P2EI-WEALTH (Physiological and Psychological Edge Intelligence WEArable LoRa HealTH) System for Remote Indigenous Community and Disaster Recovery Operation
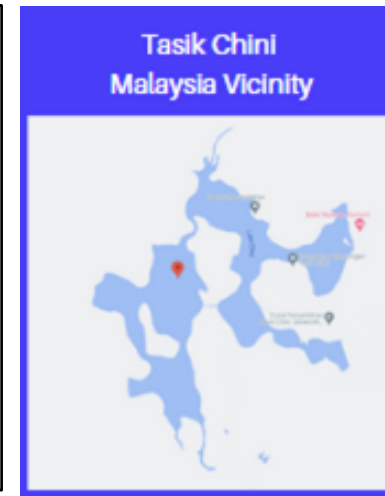
Background :
1. The indigenous people and the rescue operators in remote and dangerous vicinities cannot profit from the use of intelligent wearable health support system due to limited connectivity
2. Current wearables have multiple measurements from Physio and Psychological sensors but not supported by edge-intelligence to be analyzed together
3. Current wearables are for individual purposes and not for common monitoring and intervention purposes

Targets :
1. Working P2EI-Wealth Prototype using LoRA connected to a portable data center
2. Edge Intelligence model for the physio and psychological measurements and correlation establishment
3. Test and analysis using **2 use cases**
   1. Remote indigenous area (Tasik Chini, Malaysia)
   2. ~~Disaster recovery operation (Quezon City, Philippines)~~

Tasik Chini
Malaysia Vicinity

Speaker :
Project Leader - Asma Abu-Samah
Wireless Researach@UKM, Universiti Kebangsaan Malaysia (UKM)

P2EI-WEALTH (Physiological and Psychological Edge Intelligence WEArable LoRa HealTH) System for Remote Indigenous Community and Disaster Recovery Operation

Project Members :

Full Name	Department, Institution, Country
Asma Abu-Samah *	Universiti Kebangsaan Malaysia, Malaysia
Rosdiadee Nordin	Universiti Kebangsaan Malaysia, Malaysia
Nor Fadzilah Abdullah	Universiti Kebangsaan Malaysia, Malaysia
Mohd Radzi Ab Rahim	Universiti Kebangsaan Malaysia, Malaysia
Reginald Juan Magpantay Mercado	GTek Entreprise, Philippines
Xarxes C. Alejos	GTek Entreprise, Philippines
Jennifer C. De La Cruz	Mapua University, Philippines
Glenn V. Magwili	Mapua University, Philippines

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MR. REGINALD JUAN M. MERCADO

MR. GLENN V. MAGWILI

MR. XARXES C. ALEJOS

Project Duration : 18 Months (01/06/2022 – 31/12/2023) + 12 Months Ext.

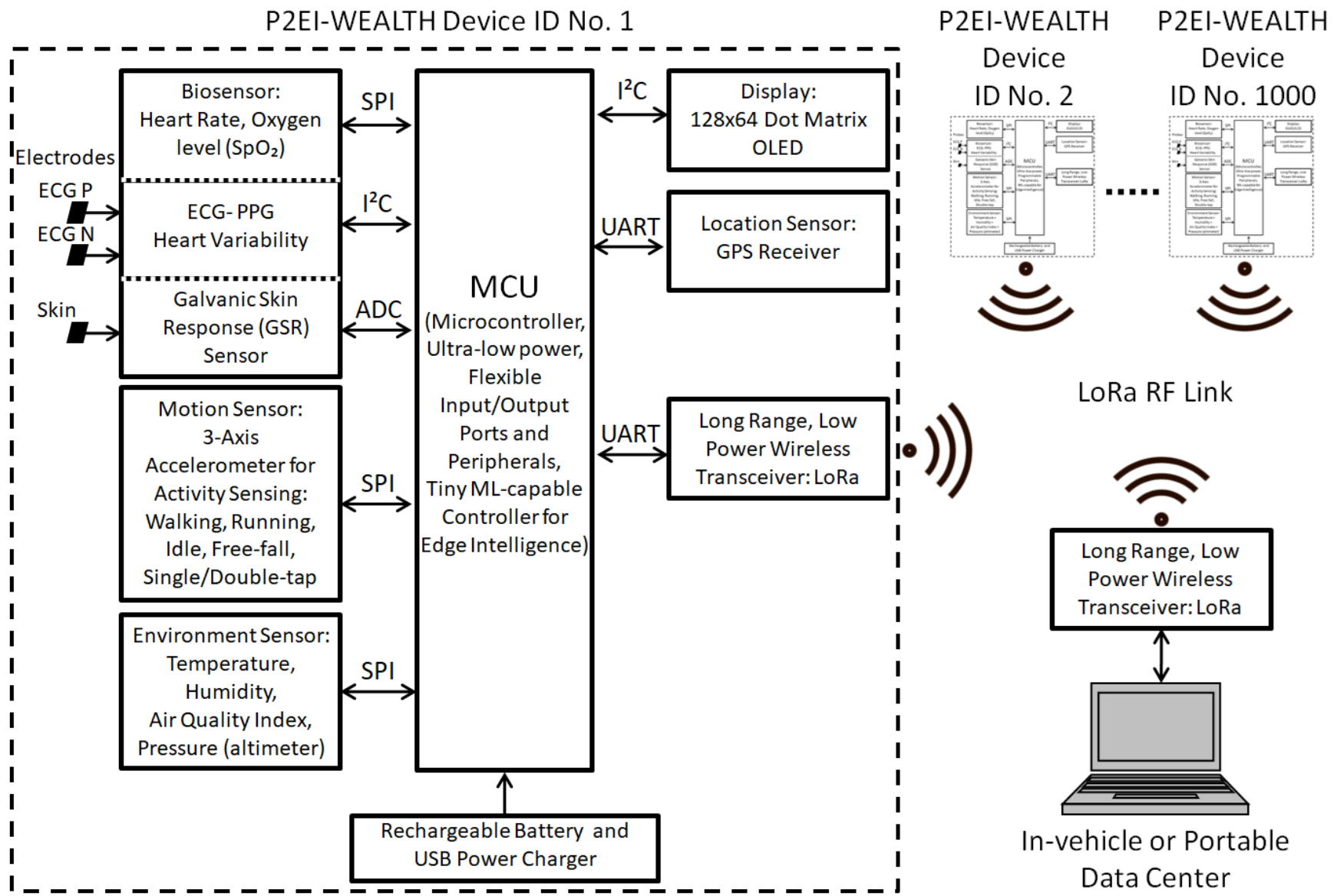**Project Budget (40,260 USD):**
Expense of 30/10/2023 = 10,700 USD
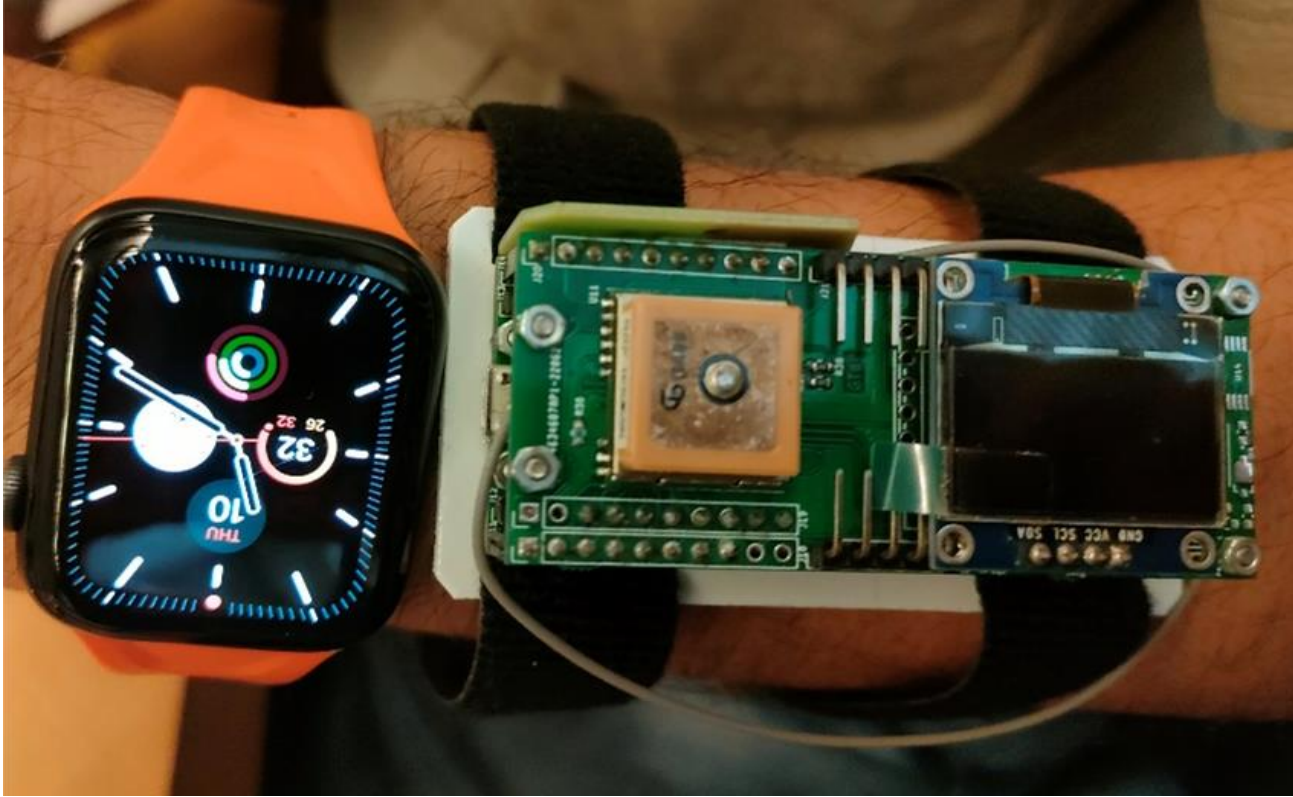Balance of 30/10/2023 = 29,560 USD

MAPÚA UNIVERSITY

Gtek Enterprise

Overview of the proposed P2EI-WEALTH system

The first version of the device with comparison to an Apple Watch
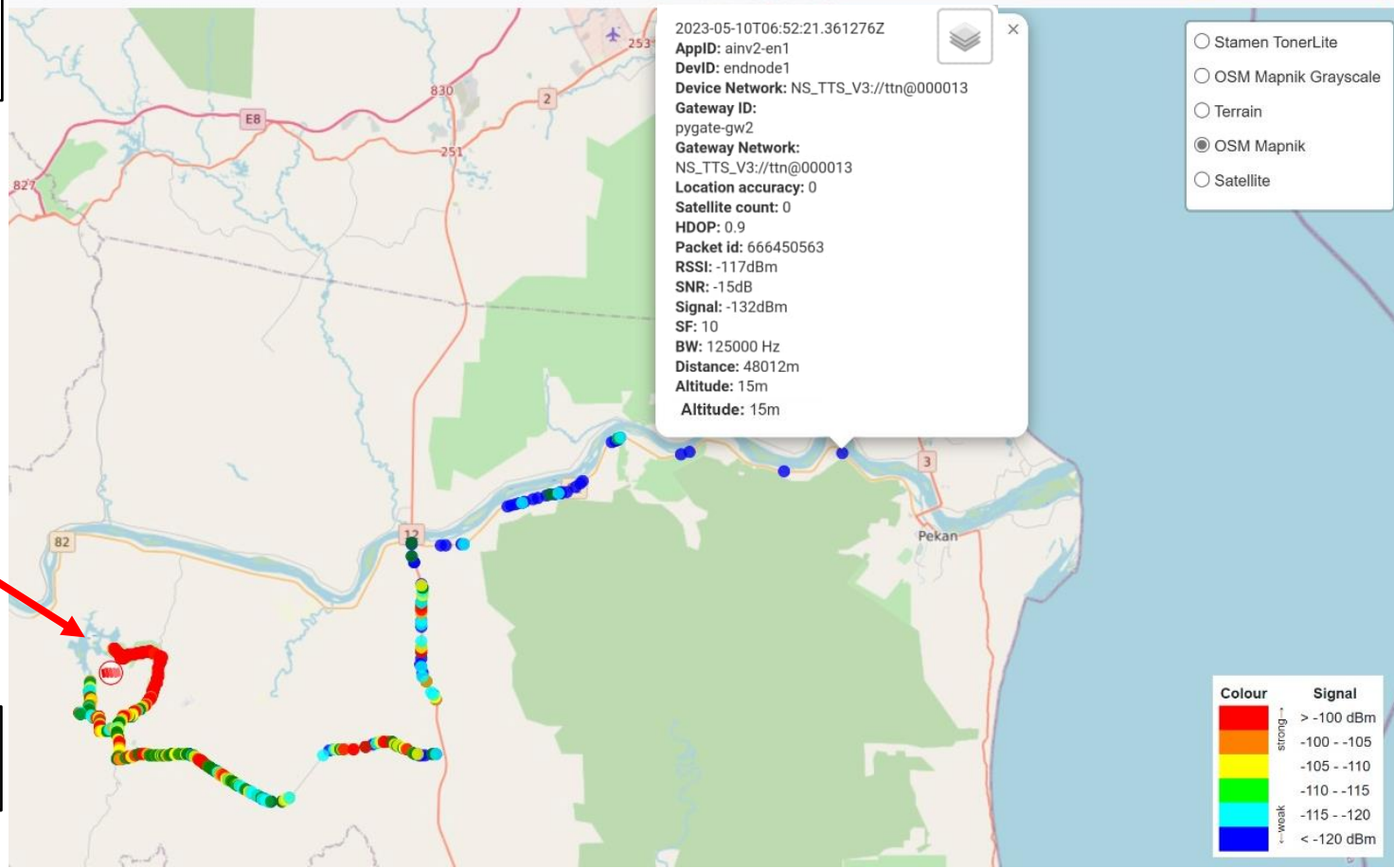

Visit to the Philippines and feedback for the improvement of device

Installement of LoRa Gateway on identified point in Mount Ketaya at 208m ASL by Dr. Fadzilah

Measurement using 3 different End Nodes, including a proprietary (RAK Wireless) field tester

2023-05-10T06:52:21.361276Z
AppID: ainv2-en1
DevID: endnode1
Device Network: NS_TTS_V3://ttn@000013
Gateway ID:
pygate-gw2
Gateway Network:
NS_TTS_V3://ttn@000013
Location accuracy: 0
Satellite count: 0
HDOP: 0.9
Packet id: 666450563
RSSI: -117dBm
SNR: -15dB
Signal: -132dBm
SF: 10
BW: 125000 Hz
Distance: 48012m
Altitude: 15m
Altitude: 15m

- Stamen TonerLite
- OSM Mapnik Grayscale
- Terrain
- ● OSM Mapnik
- Satellite

Colour	Signal	
	strong	> -100 dBm
		-100 - -105
		-105 - -110
		-110 - -115
	weak	-115 - -120
		< -120 dBm

Furthest point reached at 48.012km
Using Pycom-based EN
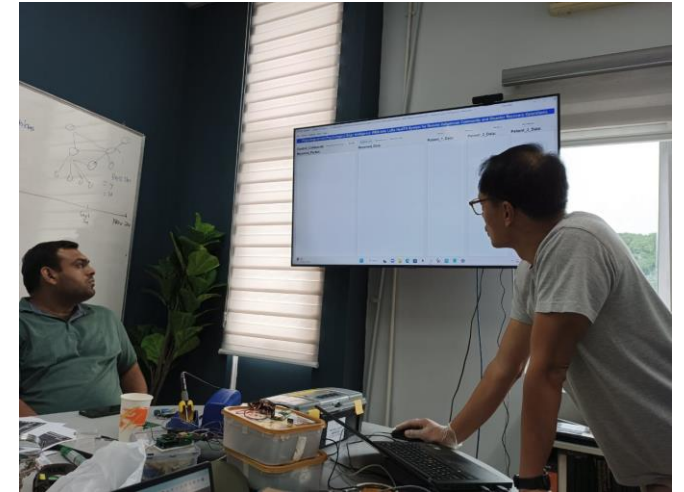*SF-7*

Brainstorming of measurement plans in Chini

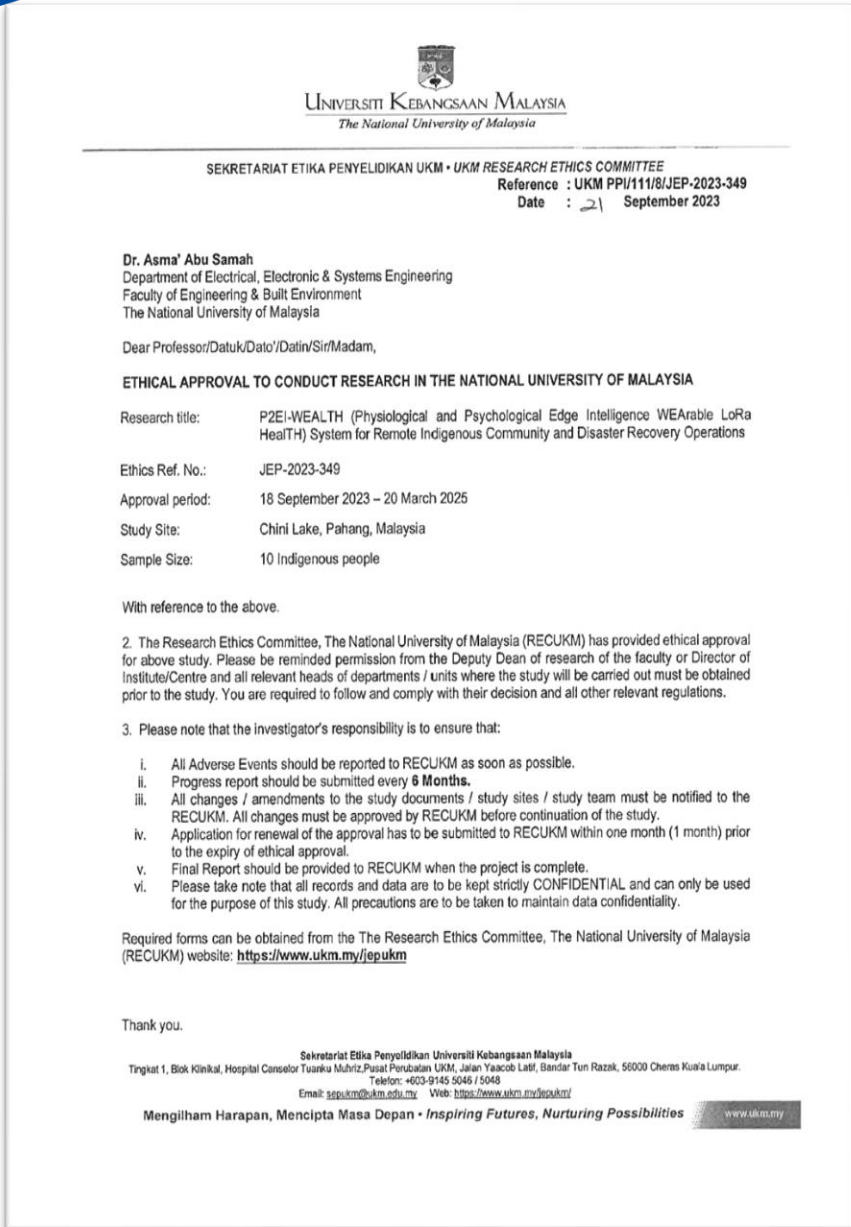
Testing using P2P protocol developed by Mr. Reggie (Gtek)

Mount of permanent structure for Bukit Ketaya by Prof. Rosdiadee

Bringing everyone together for 2 days
(Project members and voluntary students)

Engagement with a Medical Doctor from Public Health HQ with experience on the indigeneous communities around Malaysia

+

Obtained approval for 18 Months, 18/09/2023 – 20/03/2025

+

Need to work on Medical Device Authority Approval

A summary of features extraction from Physiological signal

Parameters	Features	Description	Normalized Range
Heart Rate (HR)	Mean	Mean value of HR	0.056 ~ 1
	SD	Standard deviation of HR	0.008 ~ 0.131
	Minimum & Maximum	Minimum & maximum HR values	0.054 ~ 1; 0.083 ~ 0.922
Skin Temperature	Mean	Mean value of temperature	0.0007 ~ 0.824
	Minimum & Maximum	Minimum & maximum temperature values	0.0035 ~ 0.8283; 0.0035 ~ 0.8274
Electrodermal Activity (EDA)	Mean Phase	Mean phase component	0.757 ~ 0.944
	SD Phase	Standard deviation of phase components	0.001 ~ 0.949
	Minimum & Maximum	Minimum & maximum values	0.075 ~ 0.946

**Evaluation results for multiple algorithms and the resulting confusion matrix for Bootstrapping**

Algorithms	Accuracy (%)	Precision	Recall	F1 Score
Support Vector Machine	72.95	0.8500	0.6455	0.6225
Adaboost	71.45	0.7077	0.6503	0.6569
Random Forest	91.69	0.9164	0.8885	0.9164
Bootstrapping	95.82	0.9933	0.9802	0.9469
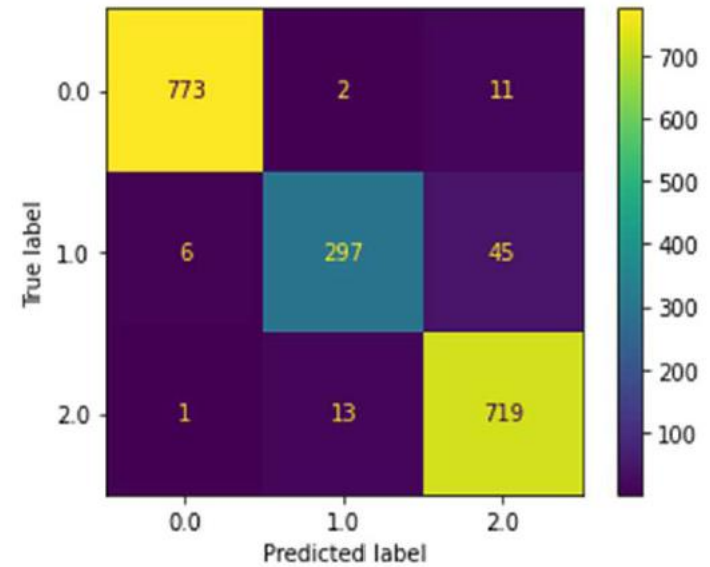
1. Merging the LoRaWAN protocol with the developed P2EI-WEALTH Protocol

2. Reproduction of 3-5 more P2EI-WEALTH devices
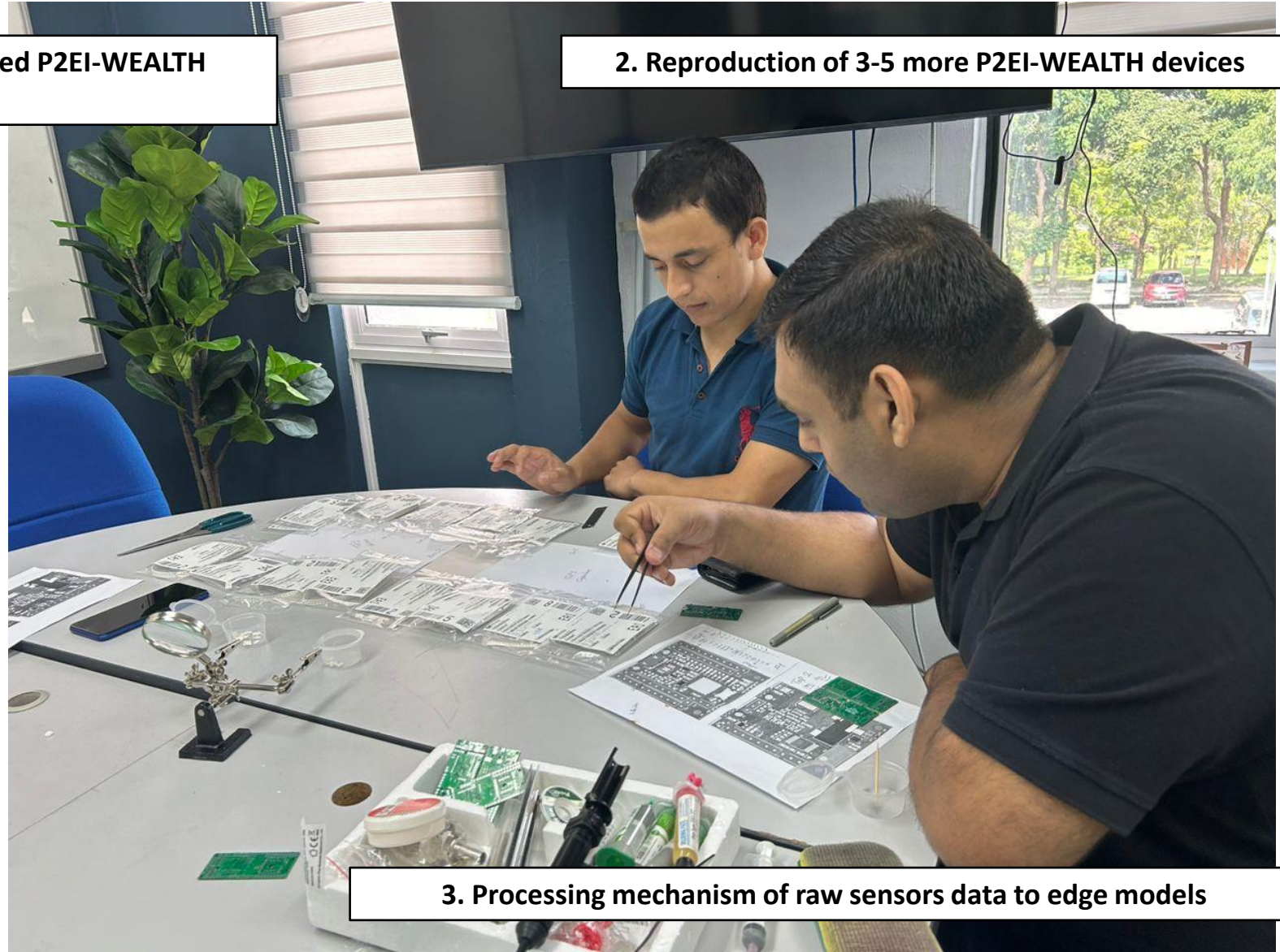
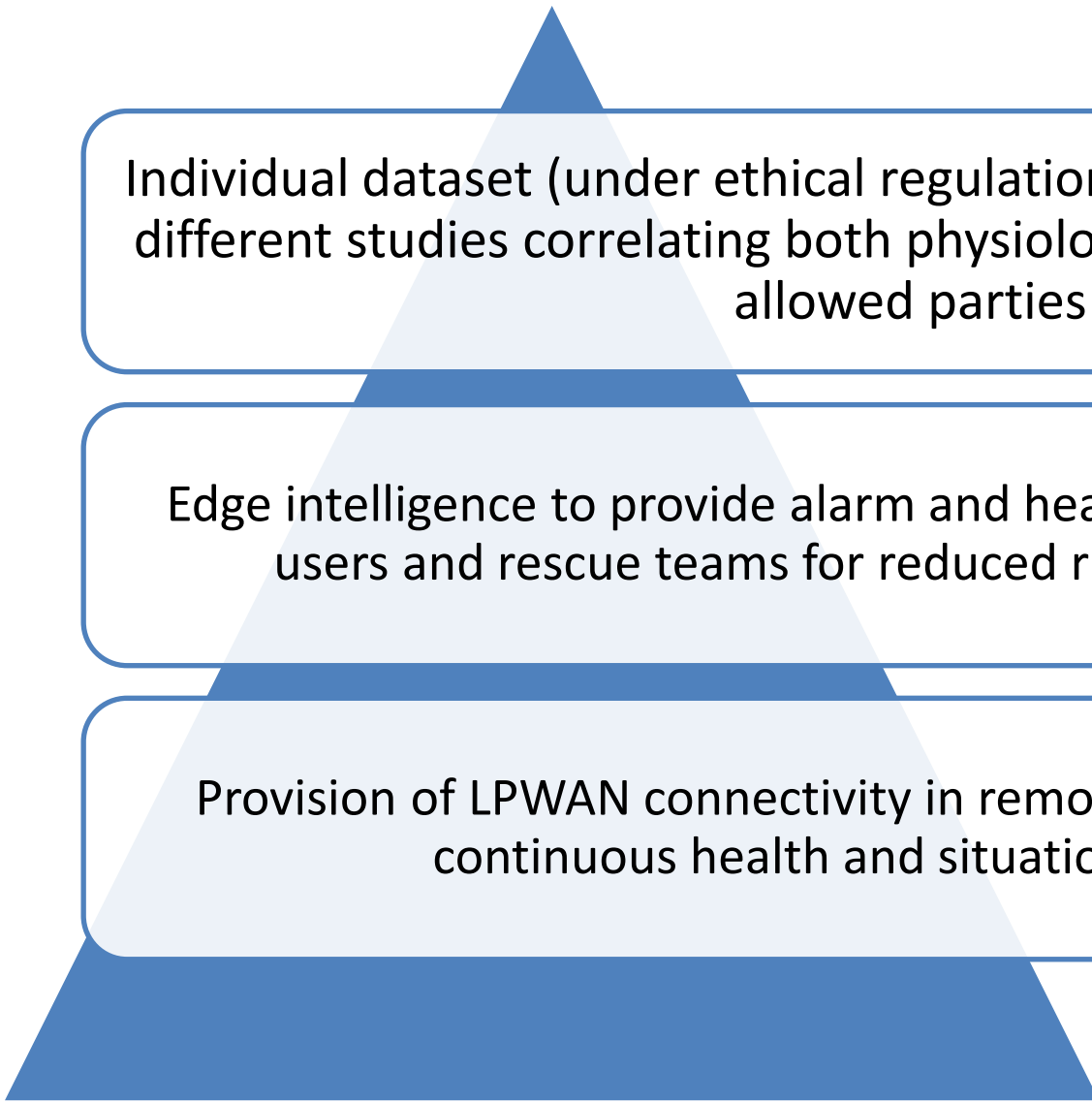3. Processing mechanism of raw sensors data to edge models

1. To purchase 2 research devices working on Bluetooth, with a health monitoring platform to compare the accuracy of P2EI-WEALTH device on the following measurements in lab environment,

- Electrodermal Activity (EDA) sensor
- Photoplethysmogram (PPG) sensor
- Accelerometer and gyroscope
- Digital temperature sensor

2. To test the functionality of the device in real environment

3. To use collected data to improve and validate the edge model

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Presentation at International Conference:

No:	Paper title:	Author names	Affiliation	Conference name:	The date of the conference	The venue of the conference
1.	Classification of stress using Machine Learning based on Physiological and Psychological Data from Wearables	Asma Abu-Samah, Jennifer Dela Cruz, Tuan Muhamad Affiq Aimullah Tuan Mohd Pauzi, Dalilah Ghaffa, Rosdiadee Nordin and Nor Fadzilah Abdullah	Universiti Kebangsaan Malaysia Mapua University Philippines	IEEE HNICEM 2023 15th International Conference on Humanoid, Nanotechnology, Information Technology, Communication and Control, Environment, and Management	November 19 - 23, 2023	Coron, Palawan, Philippines

Individual dataset (under ethical regulation) can be used to establish different studies correlating both physiological and psychological by allowed parties

Edge intelligence to provide alarm and health situation to individual users and rescue teams for reduced risk and interventions

Provision of LPWAN connectivity in remote and disaster areas for continuous health and situation monitoring

Conclusion and Future Works

Research Activity	Current results	Future Works	Allocated budget (USD)
Device design and optimization	2 working prototype with **own loRa protocol**, and with **no EDA sensor**	Merging the protocol with loRaWAN for use with existing gateways Integration of EDA sensor	500
Back-end data monitoring platform	A **working user interface**	To integrate with TTN Mapper (Cloud subscription)	1,500
Multiple prototype reproduction	4 **WIP devices**	Finish ASAP (Subject to component's availability)	1,000
Edge Intelligence modelling	**1 stress classification model** based on limited data (EDA, Skin T° and Heart Rate)	Improve Bootstrapping modelling based on complete data	500
System testing and validation	-	Device testing and data collection: January 2024	5,000
Impact analysis and project dissemination	-	Project meeting, 2 Conferences proceedings and 1 Journal	13,000
ASEAN-IVO Forum x2	*Subject to NICT plan		1,000
Research Exchange Program	*Subject to NICT approval		7,060
Total			**29,560**