UNIVERSITÄT HOHENHEIM

Water Flow and Sediment Transport in Paddy Cascades in Vietnam and their Representation in a Landscape-Scale Model

SFB 564 - The Uplands Program - Subproject C 4 –
Impact of Intensification on Land Use Dynamics and Environmental Services of Tropical Mountainous Watersheds

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1. Introduction

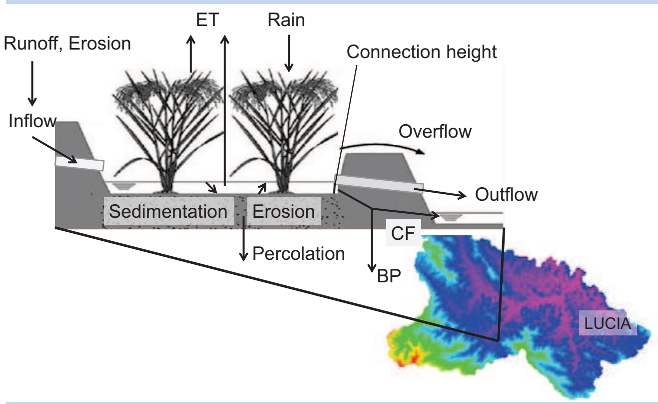
- Deforestation and continuous maize cropping (without fallow) in SE Asia increase erosion in mountainous watersheds
- Eroded material from the uplands is deposited in paddies in the lowlands influencing their soil fertility[1]
- LUCIA (Land Use Change Impact Assessment tool) simulates erosion, water, nutrient cycles and plant growth on landscape-scale[2], but does not consider paddy topography
- Research area: Chieng Khoi, Son La, NW Vietnam. Subtropical climate, unimodal rainfall distribution, steep slopes

Scope

- Developing a paddy module for LUCIA model that simulates water and sediment flows in a semi-distributed manner. Test the module based on field measurements.

2. Model Concept

- Water distribution according to elevation instead of local drain direction (→ no spatially routed flows inside the paddy)
- Water flowing in from the uplands transports sediments into the paddies. Particles in the water remaining in the paddy are assumed to settle during one day. Erosion in the paddies is calculated using the rose equation[2].
- Potential water volume is calculated as the sum of the water volume the day before and inflow. Evapotranspiration (ET), percolation, bund percolation (BP) and cross flow (CF) are subtracted. The remaining water is distributed in the cascade beginning from the highest pixel. The paddy fills up until the connection height is reached and outflow starts. Water flow between the cascades is limited by the connection capacity. When the bund height is reached, overflow starts.



3. Methods

Field measurements
- Water base flow rates measurements with water clocks in paddy fields
- Turbidity (sediment loads) measurements in paddy water flows with portable sensors (NEP160 and NEP 260, McVan Instruments)

Laboratory analyses
- Soil parameters training datasets: N_{tot}, C_{tot}(both dry combustion, using Vario MAX CN), C_{carb}(Scheibler) to calculate C_{org}, texture (laser diffraction). Extended datasets using mid-infrared spectroscopy (MIRS).
GIS: ArcGIS 10.0. Statistics: SAS 9.2. Modeling software: PCRaster

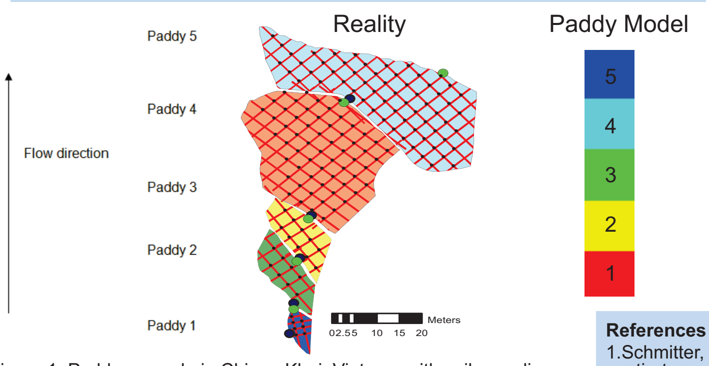


Figure 1. Paddy cascade in Chieng Khoi, Vietnam with soil sampling points (black points, n=150), paddy inlets (blue points) and outlets (green points).

4. Preliminary Results

Field measurements
- 49 m³ day⁻¹ water enters the cascade through the inflow, 24.4 m³ day⁻¹ leaves it during normal base flow (no rain) (Figure 2a)
- Turbidity decreased from the first to the third measuring point but had a peak at the outflow of Paddy 4 (Figure 3a)

Simulated data
- Parameterization to inflow of 49 m³ day⁻¹ results in an outflow of 39 m³ day⁻¹ (Figure 2b)
- Turbidity slightly decreased over the cascade (Figure 3b)

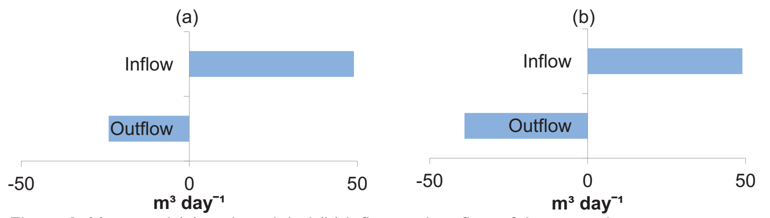


Figure 2. Measured (a) and modeled (b) inflow and outflow of the cascade

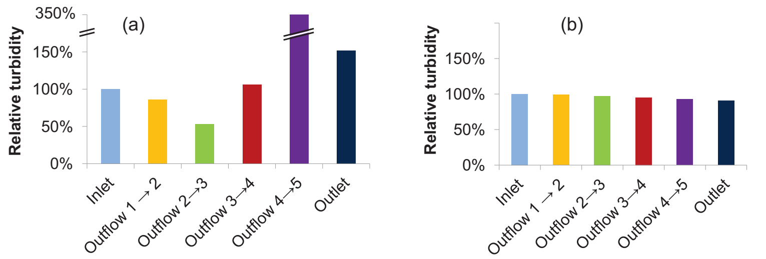


Figure 3. Measured (a) and modeled (b) turbidity at inlet, connections and outlet. Relative values to the measured turbidity at the inlet (100%)

5. Discussion and Outlook

- The low measured outflow might be due to an estimated high cross flow and bund percolation of the third paddy
- Modeled cross flow and bund percolation (data not shown) were in the range of other authors
- Measured flows between the paddies could not be directly compared with the modeled data as one pixel in the model got the average paddy size and the sizes of the real paddies vary from 42 m² to 775 m²
- High turbidity might not only be due to erosion processes but also due to disturbance during field measurement
- To calibrate the turbidity change correctly, more measurements, especially during rain events have to be taken
- For a better validation of the model also more flow measurements in other cascades should be carried out
- To simulate the sediment in one paddy and not only between paddies, a higher resolution is needed and the results of the soil analysis could be used
- Further improvement of the sediment modeling: calculate not only with one average particle size for all sediments but with average particle sizes of clay, silt and sand

Figure 4 Picture of the cascade (Nov 2011, Marohn)

6. Conclusion

The new developed paddy module for LUCIA has the potential to improve the existing model, but further field measurements and data evaluation are needed.

References

1.Schmitter, P., Dercon, G., Hilger, T., Hertel, M., Treffner, J., Lam, N., Duc Vien, T., Cadisch,G. (2011). Linking spatio-temporal variation of crop response with sediment deposition along paddy rice terraces. *Agriculture, Ecosystems & Environment, 140*(1-2), 34–45

2.Marohn, C., Cadisch, G. 2011. Documentation and manual of the LUCIA model v1.2. https://lucia.uni-hohenheim.de/.

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