Impact of land-use change on Himalayan hydrology: a modelling approach

Santosh Nepal[1], Wolfgang A. Flügel[1], Manfred Fink[1], and Peter Krause[2]

[1] Department of Geoinformatics, Hydrology and Modelling, Friedrich Schiller University Jena, Germany

[2] Thuringian Environmental and Geological agency (TLUG), Germany

Email: santosh.nepal@uni-jena.de

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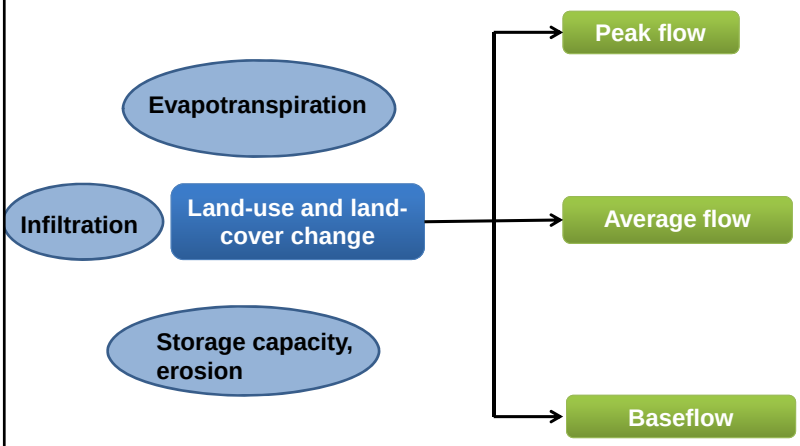
Impact of land-use change on hydrological regime



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Motivation

- Water is an integral part of livelihoods related activities in the Himalayan region
- Effects of land-use change on hydrology and downstream water availability and uses
- Is distributed hydrological model can estimate land-use change behaviour and impact on hydrological regime

Methods

- Spatially distributed J2000 hydrological model
- Land-use change scenarios

⟶ Impact of land-use chagne on hydrological regime and different runoff components

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Dudh Kosi river basin

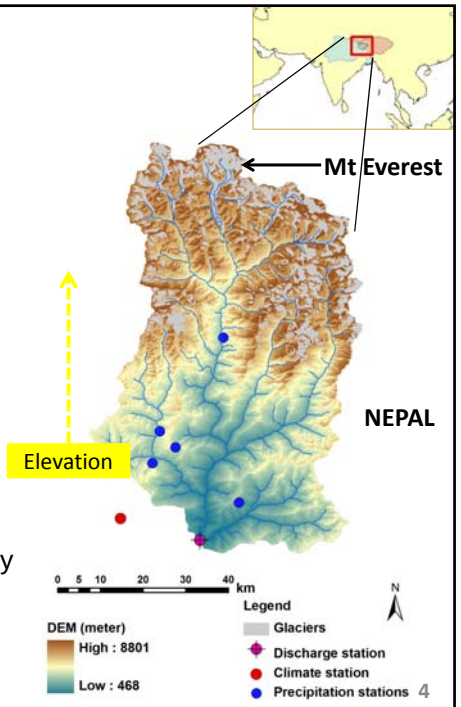
Main Features

- High gradient and steep topography (500-8,848 m)
- Sub-tropical to alpine climate
- Summer monsoon
- Total area: 3,712 km^2
- Glacierized basin

Six meteorological stations

Soil

- Lower elevation: Loamy to fine loamy
- Higher elevation: Sandy soil, unconsolidated materials, thin soil profile



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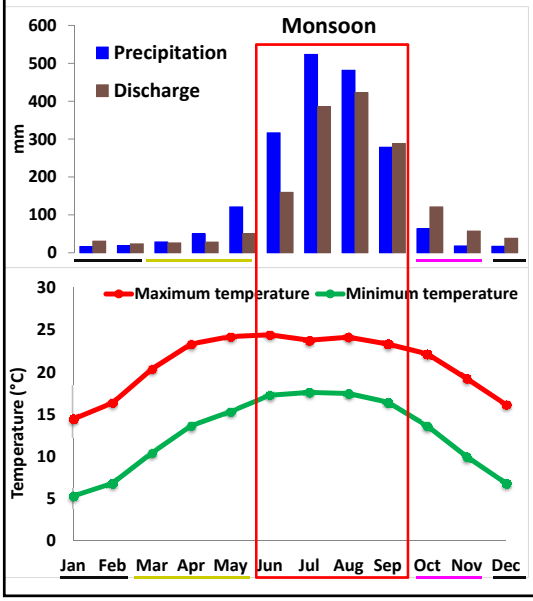
Hydro-climatic conditions



Monsoon season (June-September)

- **Precipitation: 82%**
- **Discharge: 76%**

Temperature station (1720 meters)

- **Average maximum : 21 °C**
- **Average minimum : 12 °C**

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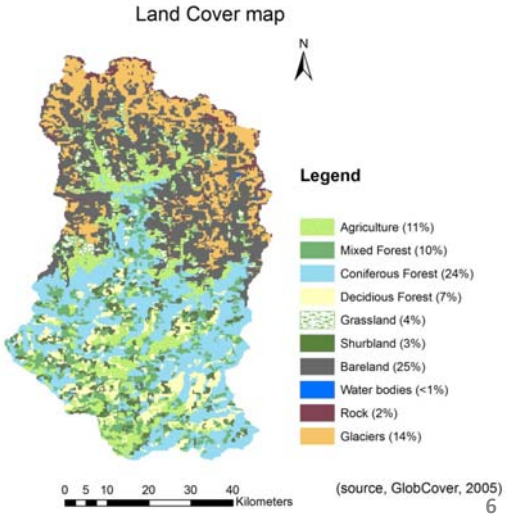
Land cover information

Land cover (%)

- Coniferous forest : 24
- Deciduous forest : 7
- Mixed forest : 10
- Agriculture : 11
- Bare land : 25
- Glaciers : 14
- Grassland and shrubland: 7
- Rock and water bodies: 2



(source, GlobCover, 2005)

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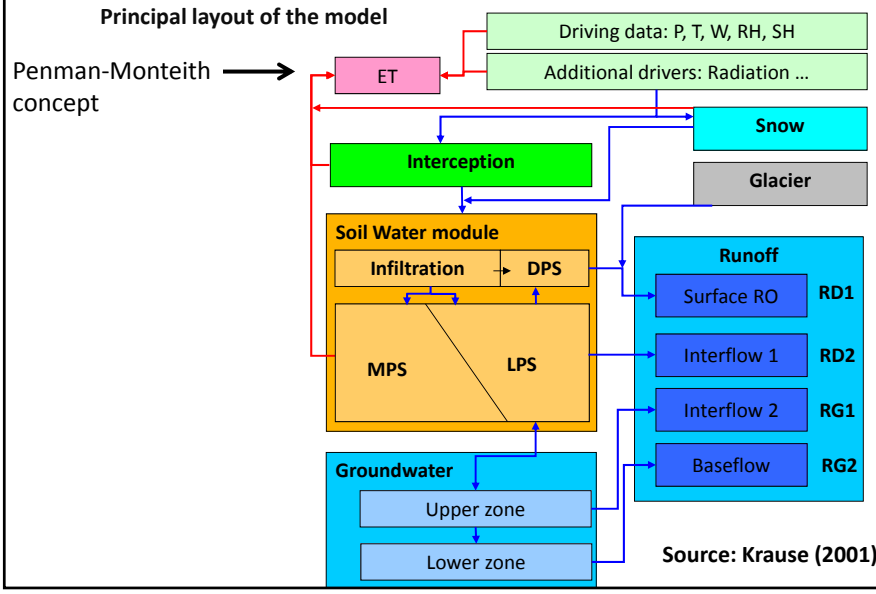
J2000 hydrological model: Process-oriented distributed model

Principal layout of the model



Source: Krause (2001)

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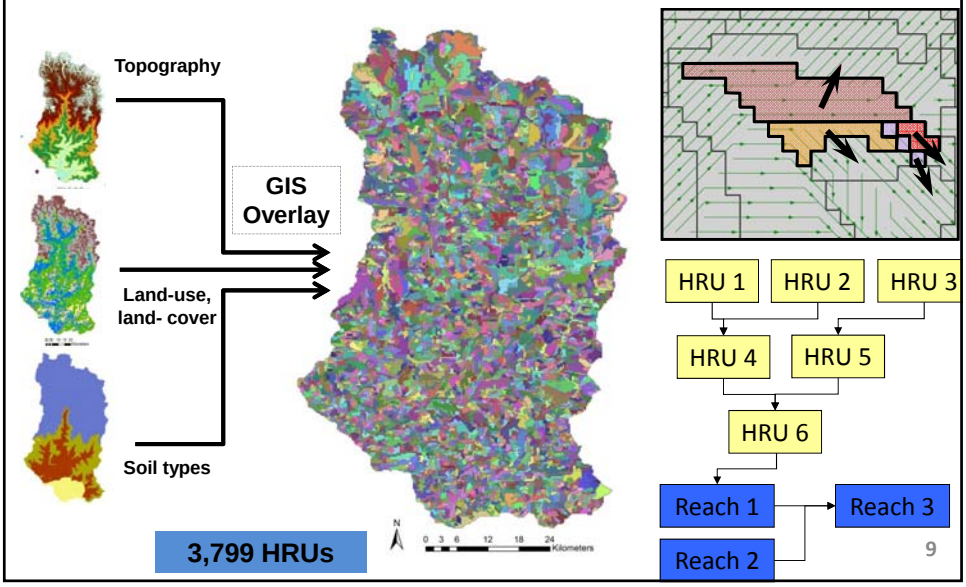
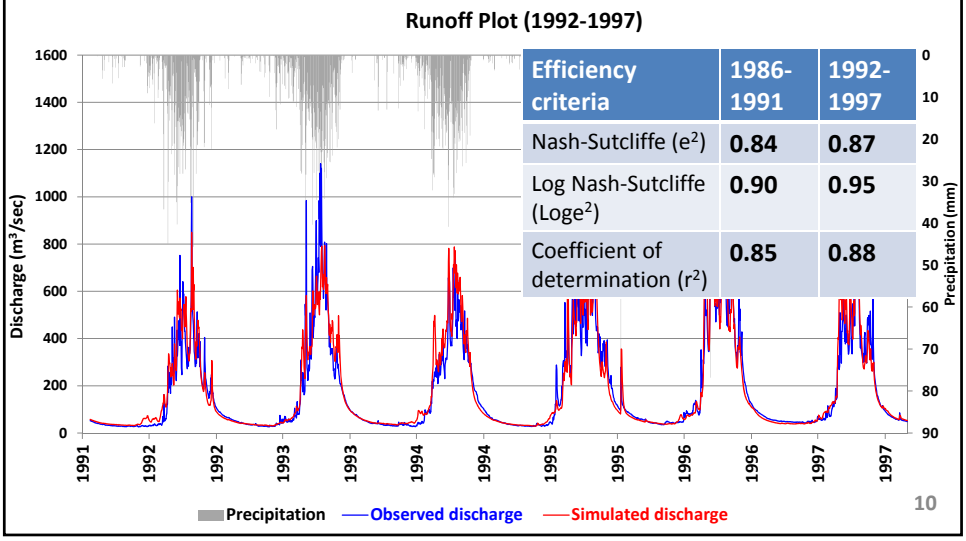
Distribution of modelling entities: Hydrological Response Unit (HRU)



Modelling results Simulated river discharge..



Efficiency criteria	1986-1991	1992-1997
Nash-Sutcliffe (e^2)	**0.84**	**0.87**
Log Nash-Sutcliffe ($Loge^2$)	**0.90**	**0.95**
Coefficient of determination (r^2)	**0.85**	**0.88**

Land-use change scenarios

Baseline period: 1985-1997

Scenario 1: (likely)

- All forests below 3000m are changed to bushes
- 28% forest changed to bushes

- Root depth changed
- LAI changed
- Effective height (Eh) changed

Scenario 2: (worst-case)

- All forests are changed to bare land
- 41% forest changed to bare land

- No vegetation
- Infiltration capacity is reduced

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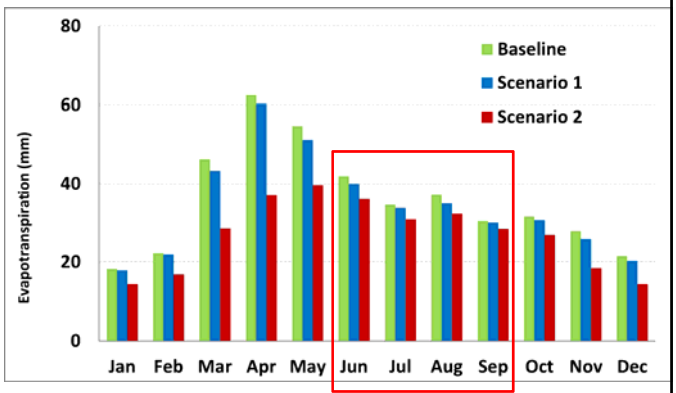
Change in evapotranspiration



- Scenario 1: decreased by 4%
- Scenarios 2: decreased by 24
- Higher influence during the non-monsoon season

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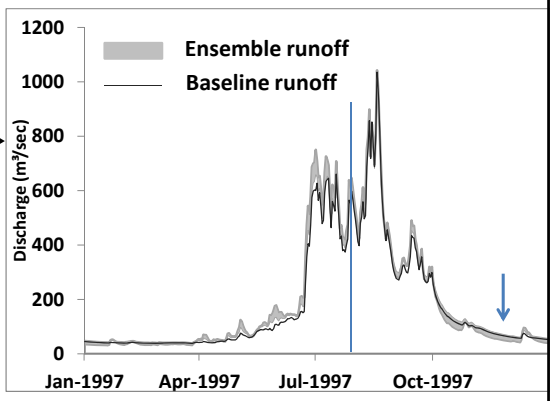
Change in streamflow

Results of Scenario 2

Change in total streamflow
- Scenario 1: increased by 1%
- Scenario 2: increased by 7%



Changes in runoff components depends upon the infiltration condition
- Overland flow could increase up to 32 percent
- Baseflow could decrease up to 20 percent
- The role of vegetation is overshadowed during the later part of the monsoon

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Conclusions and way forward

- The J2000 hydrological model is able to represent hydrological dynamics and importance processes of land-use change
- Change in vegetation has minimum impact on hydrology
- Deforestation might increase flood events
- Intense rainfall overshadows a vegetation role in the Himalayan region
- Infiltration is an important process to understand the impact of land-use change on hydrology

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Thank You