Analyzing water resources in a monsoon-driven environment – an example from the Indian Western Ghats

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1. Water resources in India

Water demand

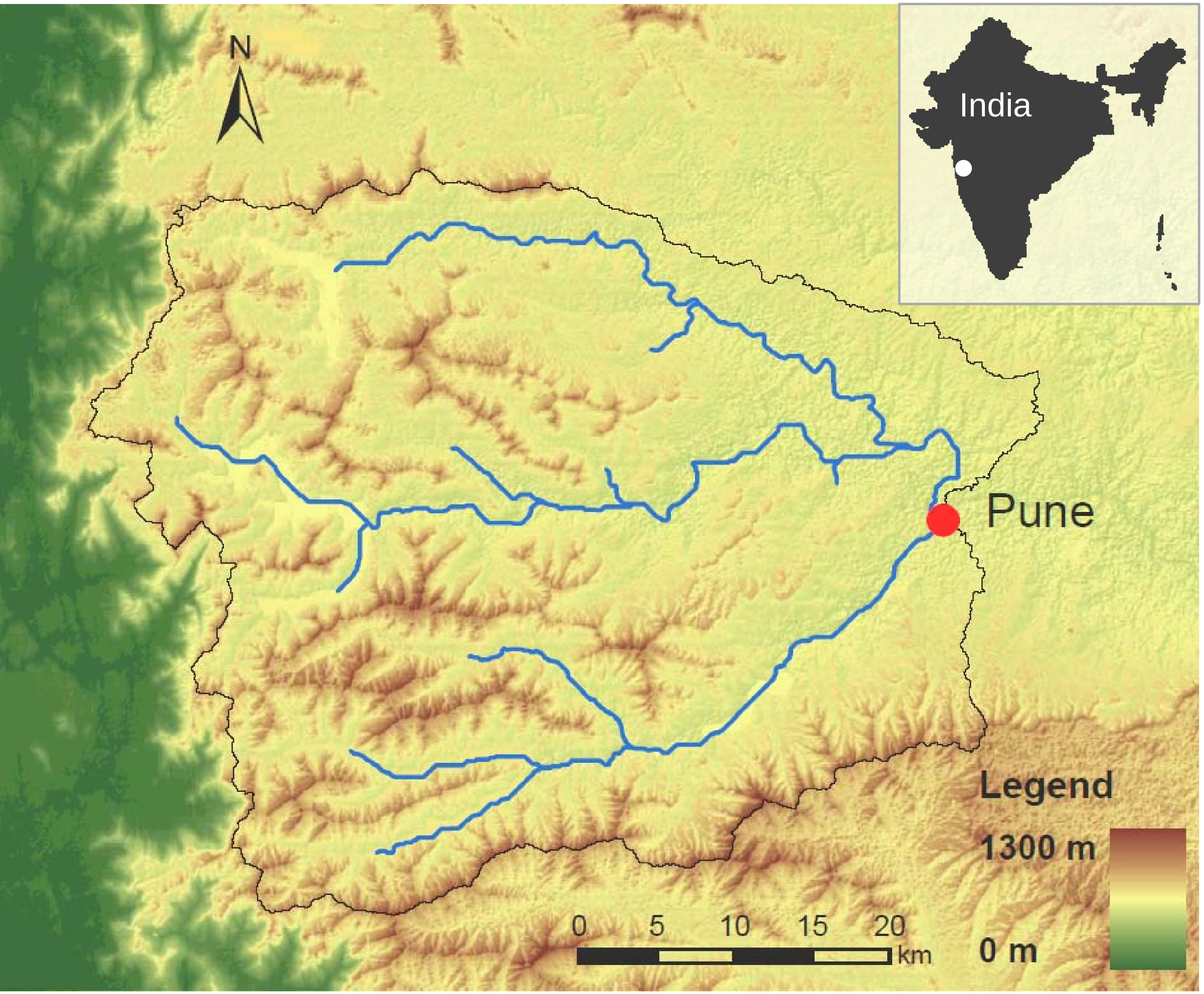
- Population growth & Urbanization
- Industrial development
- Irrigation agriculture

Water availability

- Pronounced seasonality
- Subject to future climate and land use change

This may lead to increasing water shortage in the future

1. Study area



2036 km²

1. Study area

2036 km²

- Population growth & Urbanization
- Industrial development
- Irrigation agriculture
- Pronounced seasonality of rainfall

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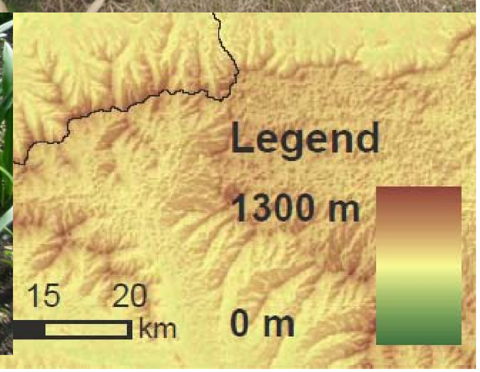

2036 km²

- Population growth & Urbanization
- Industrial development
- **Irrigation agriculture**
- **Pronounced seasonality of rainfall**

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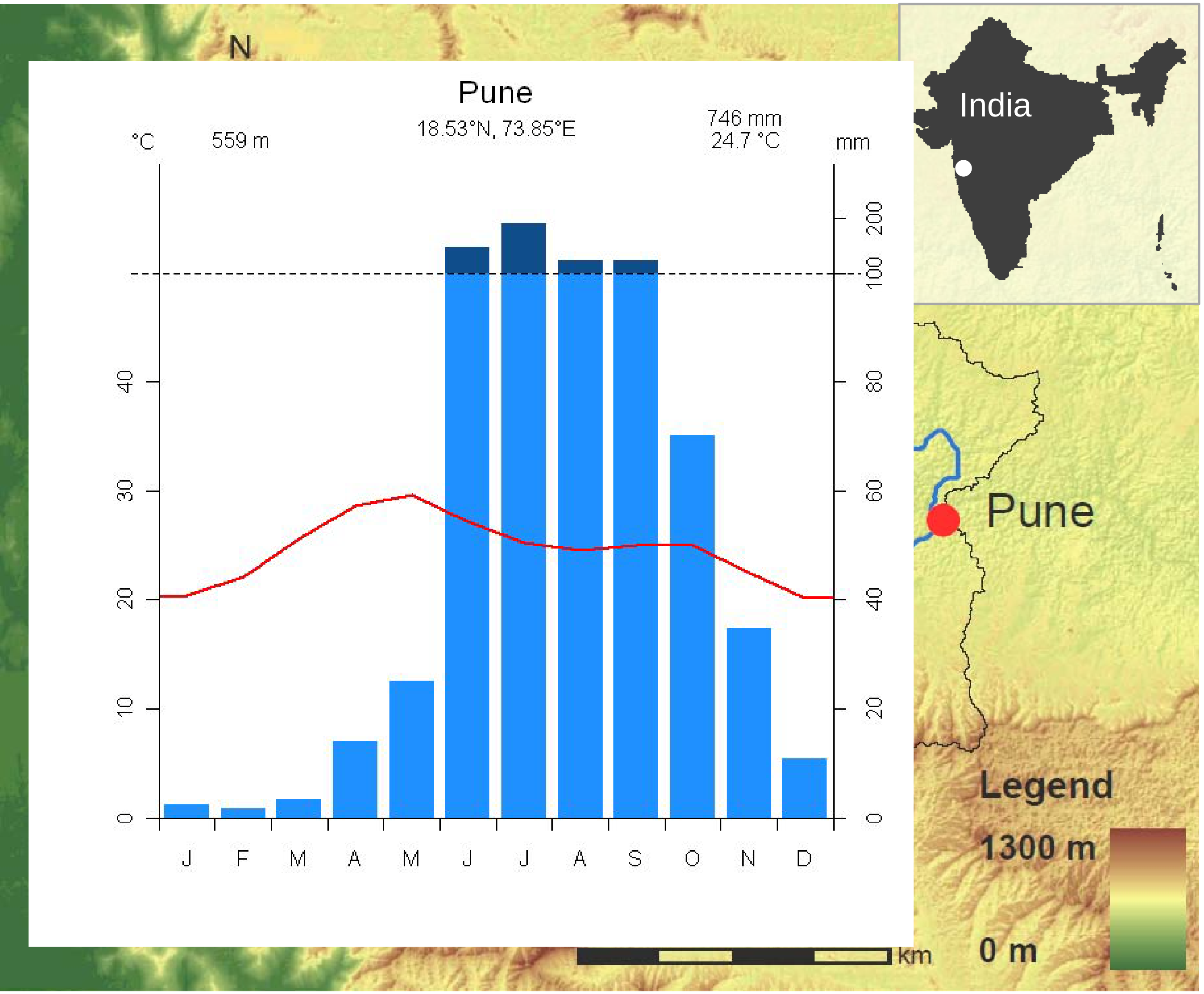


2036 km²

- Population growth & Urbanization
- Industrial development
- Irrigation agriculture
- **Pronounced seasonality of rainfall**

2. Materials and Methods

Assessment of impacts of land use change on evapotranspiration

Methodology

- 2 models based on a general (GEN) and a current (CUR) land use map
- Use of freely available data from international archives and remote sensing
- Utilization of SWAT (2005) with default values where possible

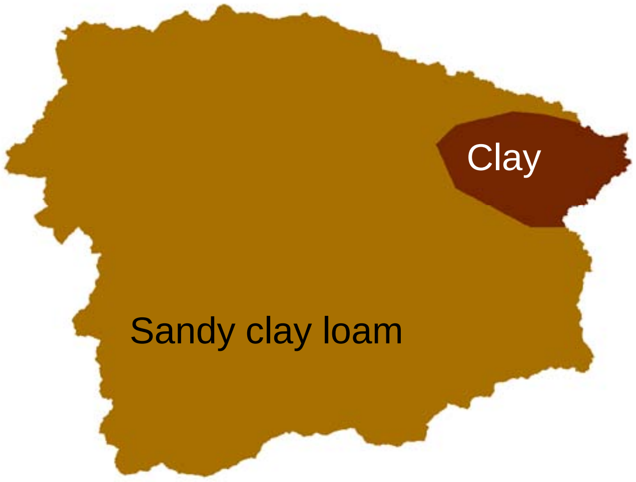
2. DEM and soil map

ASTER DEM

- 30 m resolution
- Corrected for water surfaces

FAO soil map of the world

- 2 soil types
- Parameters adapted from Immerzeel et al 2008



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2. Land use maps

CUR: derived from LISS-III data

GEN: data adapted from Hansen et al. 1998

2. Weather data

Daily rainfall data interpolated from 4 stations using

- **Linear trend of elevation and mean daily rainfall**
- **Inverse distance weighting for daily residuals**

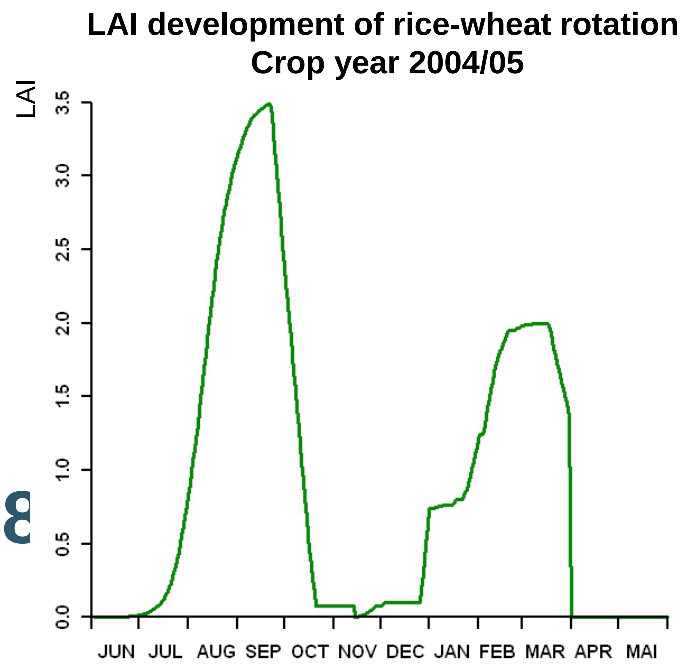
All other parameters used from Pune weather station, sub-basin specific adjustment of

- **Temperature values (using elevation)**
- **Relative humidity (using temperature)**

2. Model setup

- 18 sub-basins, 3 slope classes
- 250 HRUs (GEN) and 610 HRUs (CUR)
- Crop rotation for the two main seasons (Kharif and Rabi season)
- Heat units adjusted to growing periods of local crops
- Irrigation from reaches, triggered by plant water demand
- No representation of man-made structures like reservoirs and canals
- No model calibration
- Simulation period 2000 – 2007, 7 years used for analysis

3. Model performance



Runoff Coefficients (Q/P)

- GEN 0.61
- CUR 0.63
- Reference: Upper Krishna 0.68

Development of leaf area index (LAI)

- Rainy season: reasonable
- Dry season:
    - discontinuous, due to water and temperature stress or
    - too low, due to dormancy (forests)

3. Land use comparison

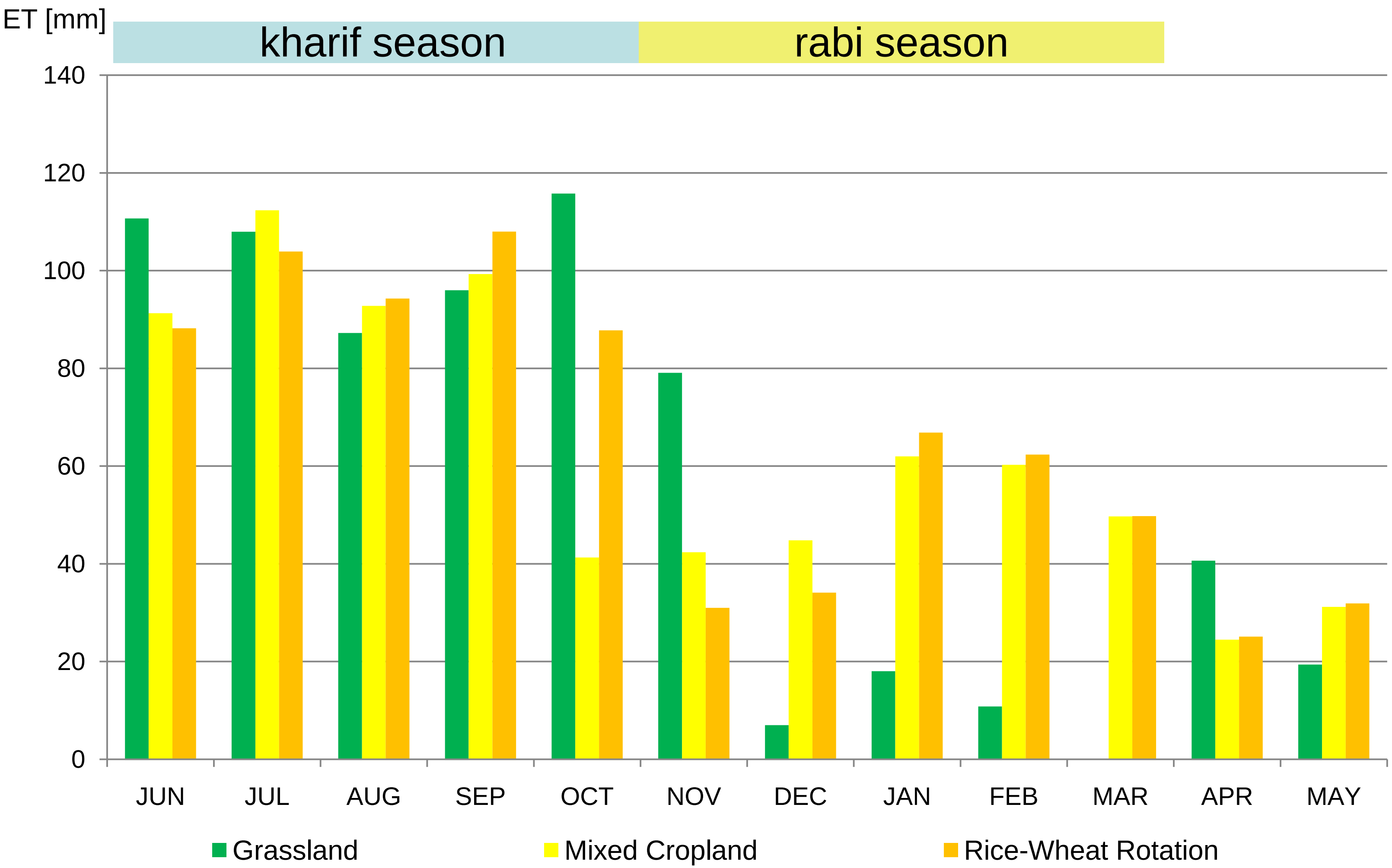
Land use	General	Current
Forest	8.5 %	20.6 %
Shrubland	74.8 %	26.6 %
Grassland	1.9 %	22.8 %
Water	6.9 %	5.8 %
Mixed Cropland	3.6 %	11.2 %
Urban	4.3 %	13.1 %

- Difference in cropland (+ 7.6 %)
- Difference in urban land (+ 8.8 %)
- Difference of semi-natural vegetation (- 15.2 %)
- Results in part linked to land use change and to different level of detail of the two land use maps

3. Impact of land use changes on ET

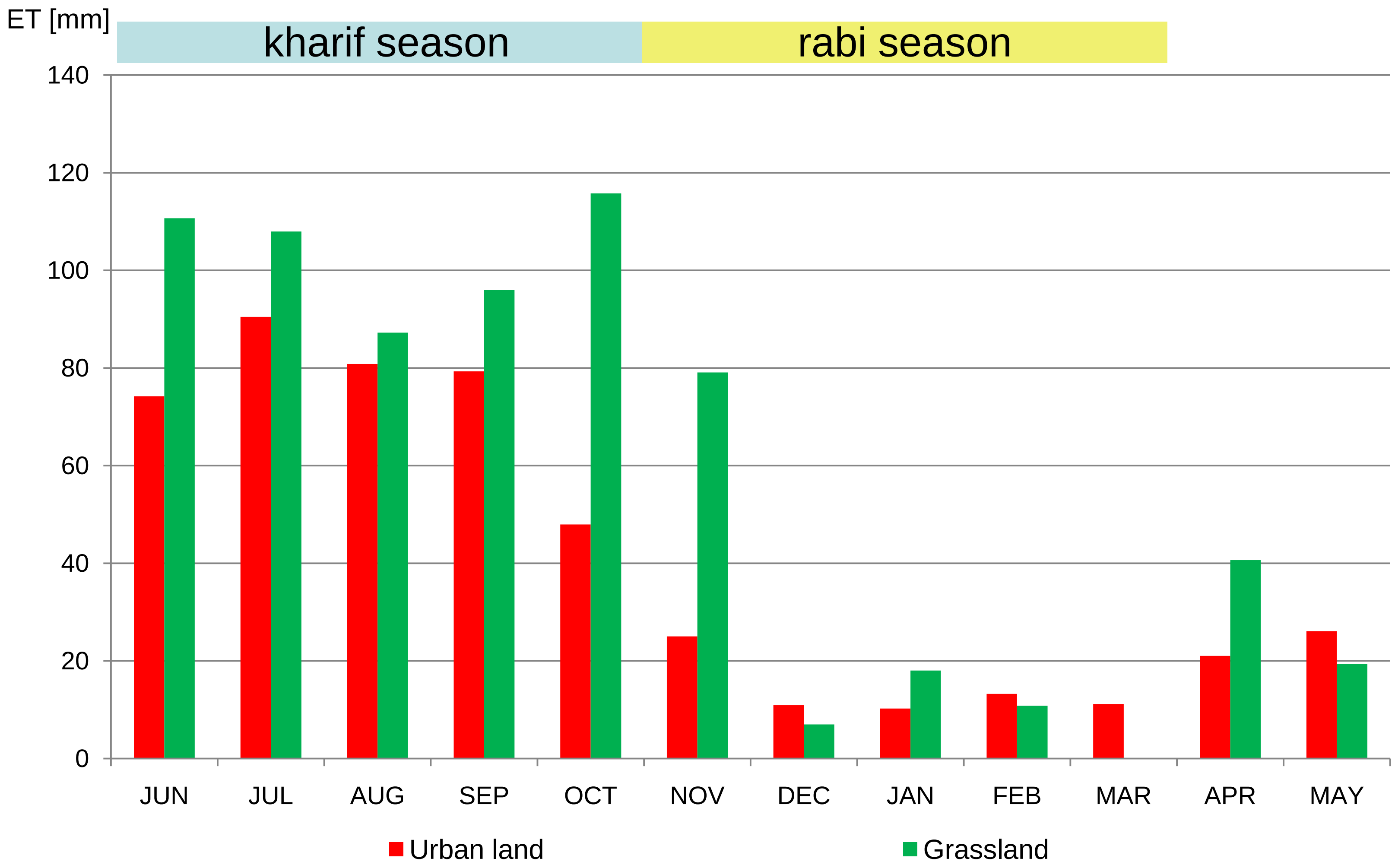
- **No eminent differences on the catchment scale**
- **Land use specific differences of ET rates**

3. Grassland -> Cropland (+ 7.6 %)



Monthly land use specific ET rates for the crop year 2004/05 (CUR model)

3. Grassland -> Urban land (+ 8.8 %)

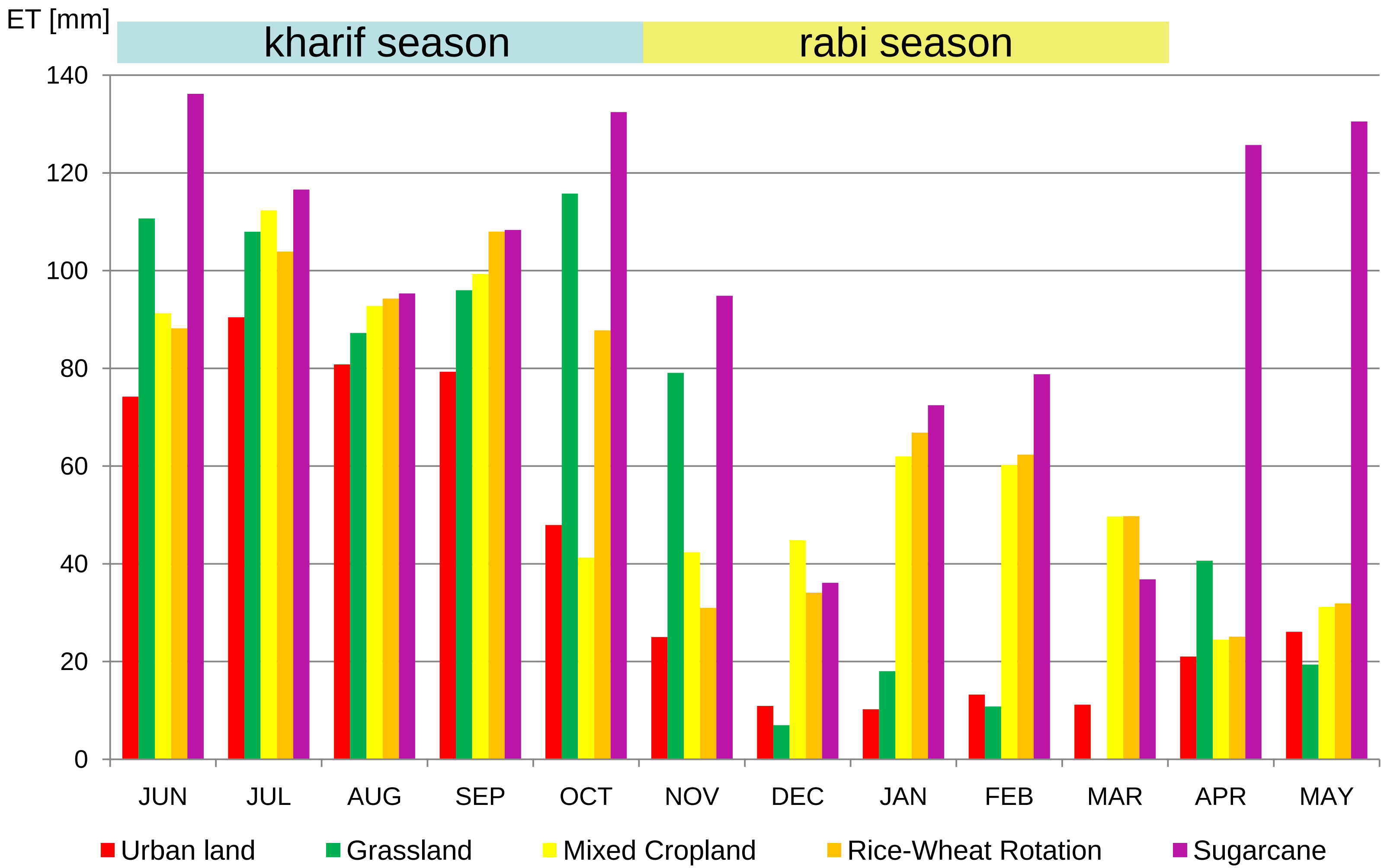


Monthly land use specific ET rates for the crop year 2004/05 (CUR model)

3. Impact of land use change on ET

- Difference in cropland (+ 7.6 %) -> higher ET
- Difference in urban land (+ 8.8 %) -> lower ET
- Compensatory effects on the catchment scale
- High water demand from irrigated cropland during dry (rabi) season
- Sugarcane shows the highest ET rates

3. Sugarcane



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3. Impact of land use change on ET

- Difference in cropland (+ 7.6 %) -> higher ET
- Difference in urban land (+ 8.8 %) -> lower ET
- Compensatory effects on the catchment scale
- High water demand of irrigated cropland during dry (rabi) season
- Sugarcane shows the highest ET rates, but covers only 0.8 % of the study area

4. Conclusion

Impact of land use changes on ET

- No impact on the catchment scale due to compensatory effects of ET from different land uses
- Possible impact on the sub-catchment scale

High water demand of crops during dry season

- High ET rates from croplands
- Particularly sugarcane (downstream cultivation)

4. Conclusion

Land use changes

- Increase of urban land is the only reliable observed land use change
- Higher percentage of cropland possibly results from higher level of detail

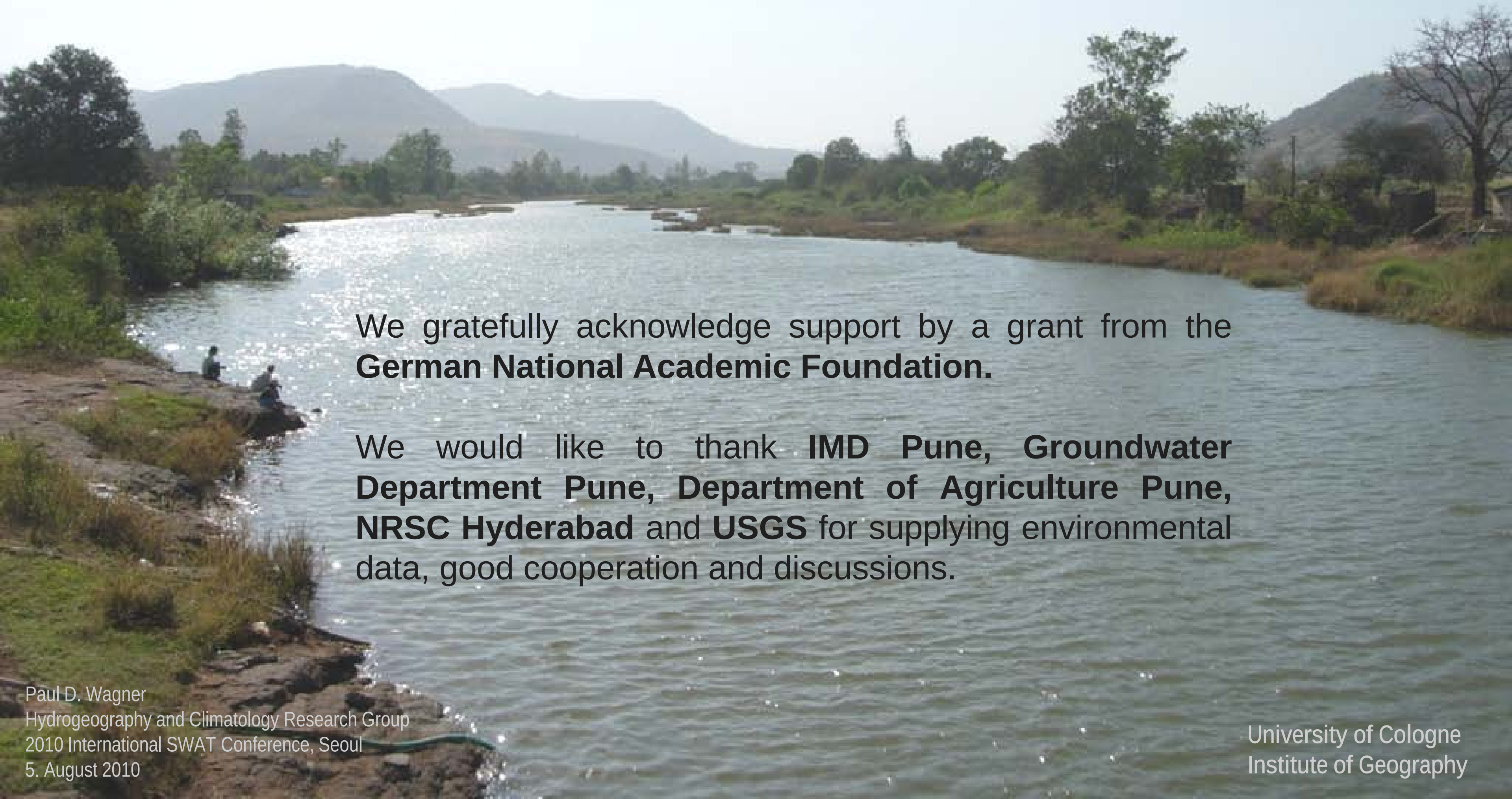
➢ High resolution data is needed for further investigation

4. Future work

- **Derivation of detailed land use maps from historical satellite scenes**
- **Derivation of crop rotations from multi-temporal satellite data**
- **Shift or deactivation of dormancy period in SWAT**
- **More accurate representation of soil and groundwater parameters by model calibration**
- **Implementation of reservoirs**

Thank you very much for your attention!

Questions welcome…



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