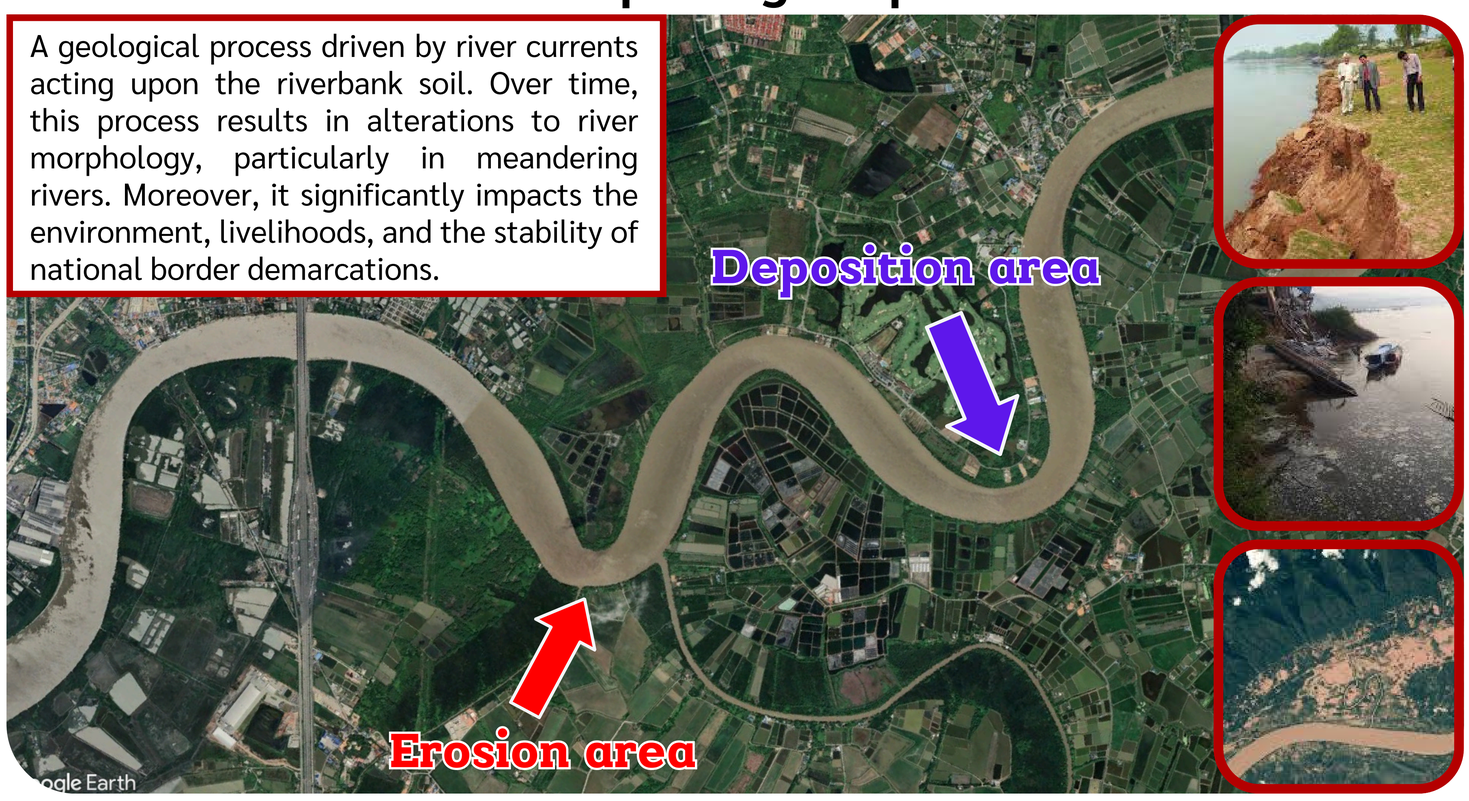
Study of River Morphological Process by Mathematical Model to be a Guideline for Developing Earth's Crust Surface Change Predicting System

Author: Mr. Peratada Sittikriengkrai & Mr. Kaweekan Kenla Advisor: Mr.Khunthong Klaythong
Princess Chulabhorn Science High School Pathum Thani

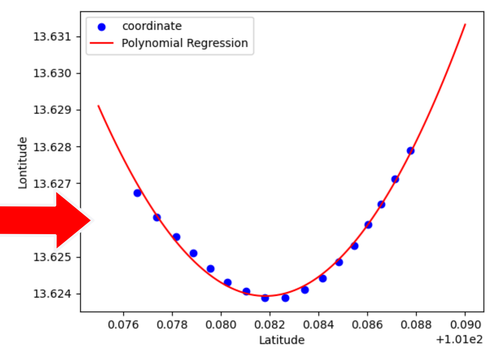
PROBLEM / QUESTION

River morphological process

A geological process driven by river currents acting upon the riverbank soil. Over time, this process results in alterations to river morphology, particularly in meandering rivers. Moreover, it significantly impacts the environment, livelihoods, and the stability of national border demarcations.



Is River morphology can explain in Mathematic Model ?



The main objective of this project is to describe the river morphology using mathematical models because the relationship of morphological changes can be easily analyzed. Our observations reveal that river morphological processes often occur with greater intensity at river bends. Mathematically, the curvature of these bends can be represented using polynomial equations. In computational and statistical fields, a method known as **polynomial regression** is available, which enables the formulation of equations from datasets arranged in a curved pattern.

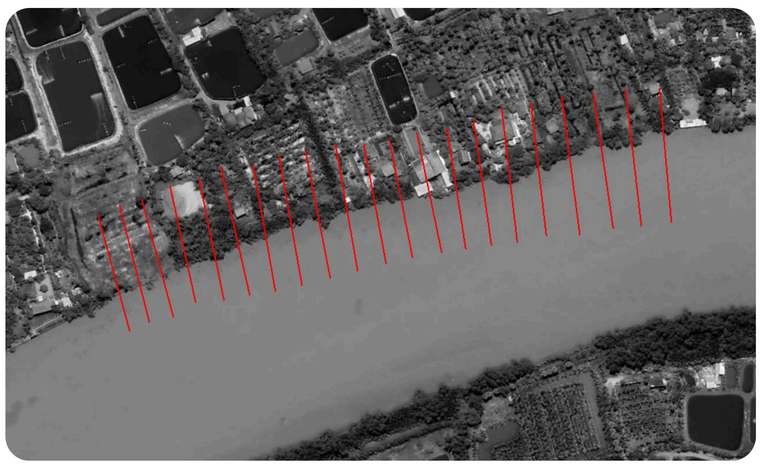
PROJECT DESIGN

This project use the **Bangpakong river** in Chachoengsao city for study case

STEP 1 - Find Study area

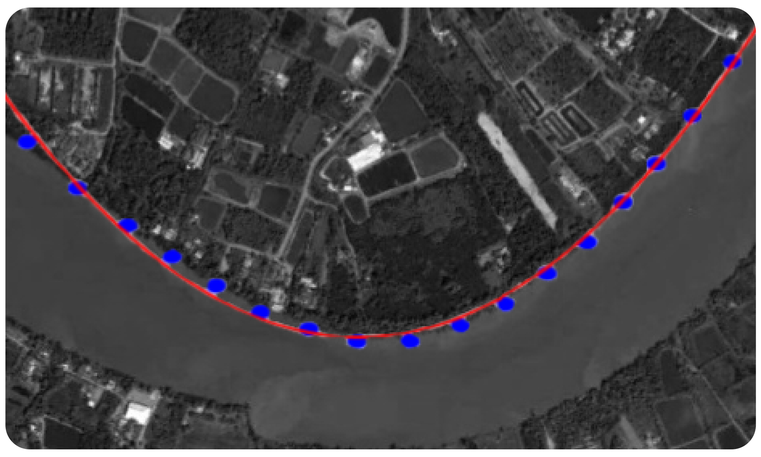
Comparison of river morphology of Bangpakong river generated using the MNDWI technique from sentinel-2 satellite imagery between 2017 & 2023.

$$\mathrm{MNDWI} = \frac{\mathrm{GREEN} - \mathrm{SWIR}}{\mathrm{GREEN} + \mathrm{SWIR}}$$



STEP 2 - Gather datasets

The coordinates of the riverbank were collected from 2017 to 2023, with data recorded three times per year. The method involved dividing the boundary between the river and its banks into 20 transects from the initial to the final point of observed morphological changes. This process resulted in datasets consisting of points arranged along a curve.



STEP 3 - Create river Morphology model

Collected riverbank coordinate datasets were subjected to polynomial regression to identify the optimal polynomial degree, ranging from 1 to 4, that yields the highest accuracy. The resulting polynomial equation serves as a model for simulating river morphology.

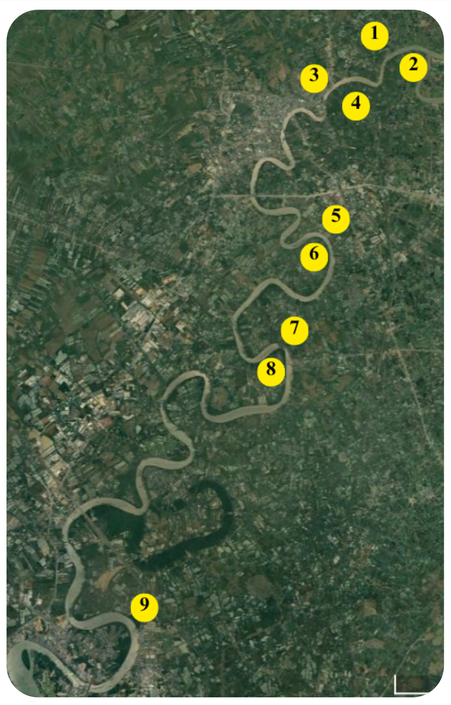
STEP 4 - Build Earth's crust change predicting system

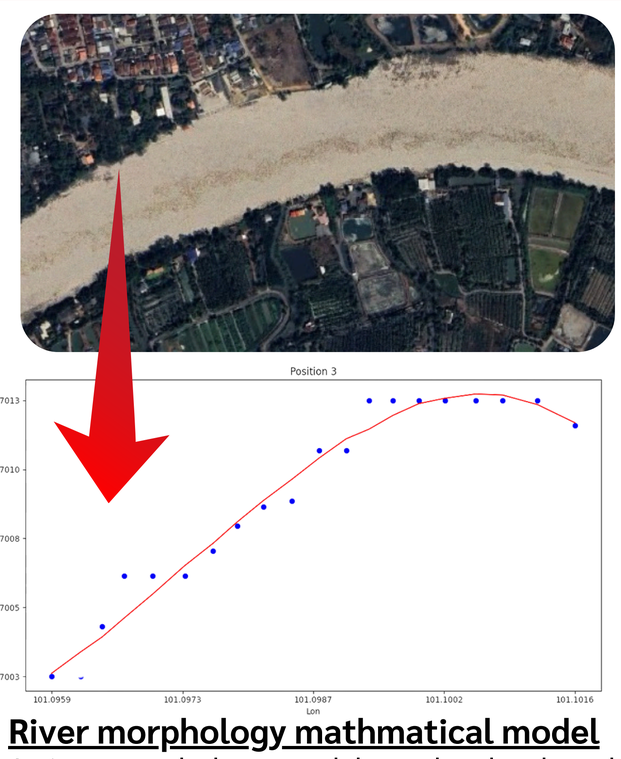
The polynomial equations modeling river morphology for each time period were analyzed to determine the relationships between them. This was done by using the coefficients of each polynomial degree from the earliest to the most recent time period and applying linear regression analysis. The resulting function was then used for prediction. Finally, the predictive model was tested using 18 test datasets.

$$\mathrm{A\%} = 100 - \left(\left| \frac{\int_{min}^{max} \mathrm{y_p}\,\mathrm{dx} - \int_{min}^{max} y_t\,\mathrm{dx}}{\int_{min}^{max} \mathrm{y_t}\,\mathrm{dx}} \right| \times 100 \right)$$

This equation operates by comparing the area difference under the curve, which represents the actual river morphology area (y_t) versus the predicted river morphology area (y_p).

FINDING





Study area

Bangpakong river exhibits changes in the riverbank across 9 distinct sections.

River morphology mathmatical model

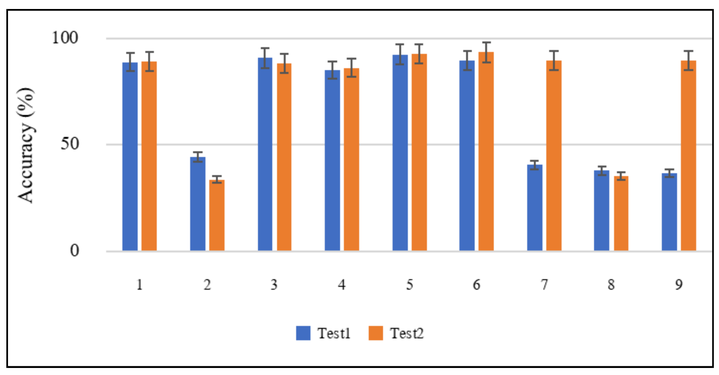
A river morphology model can be developed using polynomial regression, with each section requiring a polynomial degree optimized for its specific physical characteristics and the size of the study area.

$$y_p = \sum_{n=0}^{n=N} c_n x^n$$

Future river predicting function

This function can be used to predict future river morphology, where

- **y** is the prediction river bank coordinate in the y-axis
- **x** is the river bank coordinate in the x-axis
- **n** is the degree of the polynomial equation
- **N** is the maximum degree of the polynomial eqaution
- **c** is the coefficient predicting function of each degree



Test the prediction

It was found that 12 out of 18 test datasets achieved an accuracy exceeding 85%, which is considered sufficient for application to other rivers worldwide. Factors contributing to lower accuracy were primarily due to human disturbances affecting the river.

CONCLUSIONS

1. A river morphology model can be constructed in the form of mathematical equation by applying polynomial regression analysis to river bank coordinate data. Each section will have distinct equation forms and maximum exponent levels, depending on the morphological characteristics and scale of the river's morphological features.
2. The predicting system for earth's crust surface due river morphological processes has shown effective performance and demonstrates the potential for applying this study and data analysis approach to other rivers globally

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