keywords: Unmanned Aerial Vehicles (UAVs), Human Action Recognition, YOLOv11, Aerial Imagery, Deep Learning

Plastic Trash Detection in Local Water Bodies

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Abstract

Plastic pollution in local water bodies such as rivers, lakes, and ponds has become a critical environmental issue, adversely affecting ecosystems and human health. Traditional monitoring methods rely on manual observation, which is labor-intensive, time-consuming, and prone to errors. The Hydro Clean project proposes an automated approach for detecting plastic waste using deep learning and computer vision techniques. The system utilizes a dataset of images collected from local water bodies, annotated with categories such as plastic bottles, plastic bags, wrappers, styrofoam, and other plastic debris. Using state-of-the-art object detection models like YOLOv8 and instance segmentation models like Mask R-CNN, the system identifies and localizes plastic litter within the images. Data augmentation techniques are applied during training to ensure robustness against variations in lighting, water reflection, angles, and partial occlusions. The trained model outputs the location, count, and approximate coverage area of plastic trash in a given water body. These results can be visualized through annotated images or heatmaps, assisting local authorities, environmental agencies, and community organizations in identifying pollution hotspots and planning cleanup activities. By providing a scalable, automated, and accurate method for plastic waste detection, Hydro Clean contributes to environmental monitoring, community awareness, and pollution management, ultimately supporting the goal of cleaner and healthier water ecosystems.

Keywords: Plastic Pollution, Deep Learning, Computer Vision, Object Detection, Environmental Monitoring

Road Damage Detection using SAM Segmentation & YOLOv11m

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Abstract

Road infrastructure maintenance is critical for transportation safety, yet traditional road damage inspection is inefficient and prone to human error. This project presents an automated road damage detection and segmentation approach using deep learning. A YOLOv11m object detection model is trained on the RDD2022 India road damage dataset to localize various pavement distresses. Additionally, the Segment Anything Model (SAM) is leveraged to generate precise segmentation masks for each detected damage region, providing granular delineation of cracks and potholes without requiring pixel-level annotations. The methodology includes data preparation with an 80/20 train-test split, model training and validation, and extensive evaluation using precision-recall (PR) curves, confusion matrix analysis, and confidence-threshold tuning. The results demonstrate that the YOLOv11m detector achieves high accuracy in identifying multiple classes of road damages, and the integration of SAM yields fine-grained masks outlining the exact extents of the damages. This report discusses the rationale behind the chosen models, the training process, and the outcomes achieved, including qualitative examples of detections and segmentations. The proposed YOLOv11m+SAM framework offers a robust and efficient solution for road damage detection, with potential to significantly aid in proactive road maintenance and safety improvements.

Keywords: Road Damage Detection, Deep Learning, YOLOv11m, Segment Anything Model (SAM), Road Maintenance

Helmet And Safety Shoes Detection in Workplaces Using Deep Learning

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Abstract

Workplace safety is a critical concern in industrial and construction environments, where non-compliance with personal protective equipment (PPE) guidelines often leads to serious injuries. To address this issue, this project proposes an automated detection system for helmets and safety shoes using deep learning and computer vision techniques. The system leverages the latest YOLOv11 object detection model, which offers improved speed, accuracy, and robustness in real-time monitoring. Images and video frames from workplace environments are processed to detect whether workers are wearing helmets and safety shoes properly. The model is trained on a labeled dataset containing multiple classes: helmet, no-helmet, shoe, and no-shoe with augmentation techniques to improve generalization. Evaluation metrics such as Precision, Recall, F1-score, and mean Average Precision (mAP) are used to measure performance. The proposed YOLOv11-based system achieves high detection accuracy while maintaining real-time inference capability, making it suitable for deployment in industrial surveillance cameras or edge computing devices. This automated safety monitoring approach can significantly reduce manual supervision efforts and enhance overall workplace safety compliance.

Keywords: Workplace Safety, Personal Protective Equipment (PPE), Deep Learning, YOLOv11, Computer Vision

AutoID: Real-Time Car Brand & Model Detection

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Abstract

The manual identification of vehicle brands in video streams is a time-consuming and inefficient process, posing significant challenges for applications in traffic analysis, security, and automated inventory. This project, "AutoID," presents an end-to-end deep learning system for automated, real-time car brand detection. Leveraging the state-of-the-art YOLOv8 architecture, the system is designed to process video input, identify vehicles, and classify them with their respective brands. A YOLOv8s model, pre-trained on the COCO dataset, was fine-tuned on a custom-annotated dataset of over 19 car brands, employing transfer learning to achieve high accuracy with efficient training. The core functionality includes frame-by-frame detection and the generation of an output video with overlaid bounding boxes and brand labels. To enhance its practical utility, the system was extended with the ByteTrack algorithm to perform object tracking, enabling the accurate counting of unique vehicles over time. The results demonstrate a robust and high-performing solution with significant potential for applications in intelligent traffic management, automated surveillance, and market analysis.

Keywords: Vehicle Brand Detection, Deep Learning, YOLOv8, Object Tracking, Intelligent Traffic Management

AI based Real World Road Surface Informant

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Abstract

This project presents a comprehensive deep learning framework called Real World Road Guide**,** integrating segmentation and classification for automatic road surface analysis. The system identifies and classifies road conditions—Dry, Wet, Snow, Saline, and Unlabelled—crucial for intelligent transportation and autonomous driving applications. A pretrained SegFormer model is used for precise road mask generation, creating structured training and validation datasets. Images and masks undergo preprocessing, including resizing, normalization, and binary conversion, along with data augmentation techniques such as flipping, rotation, and brightness or contrast adjustments to improve robustness. A TensorFlow data pipeline efficiently handles image loading, preprocessing, and batching. The core model combines U-Net architecture with a classification head to perform road segmentation and surface type classification simultaneously. Training employs a hybrid loss function—Binary Cross-Entropy, Dice, and Sparse Categorical Crossentropy—optimized using the Adam optimizer**,** with callbacks like ModelCheckpoint, ReduceLROnPlateau, and EarlyStopping to enhance performance and stability. Model evaluation using Dice score, IoU, and accuracy demonstrates high precision and consistency. In testing, the trained model processes video frames in real time, predicting and labeling road surfaces accurately under diverse conditions. The framework showcases strong generalization across environments and lighting variations, offering a reliable solution for real-time road surface detection**.** This system enhances the safety and intelligence of autonomous driving by providing accurate, efficient, and adaptive road condition monitoring.

Keywords: Road Surface Classification, Deep Learning, SegFormer, U-Net, Intelligent Transportation Systems

Cotton Leaf Disease Detection with Gen-AI Recommendation

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Abstract

This project presents an intelligent cotton leaf disease detection system that integrates deep learning and generative AI to deliver accurate diagnoses and actionable treatment recommendations for farmers. Using transfer learning with pre-trained convolutional neural networks (VGG-19 and ResNet-50), the system classifies cotton leaf images into four categories: Bacterial Blight, Curl Virus, Fusarium Wilt, and Healthy. Comparative analysis identified ResNet-50 as the superior model, achieving 99.9% validation accuracy and selected for deployment. Principal Component Analysis (PCA) is applied for dimensionality reduction, compressing features from 200,704 to 128 dimensions while preserving 95% of key information to enhance computational efficiency. Grad-CAM visualizations provide explainable AI by highlighting the specific leaf regions influencing predictions, improving model transparency and trust. The system further integrates Google's Gemini 2.5 Flash API to generate context-aware agricultural guidance, converting technical outputs into practical treatment recommendations. An intuitive Gradio-based web interface allows users to upload images and receive results within 3–5 seconds, including disease classification, confidence scores, and visual explanations. This end-to-end framework enables early detection, reduces reliance on expert diagnosis, and democratizes access to advanced diagnostic tools. By bridging the gap between AI technology and real-world agriculture, the system contributes to sustainable farming practices, improved crop yields, reduced economic losses, and enhanced food security.

Keywords: Cotton leaf disease detection, Deep learning, ResNet-50, Explainable AI, Precision agriculture

Disaster Damage Assessment using Satellite Imagery

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Abstract

The proposed research introduces a deep learning method for detecting disaster damage using satellite images. It relies on the xView2 dataset, which contains pre- and post-disaster images labeled with building outlines and damage levels. The paper outlines an end-to-end pipeline for generating masks, processing the dataset in sections, and visualizing change detection. It uses polygon coordinates from JSON label files to create binary and color-coded masks for different damage classes: no damage, slight damage, significant damage, and destroyed. To effectively handle large data, a fragmented processing method divides the dataset into manageable parts. For each pair of images, the system calculates the Intersection over Union (IoU) between pre- and post-disaster masks to evaluate structural changes and create visual overlays highlighting affected areas. Supporting this preprocessing pipeline, the research explores deep learning models such as U-Net, Vision Transformer (ViT), and EfficientNet to improve damage classification and segmentation. Early results indicate these models have strong potential for recognizing complex spatial patterns and contextual relationships in disaster imagery. This study promotes developing scalable, AI-based systems that can accelerate damage assessment and emergency response. It could greatly influence real-time geospatial analysis and disaster management in the future.

Keywords: Disaster damage detection, Satellite imagery, Deep learning, U-Net, Vision Transformer

Miscellaneous

Quantum Machine Learning for Geospatial Image Classification: A Hybrid SVM Approach

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Abstract

The exponential growth of remote sensing and spatial imaging technologies has led to massive datasets requiring efficient and accurate classification methods. Traditional machine learning techniques, though powerful, often struggle with the high dimensionality and complexity of geospatial image data. This study presents a hybrid Quantum Machine Learning (QML) framework that integrates classical and quantum Support Vector Machines (SVMs) for geospatial image classification. Using standardized preprocessing—grayscale conversion, normalization, and principal component analysis (PCA)—the pipeline reduces data complexity and enhances model interpretability. The classical SVM, employing a radial basis function (RBF) kernel, serves as the baseline for comparison against a Quantum SVM (QSVM) implemented with Qiskit's Fidelity Statevector Kernel, leveraging quantum feature maps composed of Hadamard, RZ, and CZ gates. Experimental evaluations demonstrate that the QSVM achieves comparable or superior accuracy to the classical model, particularly in identifying minority or subtle spatial classes. Performance benchmarks highlight up to a 20% improvement in prediction accuracy and significant efficiency in detecting positive spatial cases. The hybrid architecture underscores the potential of QML in advancing geospatial analytics, remote sensing, and environmental monitoring, offering scalable, data-driven decision support for complex spatial datasets. As quantum hardware continues to evolve, such hybrid frameworks pave the way toward real-time quantum-enhanced geospatial analysis and sustainable smart decision systems.

Keywords: Quantum Machine Learning, Quantum Support Vector Machine (QSVM), Geospatial Image Classification, Remote Sensing, Hybrid Classical–Quantum Computing, PCA, Qiskit, Spatial Analytics.

Food Calories and Weight Prediction Using Deep Learning

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Abstract

In today's fast-paced lifestyle, maintaining a balanced diet and monitoring calorie intake has become increasingly important for health and fitness. Manual methods of calorie estimation are often time-consuming and prone to error. To address this issue, this project proposes an automated system for Food Calories and Weight Prediction using Computer Vision and Deep Learning techniques. The system aims to identify different types of food from images and accurately estimate their caloric content and approximate weight based on visual features. The proposed model uses a Convolutional Neural Network (CNN) for food image recognition. The CNN is trained on a large dataset containing labeled images of various food items, along with their known calorie values and weights. Preprocessing techniques such as image resizing, normalization, and augmentation are applied to enhance model performance. Once trained, the model extracts deep visual features from the image and classifies the food item. A regression layer or additional dense layers are then employed to predict the food's approximate weight (in grams) and its caloric value (in kcal). The system can be deployed as a mobile or web application, where users upload or capture a food image. The model processes the image and provides instant feedback about the type of food, its estimated portion size, and calorie count. Such a system can assist users in diet management, healthcare monitoring, and obesity prevention. Experimental results show that deep learning models such as VGG16, ResNet50, or MobileNet achieve high accuracy in food classification and calorie estimation when trained with sufficient labeled data. Future enhancements may include 3D food volume estimation using depth sensing and integration with nutrition tracking apps for personalized recommendations. Overall, this project demonstrates the potential of AI-powered food recognition in promoting healthier lifestyles through automated calorie and weight prediction.

Keywords: Food Calorie Estimation, Computer Vision, Deep Learning, Convolutional Neural Network (CNN), Diet Management

Food Calories and Weight Prediction Using Deep Learning

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Abstract

In today's fast-paced lifestyle, maintaining a balanced diet and monitoring calorie intake has become increasingly important for health and fitness. Manual methods of calorie estimation are often time-consuming and prone to error. To address this issue, this project proposes an automated system for Food Calories and Weight Prediction using Computer Vision and Deep Learning techniques. The system aims to identify different types of food from images and accurately estimate their caloric content and approximate weight based on visual features. The proposed model uses a Convolutional Neural Network (CNN) for food image recognition. The CNN is trained on a large dataset containing labeled images of various food items, along with their known calorie values and weights. Preprocessing techniques such as image resizing, normalization, and augmentation are applied to enhance model performance. Once trained, the model extracts deep visual features from the image and classifies the food item. A regression layer or additional dense layers are then employed to predict the food's approximate weight (in grams) and its caloric value (in kcal). The system can be deployed as a mobile or web application, where users upload or capture a food image. The model processes the image and provides instant feedback about the type of food, its estimated portion size, and calorie count. Such a system can assist users in diet management, healthcare monitoring, and obesity prevention. Experimental results show that deep learning models such as VGG16, ResNet50, or MobileNet achieve high accuracy in food classification and calorie estimation when trained with sufficient labeled data. Future enhancements may include 3D food volume estimation using depth sensing and integration with nutrition tracking apps for personalized recommendations. Overall, this project demonstrates the potential of AI-powered food recognition in promoting healthier lifestyles through automated calorie and weight prediction.

Keywords: Food Calorie Prediction, Computer Vision, Deep Learning, Convolutional Neural Network (CNN), Health and Fitness

Applications of Geo AI and Remote Sensing in Fisheries and Aquaculture: A Comprehensive Review of Tools, Trends and Future Directions

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Abstract

The integration of Geospatial Artificial Intelligence (GeoAI) and remote sensing technologies is revolutionizing fisheries and aquaculture, offering advanced solutions for sustainable management, environmental monitoring, and productivity enhancement. This comprehensive review synthesizes current research, tools, and applications of GeoAI and remote sensing in the domain, drawing insights from recent advancements across satellite imagery, unmanned aerial systems (UAS), Internet of Things (IoT), and machine learning models. Key areas of impact include habitat mapping, water quality assessment, fish stock estimation, disease detection, and precision aquaculture operations. The study highlights emerging trends such as real-time monitoring, multi-source data fusion, cloud-based geospatial platforms, and the use of deep learning for predictive analytics. Challenges such as data quality, model scalability, and limited integration in low-resource settings are critically examined. Finally, the review outlines future directions focused on increasing accessibility, enhancing interoperability, and fostering cross-disciplinary collaboration to accelerate innovation. The convergence of GeoAI and remote sensing holds transformative potential for the blue economy, promoting resilience, efficiency, and ecological balance in fisheries and aquaculture systems worldwide.

Keywords: Geospatial Artificial Intelligence (GeoAI); Remote Sensing; Fisheries Management; Internet of Things (IoT); Water Quality Monitoring

About Centurion University

Centurion University of Technology and Management (CUTM) is the first private University in Odisha which was established through the CUTM Act 4 of the Odisha State Legislative Assembly in 2010. In due course, it has got recognition as Grade-A+ University by National Assessment and Accreditation Council (NAAC), Ministry of HRD and 12 B status by the University Grants Commission (UGC). Centurion University's School of Vocational Education and Training has been recognized as a Centre of Excellence by Ministry of Skill Development and Entrepreneurship, Government of India and MSS School of Agriculture & School of Fisheries have been accredited by ICAR, India. This University is duly recognized as a pioneer in 'Skill Integrated Higher Education". Centurion has embraced the Agenda for Sustainable Development and the associated Sustainable Development Goals (SDGs) since being formally announced in 2015. Whilst having an indirect impact and contribution on almost all 17 SDGs, Centurion has specifically focused on 9 SDGs and embedded it in each vertical from its strategy, governance, institutional management and outcomes.

About Department of Civil Engineering

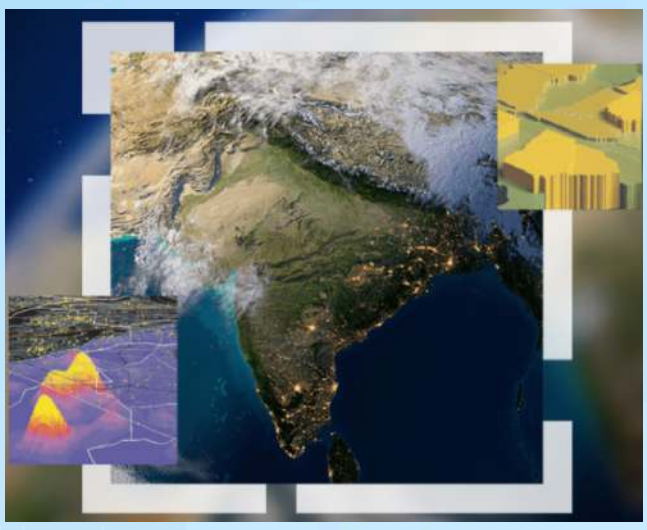
Department of Civil Engineering of SoET, that offers B. Tech programme in Civil Engineering and M. Tech pro-gramme in Structural, Transportation and M.Sc. (Geoinformatics) has plentiful infrastructure to cater to the academic needs of its students. The department is supported by both senior faculty with vast experience and young qualified faculty who not only disseminate knowledge but also motivate the students and raise their aptitude of learning and become knowledgeable and wise as well. The distinctiveness of CUTM in general and the department of civil engineering in particular is its curriculum planned under Choice Based Credit System (CBCS) as well as offers Domain project (Aerial Surveying and Remote sensing applications) which enable the students to choose the subjects that match their interest of professional career.

About Centre for Data Science and Machine Learning

The Centre for Data Science and Machine Learning at Centurion University of Technology and Management focuses on applying scientific methods to extract knowledge from data through its research and academic programs. The center conducts research in areas like multispectral image processing, plant disease detection, natural language processing, and big data analysis, often using technologies like Hadoop and MongoDB. The university offers a B.Tech in Computer Science and Engineering (CSE) with a specialization in Artificial Intelligence and Machine Learning, which integrates core CSE concepts with advanced data science topics.

About ESRI India

Esri, the global market leader in geographic information system (GIS) software, location intelligence, and map-ping, helps customers unlock the full potential of data to improve operational and business results. Founded in 1969 in Redlands, California, USA, Esri software is deployed in more than 350,000 organizations globally and in over 200,000 institutions in the Americas, Asia and the Pacific, Europe, Africa, and the Middle East, including Fortune 500 companies, government agencies, non-profits, and Universities. Visit us at esri.in.



About GIS Day

GIS Day is an annual event celebrated on the third Wednesday of November to promote awareness of Geographic Information Systems (GIS) technology and its applications. It is a global celebration that encourages people to learn about GIS through events like workshops, seminars, and map exhibitions, which help showcase how GIS is used to make better decisions and solve real-world problems. The first GIS Day was held in 1999. The purpose is to:

- **Raise awareness of GIS technology and its impact on daily life.**
- **Provide a forum for users to showcase real-world applications of spatial data analysis.**
- **Inspire the next generation of geospatial thinkers and professionals.**