Sediment Runoff in Irrawaddy (Ayeyarwady) River Basin and The Sediment Management

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1. INTRODUCTION TO THE RESEARCH AREA

1.1 The Irrawaddy (Ayeyarwady) River Basin

- The largest river in Myanmar
- The basin area is 173,411 km^2
- Almost reach is very mild slope.
- Narrow Mountainous area.
- Main commercial transportation route
- Commercial Transportation length (along the river) =1300-km
- Navigable length in the main and delta area = 1534-km
- Third-highest sediment load and fourth-largest total dissolved load {By Gordon and Robinson et al. (2007)}

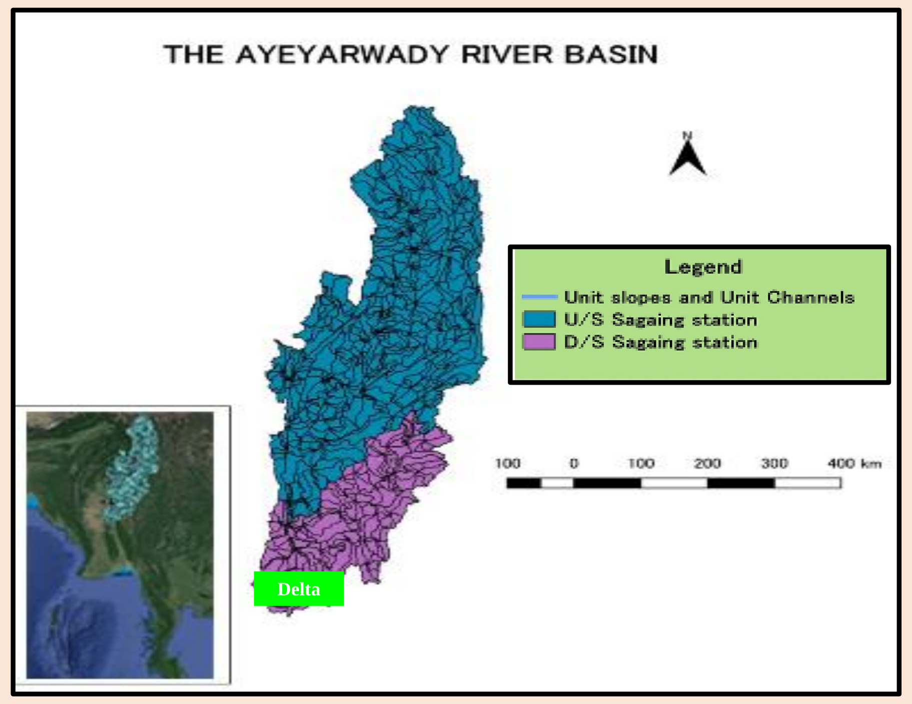

Fig 1. Research Area

1.2 Sediment Related Problems

- Huge deposition of sediment and decreases of water discharge create **many sandbars**
- Water depth becomes shallower
- Maintenance of navigation waterway is difficult.
- The stabilization of navigable waterway is very important.
- It is very essential to understand the rainfall and sediment runoff in the basin.

Fig 2. Sand bars formation in the river

2. NUMERICAL SIMULATION MODEL (Fujita and Yamanoi, 2014)

❖ **Basin Model** ❖ **Rainfall Runoff Model**

To make the analysis of rainfall and sediment runoff in the Irrawaddy (Ayeyarwady) River Basin, **Fujita and Yamanoi,2014** is used. This basin model can identify by dividing it into two parts such as **(1) unit slope and (2) unit channel** to estimate the runoff of the slope on a basin-scale.

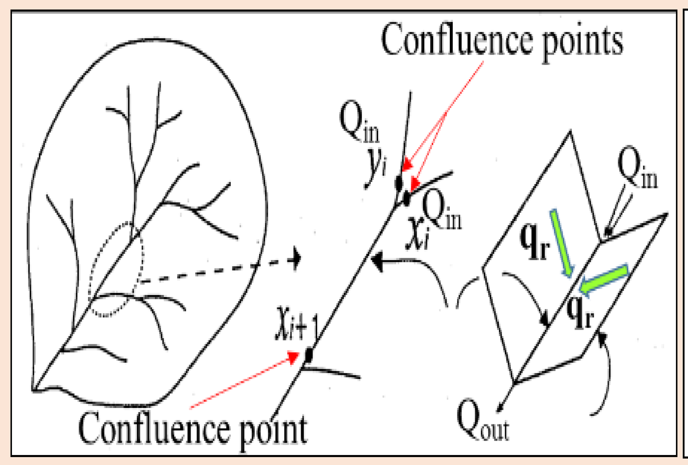

Fig 3. Unit Channels and Unit Slopes as a watershed model

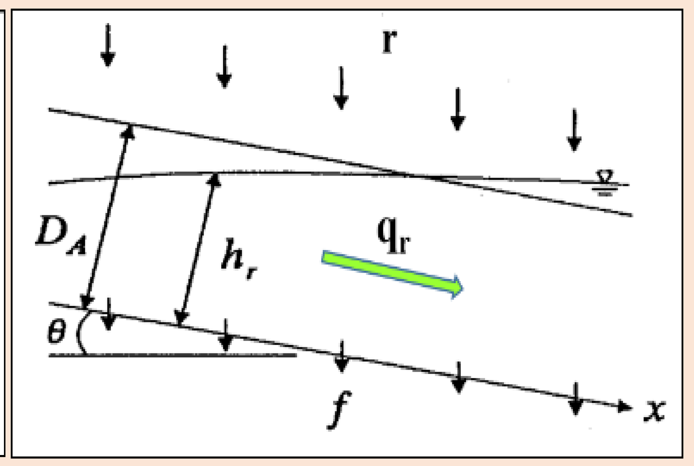

Fig 4. Overview of the Rainfall Runoff Model in Unit Channels

By Kinematic Wave model,

$$\alpha \frac{\partial h_r}{\partial t} + \frac{\partial q_r}{\partial x} = (r - f)\cos\theta$$

$h_r < D_A$: $\alpha = \lambda_s$ ⇒ $q_r = k h_r \sin\theta$

$h_r \geqq D_A$: $\alpha = 1$ ⇒ $q_r = k D_A \sin\theta + \frac{1}{N}\sqrt{\sin\theta}\,(h_r - D_A)^{5/3}$

where, h_r is the water depth from the bed rock, r is the rainfall intensity, f is the infiltration ratio, and θ is the gradient of the unit slope. D_A is the soil thickness of the unit slope, and λ_s is the effective porosity of the soil on the unit slope surface. q_r is the unit water discharge.

❖ **Conservation Law of Water,**

$$\frac{\partial h}{\partial t} = \frac{1}{BL}\{Q(x_i)+Q(y_i)-Q(x_{i+1})\} + \frac{1}{B}q_r$$

❖ **Conservation Law of sediment discharge,**

$$\frac{\partial z}{\partial t} = \frac{1}{(1-\lambda)BL}\{Q_s(x_i)+Q_s(y_i)-Q_s(x_{i+1})\}$$

where, $Q_s = Q_b + Qsus$

Conservation Law of sediment discharge of each grain size,

$$\frac{\partial P_j}{\partial t} = \frac{1}{\Delta BL}\{Q_{sj}(x_i)+Q_{sj}(y_i)-Q_{sj}(x_{i+1})\} - \frac{\partial z}{\partial t}\frac{f_j}{\Delta}$$

where, $f_j = p_{j0}\left(\frac{\partial z}{\partial t} \le 0\right),\ f_j = p_j\left(\frac{\partial z}{\partial t} > 0\right)$

where, B and L are the width and length of the unit channel, respectively, and Q is the water discharge at the downstream end of the unit channel. x_i and y_i are the two unit-channels which flow into the unit channel x_{i+1}. q_{rleft} and q_{rright} are the water discharges at the ends of both unit slopes connecting to the unit channel x_{i+1} and these flow into the unit channel x_{i+1}.

3. Methodology and Simulation Results

3.1 Rainfall Distribution

The satellite-oriented precipitation data obtained by GSMaP is modified as shown in Figure 5 by $R_m = \alpha R_{sat}$. The precipitation data is modified to the effective precipitation R_e and Figure 6 shows the comparison of the annual total volume of modified precipitation in the target drainage basin V_m, annual discharge V_{dis} and its ratio β.

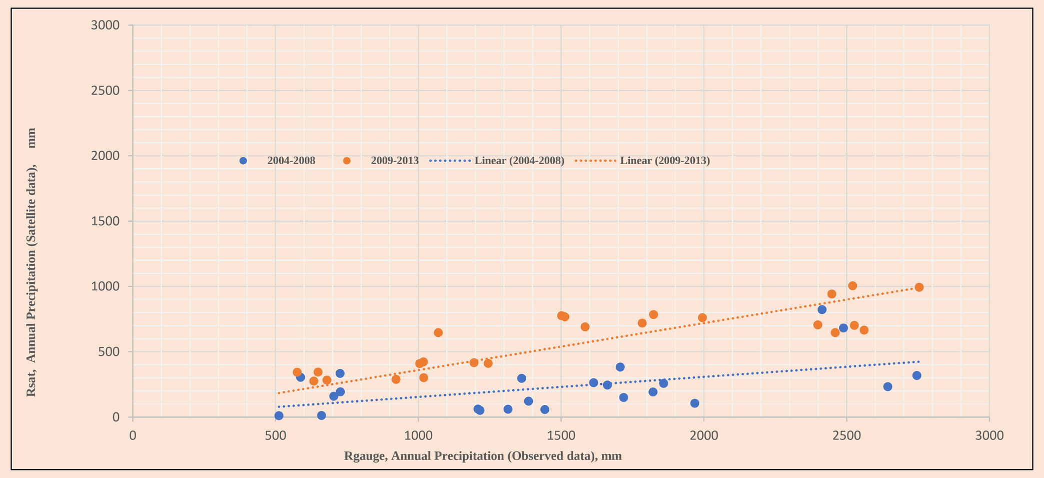

Fig 5. Comparison of the gauge-observed and satellite-oriented annual precipitation

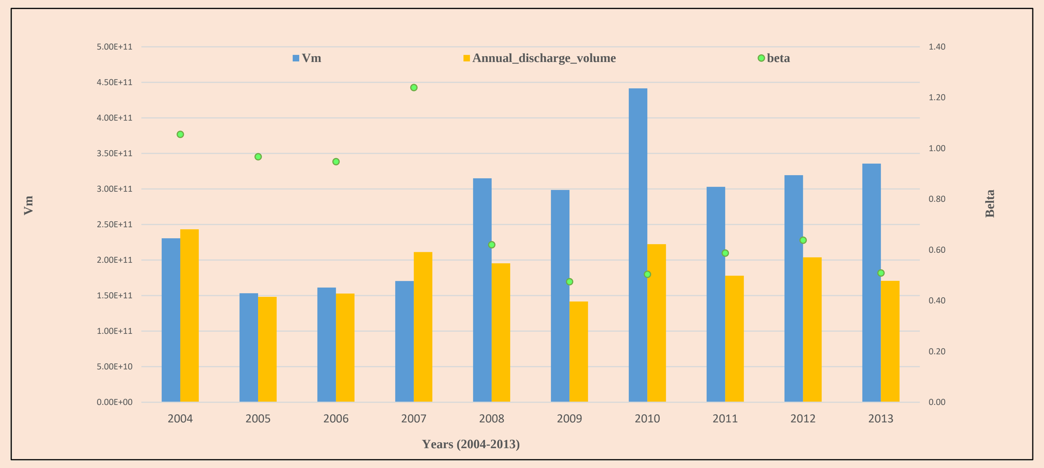

Fig 6. Comparison of the annual total precipitation in the whole catchment V_m, , annual discharge V_{dis} and its ratio β.

3.2 Condition

❖ **Rainfall**

Satellite Data from 2009 to 2013

❖ **Grain size distribution of bed material**

(Assumption)

Grain size distribution in Sagaing

❖ **Sediment supply (Assumption)**

- The supplied sediment is set on each unit channel.
- Total annual sediment supply volume is equal to the observed annual sediment discharge from the downstream end.
- The sediment volume set on the channel is calculated considering the ration of the sub-basin area to all the basin area.

V_i = sediment supply volume for each channel, (m^3)
V_{sup} = total volume of sediment supply, (m^3)
A_T = total area of the river basin, (m^2)
A_i = sub-basin area of channel i, (m^2)

3.3 Rainfall Runoff Results

Decision of a best parameter set (ns, D and k) is another one importance to continue the rainfall and sediment runoff simulation.

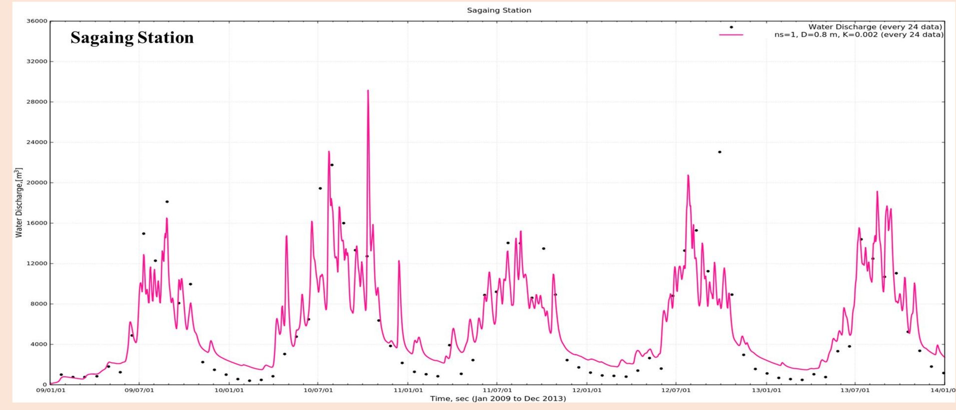

Fig 7. Comparison of observation and calculation data with best parameters (D=0.8-m, ns=1 and k=0.002)

Sediment is supplied by using the equation V_i and investigated the situation of river bed deformation by **decreasing the sediment supply volume to 0.1 times of the supply rate** of the current situation. It has been realized that little sediment supply condition is causing bed degradation and the bed degradation is gradually developing. Active streams could be fixed and become much deeper. The waterway condition seems to be much better, but the irrigation system may have some troubles. Also, in future local scouring near bridge piers must be very serious.

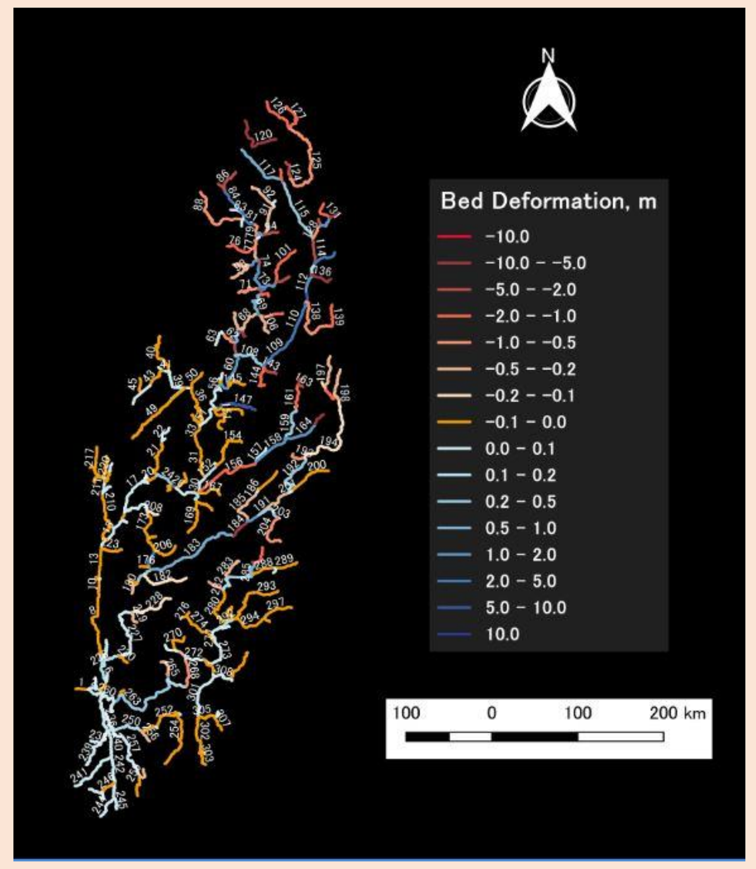

Fig 8. Bed Deformation Results

4. Conclusions

For the analysis of the characteristics on the sediment runoff in the research area, we tried to apply the GSMaP (Global Satellite Mapping of Precipitation). Regarding the problems on sediment management, it is essential to take the countermeasures before the problem becomes apparent, and it is important to perform the predictions by numerical simulation of sediment runoff.