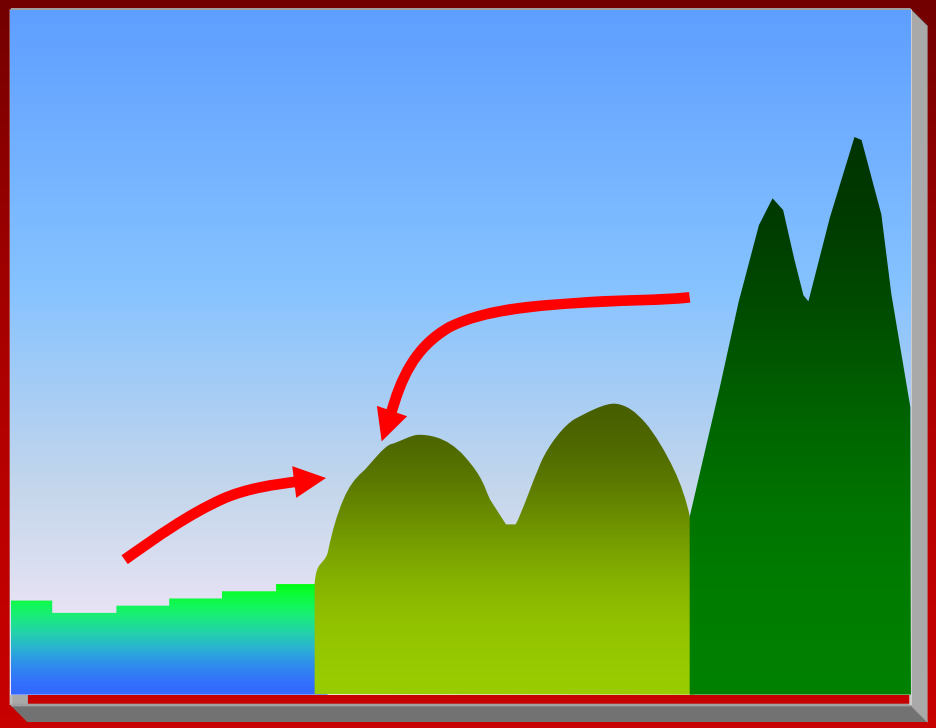
Impact of innovative land management practices on annual runoff and soil losses from 27 catchments of South-East Asia

Valentin, C., Agus F., Alamban, R., Boosaner A., Bricquet, J.P., Chaplot V., de Guzman, T., de Rouw, A., Janeau J.L., Maglinao, A., Orange, D., Phachomphonh K., Phai Do, Podwojewski P., Ribolzi.

Rapid changes

1. Increased population pressure:
   - natural demographic growth
   - migration to the upland areas



2. Government policies:
   - resettlement and land conservation

Rapid changes

3. market forces
   - market demand
   - market access
   - needs of farmers

On-site impacts

- Vegetation
- Biodiversity
- Water regimes
- Soils

Off-site impacts
Improved watershed services

- *Water yield*
- *Streamflow distribution*
- *Water quality*
- *Sediment in streams*

different strategies → environment & livelihoods

Which management strategies?

- Conserving forests
- Non-wood forest products (NWFPs)
- Agroforestry systems

- **Center for International Forestry Research**

- Food and Agriculture Organisation of the United Nations

- **ICRAF**

Which management strategies?

- Construction of terraces

- International Rice Research Institute

- Direct sowing, mulch-based conservation agriculture

- French Agricultural Research Centre for International Development

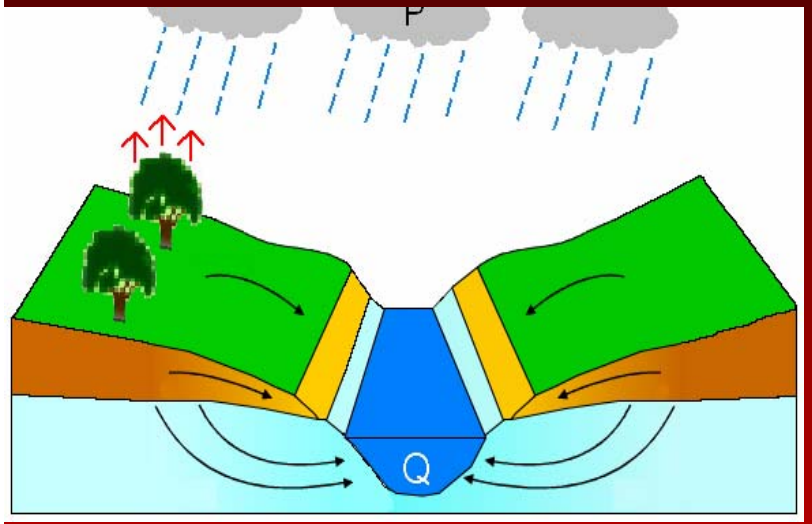
- Improved tropical forages

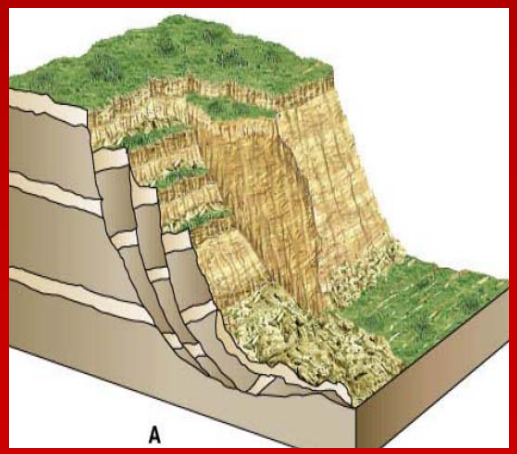
- The International Center for Tropical Agriculture

Field plot studies

- On-site
- Off-site?

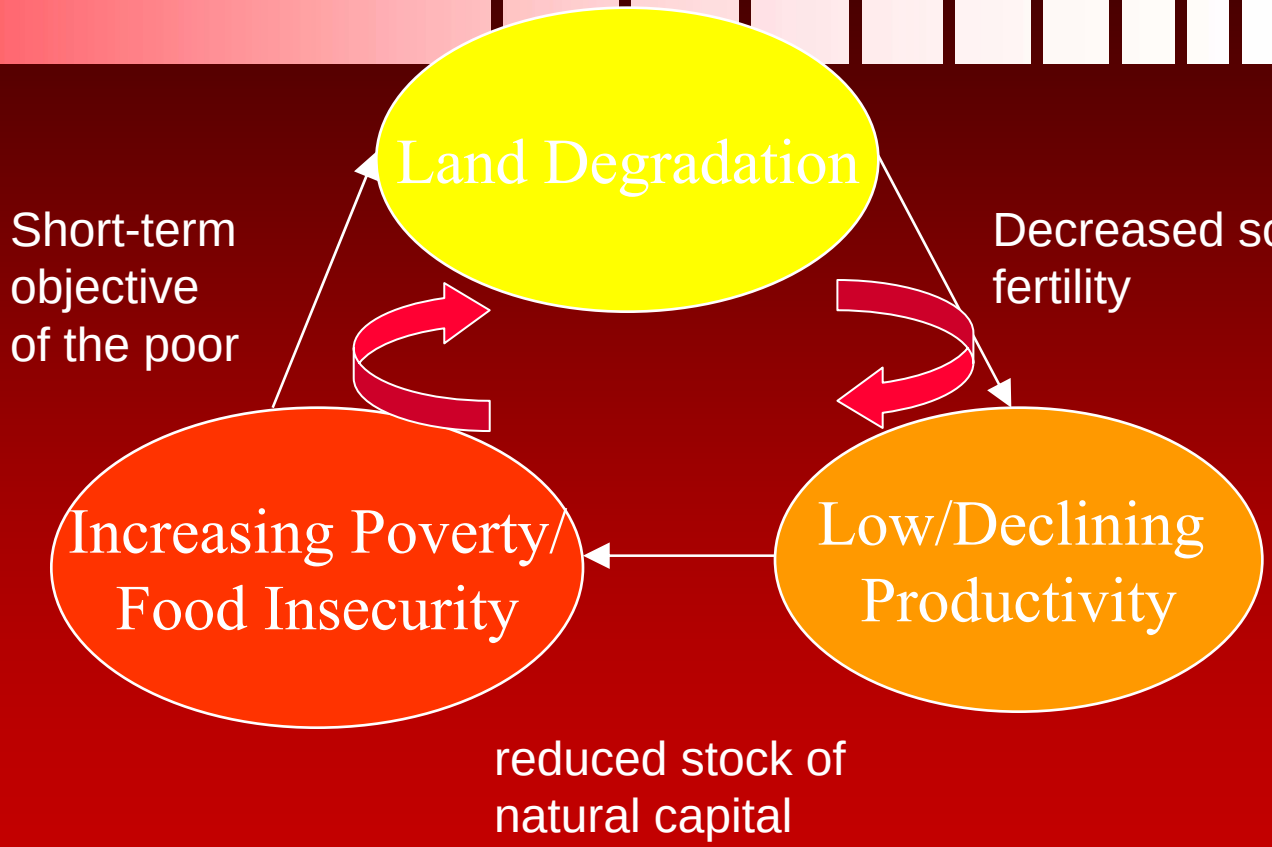
A real link between upland agriculture and off-site impacts?





- Other processes : deposition, landslides, bank erosion
- Other sources: roads, …
- Little impact of deforestation on large scale flooding

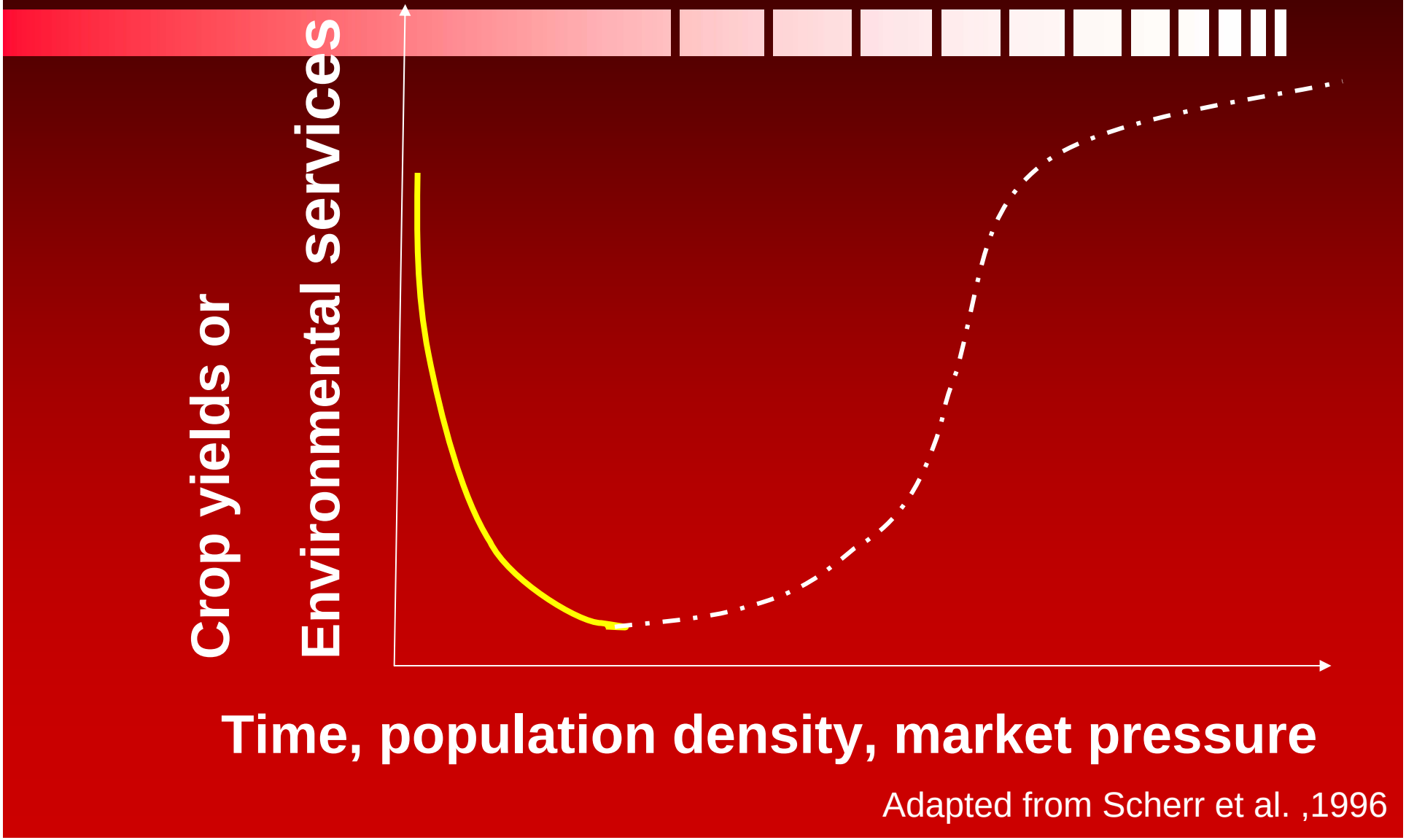
Time dynamics



A downward spiral?

After John Pender, 2001. IFPR and others

Or a ‘U curve’



Adapted from Scherr et al. ,1996

Three crucial questions for environmental policies

1. Agricultural activities → off-site impacts?
2. Conservation strategies → catchment services?
3. Better access to market → conservation technologies?

Research needs

- Different spatial and temporal scales
- Effects of management strategies
- Rare climatic events

Long term catchment studies

Management of Soil Erosion Consortium

Indonesia, Laos, Philippines, Thailand, Vietnam,

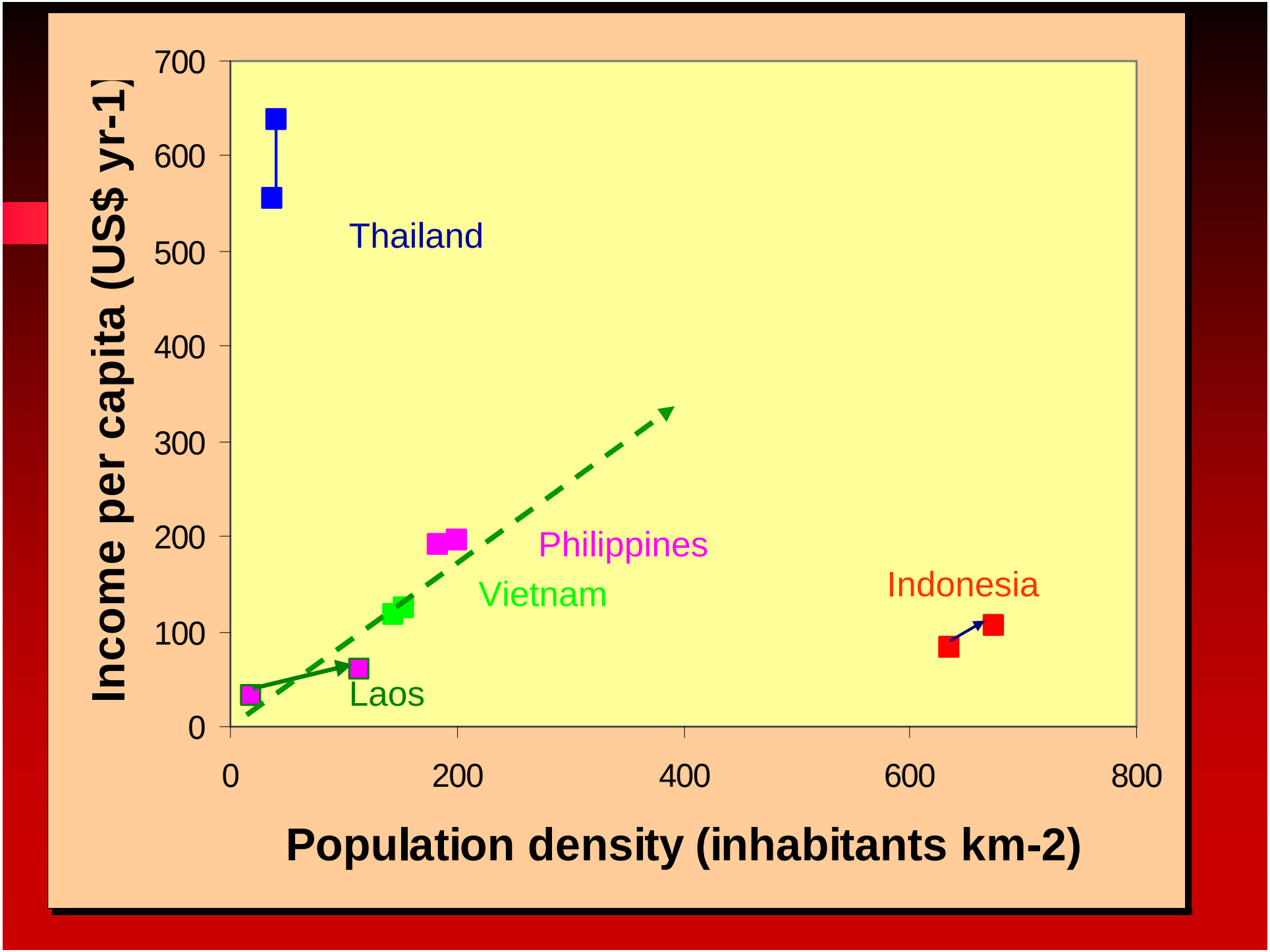


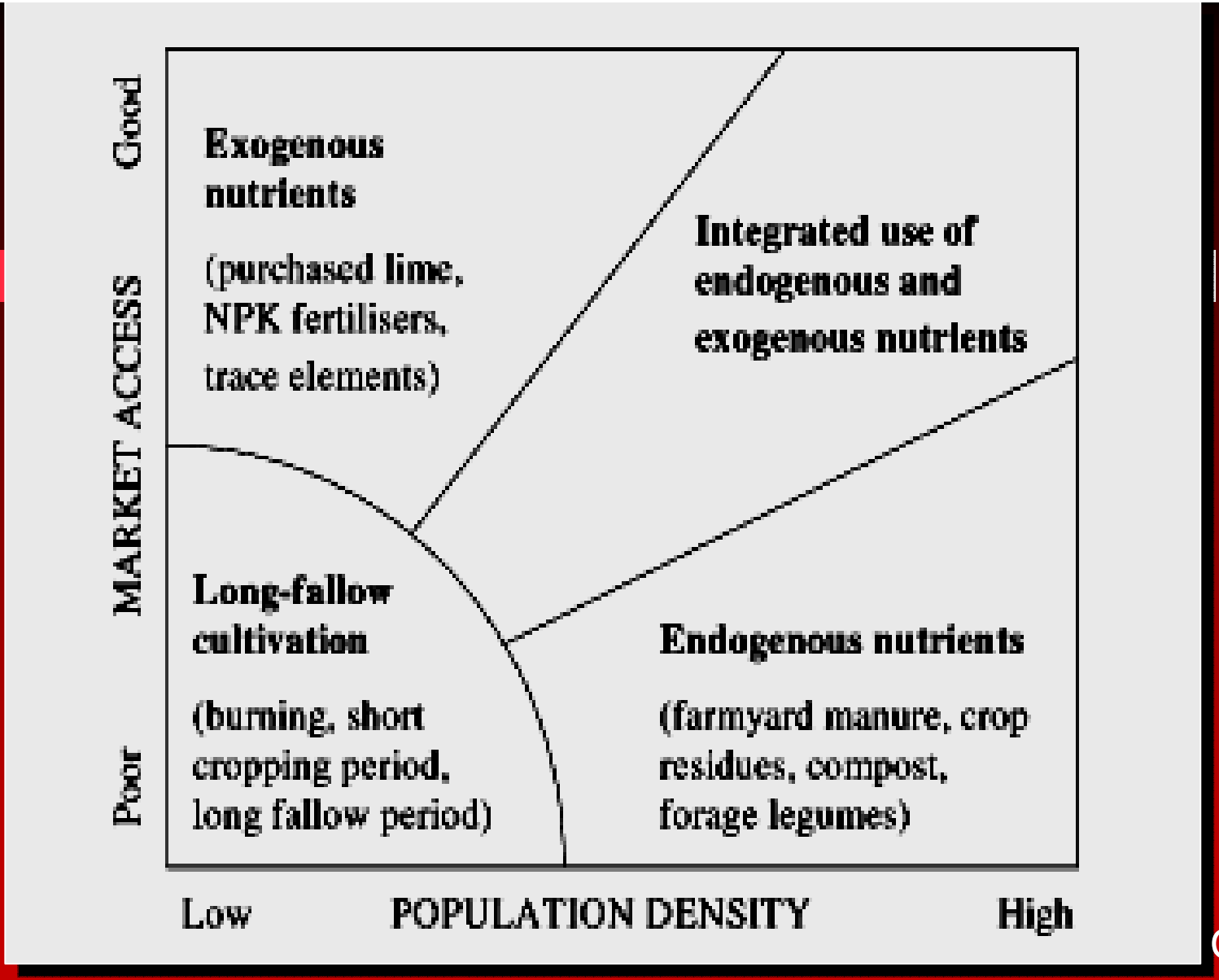


ADB-IBSRAM-IWMI-IRD

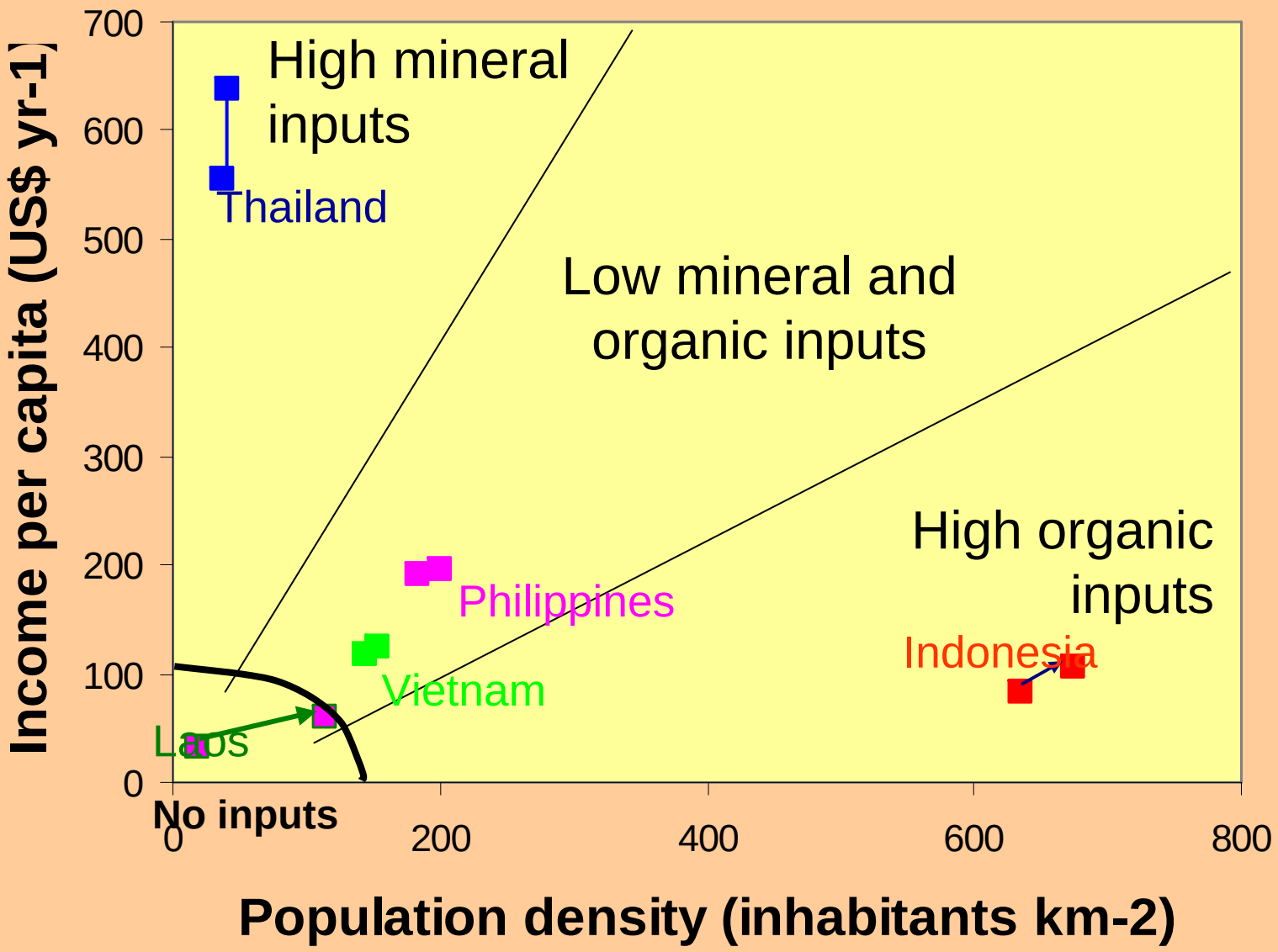
Objective

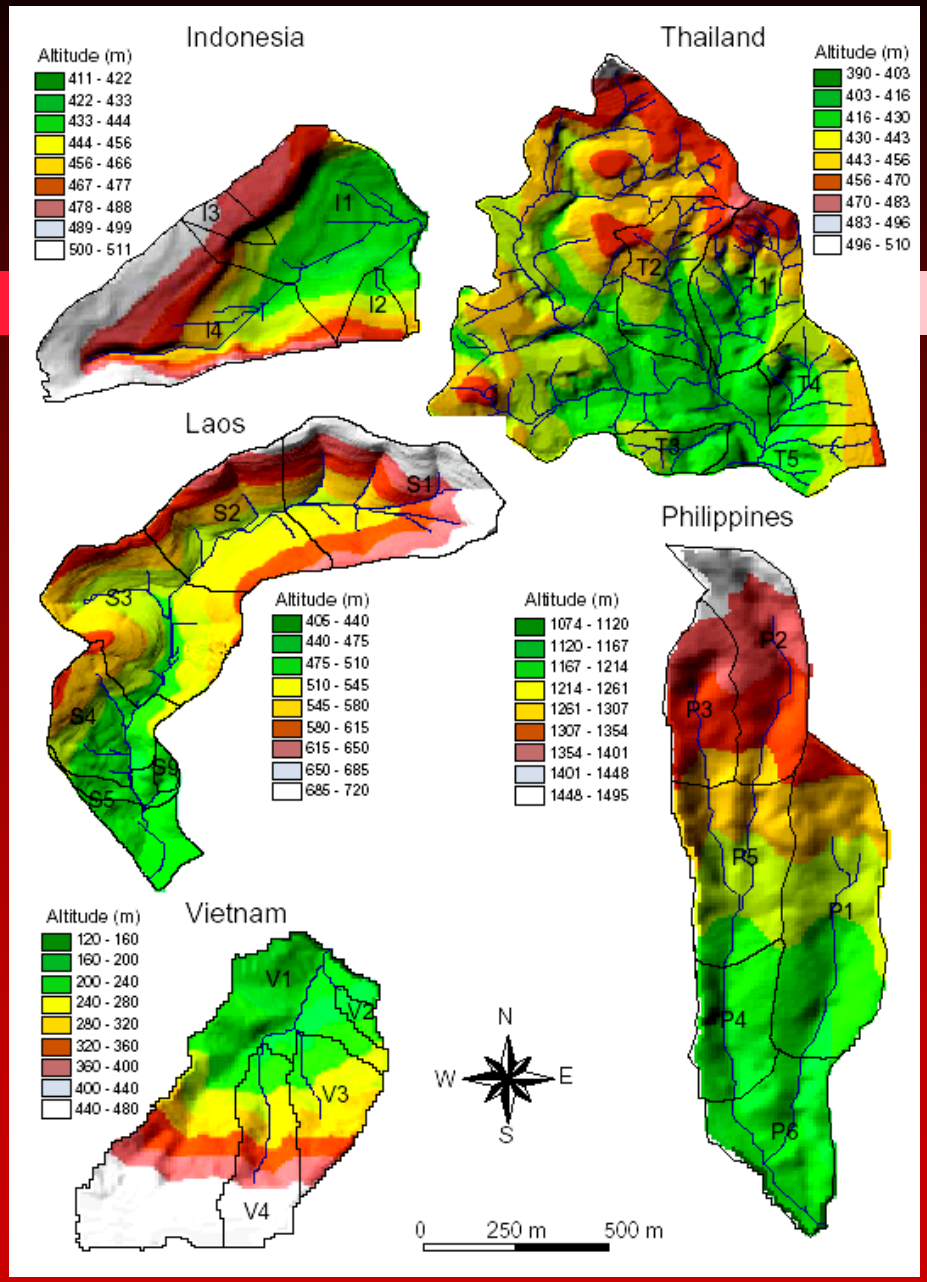
- Main results from 27 catchments on the impact of the rapid land use changes and selected alternative strategies on


Income per capita (US$ yr-1)
700
600
500
400
300
200
100
0
0
200
400
600
800
Population density (inhabitants km-2)
Thailand
Philippines
Vietnam
Laos
Indonesia


Good
MARKET ACCESS
Poor
Exogenous nutrients
(purchased lime, NPK fertilisers, trace elements)
Integrated use of endogenous and exogenous nutrients
Long-fallow cultivation
(burning, short cropping period, long fallow period)
Endogenous nutrients
(farmyard manure, crop residues, compost, forage legumes)
Low
POPULATION DENSITY
High

Cramb, 2005


Income per capita (US$ yr-1)
700
600
500
400
300
200
100
0
High mineral inputs
Thailand
Low mineral and organic inputs
High organic inputs
Philippines
Indonesia
Vietnam
Laos
No inputs
0
200
400
600
800
Population density (inhabitants km-2)



Survey

- Topography
- Soils

Monitoring

- Land use
- Crop yields
- Farmers income
- Climatic data
- Hydrologic data
- Bed load
- Suspended load

Main catchment attributes

Country	Site	Catch.	Years	Mean Slope (%)	Rainfall (mm)
Indonesia	Kalisidi	3	3	30-46	1,208-3,840
Laos	Huay Pano	8	5	18-61	1,305-1,414
Philippines	Mapawa	5	3	18-26	347-548
Thailand	Huay Yai	5	5	8-15	1,028-1,493
Vietnam	Dong Cao	5	5	28-38	1,048-2,368

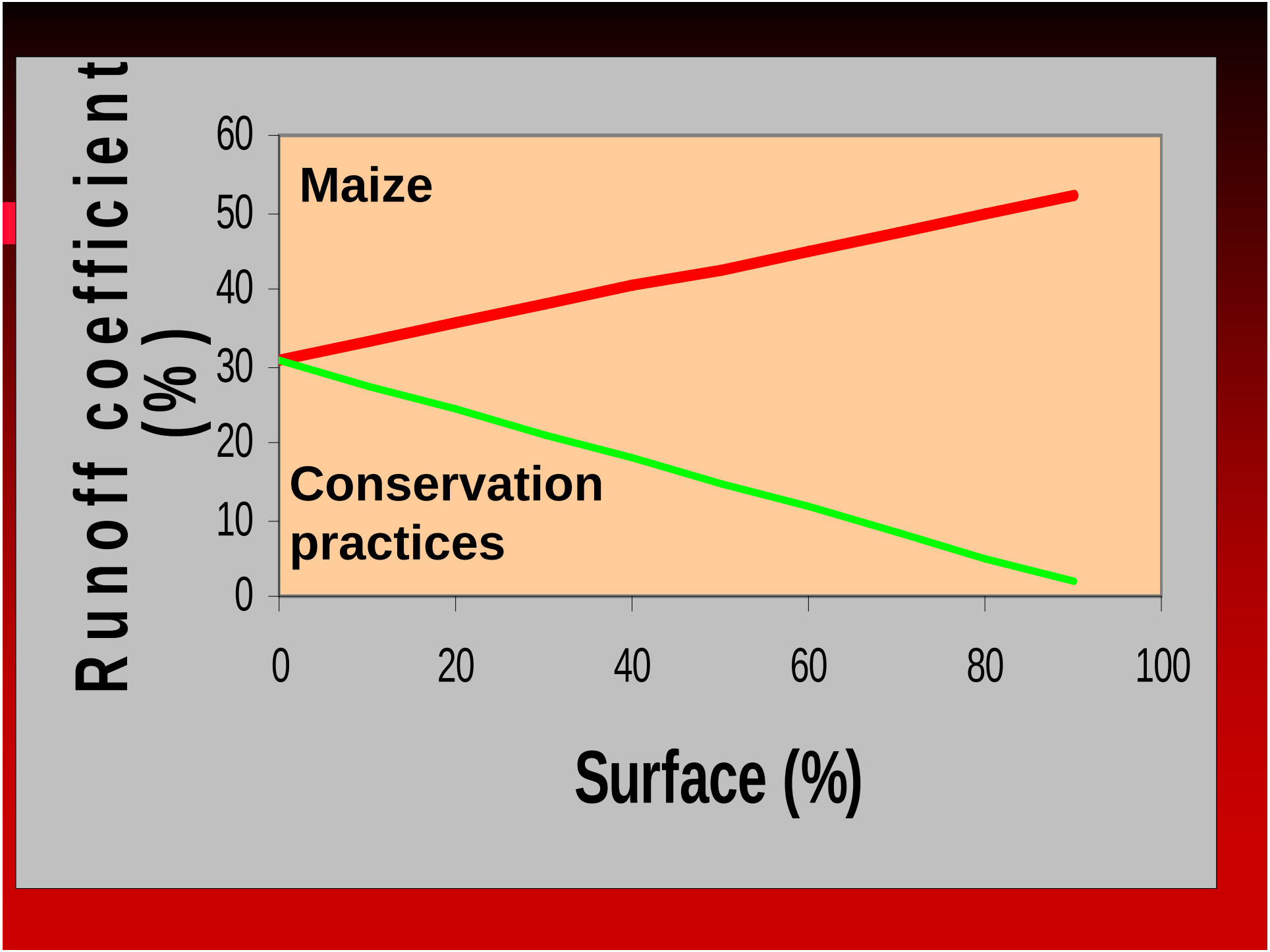
104 catchment-years

Runoff coefficient

$$Rc = 4.87 - 0.32\ Cp + 0.24\ Mz + 0.01\ \Delta z + 0.38\ Sa - 0.51\ Eu$$

$n=95$ $R^2=0.59$

Cp: conservation practices (%),
Mz: total area cultivated in maize (%)
Δz: range of elevation (m).
Sa: topsoil sand content (%).
Eu: Eucalyptus (%)


Runoff coefficient (%)
60
50
40
30
20
10
0
Maize
Conservation practices
0
20
40
60
80
100
Surface (%)

Bed load

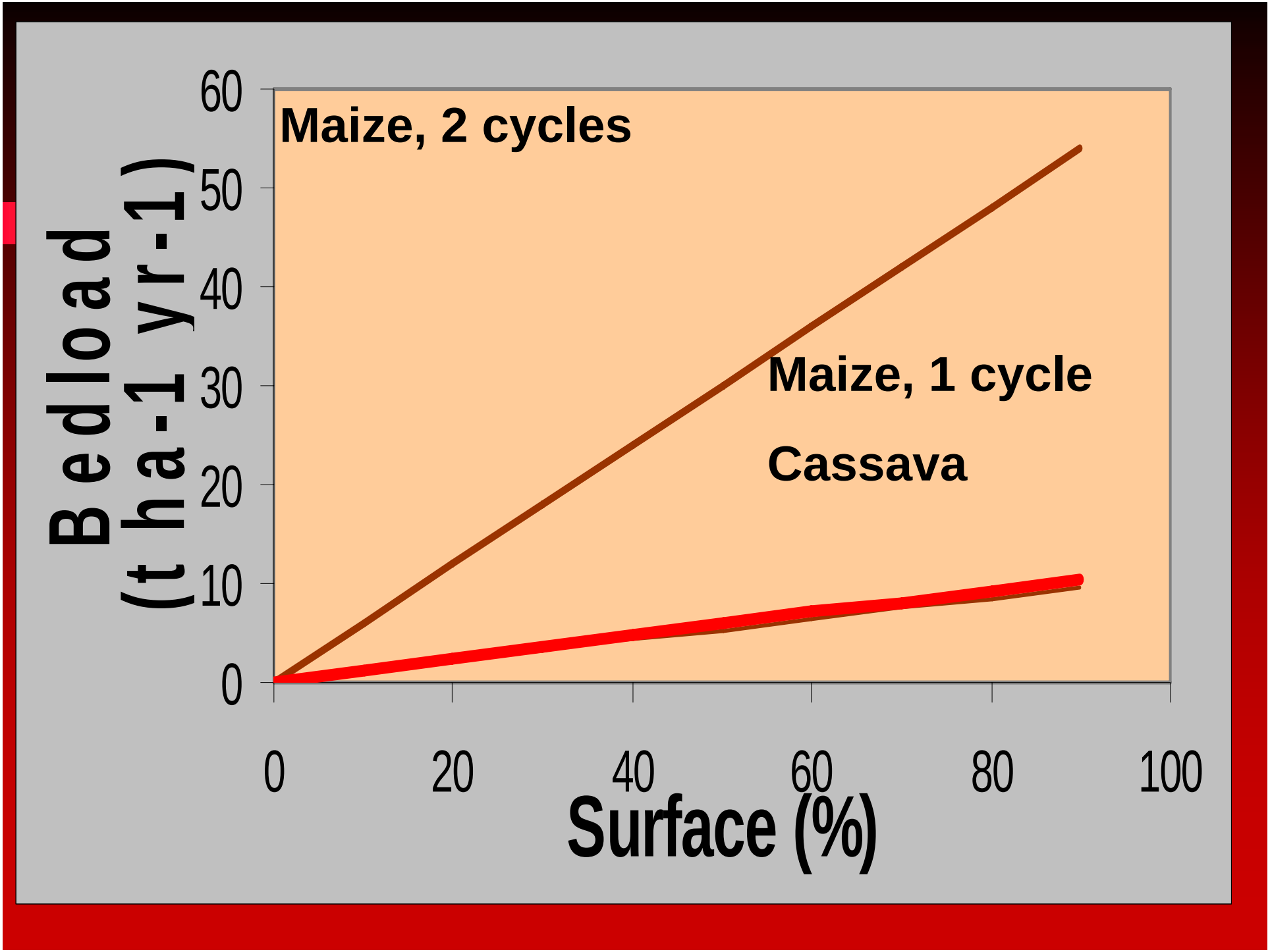
$BLD = 0.181 + 0.596Mz_2 + 0.114\ Mz_1 + 0.104\ Ca$

$n=104\ R^2=0.79$

Mz_2: maize, two cycles per year (%).

Mz_1 : maize, one cycle per year (%).

Ca: cassava (%).


Maize, 2 cycles
Maize, 1 cycle
Cassava
Bedload (t ha-1 yr-1)
60
50
40
30
20
10
0
0
20
40
60
80
100
Surface (%)

Suspended load

SUL = 1.842 + 0.208 Ca + 0.038 Mz – 0.03 Cp

n=79 R^2=0.25

Sediment yield

TSY = 3.265 + 0.109 Mz

n=79 R^2=0.22

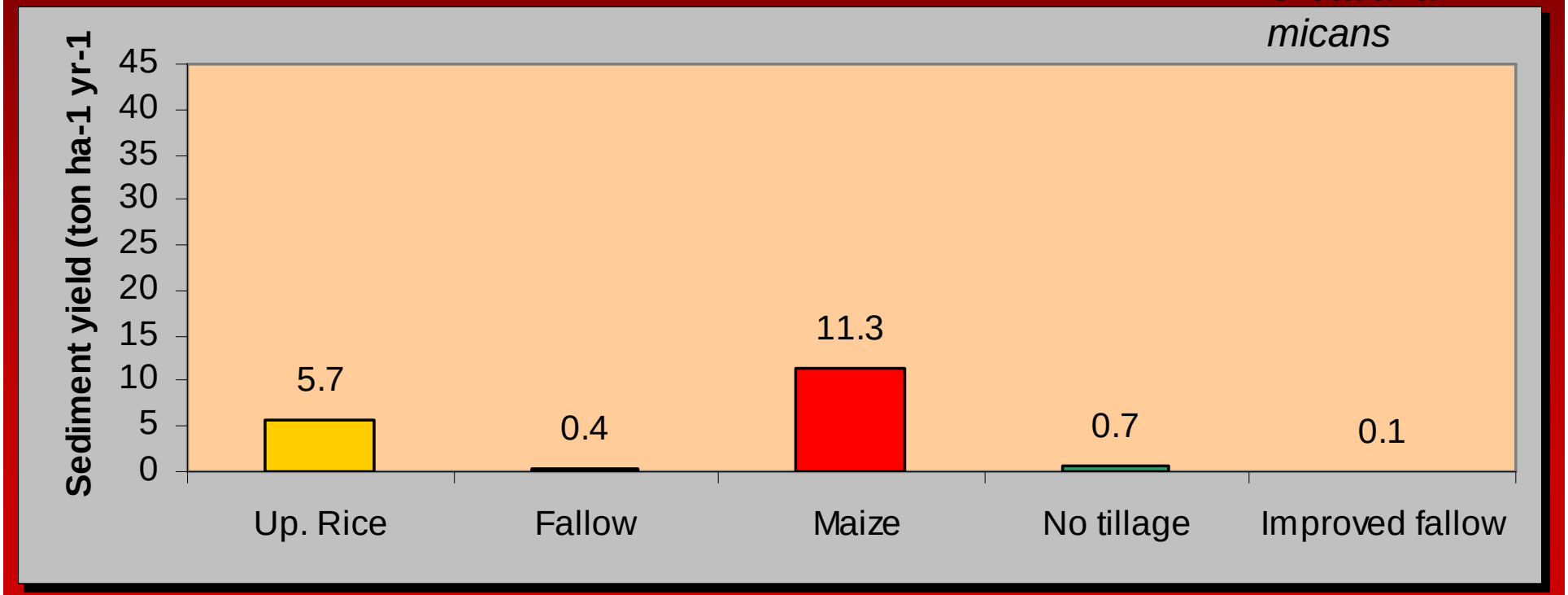
A farmer in northern Laos

- Weed infestation
- Decline in the land productivity (crop yields)
- A greater labour input per hectare and per worker
- Decreased labour productivity

Laos

Brachiaria ruziziensis

Cajanus cajan & *Crotalaria micans*



Vietnam


Fodder
Brachiaria ruziziensis


Tree plantations
Acacia mangium, Styrax

Bed load (ton ha-1 yr-1)
45
40
35
30
25
20
15
10
5
0
7.3
1.0
0.7
Cassava
Grass fodder
Tree Plantation

Philippines

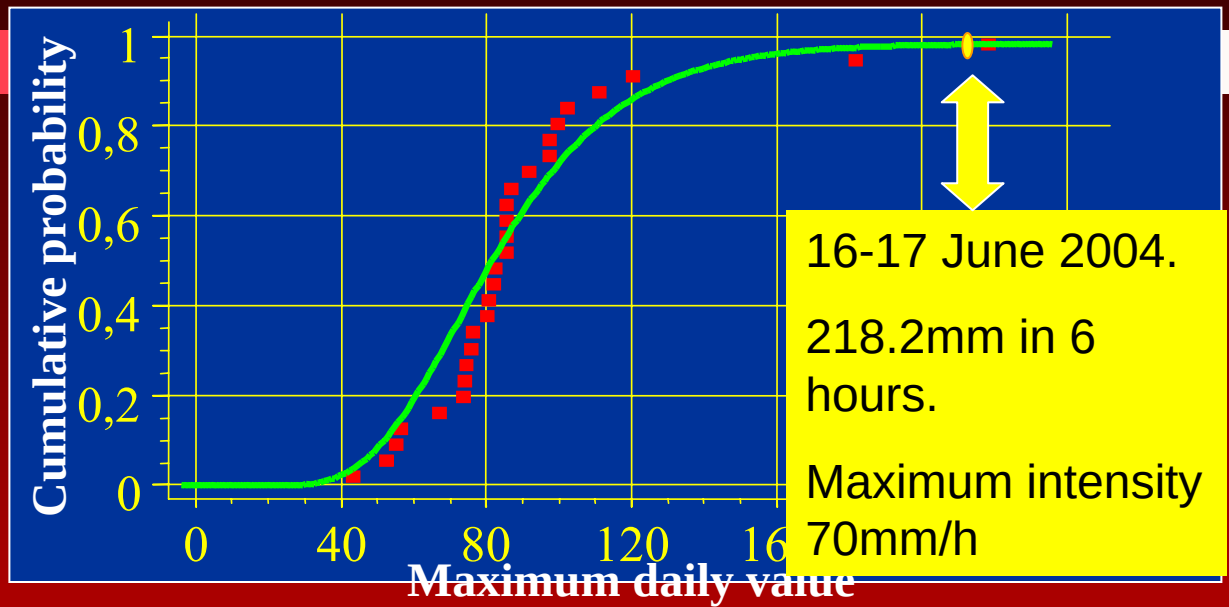
Indonesia

Sediment yield (ton ha-1 yr-1
35
30
25
20
15
10
5
0
2.9
13.1
10.8
2.7
Tree
25%Cassava
Maize+Cassava
Grass

Thailand

Sediment yield (ton ha-1 yr-1)
30
25
20
15
10
5
0
4.9
3.0
11.7
Soybeans&Mungbeans
Fruittree&Soybeans
Maize

Extreme event



16-17 June 2004.

218.2mm in 6 hours.

Maximum intensity 70mm/h

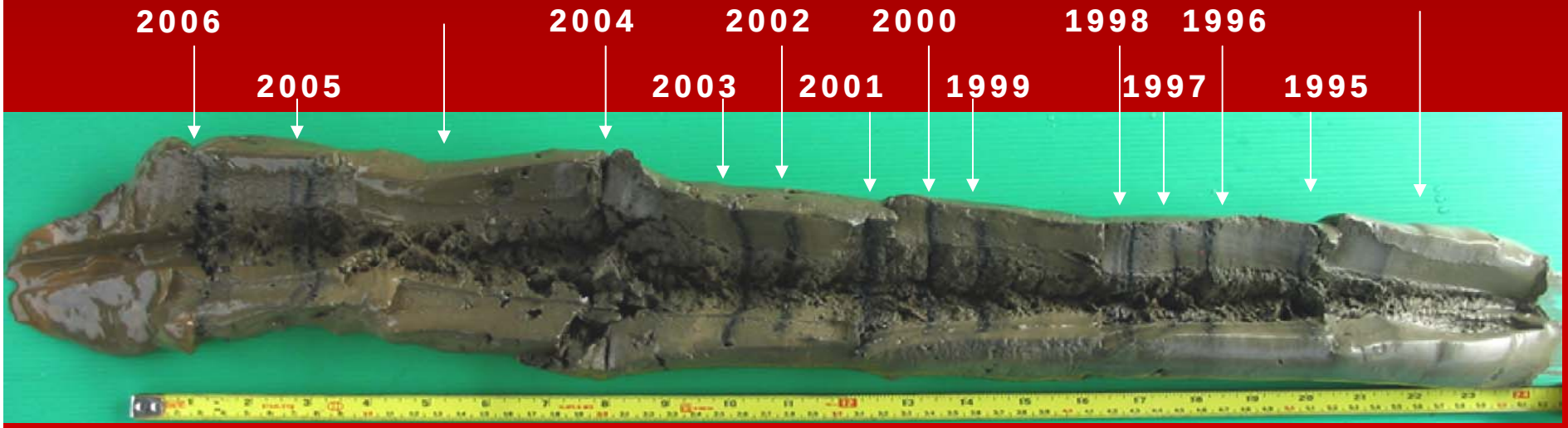
Concentrations 35 g l^{-1}

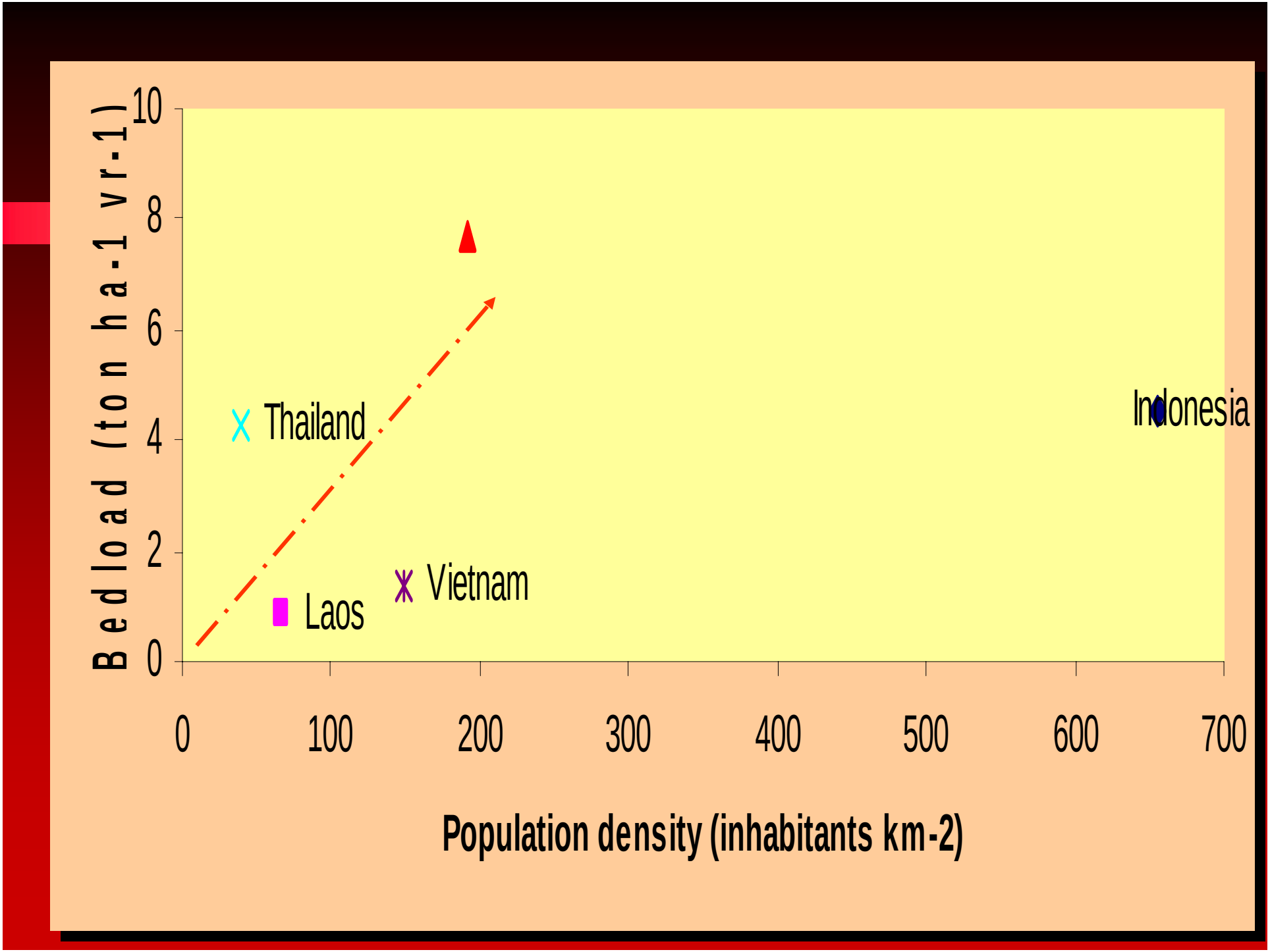
45 ton ha^{-1}

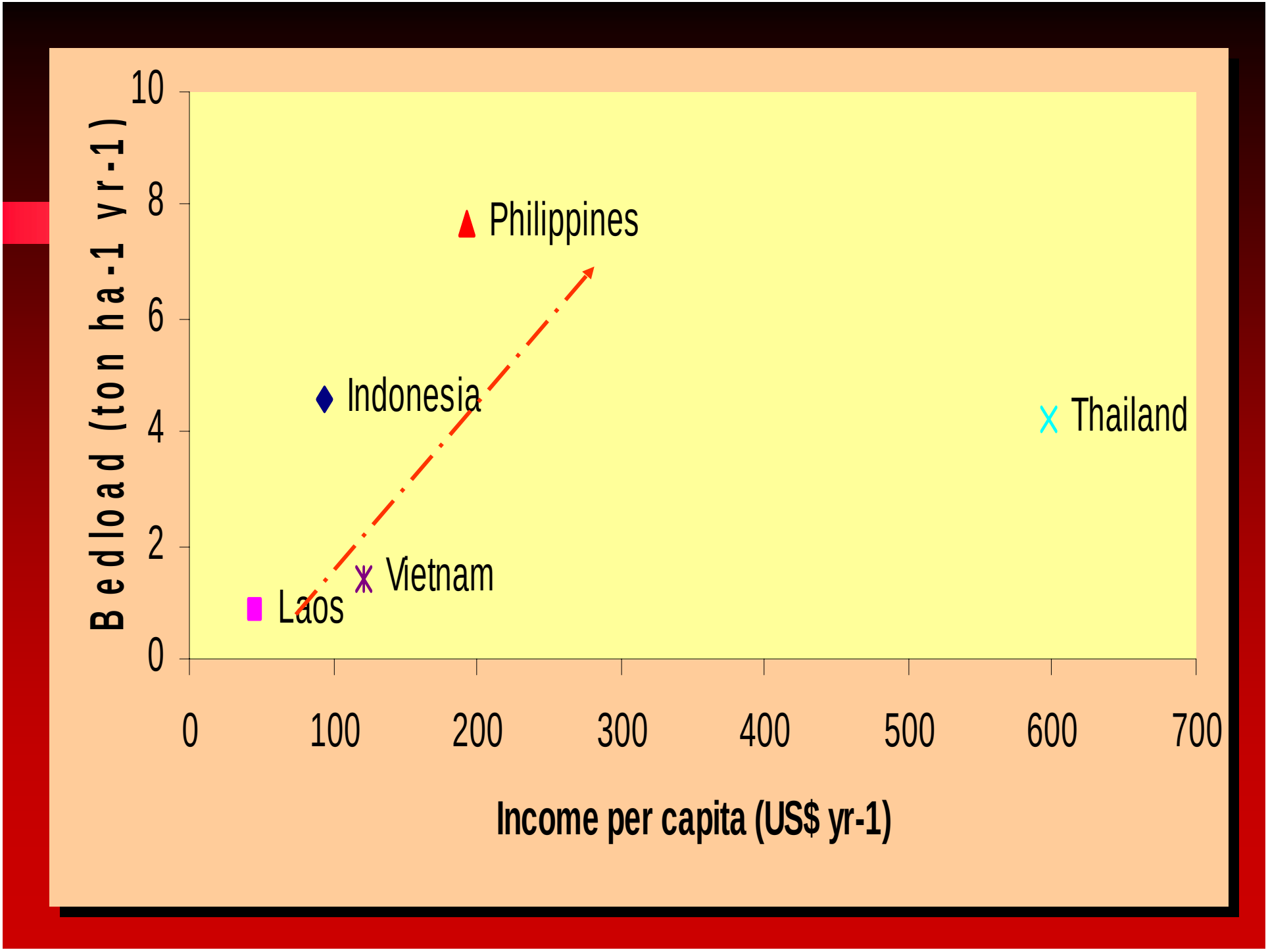
121 km²

17 June

River sediments
<1995




Bedload (ton ha-1 yr-1)
10
8
6
4
2
0
Thailand
Laos
Vietnam
Indonesia
0
100
200
300
400
500
600
700
Population density (inhabitants km-2)


Bedload (ton ha-1 yr-1)
10
8
6
4
2
0
Philippines
Indonesia
Thailand
Vietnam
Laos
0
100
200
300
400
500
600
700
Income per capita (US$ yr-1)

Conclusions

- A network of long term catchments

- Capture land use change under real world conditions
- Test adoption and impacts of new technologies
- Need for more in depth analyses and modelling

Three crucial questions for environmental policies

1. Agricultural activities ➔ off-site impacts

Answer : YES

- Maize and cassava much more detrimental than upland rice

Three crucial questions for environmental policies

2. Conservation strategies ➔ watershed services?

Answer : YES

- they reduce runoff and suspended load at the catchment scale

Three crucial questions for environmental policies

3. Better access to market → conservation technologies?

Comparison suggests: NO

- No trend of reduction of soil erosion with increasing income
- Pay watershed services to upland communities

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