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

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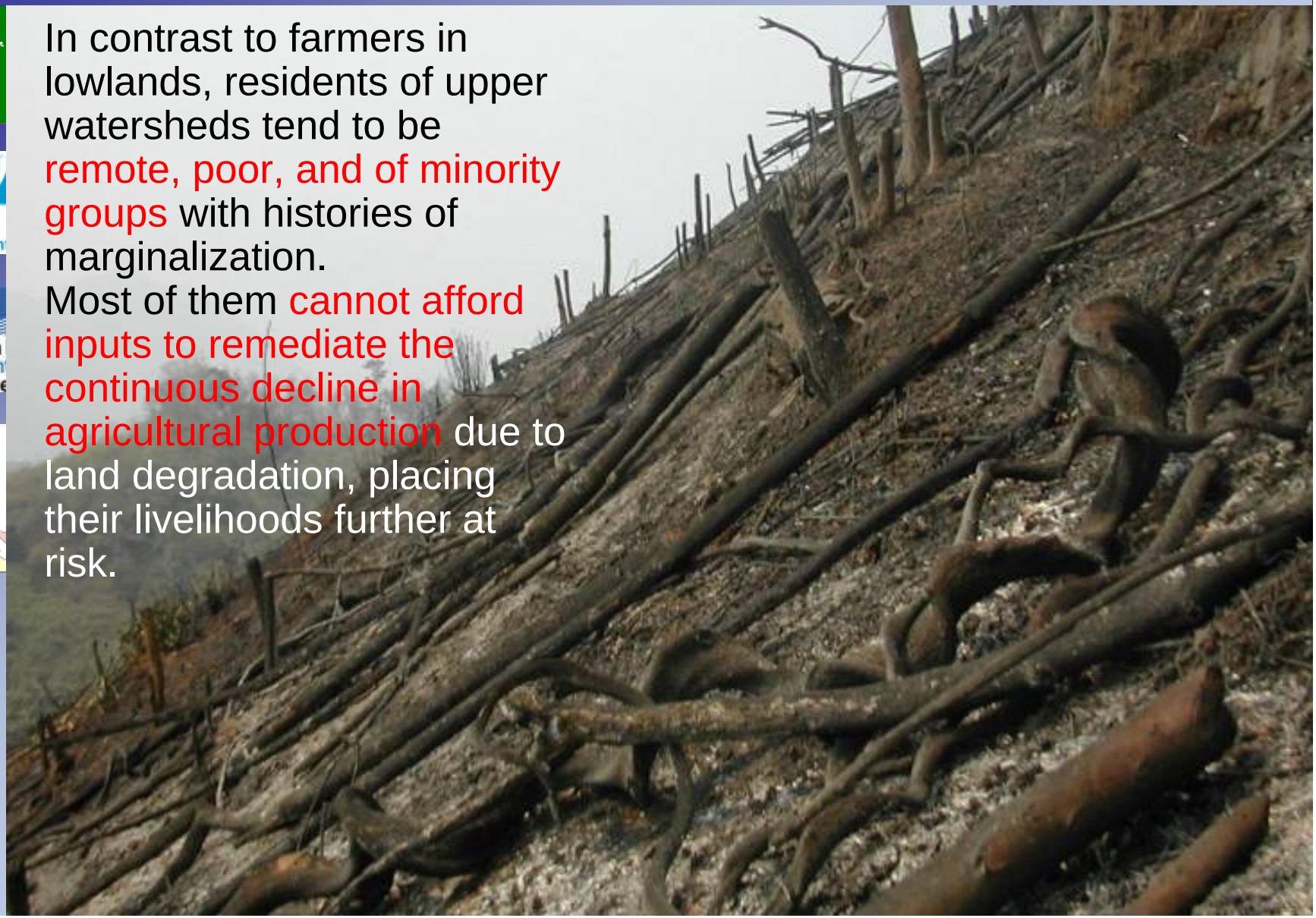
# Rationale

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.



# Rationale (cont'd)

- 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.

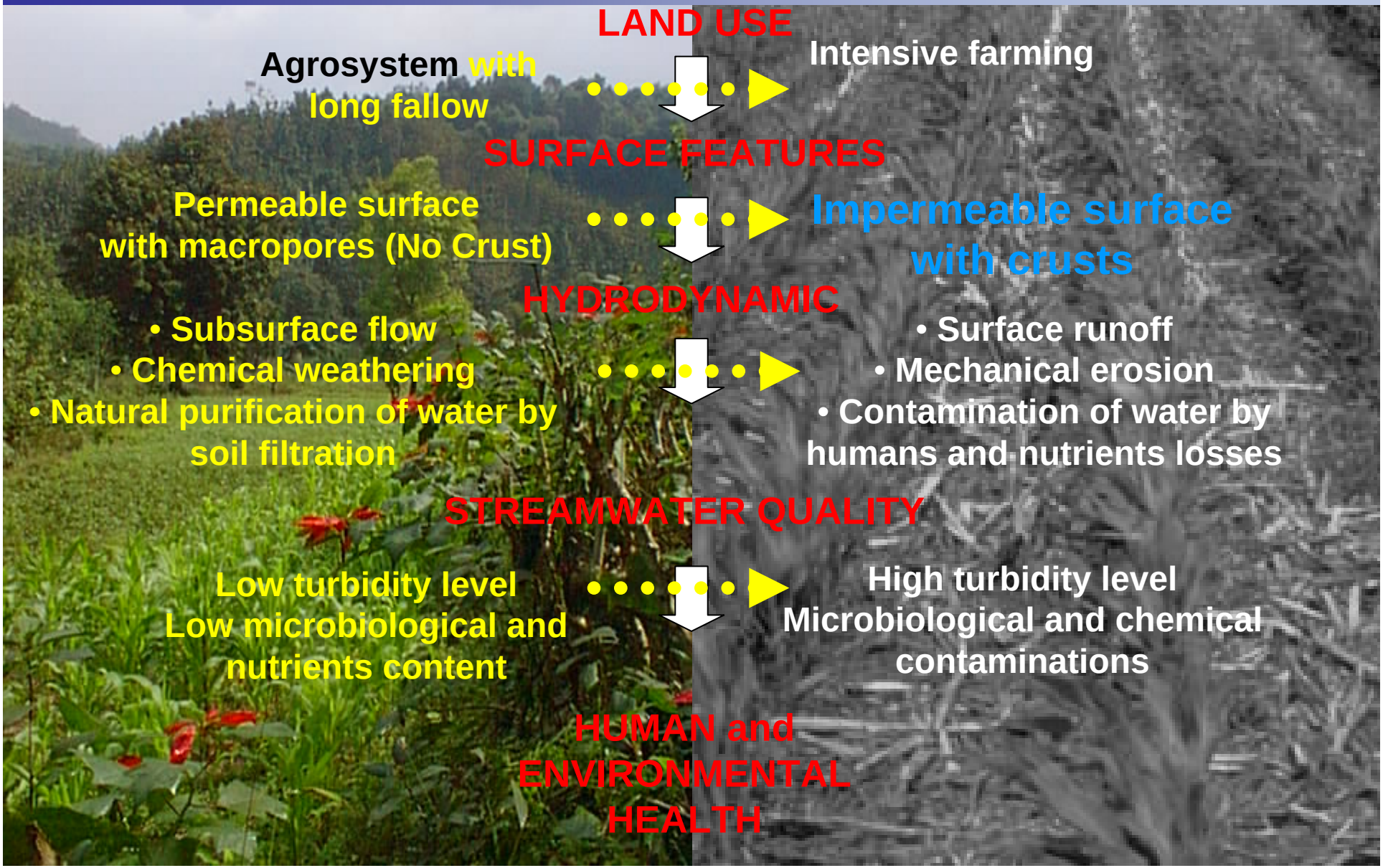
# Rationale (cont'd)

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*



# 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



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# 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

# Outline

**The study site:**

- **The Houay Pano Catchment, northern Laos**

**Results:**

- **The major factors affecting flows and sediment yields**

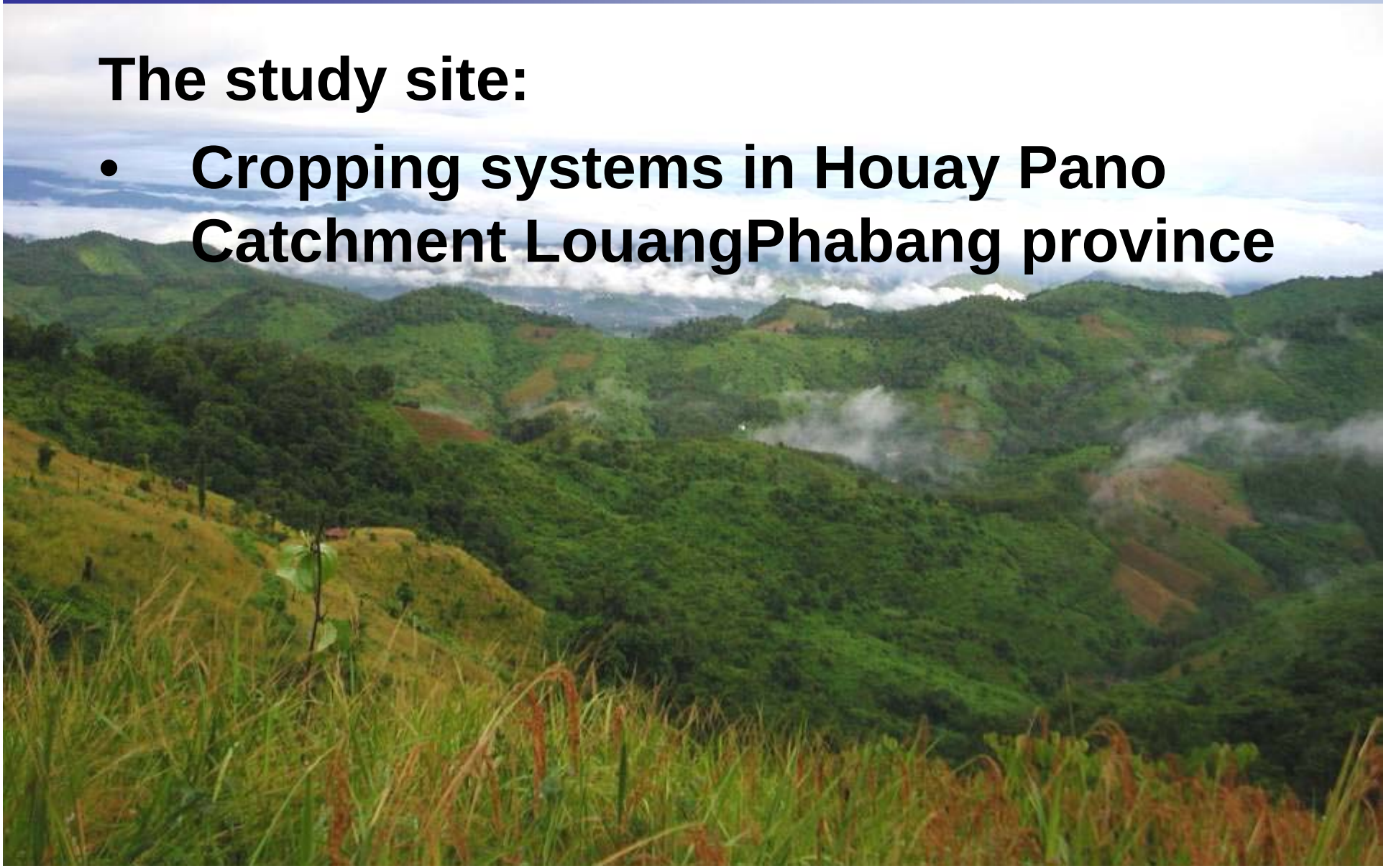
**Discussion**

**Conclusions**

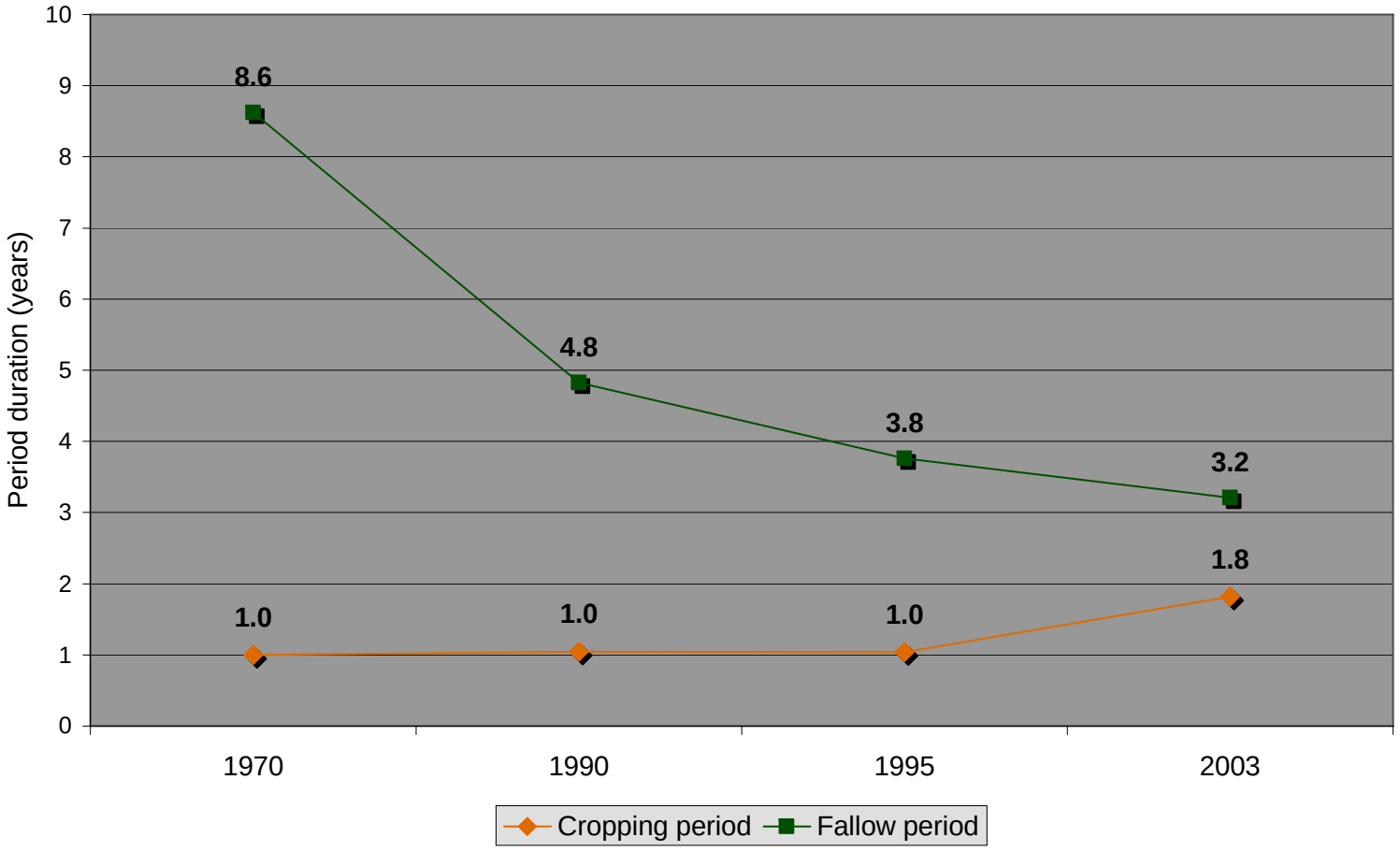
# Outline

**The study site:**

- **Cropping systems in Houay Pano Catchment LouangPhabang province**

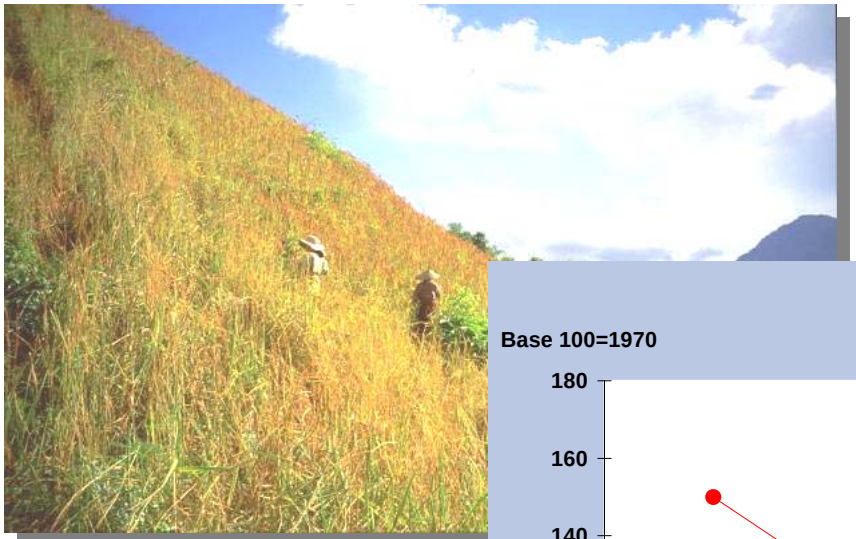


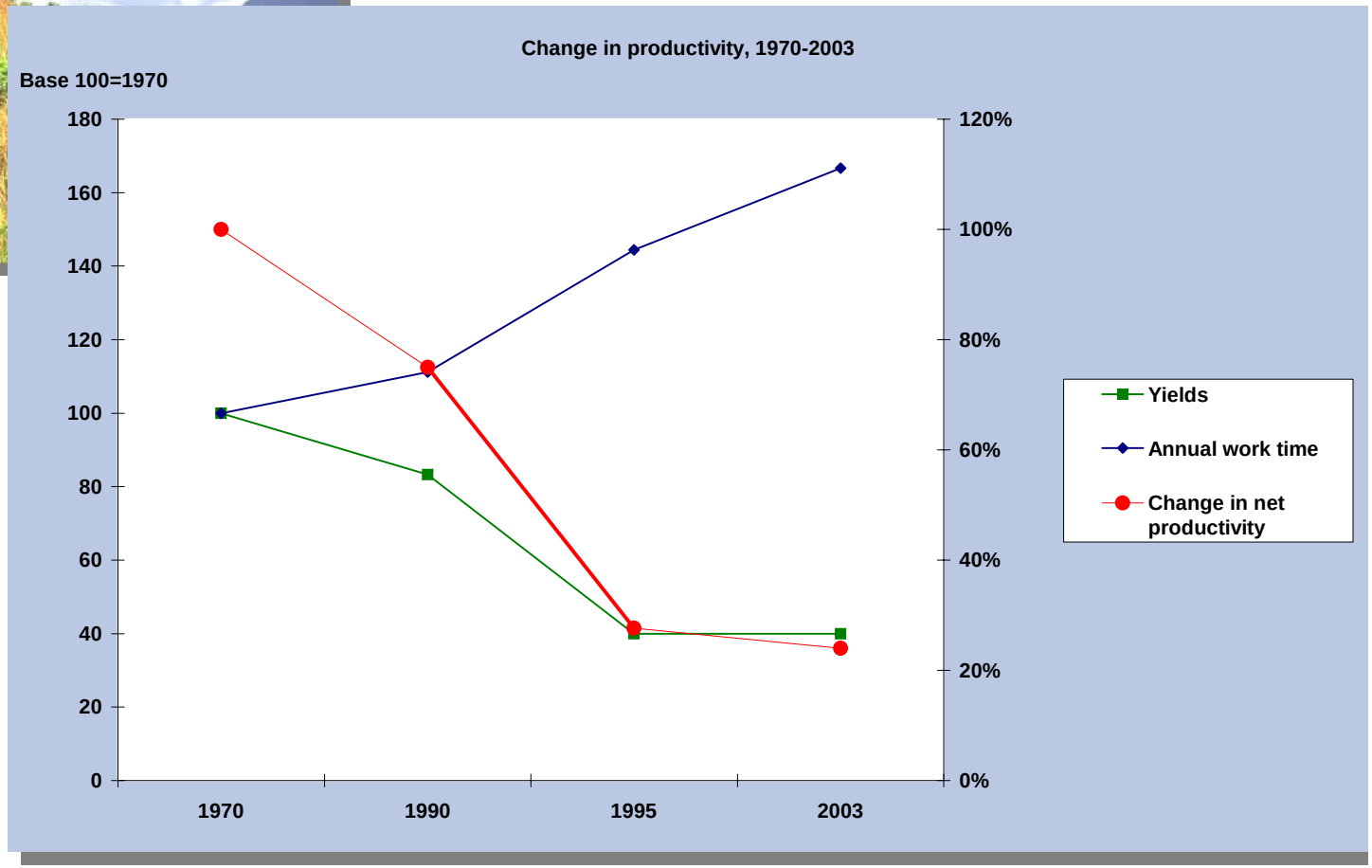
# Average fallow and cropping periods for the fields under annual crops, 1970-2003




Source: Lestrelin G., Giordano M., Keohavong B., 2005. When "Conservation" leads to land degradation lessons from Ban Lak Sip, Laos. IWMI, Colombo, Research Report 91, 34 p.

# Decreased labour productivity

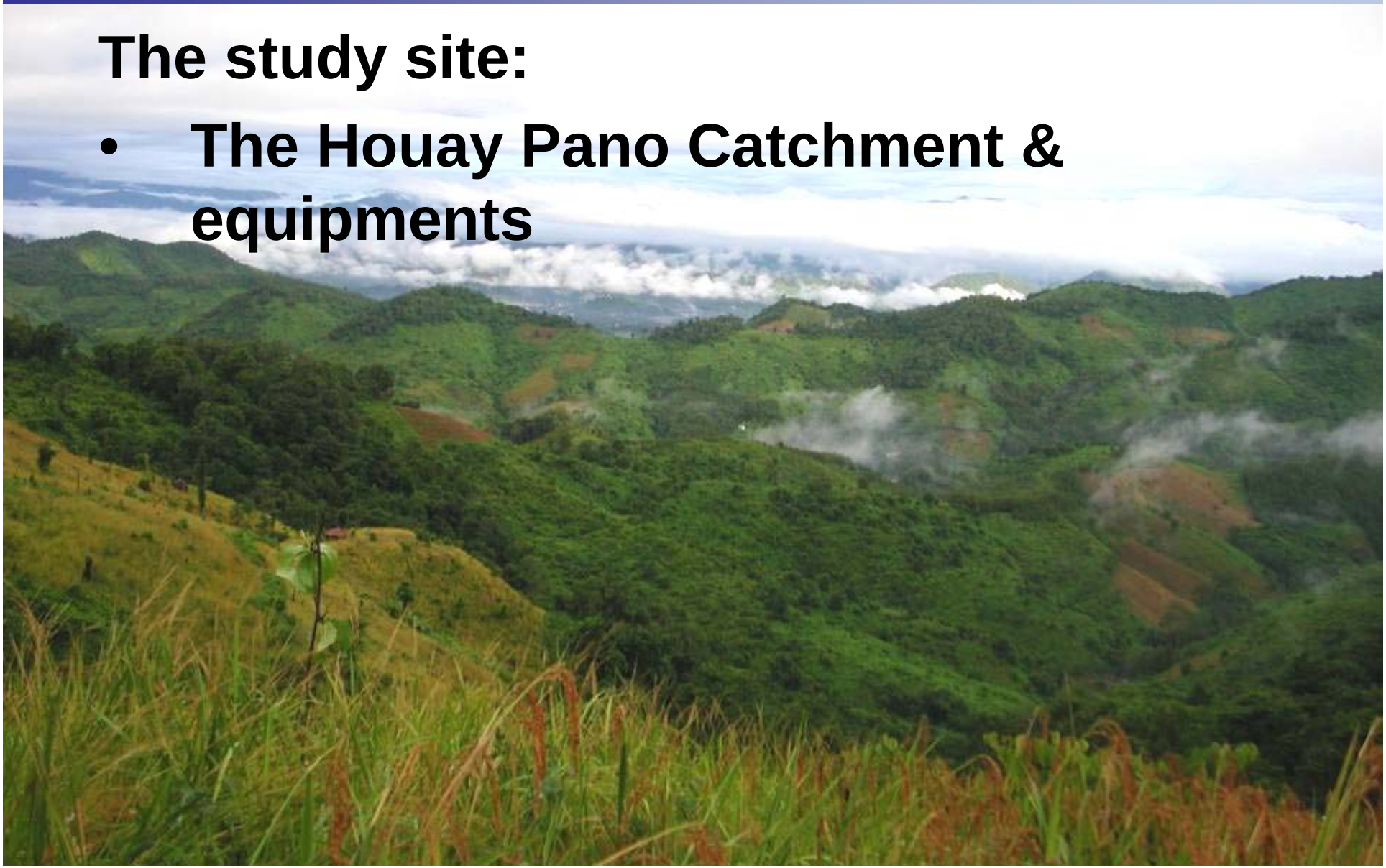




# Outline

**The study site:**

- **The Houay Pano Catchment & equipments**



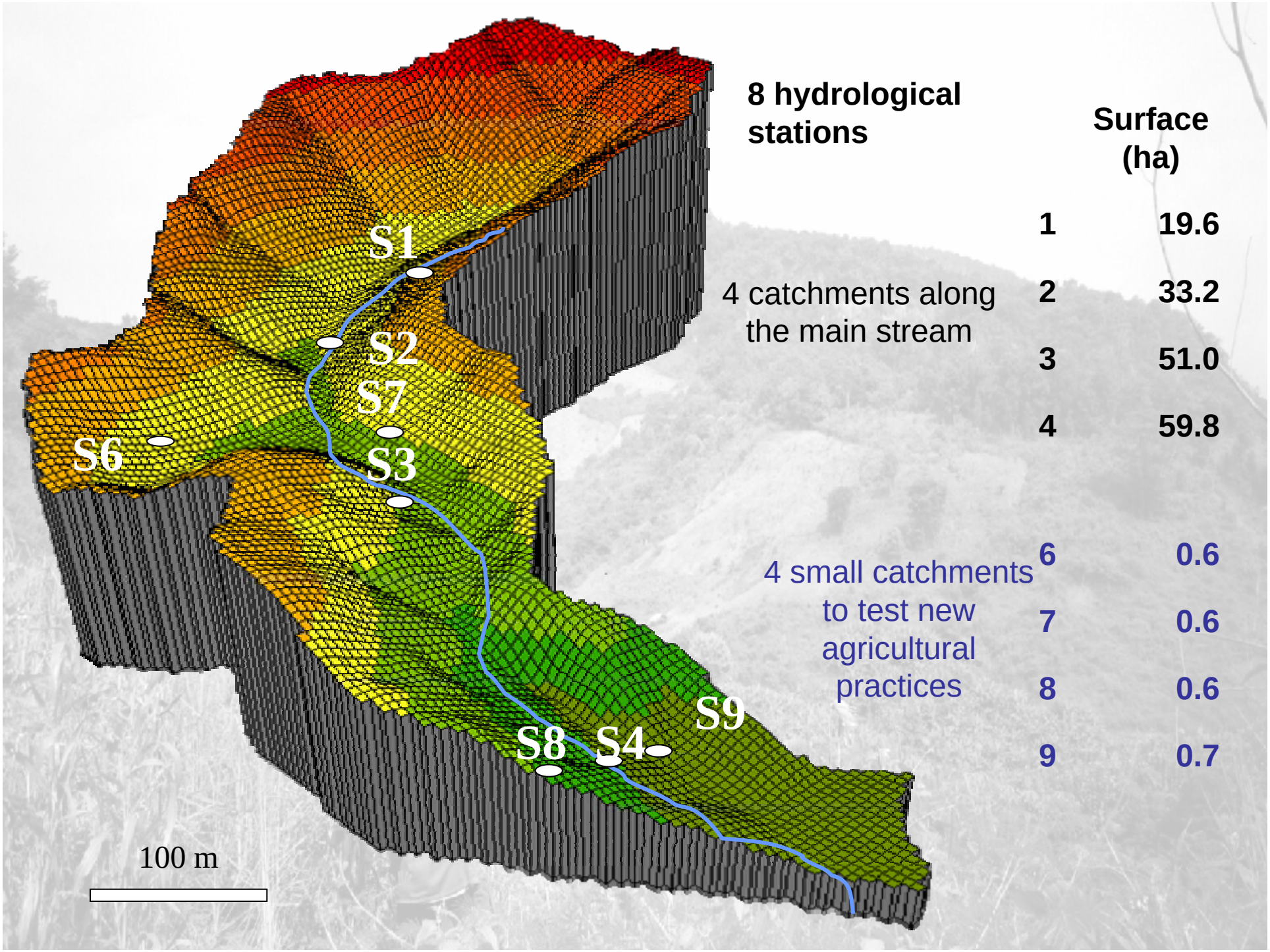
# The Houay Pano catchment

**60 ha**

**Ban Lak Sip village located 10 km from Luang Phrabang**

**115 inhabitants km$^{-2}$**

Photo. I. Makin



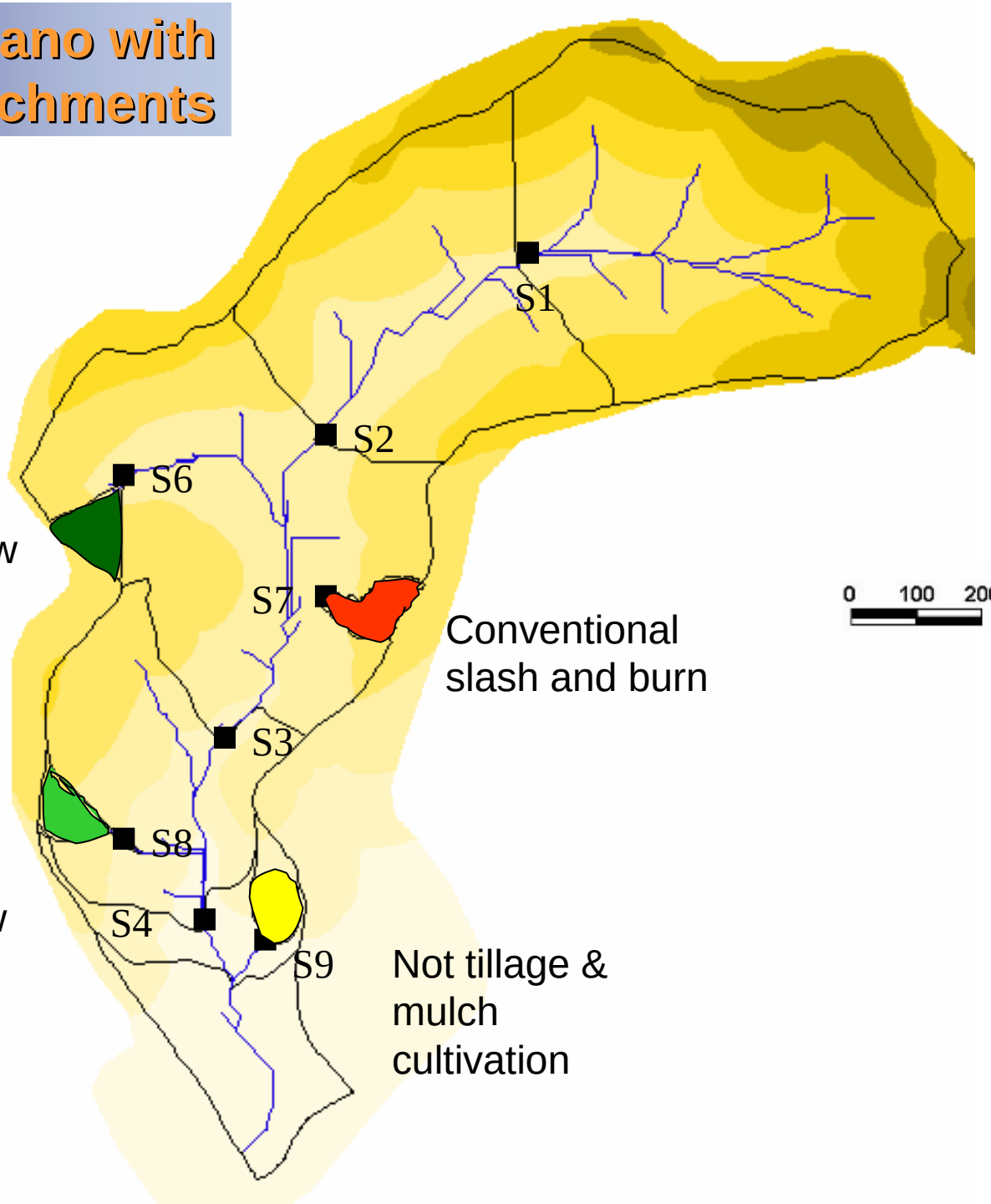

**8 hydrological stations**

4 catchments along the main stream

4 small catchments to test new agricultural practices

| | Surface (ha) |
|---|---|
| 1 | 19.6 |
| 2 | 33.2 |
| 3 | 51.0 |
| 4 | 59.8 |
| 6 | 0.6 |
| 7 | 0.6 |
| 8 | 0.6 |
| 9 | 0.7 |

# Houay Pano with catchments



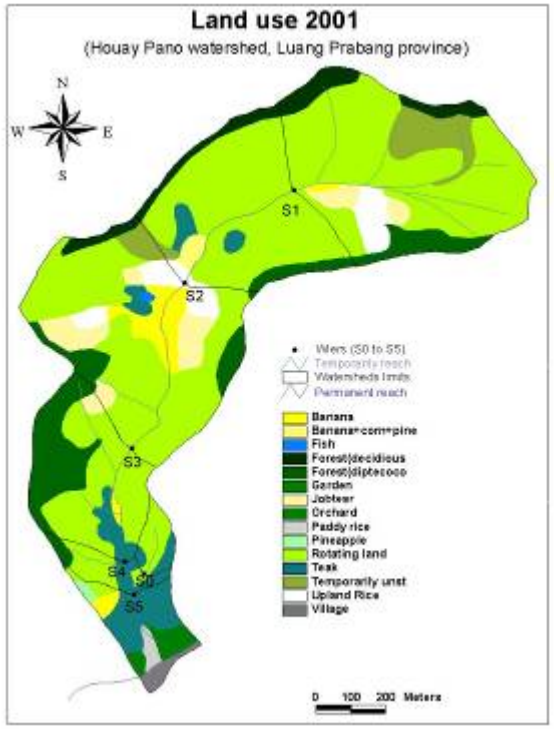

Improved fallow

Conventional slash and burn

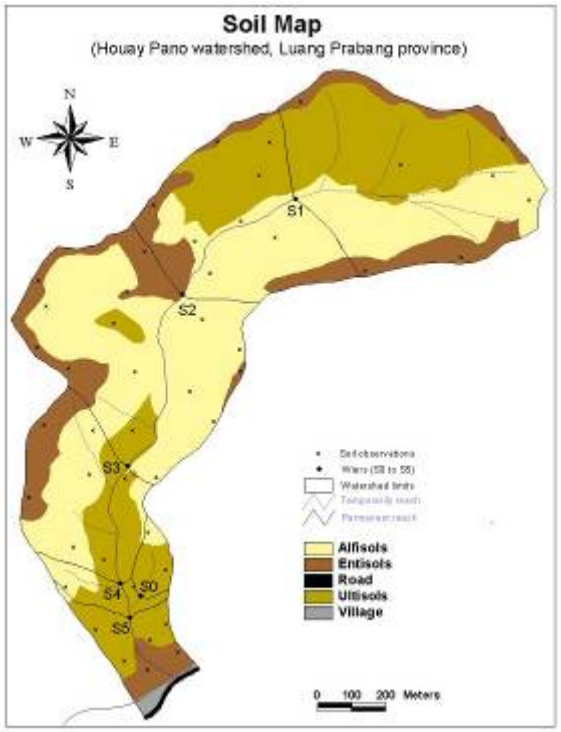
Improved fallow and contour planting

Not tillage & mulch cultivation

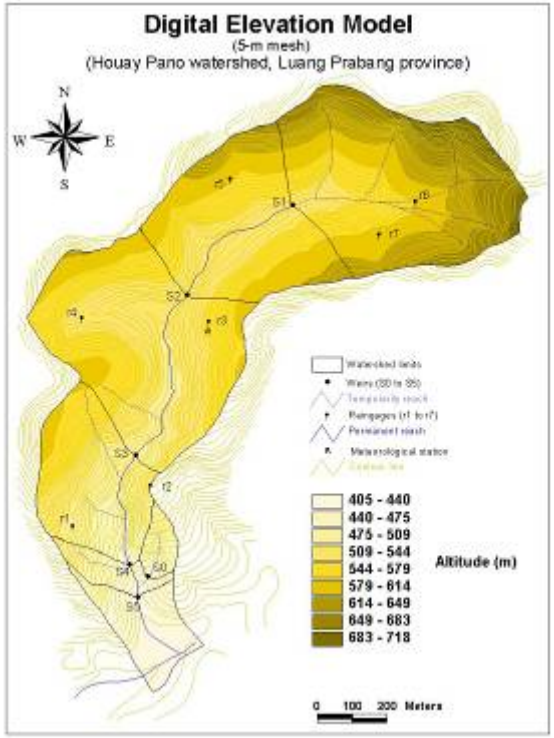
## Yearly Land use maps



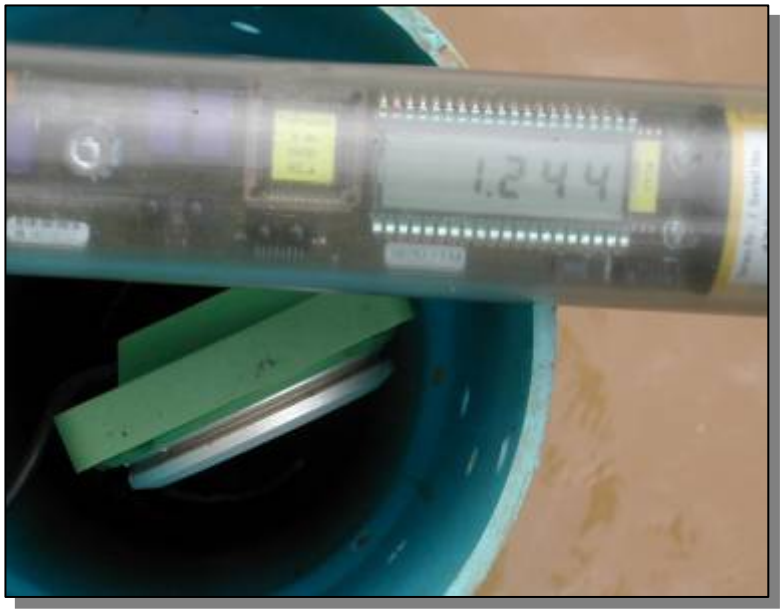

## Soil map




## Topographic map and Digital elevation model



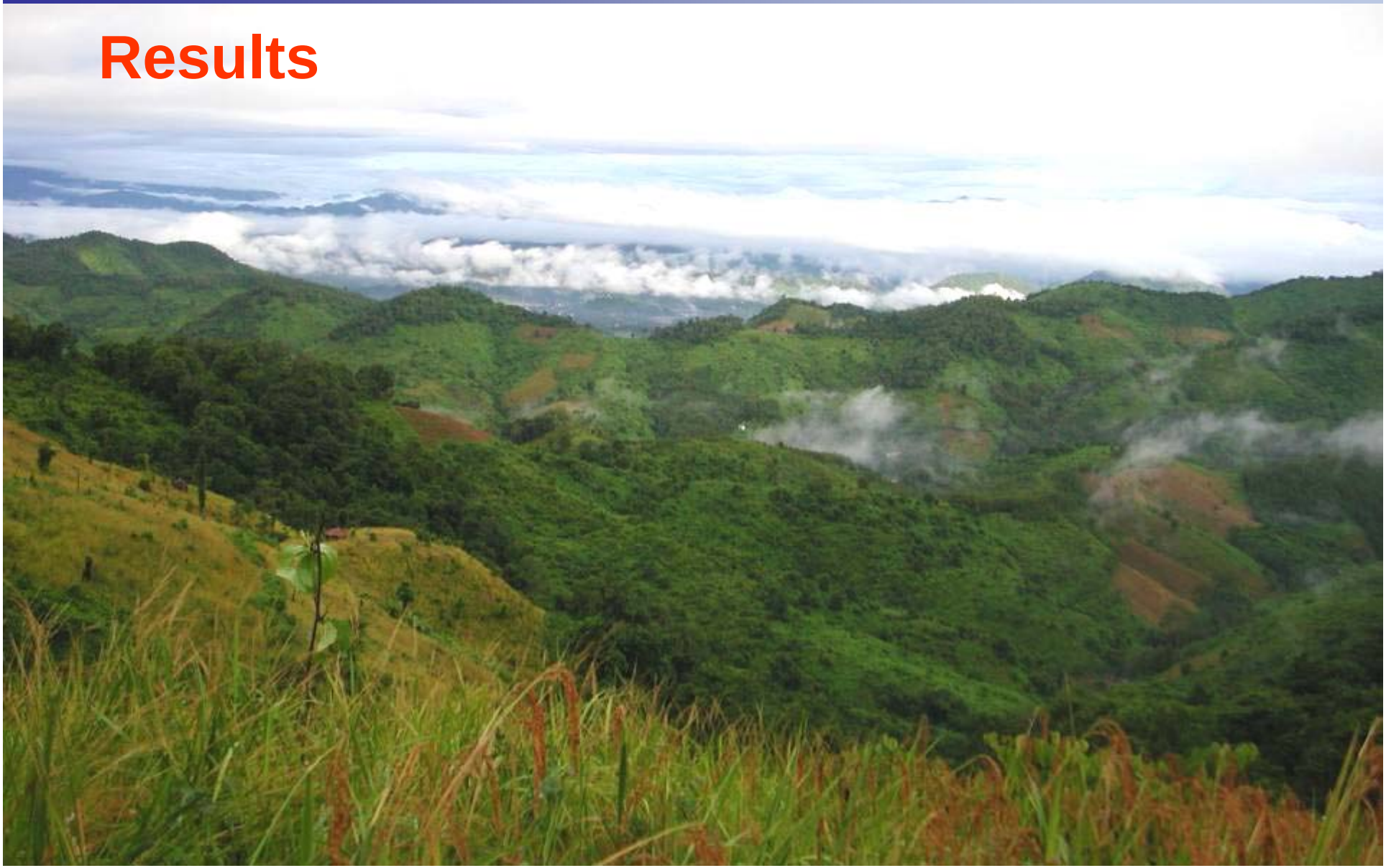
**The 8 stations are equipped with velocimeters and automatic water level recorders to measure flows**



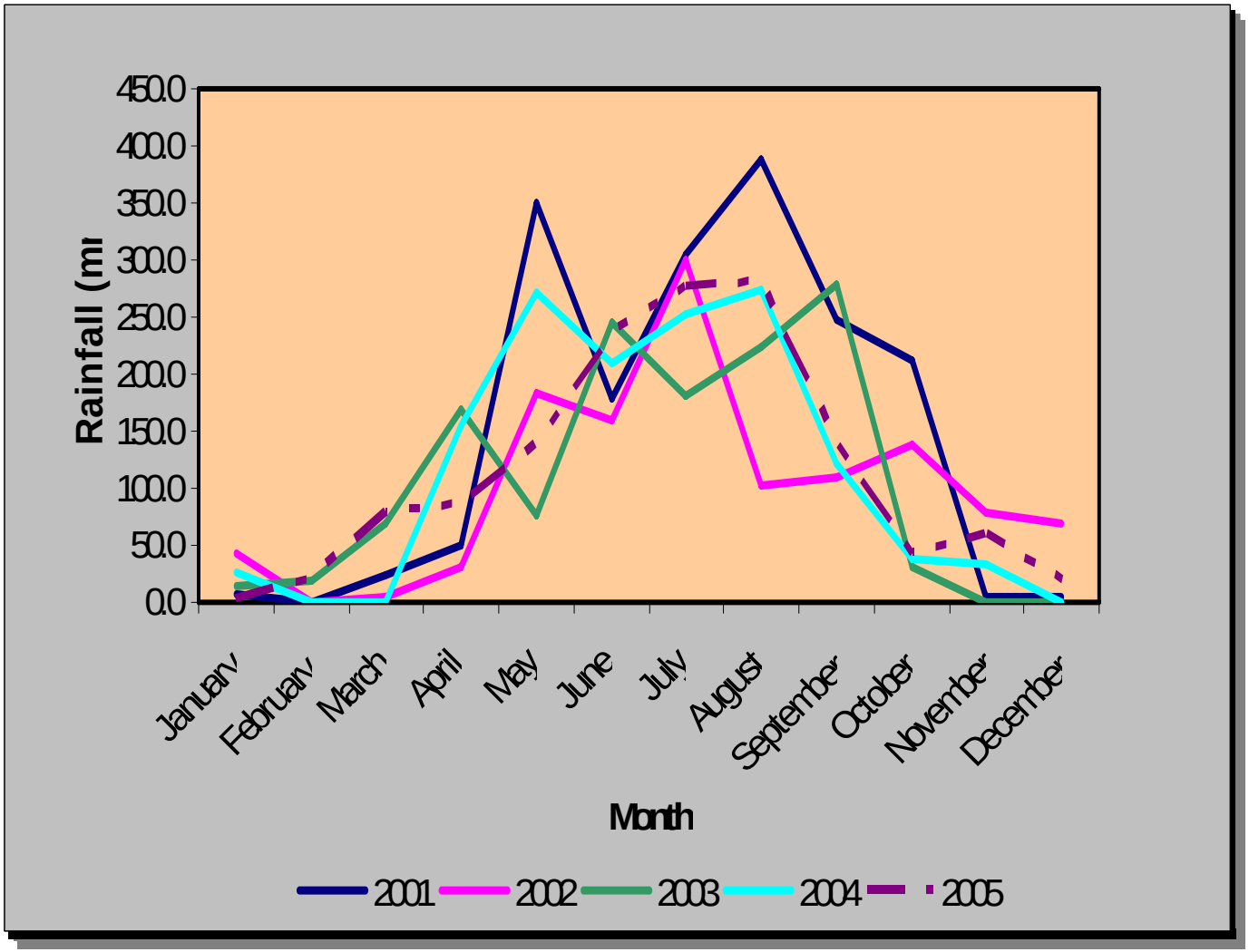
# These water level recorders are coupled with automatic water samplers to measure suspended loads (flow x sediment concentration)

# Sediments trapped in the weir are manually removed to estimate the bed load after each main rainfall

# Results



# Rainfall (mm) 2001-2005



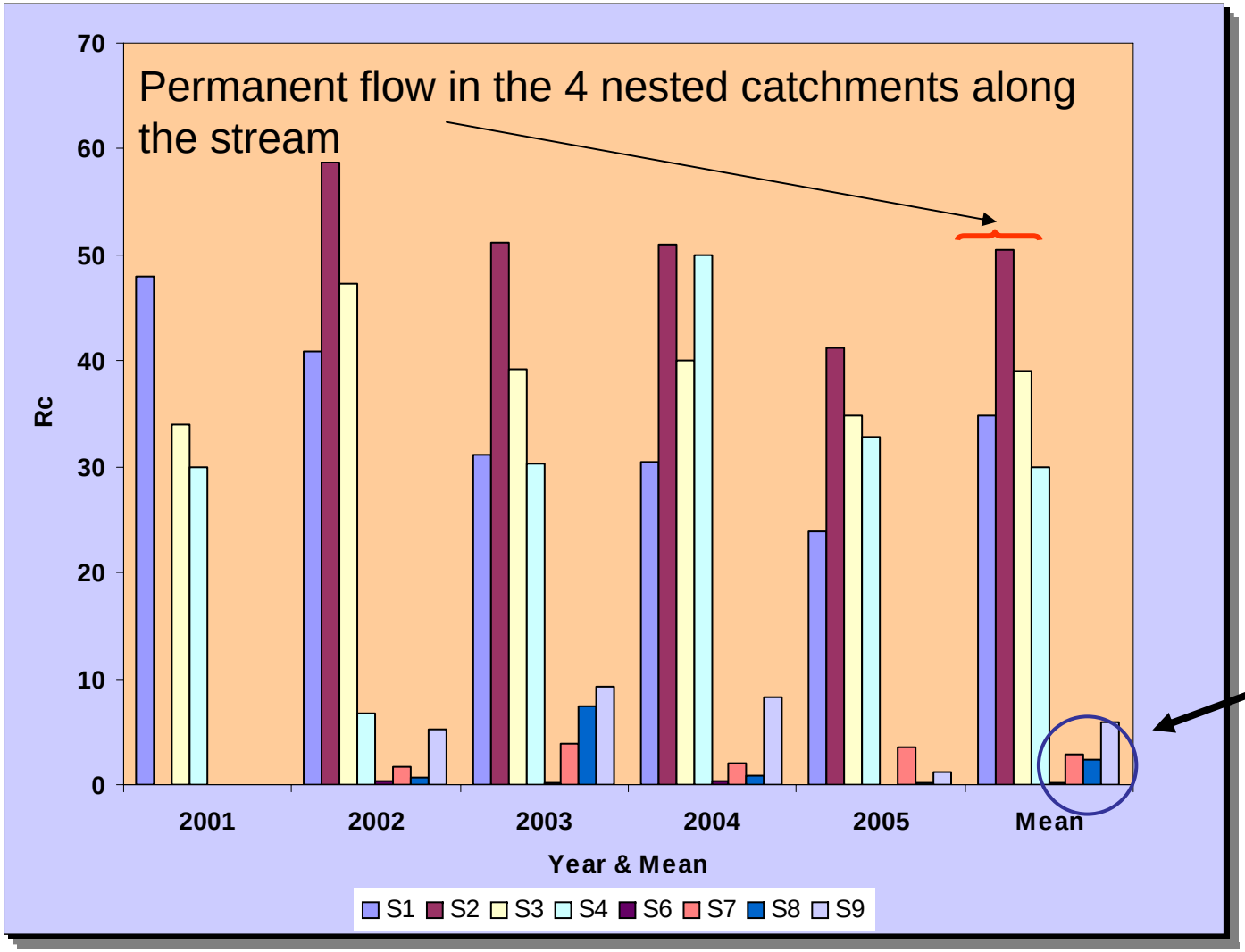

**Rather low variations:**

- **2001: 1403 mm**
- **2002: 1414 mm**
- **2003: 1325 mm**
- **2004: 1378 mm**
- **2005: 1414 mm**

**mean = 1365 mm**

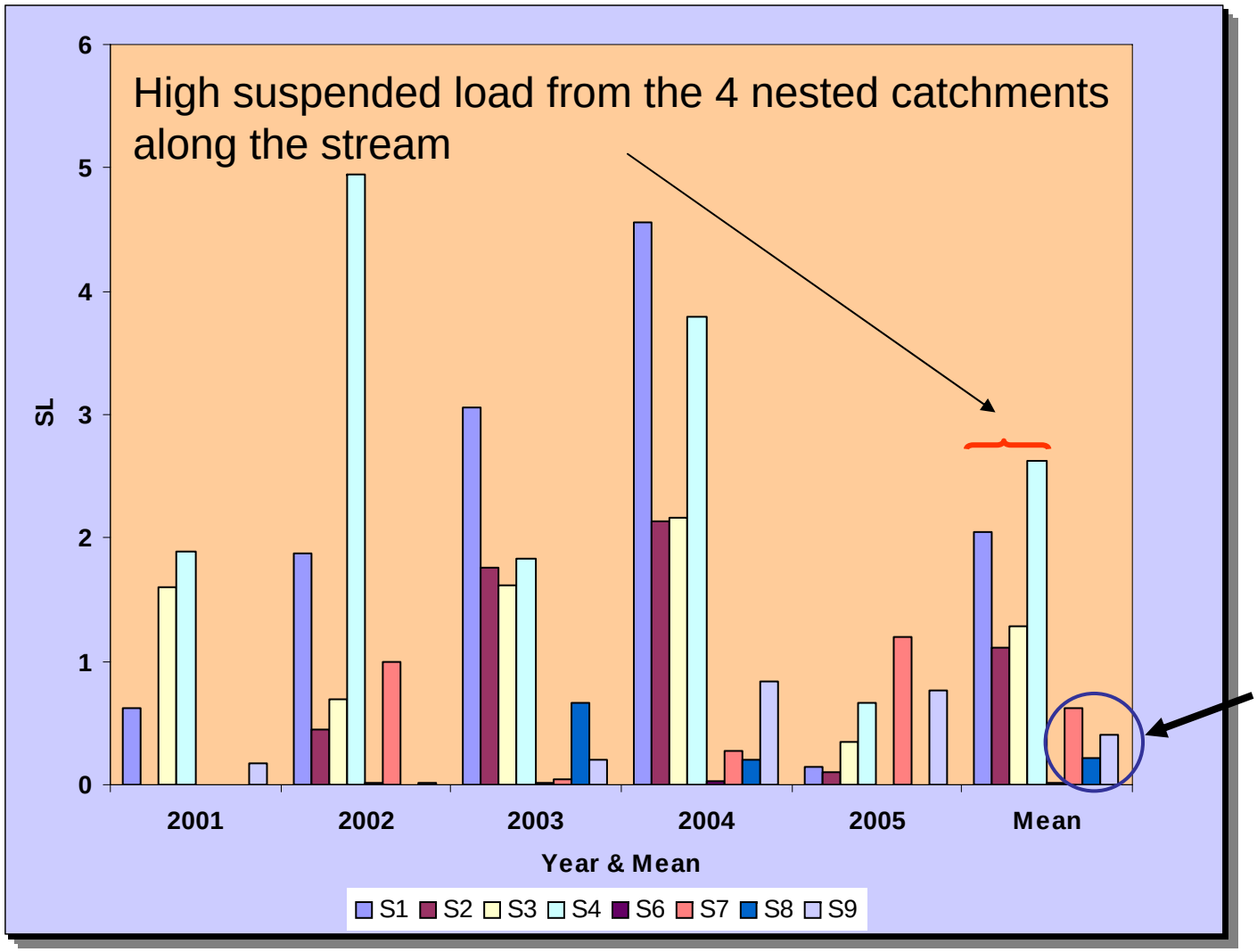
**st.dev.= 48 mm**

# Runoff coefficient (%) 2001-2005



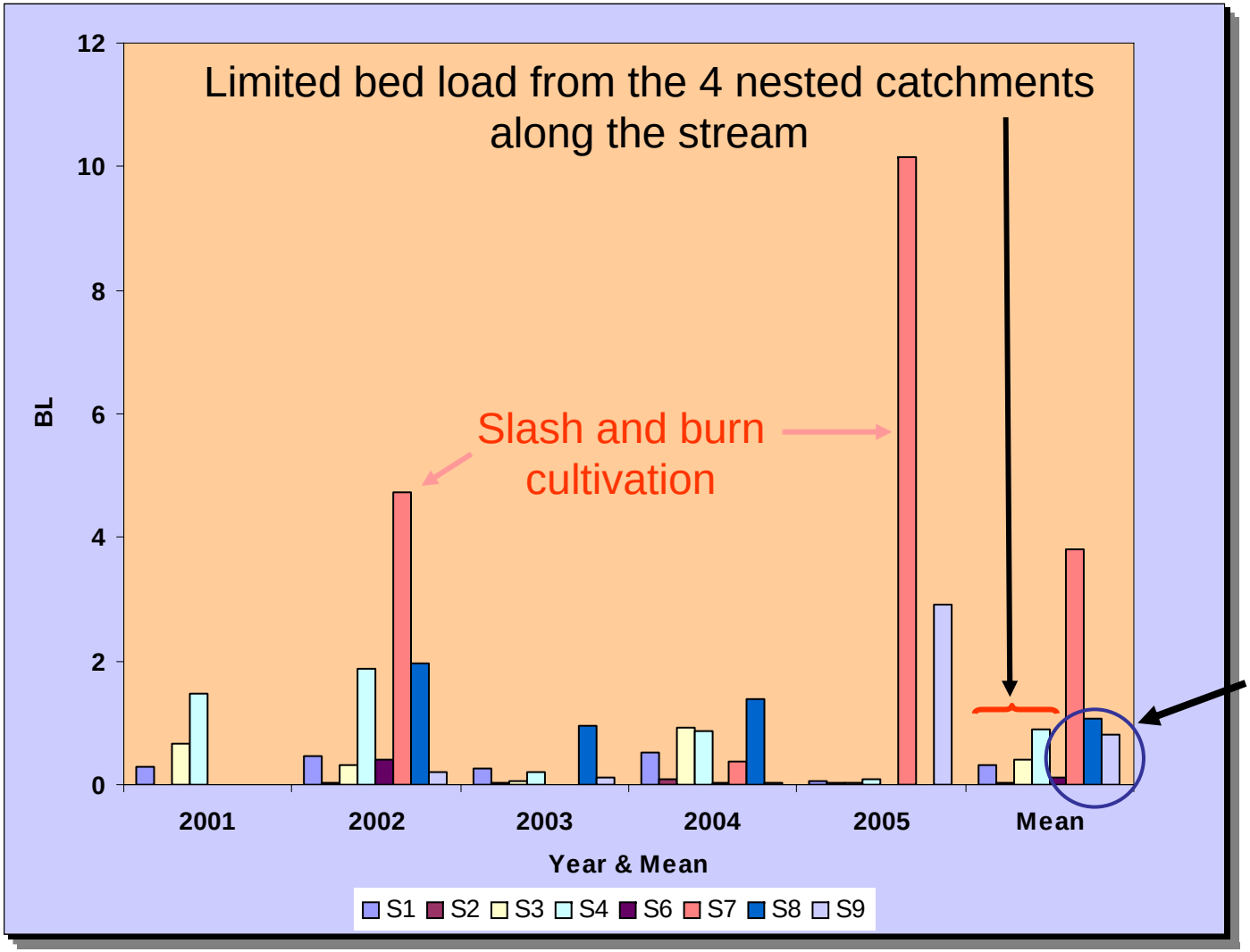

Ephemeral and limited flow from the 4 hillslope sub-catchments

# Suspended load (SL; Mg $ha^{-1}$ $yr^{-1}$) 2001-2005



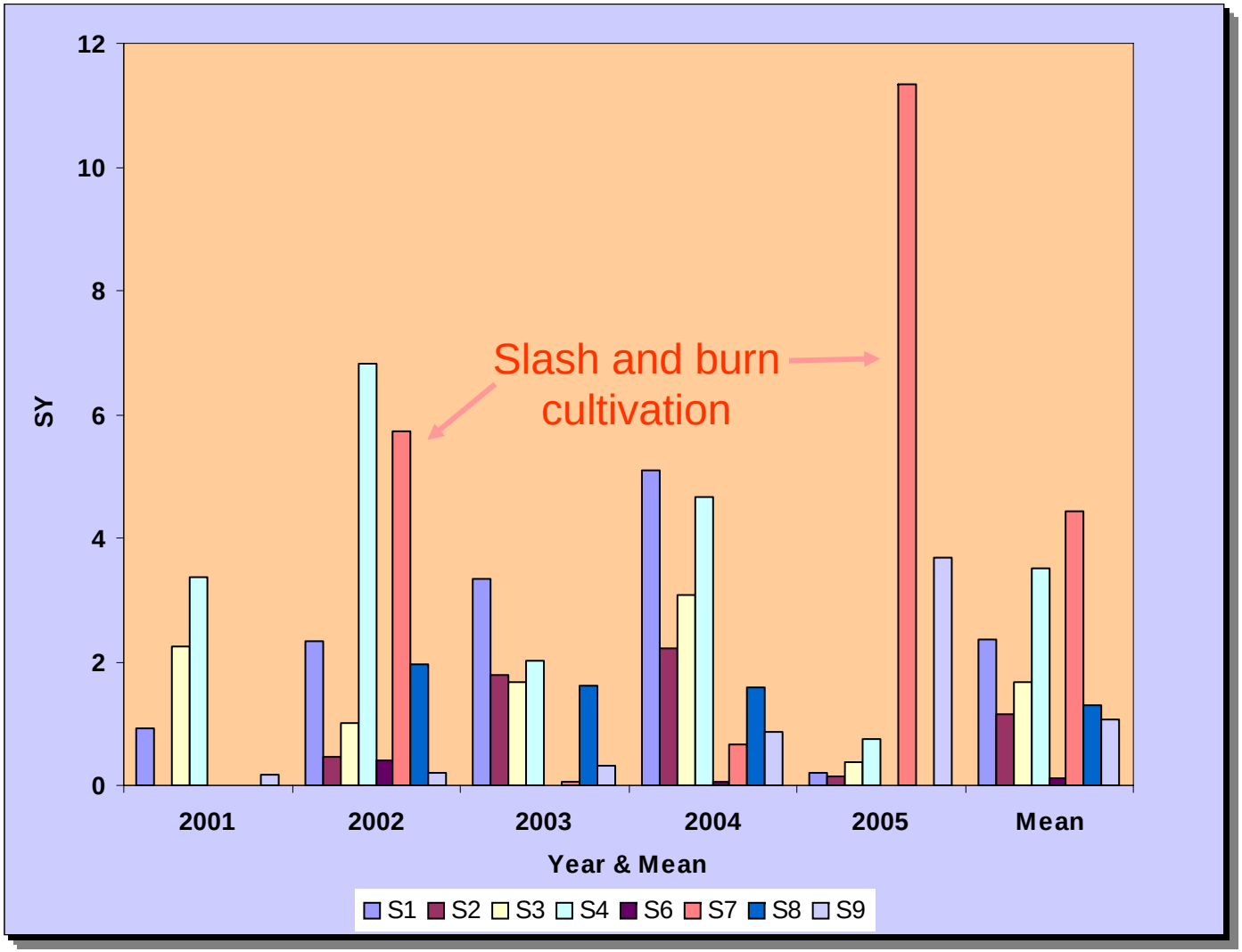

Limited suspended load from the 4 hillslope sub-catchments

# Bed load (SL; Mg $ha^{-1}$ $yr^{-1}$) 2001-2005




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



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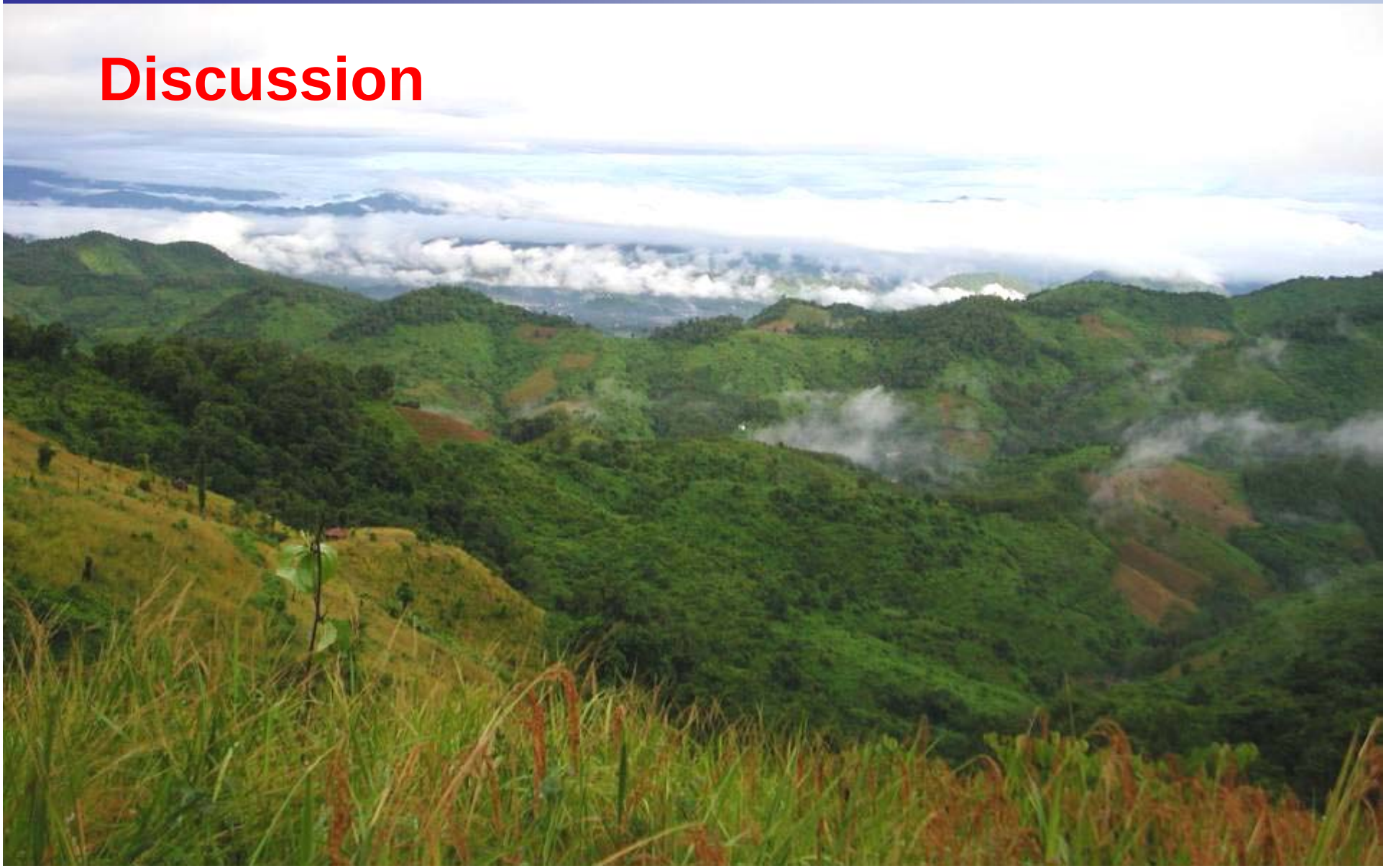
# Discussion



# Land use change vs climate change

- 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*

*Chaplot V., Giboire G., Marchand P., Valentin, C, 2005b.. Dynamic modelling for gully initiation and development under climate and land-use changes in northern Laos. Catena, 63 : 318–328

# 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.

*Rumpel, C., Chaplot, V., Planchon, O., Bernadou, J., Le Bissonnais, Y, Valentin, C., Mariotti, A., 2006, Preferential erosion of black carbon on steep slopes with slash and burn agriculture. *Catena*, 65(1): 30-40.

# 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

*Chaplot V., Coadou le Brozec E., Silvera N. Valentin, C., 2005a. Spatial and temporal assessment of linear erosion in catchments under sloping lands of Northern Laos. *Catena*, 63 :167–184

# Innovative practices

- 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.