BRIDGING REMOTE ENVIRONMENTS WITH NTN, INTELLIGENT IOT AND EDGE AI

Extending connectivity to the unconnected

Mehran Behjati, PhD

Faculty of Engineering & Technology

Sunway University, Malaysia

✉ **mehranb@sunway.edu.my**

SUNWAY UNIVERSITY

MY RESEARCH

- Wireless Communications & Networking (Cellular, NTN, LPWAN)
- Applied AI, Federated Learning, and TinyML
- IoT
- Intelligent systems for environmental monitoring/preservation

Designing intelligent systems for environmental monitoring

WHY REMOTE MONITORING MATTERS

Urgent Need

- Protecting Earth, ecosystems, and planetary health requires immediate action.
- Demands collaboration among researchers, scientists, policymakers, and communities.

Technical Limitations Today

- Lack of infrastructure & connectivity.
- Intermittent / delay-prone links.
- Energy & cost constraints.
- Difficult & unsafe access to remote sites.

Opportunity

- Advancing IoT, Edge AI, NTN & DTN can unlock scalable, sustainable monitoring.
- A shared mission: bridging technology with planetary health.


CANTERBURY
AUTHENTIC
RED DEER
DIVISION

EDGE INTELLIGENCE FOR WILDLIFE CONSERVATION: REAL-TIME HORNBILL CALL CLASSIFICATION USING TINYMLEGY

Real-Time Hornbi

Audio Input (Hornbill Calls from Environment)

Source: Xeno-Canto

TinyML Model Inference (1D CNN)

Classifying hornbill species

Deployment on Edge Device (Arduino Nano 33 BLE Sense)

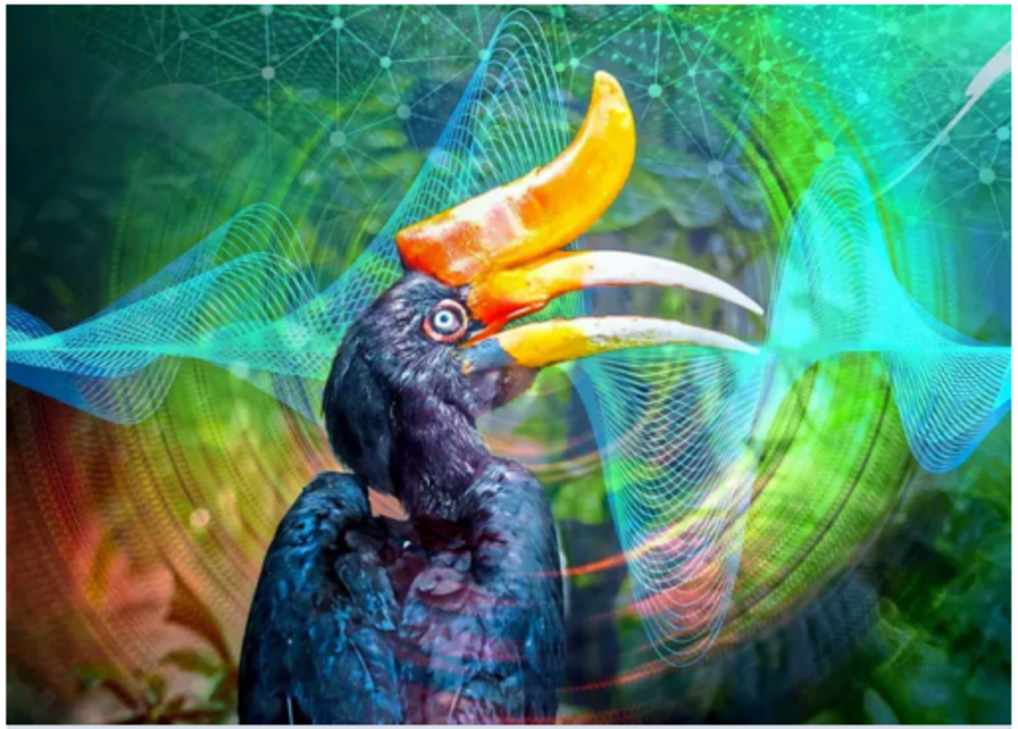
Implementing on edge device

Ecowatch: Smart tech takes flight in Malaysian jungles

By SIM LEOI LEOI

ENVIRONMENT

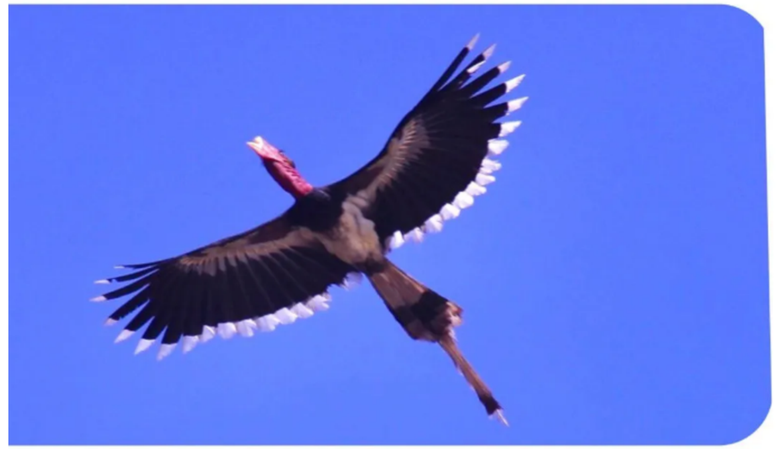
Wednesday, 11 Jun 2025

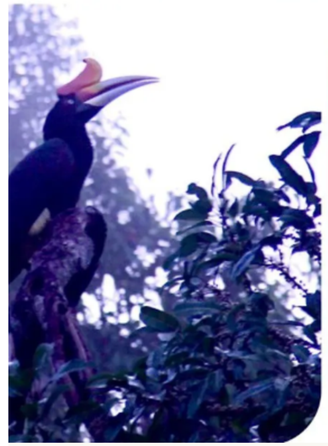


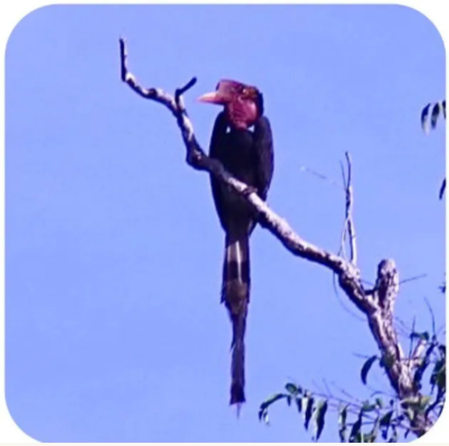
Artificial intelligence is transforming the world as we know it – so why not in the field of conservation? AI might just prove to be a game changer in helping to track hornbills in Malaysian jungles to protect them. — TheStarGraphic

FOR years, lecturer Dr Mehran Behjati and his wife would spend their weekends outdoors, taking to the bike trails and cycling into the remote areas and villages of Selangor, and even as far as Bukit Tinggi in Pahang, some 70km away from the Klang Valley.

Armed with binoculars, they would keep a lookout for birds, particularly hornbills.







UAV-ASSISTED FEDERATED LEARNING WITH HYBRID LORA P2P/LORAWAN FOR SUSTAINABLE BIOSPHERE MONITORING

Problem:

- Remote ecosystems = limited infrastructure.
- Challenges: long-distance communication, link reliability, and scalability.
- Conventional systems: costly & inefficient.

Proposed System (UFEM):

- Aerial Access Networks (AAN) using UAV relays.
- Federated Learning (FL) for distributed model training.
- Hybrid LoRa P2P/LoRaWAN for flexible connectivity.

Preliminary Results:

- Improved coverage & data reliability in remote settings.
- Demonstrated feasibility of AAN + FL + hybrid LoRa integration.

Outlook:

- Planned deployments in Malaysia’s natural lakes.
- Testing under dynamic terrain & conditions.
- Contributions: scalability, resilience, sustainability.

Federated Edge Intelligence for Scalable and Sustainable Water Quality Monitoring in Tropical Remote Lakes

Scope:

Deploy a **scalable, resilient, and cost-effective water quality monitoring system** for **remote tropical lakes**, with a Proof-of-Concept (PoC) implementation at **Tasik Chini**, Malaysia's UNESCO Biosphere Reserve.

Problem:

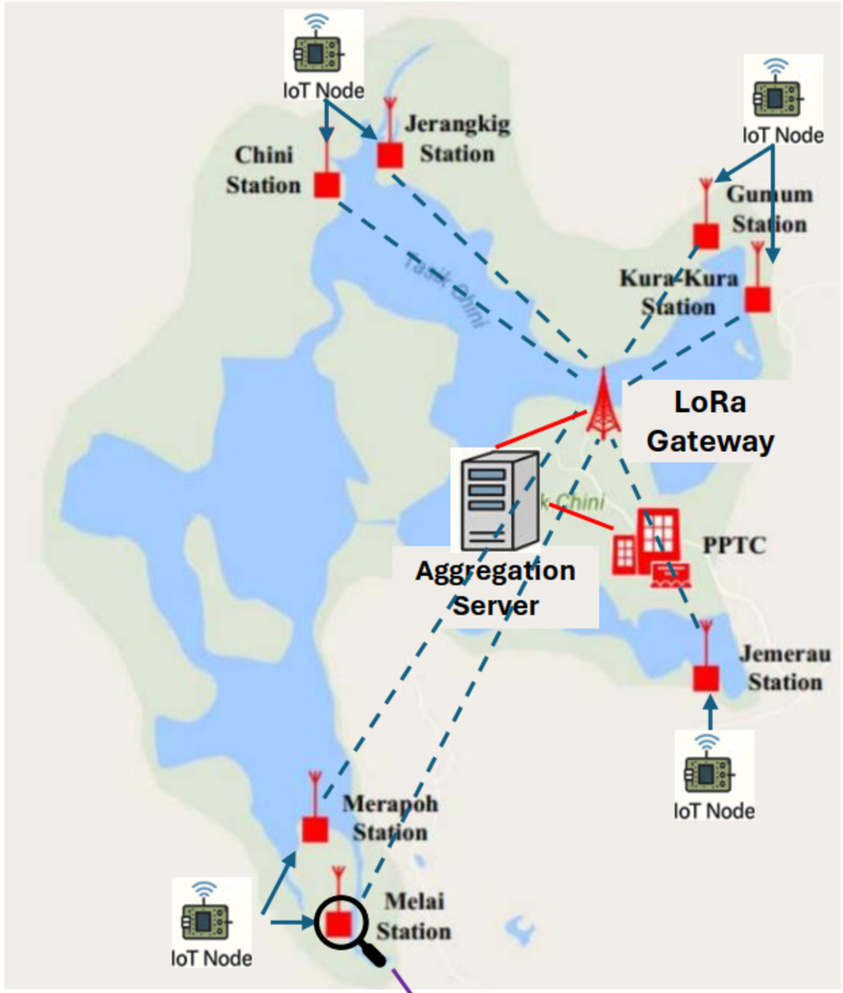
Conventional centralized monitoring systems are **unsuitable for tropical remote environments** due to:

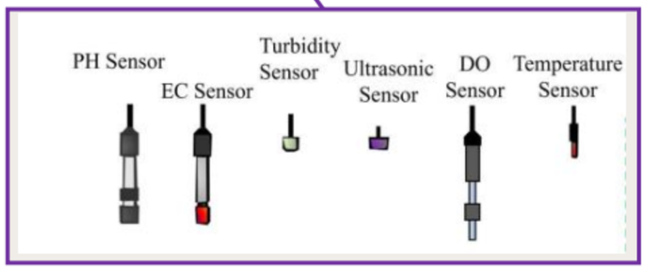
- Severe signal loss (dense foliage, terrain) High infrastructure costs and poor coverage
- Energy inefficiency and operational sustainability issues
- Data privacy and regulatory constraints

Idea:

Integrate **Federated Learning (FL)** with **LoRaWAN-enabled IoT nodes** to enable:

- **Decentralized model training** at the edge,
- **Low-power, long-range data transmission,**
- **Resilient and scalable monitoring** with minimal infrastructure reliance.





Concept:

We have already developed the **system concept and architecture**.

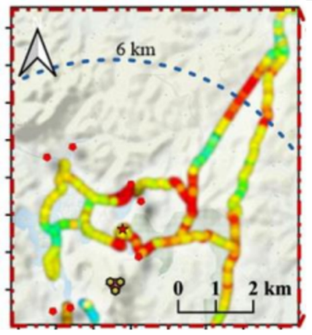
This project seeks funding to implement a Proof-of-Concept (PoC) across seven water monitoring stations at **Tasik Chini (PPTC)**, demonstrating:

- Enhanced communication reliability,
- Energy-efficient FL model training,
- Cost-effective and sustainable operation

in harsh tropical ecosystems.

Methodology:

- **Design & Prototype**: FL-enabled nodes + LoRaWAN aggregation.
- **Field Deployment**: Setup across 7 Tasik Chini monitoring stations.
- **Optimization**: Lightweight FL scheduling, communication efficiency.
- **Validation**: Real-world performance analysis vs conventional systems.



Heatmap of LoRa coverage at Chini Lake

Enhancing Hiker Safety in Rainforest National Parks

🚩 The Challenge

Many rainforest national parks lack reliable wireless connectivity due to **dense canopies**, **rugged terrain**, and **infrastructure gaps**.

🌿 **No real-time tracking** or **emergency alerts** exist.

🛰️ **Satellite-based solutions** are **expensive**, **power-hungry**, and **unreliable** in dense forest conditions.

💡 The Solution

A **scalable, low-power LoRaWAN-based system** tailored for dense rainforest terrain:

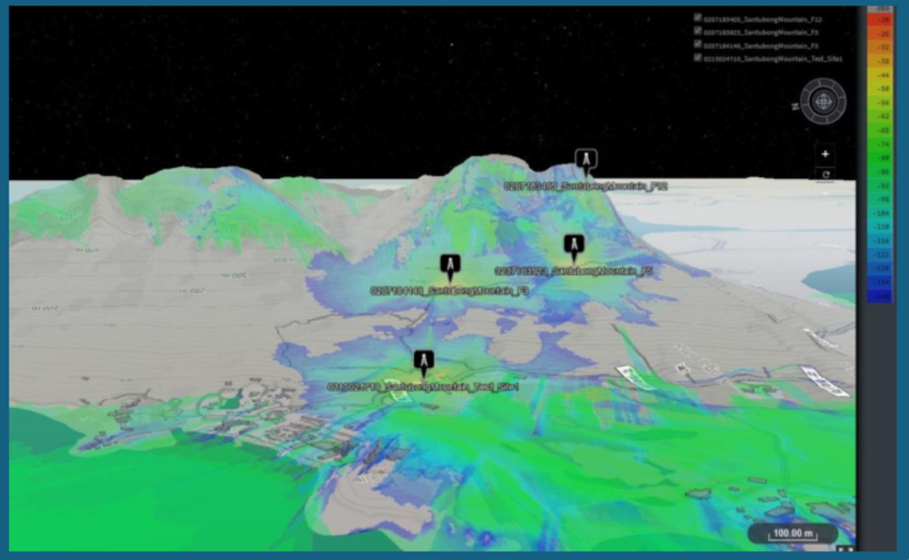
- **Wearable GPS trackers** with SOS buttons and geofencing
- **LoRaWAN gateways** deployed in strategic high-elevation points
- **Cloud platform** for real-time monitoring and emergency response
- **Training & engagement** with rangers and indigenous communities

✅ *Preliminary study and simulation completed (TRL 3)*

🚀 *This project will scale it up to TRL 7 with full deployment and testing*

🌍 Pilot Location

Santubong National Park, Sarawak, Malaysia



Coverage prediction result in Santubong Nature Park

🔧 What's Included?

- Hardware & software development
- Field deployment (20+ trackers, 4 gateways)
- System performance & safety evaluation
- Stakeholder training (30+ participants)
- Environmental & economic sustainability model
- Open-source documentation for replication

🌟 Expected Impact

📶 Extend digital connectivity in underserved rainforest zones

🧭 Enable real-time hiker tracking, alerts & rapid response

🌳 Promote sustainable eco-tourism & safer outdoor recreation

🤝 Strengthen digital inclusion for remote communities

📊 Contribute to **IoT policy and technical standards**

🧪 Produce **2 journal articles + 1 international conference paper**

APNIC FOUNDATION

isif asia

6G White Paper on Connectivity for Remote Areas

BROADER RESEARCH VISION

Intelligent & Integrated Environmental Sensing Systems (IIESS)

Our Mission

- Pioneer scalable, sustainable, and intelligent sensing systems.
- Address challenges in environmental monitoring & planetary health.
- Align with SDGs, sustainability, and digital transformation.

Our Approach

- Leverage IoT, Edge/Federated AI, and Wireless/NTN.
- Design & validate end-to-end autonomous platforms.
- Focus on both natural ecosystems & built environments.

Our Role

- Hub for interdisciplinary collaboration.
- Innovation engine for sensing technologies.
- Training ground for future researchers & innovators.

Core Research Areas

Smart Environmental Sensor Networks

AI and Edge Intelligence

Wireless and Sustainable Communication

Green and Adaptive IoT Architectures

Data Fusion and Predictive Analytics

Application Domains

NON-TERRESTRIAL IOT NETWORKS:

ARCHITECTURES, APPLICATIONS, AND FUTURE CHALLENGES

CALL FOR PAPERS

SUBMISSOIN THEME

- **NT-IoT Architectures and Protocols:** Novel network designs and AI-optimized protocols for non-terrestrial IoT systems.
- **Communication and Connectivity:** Spectrum strategies, multi-access methods, and integration of terrestrial and non-terrestrial networks.
- **Edge Intelligence for NT-IoT:** ML and edge computing solutions enabling real-time decisions in non-terrestrial networks.
- **Applications and Case Studies:** Practical implementations in agriculture, disaster response, space, maritime, and environmental monitoring.
- **Standardization and Future Trends:** Insights into 6G, standardization efforts, AI-driven NT-IoT evolution, and global connectivity policies.

Manuscript Submission Deadline 29 September 2025

We welcome original research articles, comprehensive reviews, system implementations, and technical case studies that contribute to the advancement of NT-IoT networks.

Frontiers in Communications and Networks

- **WOS Indexed**
- **Scopus Indexed**
- **Impact Factor: 2.1**
- **CiteScore: 4.9**

Scan the QR code or click here to learn more and submit

Frontiers in Communications and Networks

CALL FOR PAPERS

Special Issue: Trustworthy Communication in IoT

Blockchain and Quantum Technologies at the Security Frontier

SUBMISSOIN THEME

- Post-quantum cryptographic protocols in IoT
- Blockchain-based identity management and authentication
- Lightweight cryptographic protocols for resource-constrained IoT devices
- Smart contract-based frameworks for device authentication and access control
- Quantum-secure authentication protocols for IoT communication
- Quantum key distribution in IoT networks
- Hybrid blockchain–quantum architectures enabling end-to-end trustworthy IoT communication
- Trust management and reputation models for decentralized IoT systems
- Intrusion detection and mitigation using decentralized trust models
- Adversarial modeling and attack surfaces in quantum-enabled IoT ecosystems
- Security-by-design approaches for future IoT and cyber-physical systems
- Lightweight consensus mechanisms
- Applied case studies in smart healthcare, autonomous vehicles, smart grids, and industrial IoT

IMPORTANT DATES

24 July 2025	11 November 2025	2 Months	February 2026
Abstract Submission	Manuscript Submission Deadline	Peer Review Process	Special Issue Publication

WOS Indexed
Scopus Indexed
Impact Factor: 2.1
CiteScore: 4.9

SCAN THE QR CODE OR CLICK HERE TO LEARN MORE AND SUBMIT

THANK YOU!

✉️ **mehranb@sunway.edu.my**
🔗 **LinkedIn:** https://www.linkedin.com/in/mehran-behjati/
🔗 **Medium:** https://medium.com/@mehran_behjati