Land cover change and catchment water yields: from local to regional scales

Guillaume Lacombe and Alain Pierret

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Background

• Catchment water yield: water volume leaving a catchment during a period of time

• It controls:
  – Water resources availability
  – level of flood risks
  – nature of ecosystems

• Good management of catchments: understanding the drivers of flow variability
Drivers of hydrological changes at catchment scale

1. Climate: rainfall
2. Water uses: irrigation, industrialisation
3. Water infrastructures: hydropower dams
4. **Land cover: hill-slope runoff production**
Variation in **annual flow** following 2 types of catchment treatment

From 137 experiments (80% smaller than 2 km²)

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Relationship between land cover, annual rainfall and annual evapotranspiration

Mekong Basin:
Forests → grass: +30% of flows
Total deforestation: +90% of flows

(Zhang et al., 2001)
Effect of fallow regrowth on catchment water yield in northern Lao PDR

(Ribolzi et al., 2008)
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Rainfall

Evapotranspiration

Infiltration

Sub-surface Runoff

Water table

Sub-surface Runoff

Water table

DEFORESTATION (no soil compaction)

(Lal, 1987; Bruijnzeel, 2004)

More dry-season flow
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**WET SEASON**
- Evapotranspiration
- Rainfall
- Infiltration
- Water table
- Sub-surface Runoff

**DRY SEASON**
- Water table
- Sub-surface Runoff

**WET SEASON**
- Rainfall
- Sub-surface Runoff

**DEFORESTATION (logging)**
- Soil compaction
- Reduced Infiltration
- Water table
- Sub-surface Runoff

**DRY SEASON**
- Overland Runoff
- Less dry-season flow

*(Lal, 1987; Bruijnzeel, 2004)*
Land-cover change impacts in large catchments?

- Previous studies: small catchments (< 2km²)

Reforestation: Less runoff + Deforestation: more runoff = Apparent stability

Heterogeneity of land covers and of their changes may result in apparent hydrological stability.
Bomb-induced deforestation in a >50,000 km² catchment of Southern Laos

(Lacombe et al., 2010)

2 million tons of ordnance
40% of cleared areas

+22.5 km³/year (volume about 100 fold higher than mean storage capacity of planned Mekong mainstream dams)

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Conclusion: 5 key messages

1. **Deforestation** → Annual runoff increase and **reforestation** → annual runoff decrease

2. **Seasonal flow** responses (low flow and floods) **less predictable**

3. Hydrological impacts of **broad-scale** land-cover change **hardly detectable**

4. Land-cover changes may have **greater** hydrological impacts **than** those expected from **climate change** or **hydropower development**

5. Inclusion of **land-cover change scenarios** in water resource assessments is **required** as broad-scale land-cover changes are expected to continue in the future

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