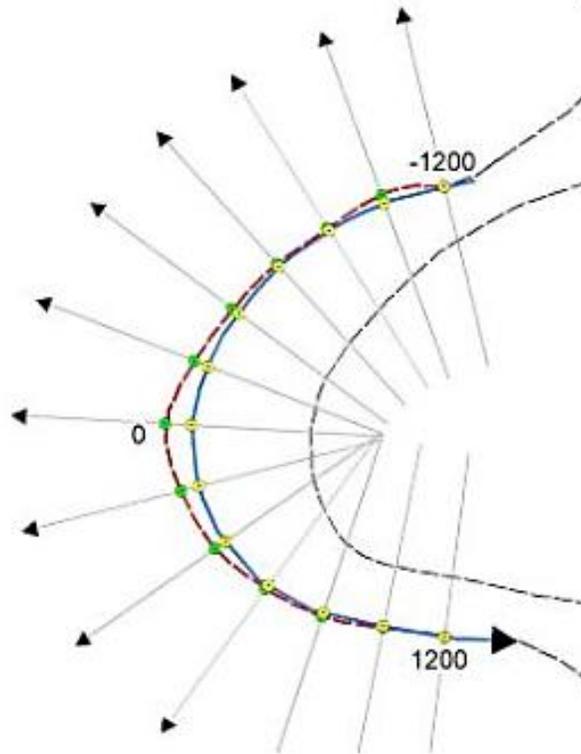


User Manual of Riverbank Erosion Prediction using Hasegawa Model

Developing an Application (App) on Erosion Prediction using Kazuyoshi Hasegawa's (1989) Model

This notebook implements the erosion prediction model proposed by **Kazuyoshi Hasegawa** in 1989. The model uses a multitude of parameters governing erosion to predict the extent of erosion in meandering bends. By following the steps below, you can input data and get predictions based on this model.



An App (Executable File, .exe) has been developed from the Python script. The Tkinter library has been used to create a user-friendly interface (UI). This interface enables seamless application of the model, allowing users to input various parameters interactively and customize the model according to their requirements.

Kazuyoshi Hasegawa's Model Workflow

Equation of Bank Erosion Rate

$$\xi = \sqrt{C_f} \times I_0 \times \left[\frac{3KT \tan \theta_k}{(1-\lambda)(\frac{\rho_s}{\rho}-1)\sqrt{\phi^*}} \right] \times u_B$$

- U_{inf} = Mean flow velocity in straight channel along valley axis (m/s)
- H_{inf} = Mean water depth in straight channel along valley axis (m)
- H_0 = Mean channel water depth (m)
- n = Manning's coefficient
- I_0 = Longitudinal bed slope
- $U_0 = (1/n) \times (H_0)^{2/3} \times (I_0)^{0.5}$
- σ = Phase shift (m)
- B = Channel width from satellite image (m)
- $g = 9.81 \text{ m/s}^2$
- R = Radius of Curvature (m)
- K = Coefficient in bed load function
- T = Average transverse slope angle of concave bank
- $\tan(\theta_k)$ = Average transverse slope angle of concave bank
- λ = Porosity of bed and bank material
- ρ_s = density of sediment in kg/m³
- ρ = Density of sediment in kg/m³
- sg = Specific gravity in m/s²
- D_{50} = Mean particle size (mm)
- I_0 = channel bed slope
- $\phi^* = (\tau^*) / (\tau^* - \tau^*_{cr})$; where
- $\tau^* = (H_0 \times I_0 \times 1000) / ((sg-1) \times (d_{50}))$
- τ^*_{cr} = Critical Shear Stress

Major Steps in Setting up the Hasegawa's model



Analysis of Hydro morphological Data & Input parameters consideration

Step-1



Extraction of river Bankline and Average width

Step-2



Creating erosion calculation points and establishing streamwise coordinates

Step-3



Calculation of Radius of curvature and near bank excess velocity

Step-4

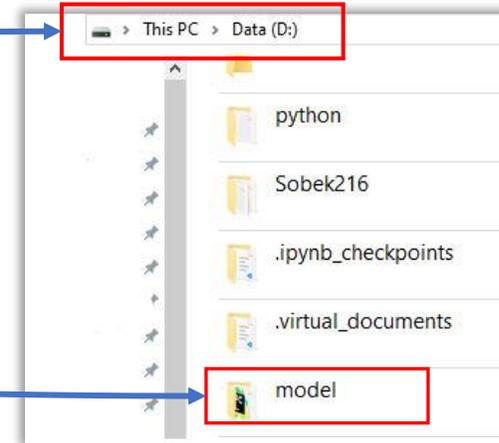


Erosion prediction and visualization

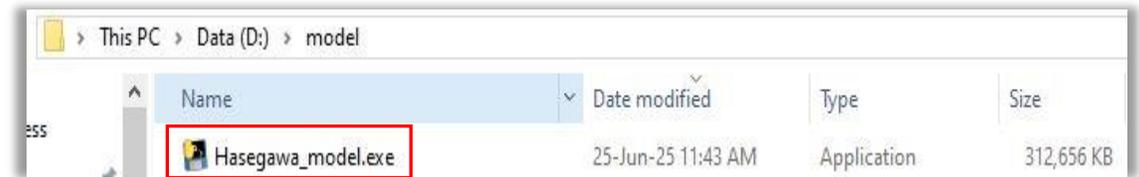
Step-5

Step 1: Copy Data & Run the Model

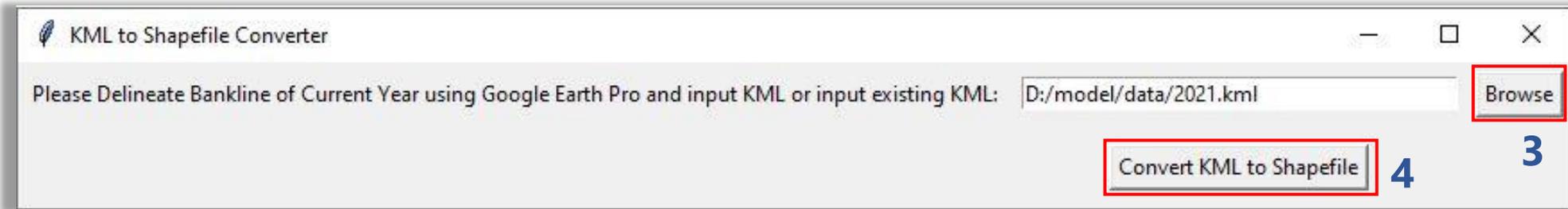
1. In the address "**D:**" of your local computer, Copy the folder named "**model**".



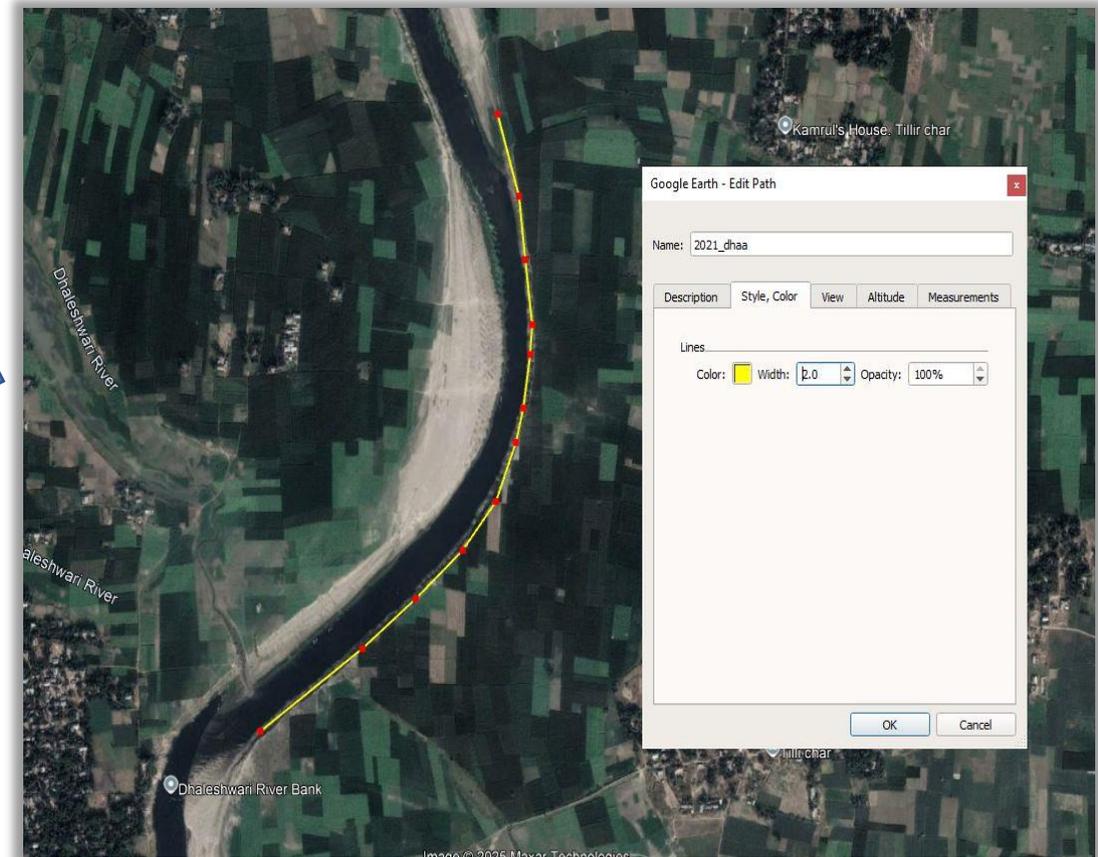
2. Navigate inside the "**model**" folder and double-click the **.exe** file which will execute the model



Step 2: Draw KML and convert to Shapefile



1. The model will prompt the user to open Google Earth Pro and draw the bankline for the current year.
2. After delineating the bankline, save it as a KML file in the "**data**" subfolder inside the "**model**" directory
3. Next, click the "**Browse**" button and select your saved KML file.
4. Click "**Convert KML to Shapefile**" to convert the file for processing.



Step 3: Input Required Parameters

Bank Erosion Rate Calculator

Bank Erosion Rate Calculator

RMD 4 (Dhaleshwari River)

2016
2019

RL (mPWD)

Distance (m)

Select River

Dhaleshwari
Kaliganga
Arial Khan
Sangu
Dudhkumar
Gorai
Pungli
Teesta
Kirtonkhola

Calculate

Uinf (Mean Flow Velocity):	0.4
Hinf (Mean Water Depth):	7
H0 (Channel Water Depth):	8
n (Manning's Roughness Coefficient):	0.023
I0 (Longitudinal Slope):	1e-5
Sigma (Phase Shift):	0
B (Channel Width):	180
g (Gravitational Acceleration):	9.81
tan(Theta_k) (Angle of Repose):	0.7
K (Coefficient for Erosion):	10.0
T (Time or Constant for Erosion):	0.6
Porosity:	0.65
Water Density:	1000.0
Sediment Density:	2650
s (Sediment density ratio):	2.65
d50 (mm):	0.2
tao_star_cr:	0.047

Mean Velocity (U0):	A:
F Squared:	exp_6:
CF:	tao_star:
exp_1:	phi_star:
exp_2:	Total Length of Centerline:
exp_3:	Coordinate System Info:
exp_4:	s (Sediment Density Ratio):
exp_5:	d50 (mm):
	tao_star_cr:

2. Input Hydro-morphological, Geotechnical, and Environmental data as per model requirements for that particular bend

1. Select the Target River from the Dropdown Menu

3. Click the "Calculate" button to obtain and save results

Step 4: Set Data Generation Resolution

Define Transect Generation Intervals and Buffer Distance

1. **Specify** the Interval Distance (m) for the generation of perpendicular transects

2. **Set** Buffer Distance for the transect length

The screenshot displays the 'Input Parameters' window. On the left, a 'Concept Image' shows a blue line representing a 'Base Year' with yellow dots for 'Erosion Calculation points'. Perpendicular black lines represent 'Perpendicular Transects' extending from the base year line. A dashed line represents the 'Bankline'. A scale bar indicates 0, 125, and 250 meters. A north arrow is also present. The 'Flow Direction (u/s to d/s)' is indicated by a pink arrow. The 'Interval Distance' is shown as the distance between two consecutive perpendicular transects (e.g., 200m, 400m, 600m, 800m, 1000m). The 'Buffer Distance' is shown as the distance from the base year line to the start of the first perpendicular transect (e.g., 200m, 400m). Below the concept image, the 'Transect Direction (Left) = 0' and 'Transect Direction (Right) = 1' are indicated. On the right, a 'Shapefile Plot' shows a blue line graph with the x-axis ranging from 496400 to 496800 and the y-axis ranging from 647400 to 648600. At the bottom of the window, the 'Interval Distance (m):' is set to 200 and the 'Buffer Distance (m):' is set to 300, both values are highlighted with a red box. The 'Transect Generation Side given bankline is drawn from u/s to d/s (0 for Left, 1 for Right):' is set to 1. A 'Submit' button is located at the bottom center.

Step 4: Set Data Generation Resolution (Contd...)

Define Transect Generation Intervals and Buffer Distance

3. Specify the side of **Transect Generation** to map the direction of lateral erosion with either 0 (for Left) or 1 (for Right), given that the bankline is drawn from upstream to downstream

4. Click the **Submit** button

The screenshot displays the 'Input Parameters' window. On the left, a 'Concept Image' shows a curved bankline with perpendicular transects. A legend identifies 'Erosion Calculation points' (yellow dots), 'Perpendicular Transects' (black lines), 'Base Year' (blue line), and 'Bankline' (dashed line). A scale bar indicates 0, 125, and 250 meters. A north arrow is also present. The bankline is labeled with values from -1000 to 1000. A pink arrow indicates 'Flow Direction (u/s to d/s)'. Two yellow boxes highlight 'Transect Direction (Left) = 0' and 'Transect Direction (Right) = 1'. Below the image, input fields are shown: 'Interval Distance (m):' with a value of 200, 'Buffer Distance (m):' with a value of 300, and 'Transect Generation Side given bankline is drawn from u/s to d/s (0 for Left, 1 for Right):' with a value of 1. A red box highlights the '1' in the last field. A 'Submit' button is located at the bottom right. To the right of the main window, a 'Shapefile Plot' shows a blue line on a coordinate system with x-axis values from 496400 to 496800 and y-axis values from 647400 to 648600.

Step 5: Setting the time period for Future Prediction

1. Specify "How many years ahead you want to predict Erosion" in years.

2. Enter the **Effective Erosion period** of a year, considering the time period of erosion calculation

3. Then, Click the "OK" button to proceed to the next step

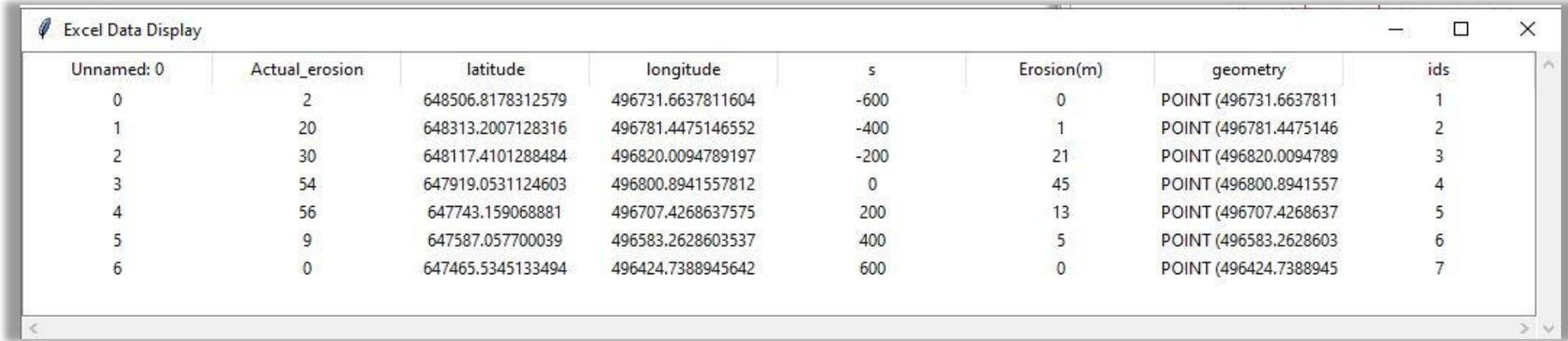
Enter Duration

How many years ahead would you like to predict erosion? (yrs): 3

Effective Erosion Period per year (months): 4

OK Cancel

Step 6: Data Visualization

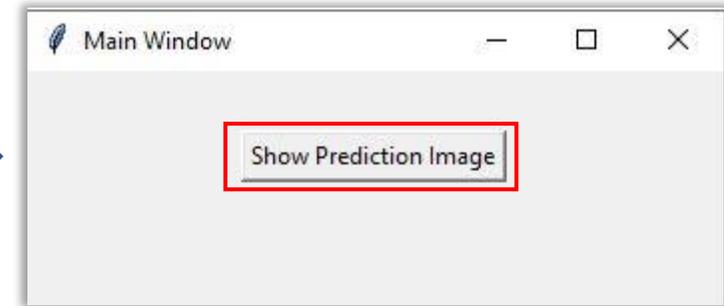


Unnamed: 0	Actual_erosion	latitude	longitude	s	Erosion(m)	geometry	ids
0	2	648506.8178312579	496731.6637811604	-600	0	POINT (496731.6637811	1
1	20	648313.2007128316	496781.4475146552	-400	1	POINT (496781.4475146	2
2	30	648117.4101288484	496820.0094789197	-200	21	POINT (496820.0094789	3
3	54	647919.0531124603	496800.8941557812	0	45	POINT (496800.8941557	4
4	56	647743.159068881	496707.4268637575	200	13	POINT (496707.4268637	5
5	9	647587.057700039	496583.2628603537	400	5	POINT (496583.2628603	6
6	0	647465.5345133494	496424.7388945642	600	0	POINT (496424.7388945	7

Figure: Data Table

1. Data table shows the Actual and Predicted erosion at the pre-defined calculation points

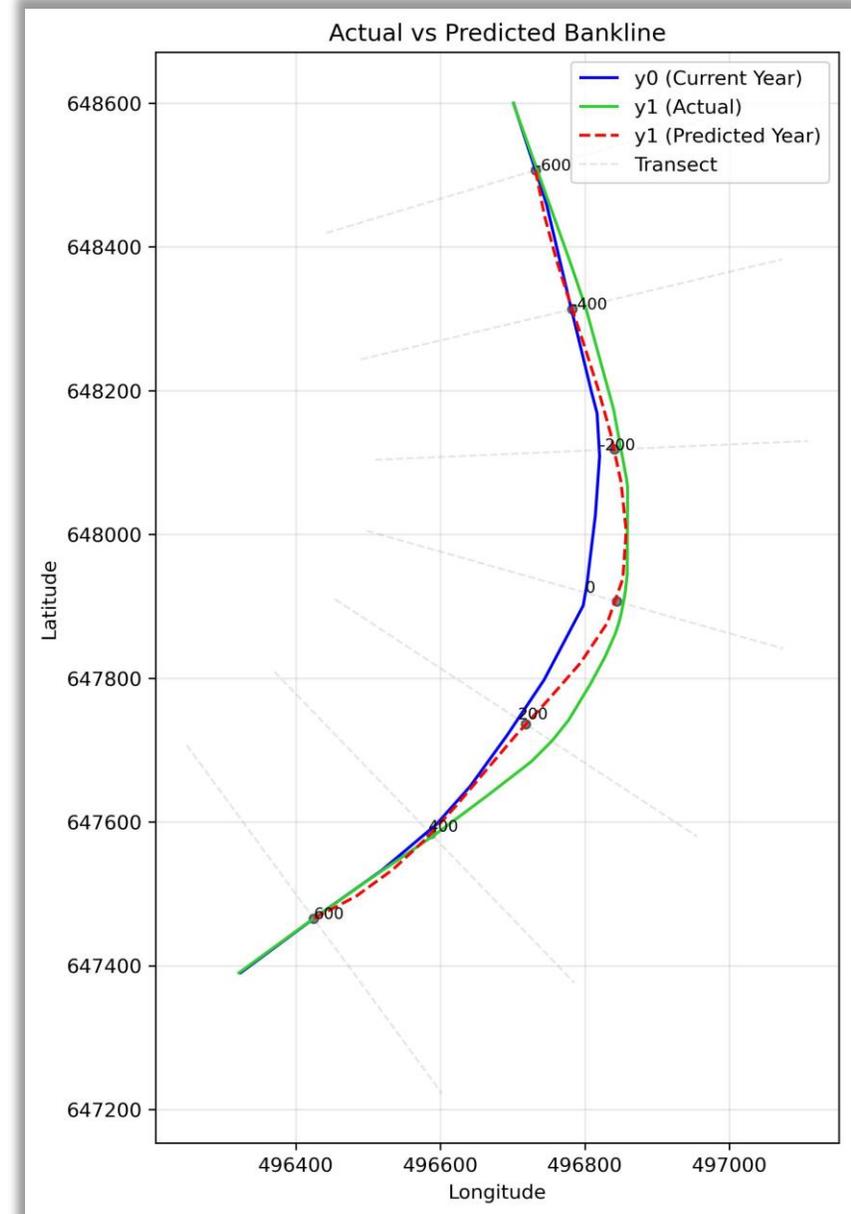
2. Click "**Show Prediction Image**" button to display the result Graph



✓ NB: Additionally, all generated files will be automatically placed in the working directory

Step 7: Prediction

Graph showing the Final Output for lateral Erosion Prediction at the desired location



Thank You