Enhancing Water Quality through the Better Land Management of Degraded Highland Regions in Northern Lao PDR

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In contrast to farmers in lowlands, residents of upper watersheds tend to be remote, poor, and of minority groups with histories of marginalization. Most of them cannot afford inputs to remediate the continuous decline in agricultural production due to land degradation, placing their livelihoods further at risk.
• Upland farmers are often blamed for the negative impacts on downstream communities.

• Off-site impacts include
  – the reduction of life span of reservoirs and other structures through sedimentation,
  – water quality deterioration,
  – degradation of downstream aquatic ecosystems and a decline in fisheries production

• all contributing to a deterioration in the livelihoods of downstream communities.
The main contaminants reducing water quality in runoff and drainage from agricultural lands are:

- **nutrients**,  
- **suspended solids**,  
- **fecal coliform bacteria**, and  
- **pesticides**.
land use change → water quality → human health

Adapted from Ribolzi, 2004

LAND USE

Agrosystem with long fallow

Intensive farming

SURFACE FEATURES

Permeable surface with macropores (No Crust)

Impermeable surface with crusts

HYDRODYNAMIC

- Subsurface flow
- Chemical weathering
- Natural purification of water by soil filtration

- Surface runoff
- Mechanical erosion
- Contamination of water by humans and nutrients losses

STREAMWATER QUALITY

Low turbidity level
- Low microbiological and nutrients content

High turbidity level
- Microbiological and chemical contaminations

HUMAN and ENVIRONMENTAL HEALTH
A need for catchment management studies

It is the natural geomorphological unit for predicting sources, movement and delivery of sediments.

It is an invaluable tool to assess both on-site and off-site effects of erosion.
Who we are

• National Agricultural and Forestry Research Institute (NAFRI), Vientiane, Laos: Soil Survey and Land Classification Center

• IRD (seconded to IWMI): IRD Research unit: « Soils, Land Use, Degradation and Rehabilitation (‘Solutions’) 

• IWMI: Research theme 2: Land, Water and Livelihoods
The study site:

- The Houay Pano Catchment, northern Laos

Results:
- The major factors affecting flows and sediment yields

Discussion

Conclusions
The study site:

- Cropping systems in Houay Pano Catchment LouangPhabang province
Average fallow and cropping periods for the fields under annual crops, 1970-2003

Decreased labour productivity

Change in productivity, 1970-2003

Base 100=1970

- Yields
- Annual work time
- Change in net productivity
The study site:

- The Houay Pano Catchment & equipments
60 ha
Ban Lak Sip village located 10 km from Luang Phrabang
115 inhabitants km$^{-2}$

Photo. I. Makin
8 hydrological stations

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4 catchments along the main stream

4 small catchments to test new agricultural practices

100 m
Houay Pano with catchments

- Improved fallow
- Conventional slash and burn
- Improved fallow and contour planting
- Not tillage & mulch cultivation
Yearly Land use maps

Soil map

Topographic map and Digital elevation model
The 8 stations are equipped with velocimeters and automatic water level recorders to measure flows.
These water level recorders are coupled with automatic water samplers to measure suspended loads (flow x sediment concentration)
Sediments trapped in the weir are manually removed to estimate the bed load after each main rainfall.
Results
Rainfall (mm) 2001-2005

Rather low variations:
- 2001: 1403 mm
- 2002: 1414 mm
- 2003: 1325 mm
- 2004: 1378 mm
- 2005: 1414 mm

mean = 1365 mm
st.dev.= 48 mm
Permanent flow in the 4 nested catchments along the stream

Ephemeral and limited flow from the 4 hillslope sub-catchments
Suspended load (SL; Mg ha\(^{-1}\) yr\(^{-1}\)) 2001-2005

High suspended load from the 4 nested catchments along the stream

Limited suspended load from the 4 hillslope sub-catchments
Limited bed load from the 4 nested catchments along the stream

High bed load from the 4 hillslope sub-catchments, especially during slash and burn cultivation
Total sediment yield (SY = SL+BL; Mg ha\(^{-1}\) yr\(^{-1}\))
2001-2005

Sediment yields are high except for those under improved fallow and no tillage conditions.
Discussion
• No influence of annual rainfall was statistically shown.
• A scenario with 100% of annual crops would lead to an annual sediment yield of 18 Mg ha\(^{-1}\) yr\(^{-1}\). Conversely a scenario with 100% of improved fallow would produce only 6 kg ha\(^{-1}\) yr\(^{-1}\).
• Our results tend so substantiate the simulations that showed that climate change is likely to have a lesser impact on soil losses than land use changes*

Off-site effects

• The 53 Mg trapped each year in average in the main weir (S4) would have normally been trapped in downstream irrigation canals.

• More important are the 156 Mg exported annually from the catchment, in the form of suspended sediments.

• With a mean carbon enrichment of 150% as compared to the bulk soils, these sediments are likely to affect downstream water quality.

The major role of annual crops

- Annual crops are the major cause of soil losses from the catchments.
- These results are consistent with those obtained:
  - in the same catchments with regard to gully erosion*
  - in the five countries of Southeast Asia involved in the Management of Soil Erosion Consortium

• Among the three tested innovative practices, improved fallow appears the most efficient in terms of reducing soil losses and improving downhill water quality.

• It is more readily accepted by farmers than hedgerows, especially if the legumes are of commercial interest.
Conclusions

- Long term catchment studies are invaluable tools
  - To monitor the impacts of land use changes upon soil losses and water quality
  - To test innovative conservation practices.
- Because soil erosion is a selective processes affecting topsoil where nutrients and carbon concentrate, sediments can be a major source of downstream pollution.
- Environmental services, as production of clean water, from uplands should be better acknowledged and rewarded.