Image Source: Maxwell Ridgeway

Using Neural Networks in Optimizing Vulnerability Indicators of Mangrove Forests Towards Climate Change

Graduate Seminar (ENS 299)

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Outline

1. Objectives
2. Related Literatures
3. Framework & Methodology
4. Expected Output
5. Limitations
6. Significance


Image Source: Maxwell Ridgeway

Objectives

To identify the level of vulnerability of mangrove forests in Cebu using an adaptive method in assessing vulnerability.

1. To identify the current extent of mangrove forests in Cebu.
2. To identify the indicators that are needed to analyze the vulnerability of mangrove forests.
3. To identify a new method in assessing the vulnerability of mangroves by using AI models.
4. To enable adaptive approach in the new method of quantifying vulnerability in mangroves.
5. To remove redundancy in the indicators for vulnerability by analyzing the created models.
6. To identify vulnerability levels in the different cities and municipalities in Cebu.

Related Literatures

According to Bellard et al. (2012), climate change is unequivocal and represents one of the greatest global threats to biodiversity and associated ecosystem services in the coming decades.

Image Source: Unsplash

Mangrove Forests

Mangrove forests live in the tropical and subtropical regions at the interface between terrestrial and marine environments (Koh et. Al, 2018). As a community, mangroves thrive in a wide range of harsh environmental conditions and they share unique adaptive traits such as salt-excreting leaves, an exposed breathing root system, and production of viviparous propagules (Duke, 1992). Mangrove habitats are ecologically important because they provide valuable ecosystem goods and services to coastal populations.

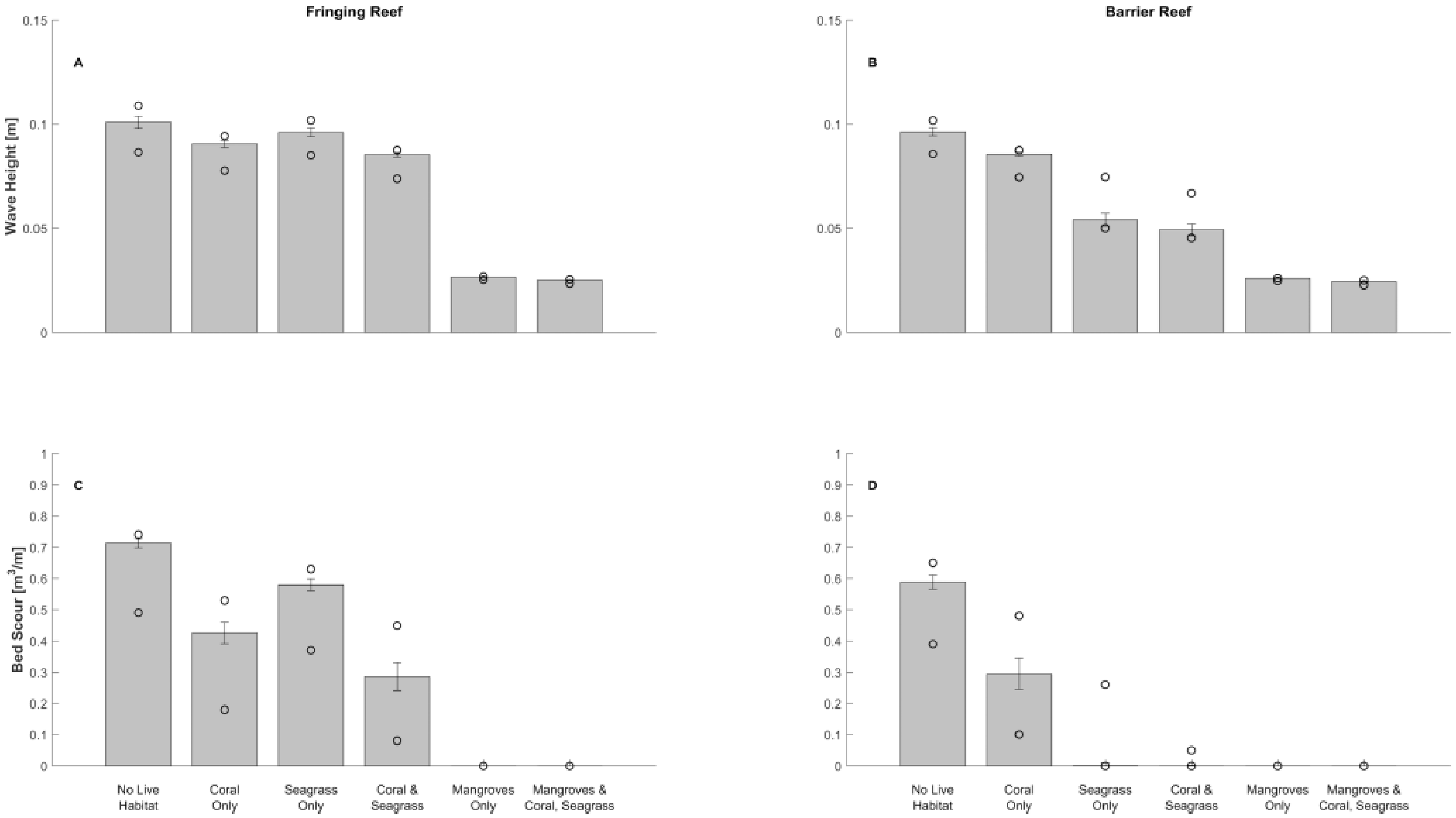


Fig 7. Protective role of corals, seagrasses and mangroves during non-storm conditions under present sea-level conditions. Bar plot of average wave height at the shoreward edge of the submerged mangrove forest (top subplots) and bed scour volume over the submerged mangrove forest (bottom subplots) computed for different combinations of live reef, seagrass meadows and mangroves presence, under present sea-level conditions. Vertical tick marks indicate 1 standard deviation value around the mean. Circles represent minimum and maximum values. See S5 Fig for box plot version of this figure for a future sea-level rise scenario.

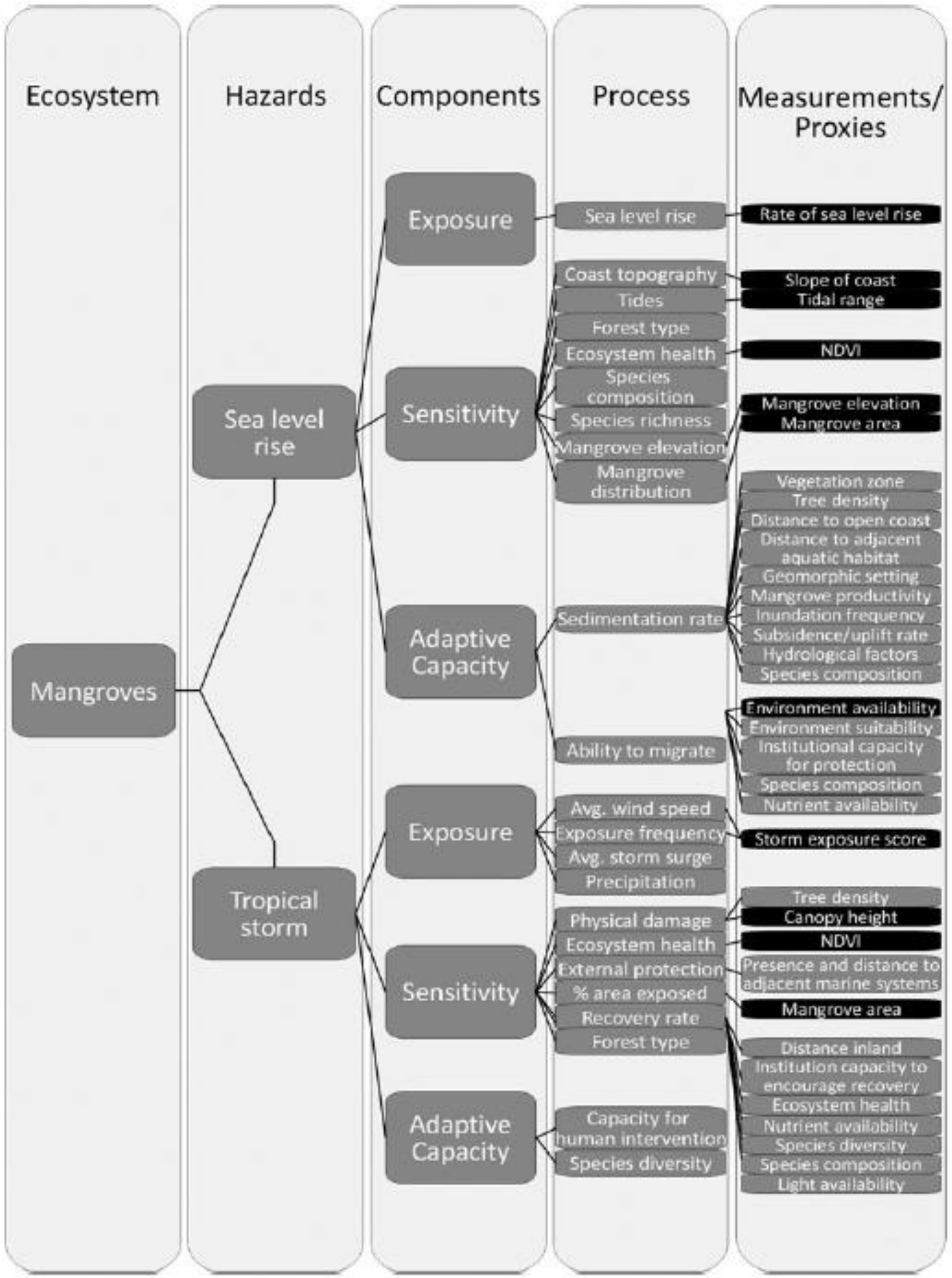
Guannel at al (2018)

A New Framework to Assess Relative Ecosystem Vulnerability to Climate Change

2017 ▪ Literature

Lee, C. K. F., Duncan, C., Owen, H. J. F., & Pettorelli, N. (2018). A New Framework to Assess Relative Ecosystem Vulnerability to Climate Change. *Conservation Letters*, *11*(2), 1. https://doi.org/10.1111/conl.12372

- This work aims to further develop the toolbox of available vulnerability assessments methodologies by developing a spatially explicit vulnerability assessment framework at the ecosystem scale, which we believe has not been attempted before.
- Our vulnerabilty assessment targets the ecosystem level, and so potential candidates include metrics capturing changes in ecosystem area, structural attributes, functional attributes, and ecosystem composition.



A Rapid, Low-Cost Approach to Coastal Vulnerability Assessment at a National Level

2016 · Literature

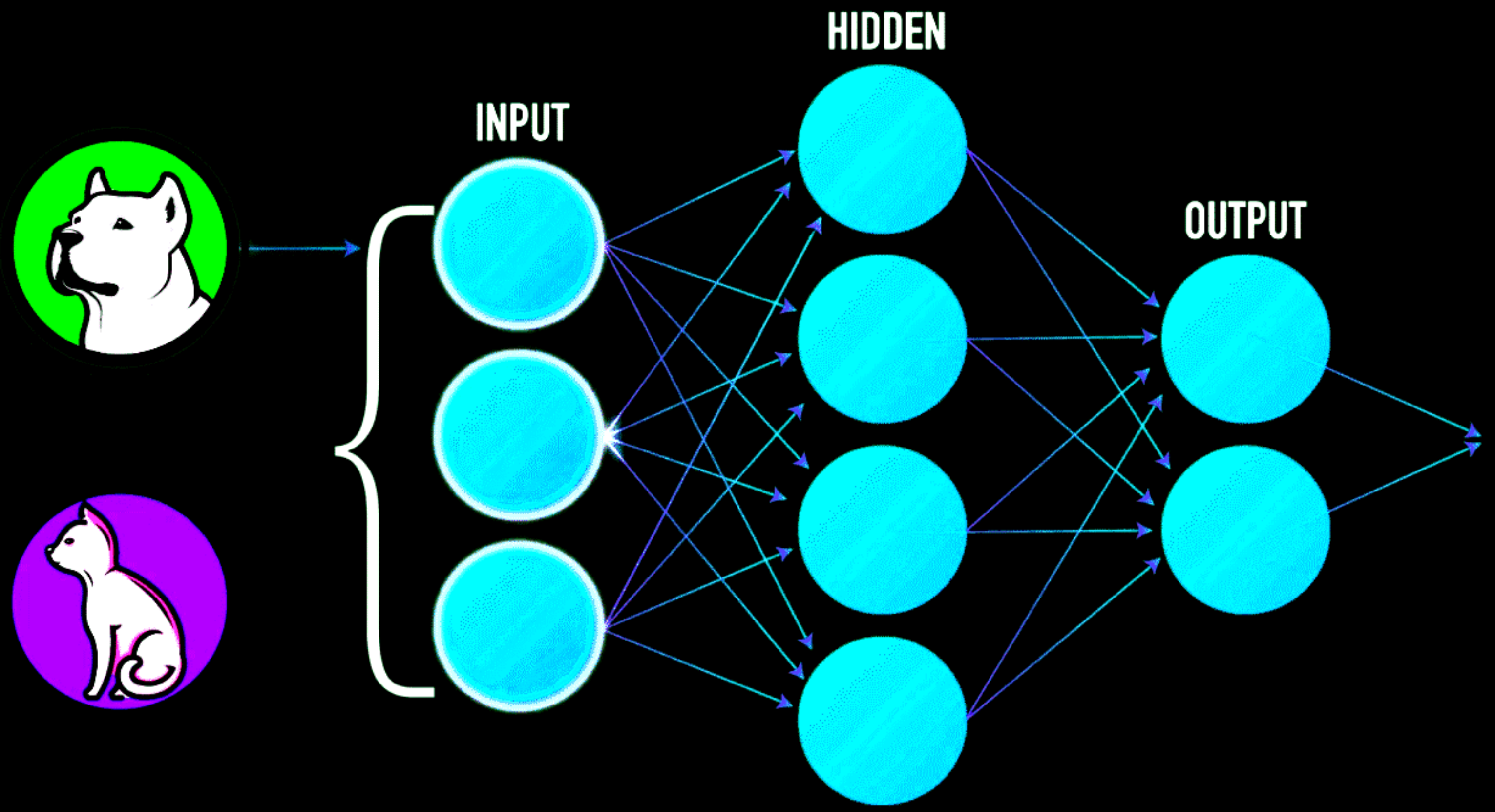
López Royo, M., Ranasinghe, R., & Jiménez, J. A. (2016). A Rapid, Low-Cost Approach to Coastal Vulnerability Assessment at a National Level. *Journal of Coastal Research*, *32*(4), 932–945. https://doi.org/10.2112/JCOASTRES-D-14-00217.1

- The lack of an easy-to-use assessment method that requires only readily available data has severely hampered efforts to assess national-scale coastal vulnerability to the potential impacts of CC and population growth in the coastal zone, particularly when project budgets are limited.
- This study presents a modified version of the Coastal Vulnerability Index (CVI) approach.

Parameter	Barcelona (Maresme)	Castelldefels/ Garraf	Castelló	Almería (Costacabana)	Almería (Delta Adra)	Cádiz (Valdevaqueros)	Ría de Arosa
Stretch number[a]	7, 9	15, 16	29, 30	60, 61	64	86	100
Geomorphology	1	1	5	5	4	5	5
Shoreline erosion/accretion	5	5	5	5	5	5	3
Coastal slope	4	5	3	4	5	3	4
Sea-level rise	3	3	3	3	3	4	3
Wave height	4	4	1	1	1	1	3
Tide range	5	5	5	5	5	4	3
Total CVI	14.14	15.81	13.69	15.81	15.81	14.14	16.43
Vulnerability[b]	H	H	H	H	H	H	H

Parameter	Besos	Llobregat	Tarragona	Ebro	Valencia	Alicante	Murcia	Málaga	Gulf of Cádiz
Stretch number[a]	12	14	17	24	38	41	47, 48	79	91
Geomorphology	5	5	5	5	5	3	5	4	5
Shoreline erosion/accretion	5	1	5	5	5	5	3	5	5
Coastal slope	4	5	5	5	5	4	5	5	4
Sea-level rise	3	3	2	3	3	2	3	2	3
Wave height	4	4	4	1	4	4	1	3	3
Tide range	5	5	5	5	5	5	5	5	3
Total CVI	31.62	15.81	28.87	17.68	35.36	20.00	13.69	22.36	21.21
Vulnerability[b]	VH	H	VH	H	VH	VH	H	VH	VH

Neural Network



- Neural networks are a computing system made up of a number of simple, highly interconnected processing elements, which process information by their dynamic state response to external inputs (Hecht-Neilsen, 1989).
- Artificial neural networks (ANNs) are receiving greater attention in the ecological sciences as a powerful statistical modeling technique; however, they have also been labeled a “black box” because they are believed to provide little explanatory insight into the contributions of the independent variables in the prediction process (Olden et al., 2004).

Research Gap

The related studies have shown that there is incoherence regarding the different approaches of large-scale vulnerability studies in mangrove resources. However the incorporation of geographic information systems in policy making and the advancement and increased application of artificial intelligence such as machine learning in ecological modelling has provided new way in assessing relative vulnerability of resources such as mangroves. There should be a way of somehow assessing the vulnerability of mangroves with the ease of a large-scale analysis with only 4 factors but still with the same accuracy as a full-blown complex vulnerability analysis with multiple indicators in a variable framework.

Methodology

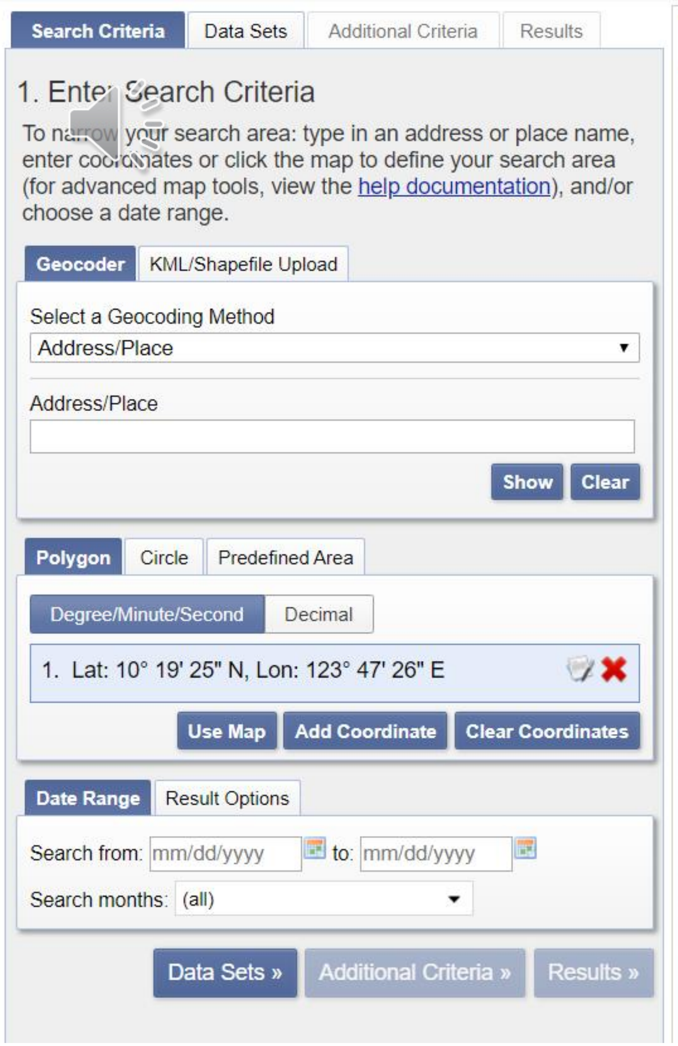
Exposure

Capacity)

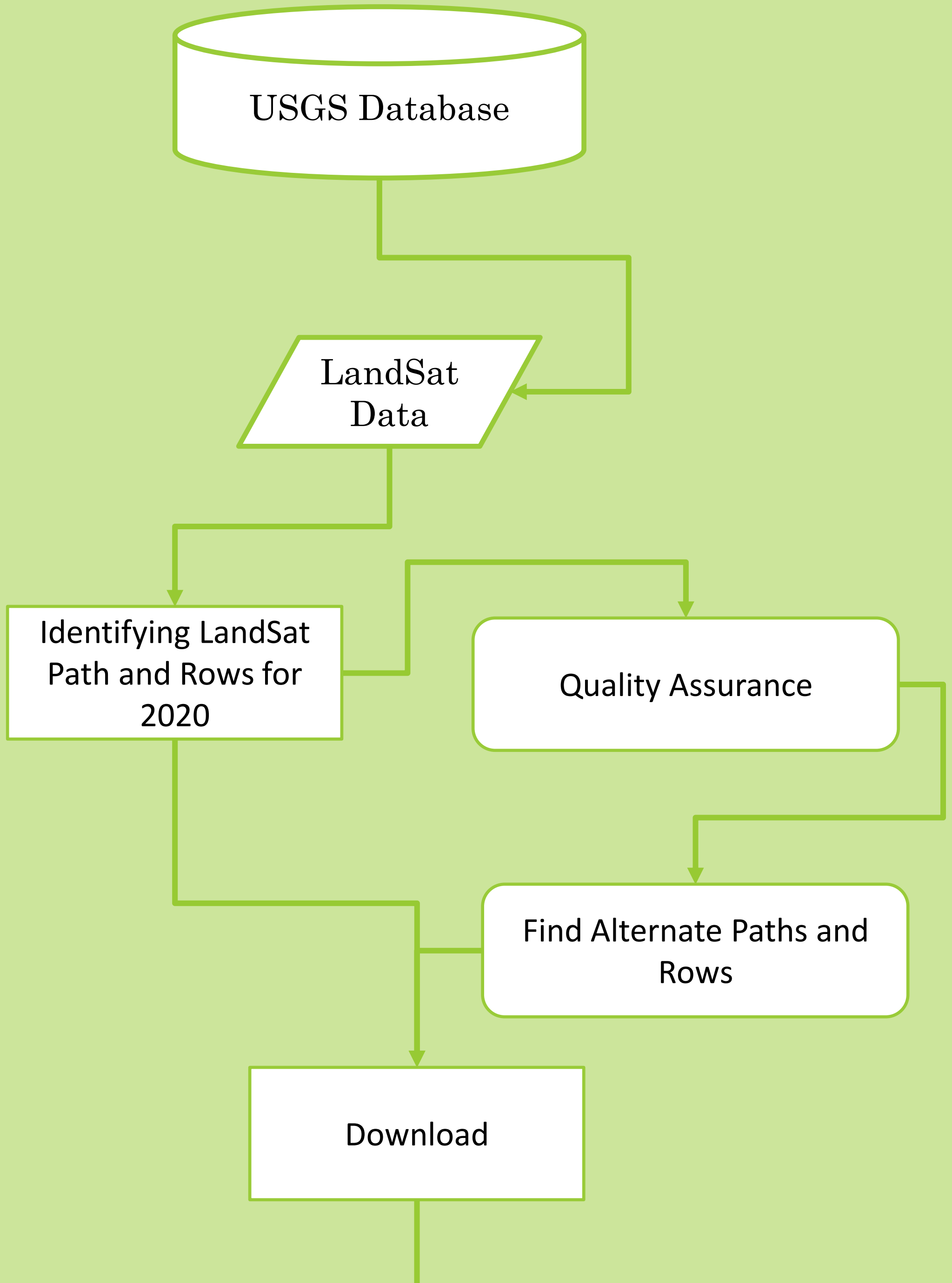
ty

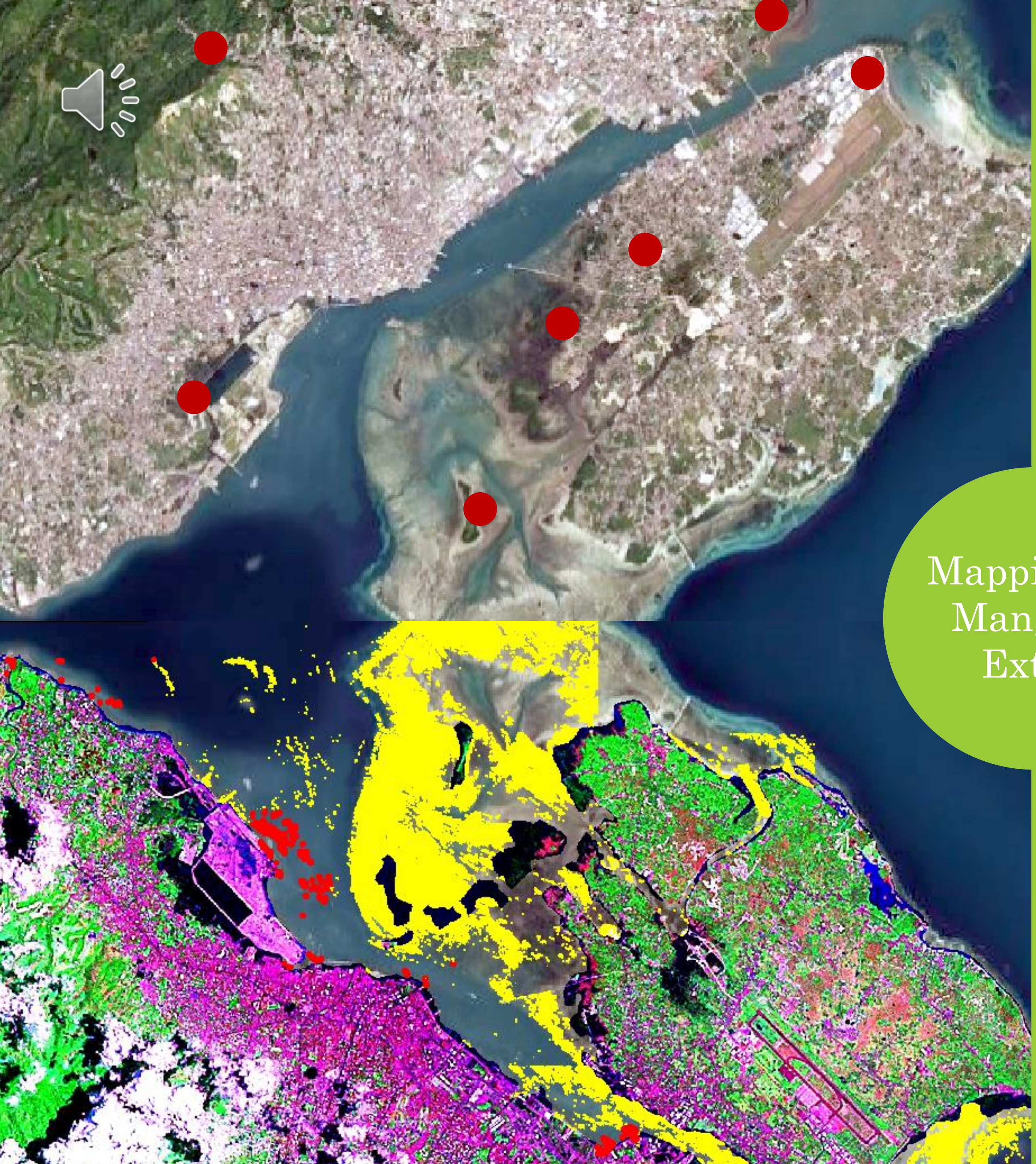
Adapted from Alino et.al (2013) guidebook on Vulnerability Assessment Tools for Coastal Ecosystems

Conceptual Framework

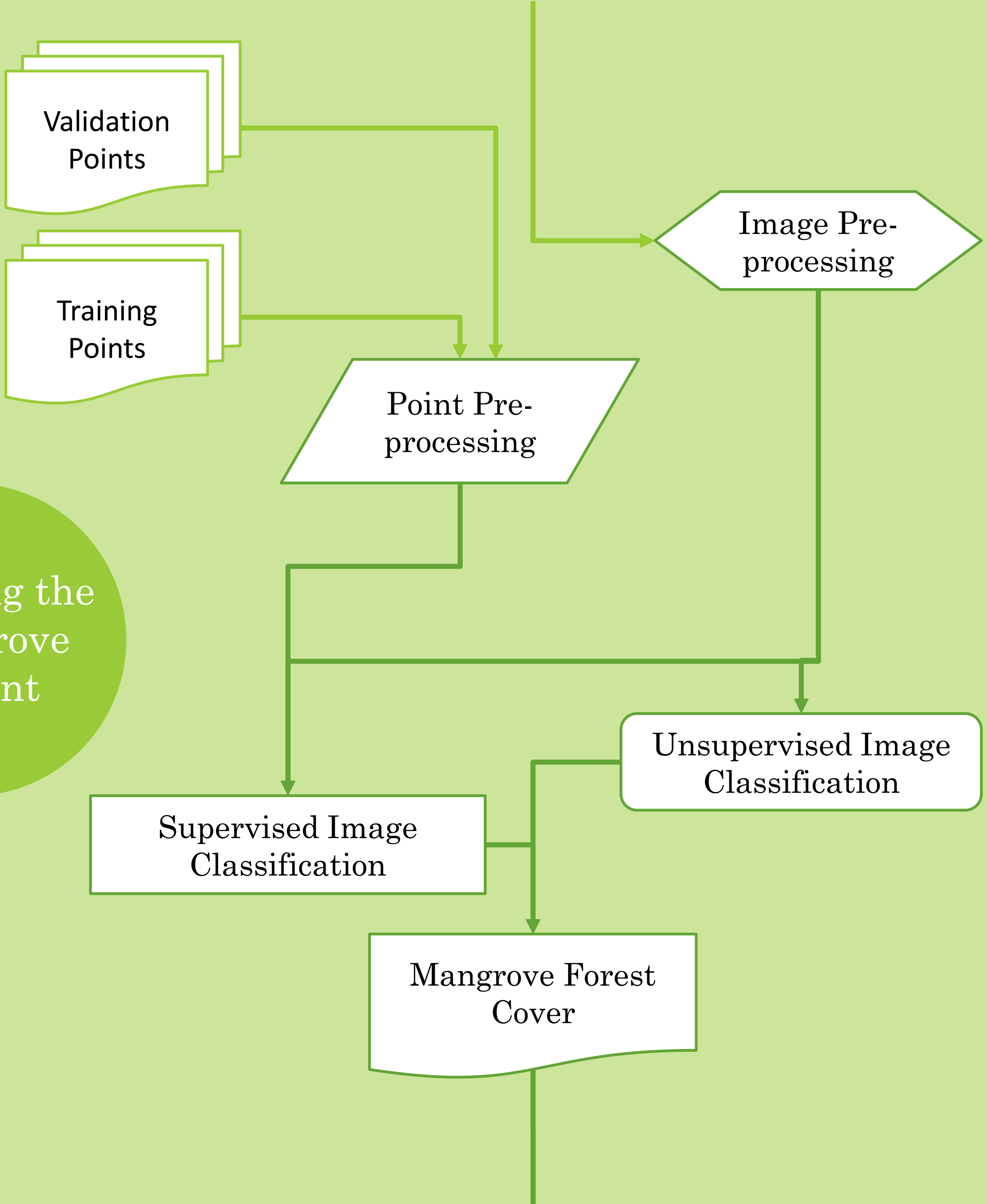


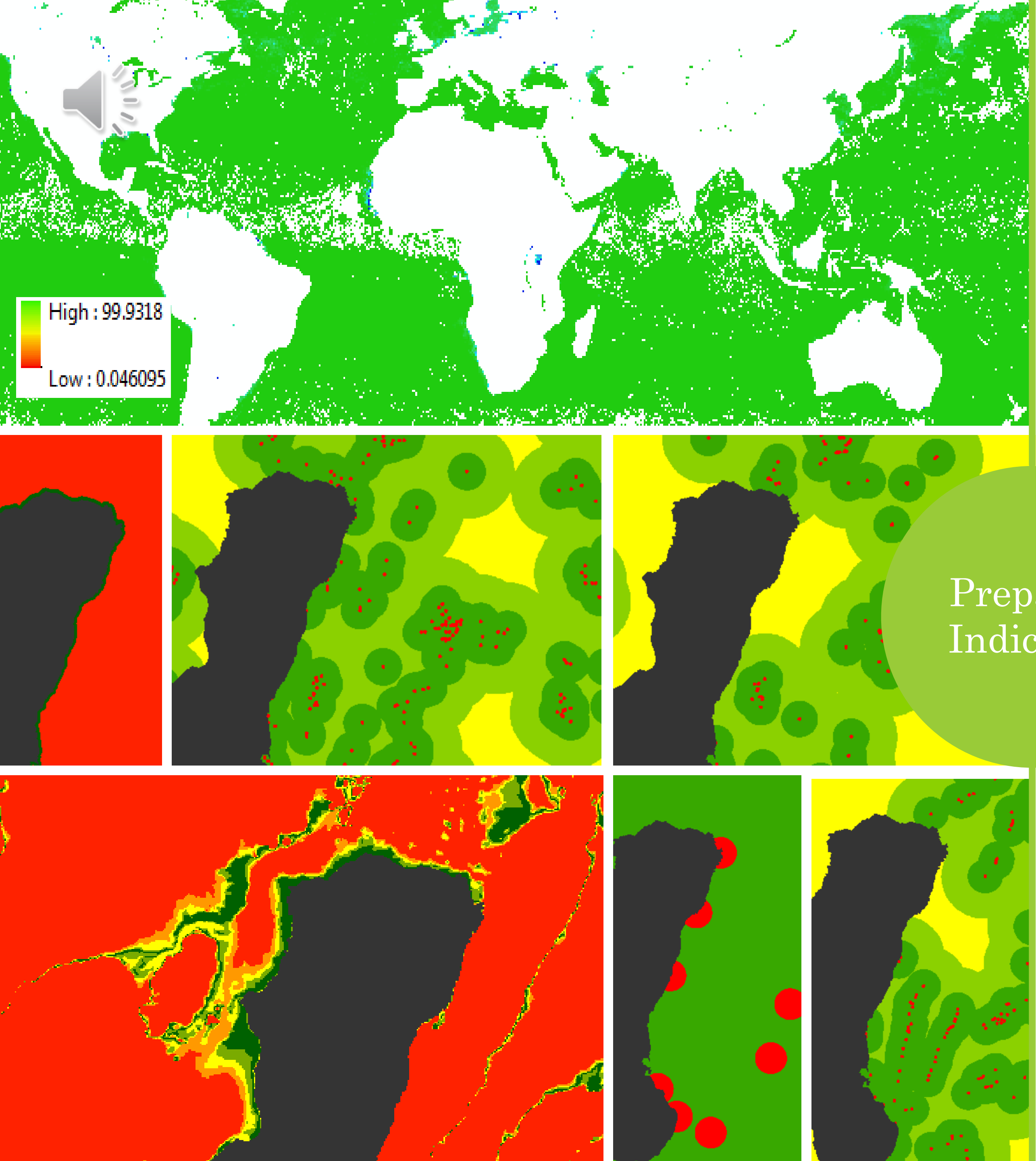
Data Acquisition





Mapping the Mangrove Extent





Various Database

Various Predefined Process

Preparing Indicators

Exposure

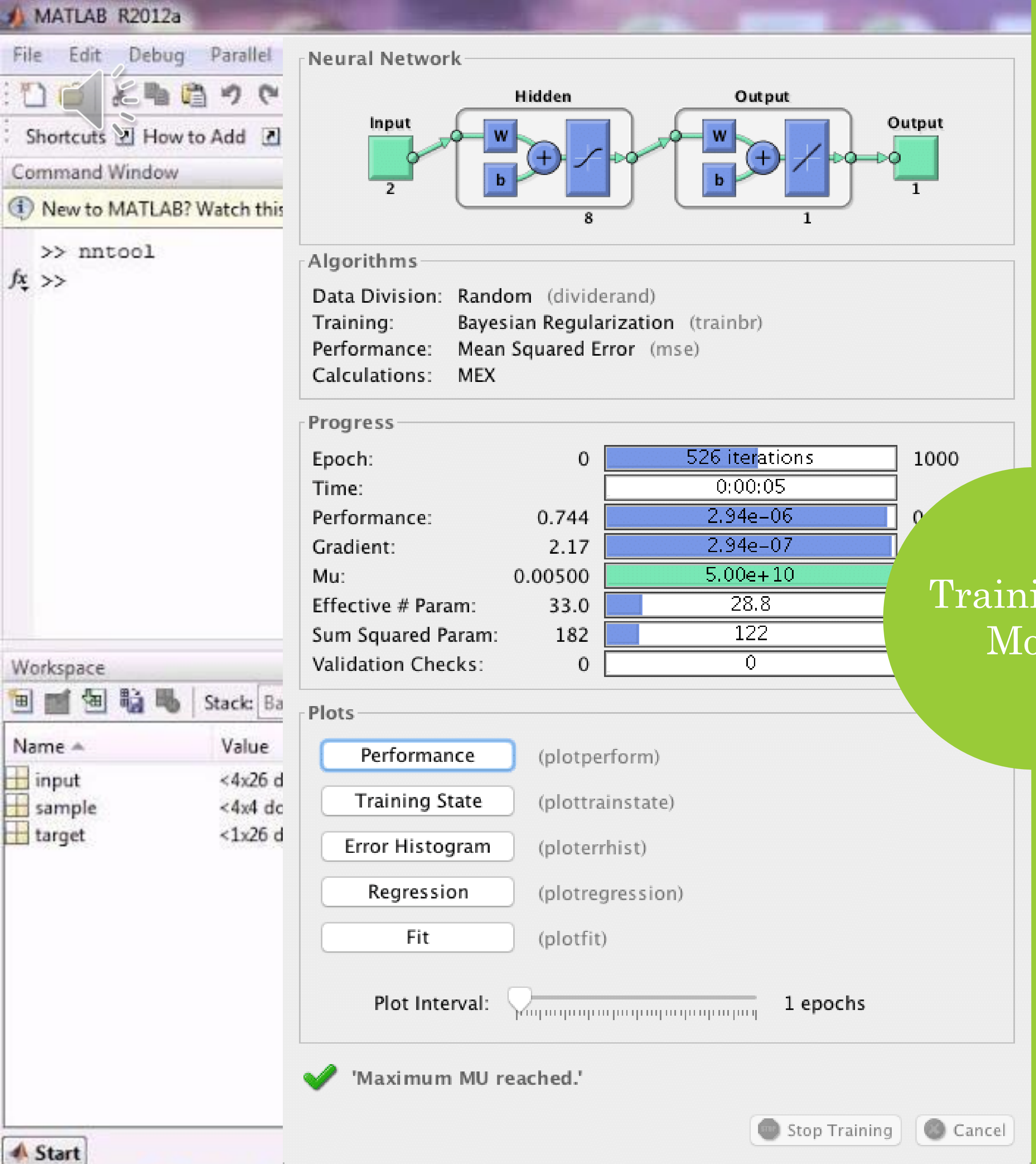
- Amount of Builtup
- Mangrove Loss
- Rate of Rlelative Sea Level Change
- Mean Temperature
- Precepitation
- Population/Sqkm
- Population Change

Sensitivity

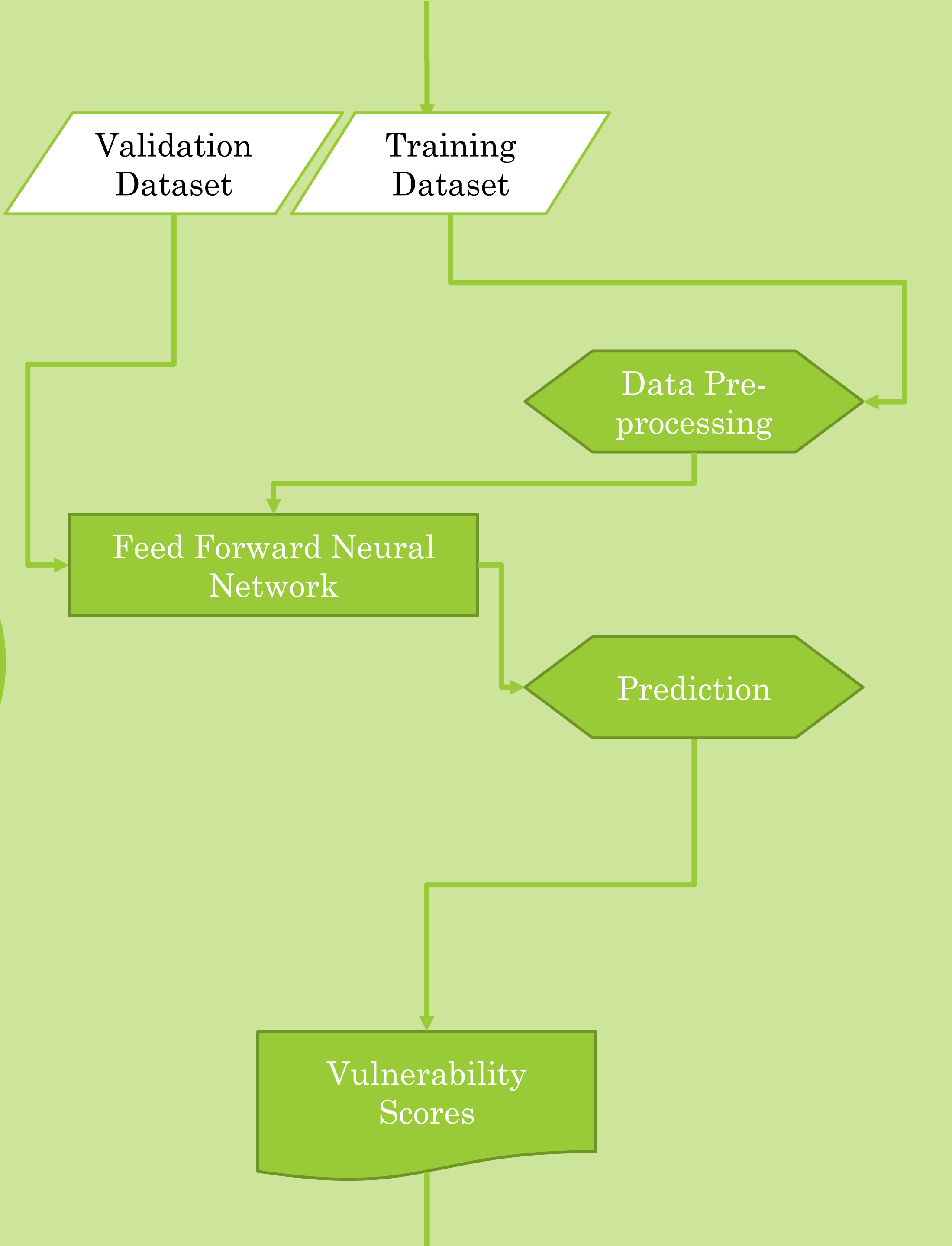
- Coastal Landform & Rock Type
- Seasonal Beach Recovery
- Slope from the Shoreline
- Width of Reef Flat
- Beach Vegetation
- Coastal Habitats Present
- Coastal & Offshore Mining
- Structures in the Foreshore
- Distance from Roads
- Distance from Economic Zones
- Distance from Ports
- Water Quality

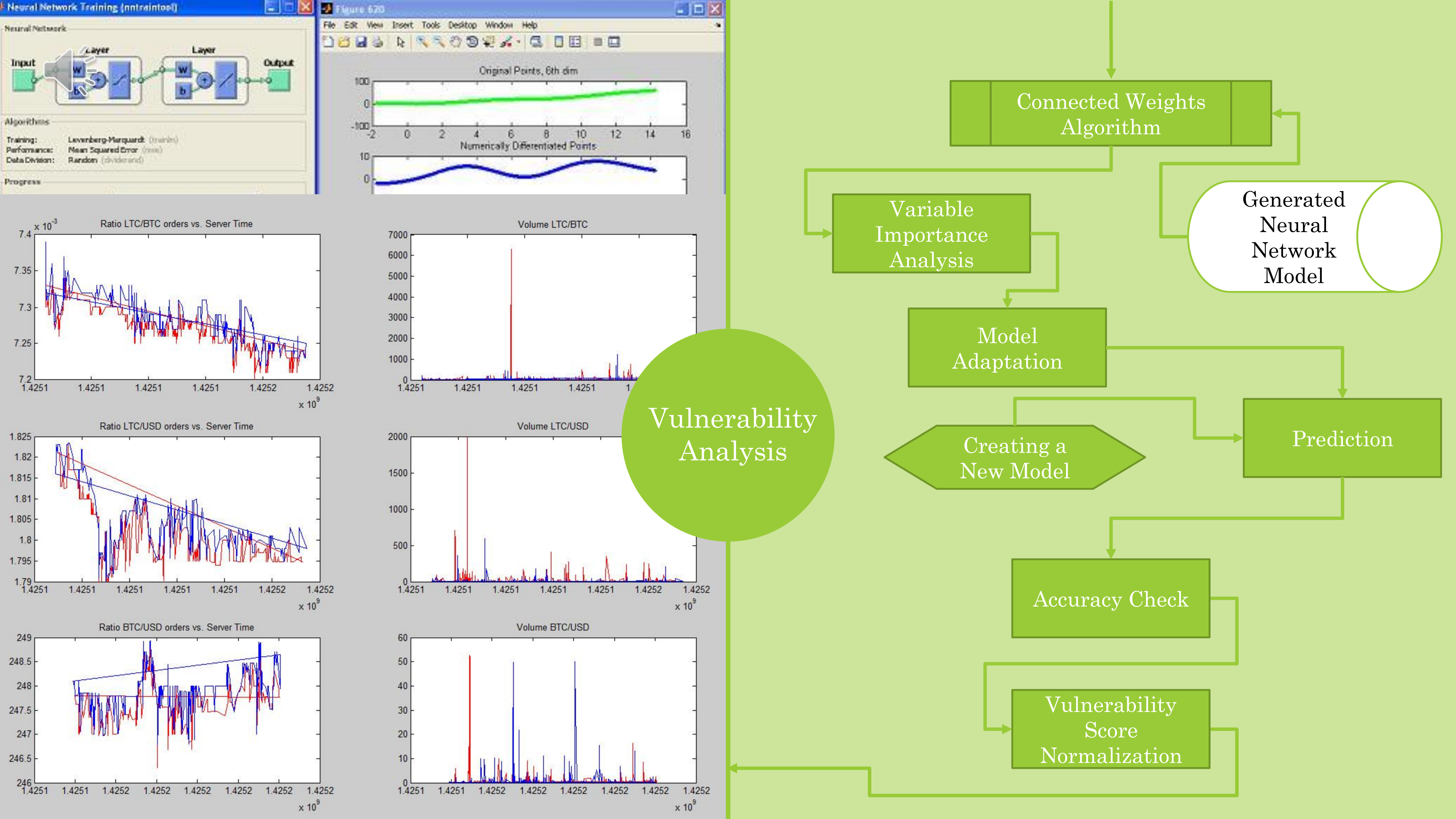
Adaptive Capacity

- Chlorophyll-a
- Coastal Structures
- Types of Coastal Development
- LGU Awareness on the Importance of Seagrass
- Local Knowledge of Residents on Seagrass
- Distance from MPAS
- Distance from Monitoring Sites
- Distance from Reefs
- Distance from Seagrass



Training the Model



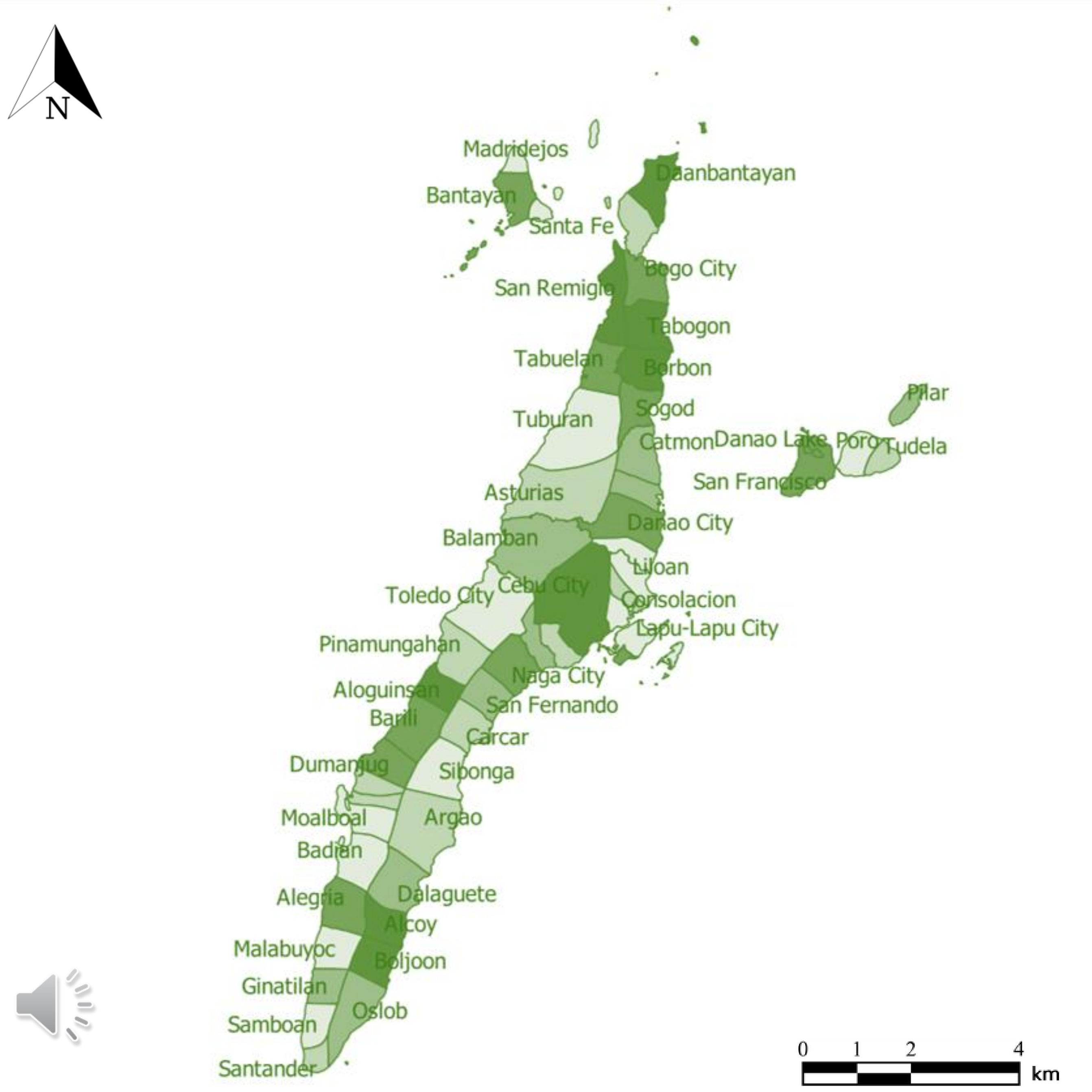

Neural Network Training (nntraintool)
Neural Network
Input
Layer
Layer
Output
Algorithms
Training: Levenberg-Marquardt (trainlm)
Performance: Mean Squared Error (mse)
Data Division: Random (dividerand)
Progress
Figure 620
Original Points, 6th dim
Numerically Differentiated Points
Ratio LTC/BTC orders vs. Server Time
Volume LTC/BTC
Ratio LTC/USD orders vs. Server Time
Volume LTC/USD
Ratio BTC/USD orders vs. Server Time
Volume BTC/USD
Vulnerability Analysis
Connected Weights Algorithm
Generated Neural Network Model
Variable Importance Analysis
Model Adaptation
Creating a New Model
Prediction
Accuracy Check
Vulnerability Score Normalization


Madridejos
Bantayan
Daanbantayan
Medellin
Bogo City
San Remigio
Tabogon
Tabuelan
Borbon
Pilar
Tuburan
Sogod
Catmon
Poro
Tudela
San Francisco
Asturias
Balamban
Toledo City
Pinamungahan
Barili
Carcar
Ronda
Sibonga
Moalboal
Argao
Badian
Alegria
Dalaguete
Alcoy
Boljoon
Oslob
Santander

Mapping

Mangrove Vulnerability Map

Cebu Province



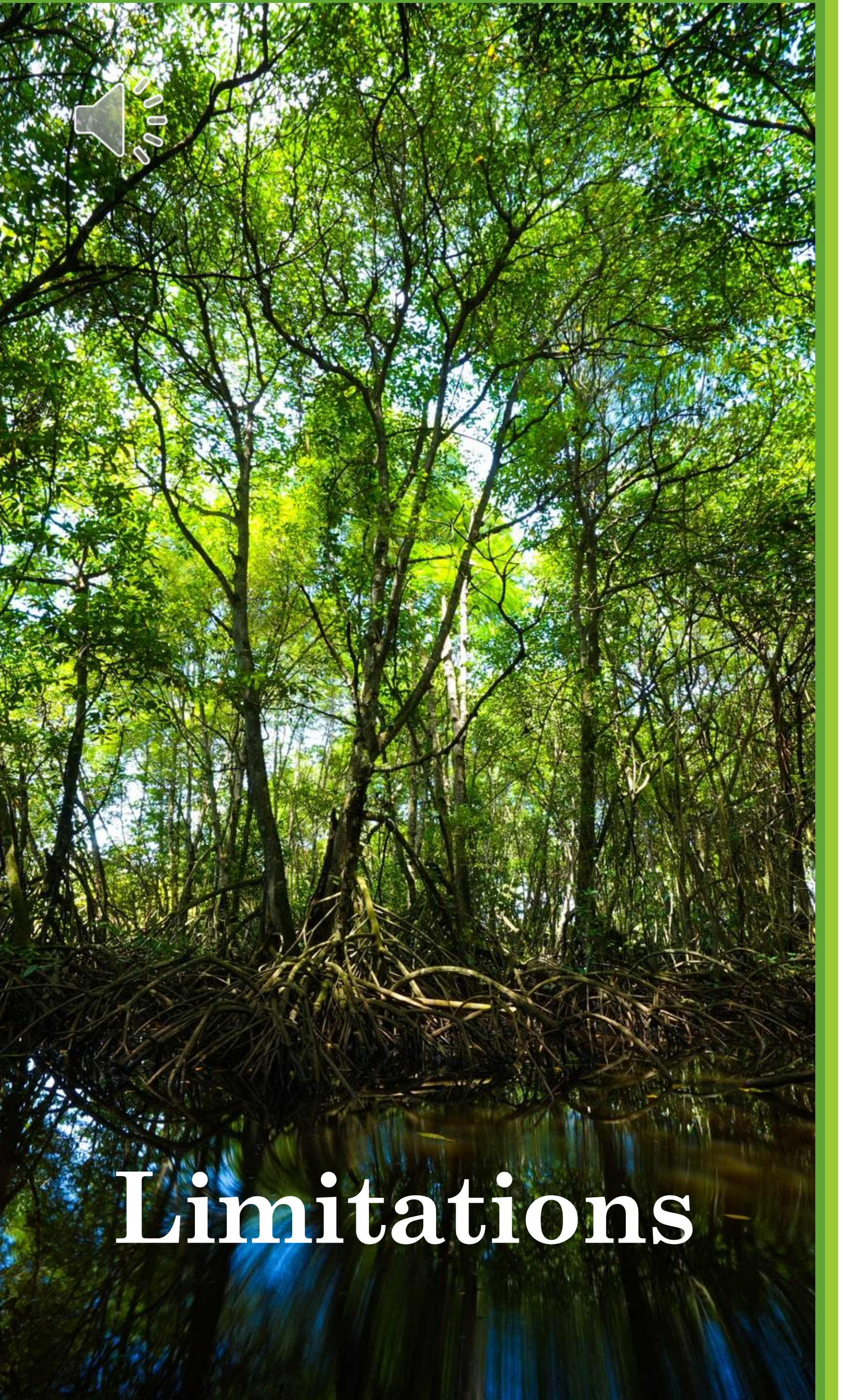
Very Low Vulnerability

Low Vulnerability

MediumVulnerability

HighVulnerability

Very High Vulnerability



Limitations

- This study is focused on the mangrove forests located in the province of Cebu in the Philippines.
- The proposed indicators that are under the different factors might be limited due to financial and time constraints of the project, however the replicability of the presented method should still accommodate if in case a new variable is introduced.
- The proposed vulnerability framework is also based on the current and accessible researches regarding coastal vulnerability alone, thus all vulnerability methods that are not apt for coastal areas has not been explored.
- Furthermore, the proposed artificial intelligence model provides a generic solution and has not been proven to be the paramount of all existing models, other researchers are encouraged to explore other artificial intelligence models as well.

Significance

Helps the Local Government Units in Prioritization

Policy Making

Opens up further research on Ecological Modelling

Aids in the fight against Climate Change

Helps Coastal Communities

Mangrove Ecosystem Protection