Advancing the modeling of land use and land cover change impacts on water resources

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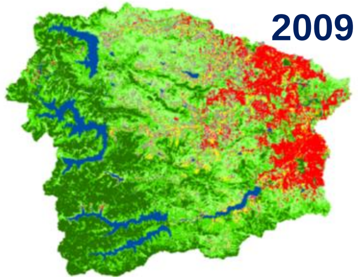
What is the common modeling approach?

Static Delta-Approach

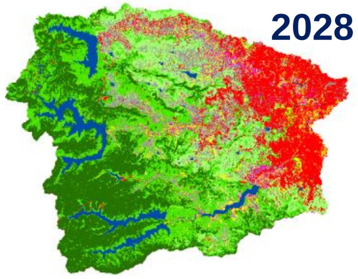
Hydrologic Model

Model run A | **Model run B**

2009-2028



2009



2028

Water balance without LULCC | **Water balance with LULCC**

Difference of water balance components

Long-term average impact

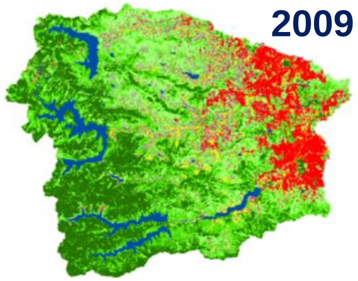
How can the modeling approach be improved?

Dynamic approach

Hydrologic model

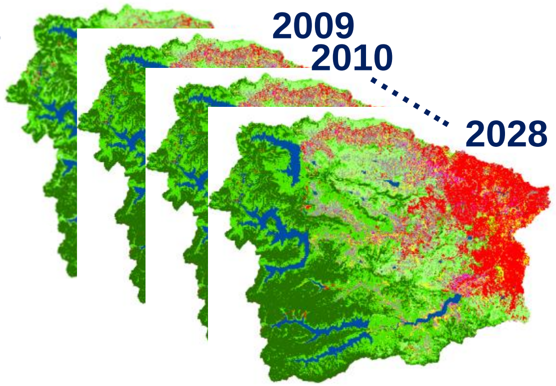
Model run A | **Model run B**

2009



2009-2028

2009
2010
2028



Water balance without LULCC | **Water balance with LULCC**

Difference of water balance components

Temporally differentiated impact

Wagner et al. 2016, *Science of the Total Environment 539*; **Wagner et al. 2019,** *Environmental Modelling & Software 122*

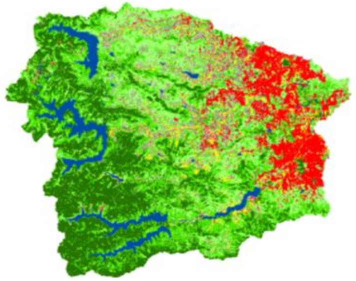
How to account for feedback effects?

Model coupling

Input

Hydrologic model

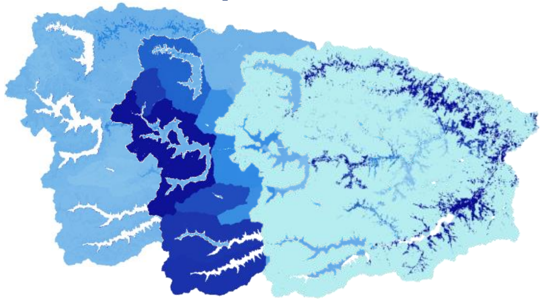
SWAT, Arnold et al., 1998



Land use map

Model run
Hydrologic model

Output



Hydrologic variables

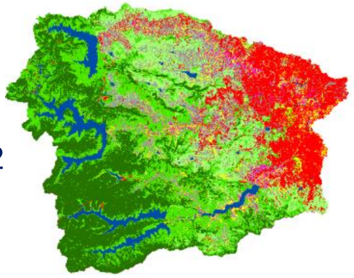
Wagner et al. 2019,
Environmental Modelling
& Software 122

Time step:
1 year

Wagner, Fohrer, **2019.**
Environmental Modelling
& Software 115

Land use model

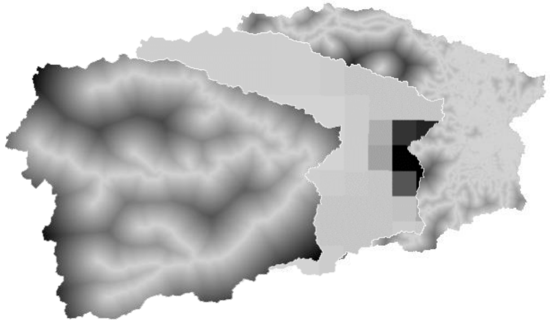
CLUE-s, Verburg et al., 2002



Land use change

Output

Model run
Land use model



Explanatory variables

Input

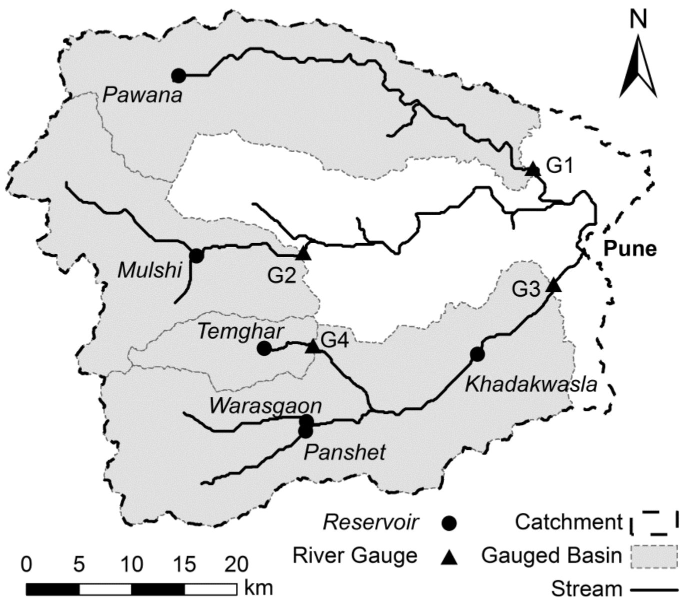
implemented in R, open source

Model validation

Study area: Mula-Mutha Catchment,
Western Ghats, India: 2036 km²

Hydrologic model SWAT (Arnold et al. 1998)

Validated with streamflow data in rainy seasons 2001-2007

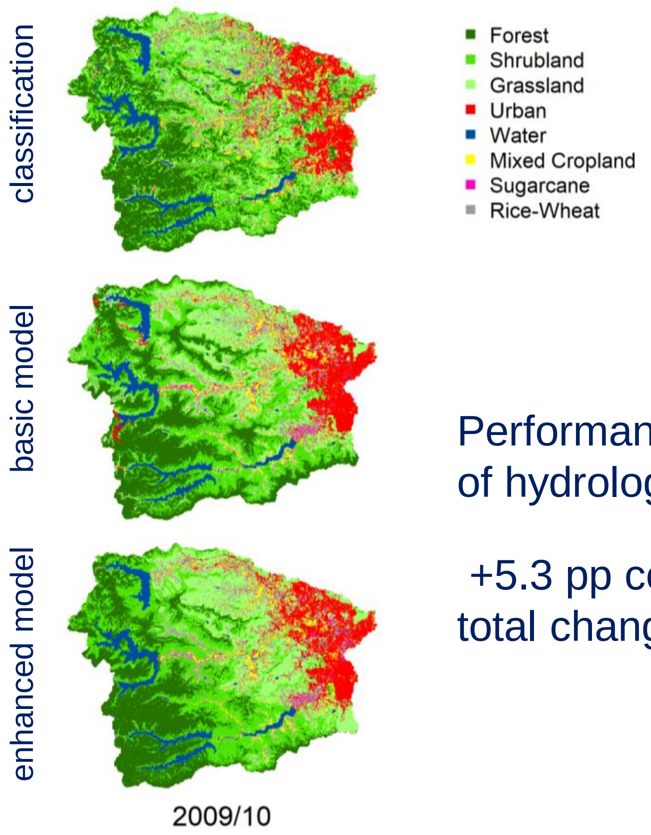


Nash-Sutcliffe Efficiency: 0.69 (G1), 0.67 (G4)

Percentage Bias: +4% (G1), +24% (G4)

Land use model CLUE-s (Verburg et al. 2002)

Validated with land use classifications



Performance gain through inclusion of hydrologic variables:

+5.3 pp correctly simulated change / total change (figure of merit)

Wagner, Fohrer, **2019.** *Environmental Modelling & Software*, 115

Scenario analysis with a coupled modeling approach

Land use change extrapolated:

+5.1% urban area

+3.8% cropland

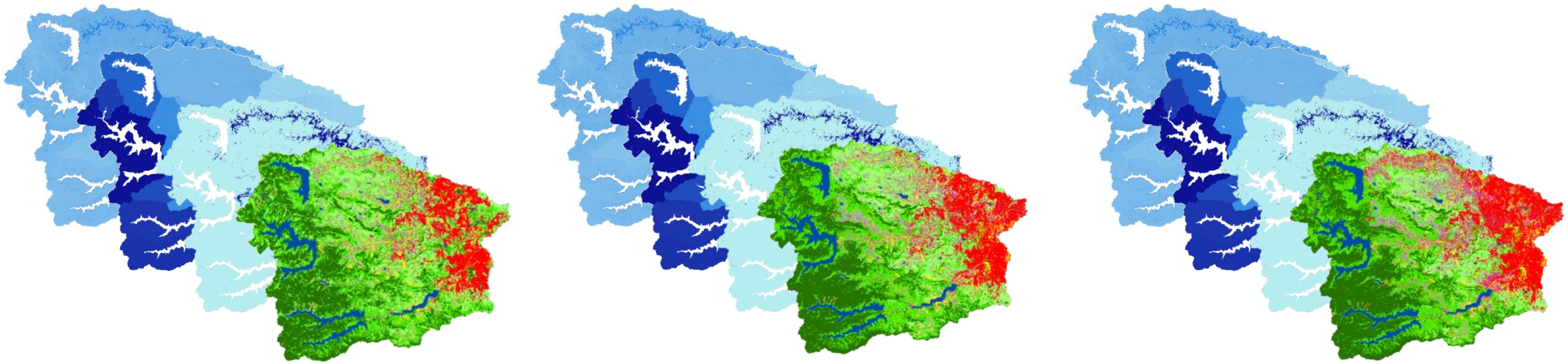
-8.9% shrubland and grassland

Cropland abandonment:

High water stress in 2 consecutive years

(WSTRS >= 8 d/months)

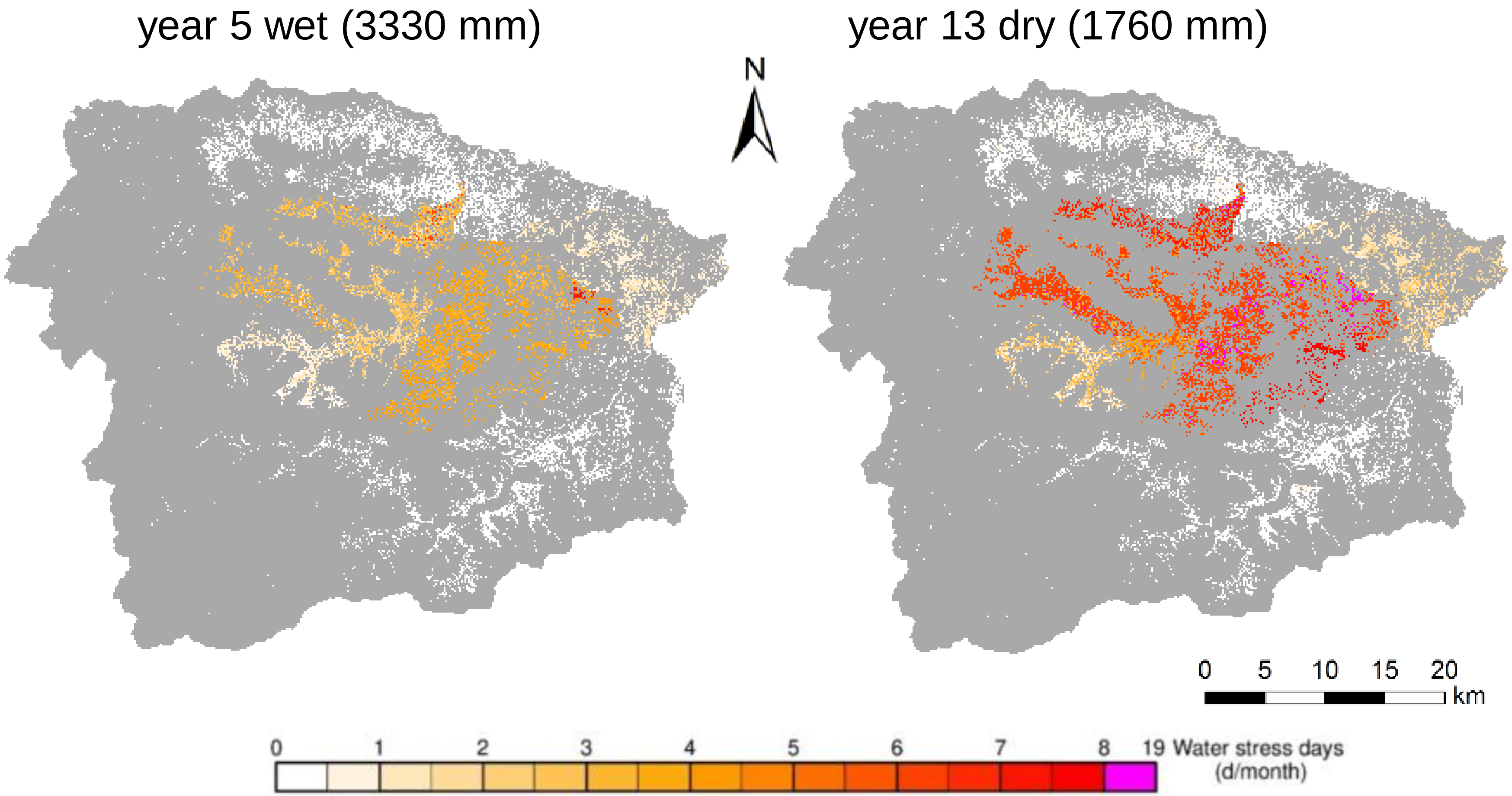
Annual identification of abandoned agricultural areas



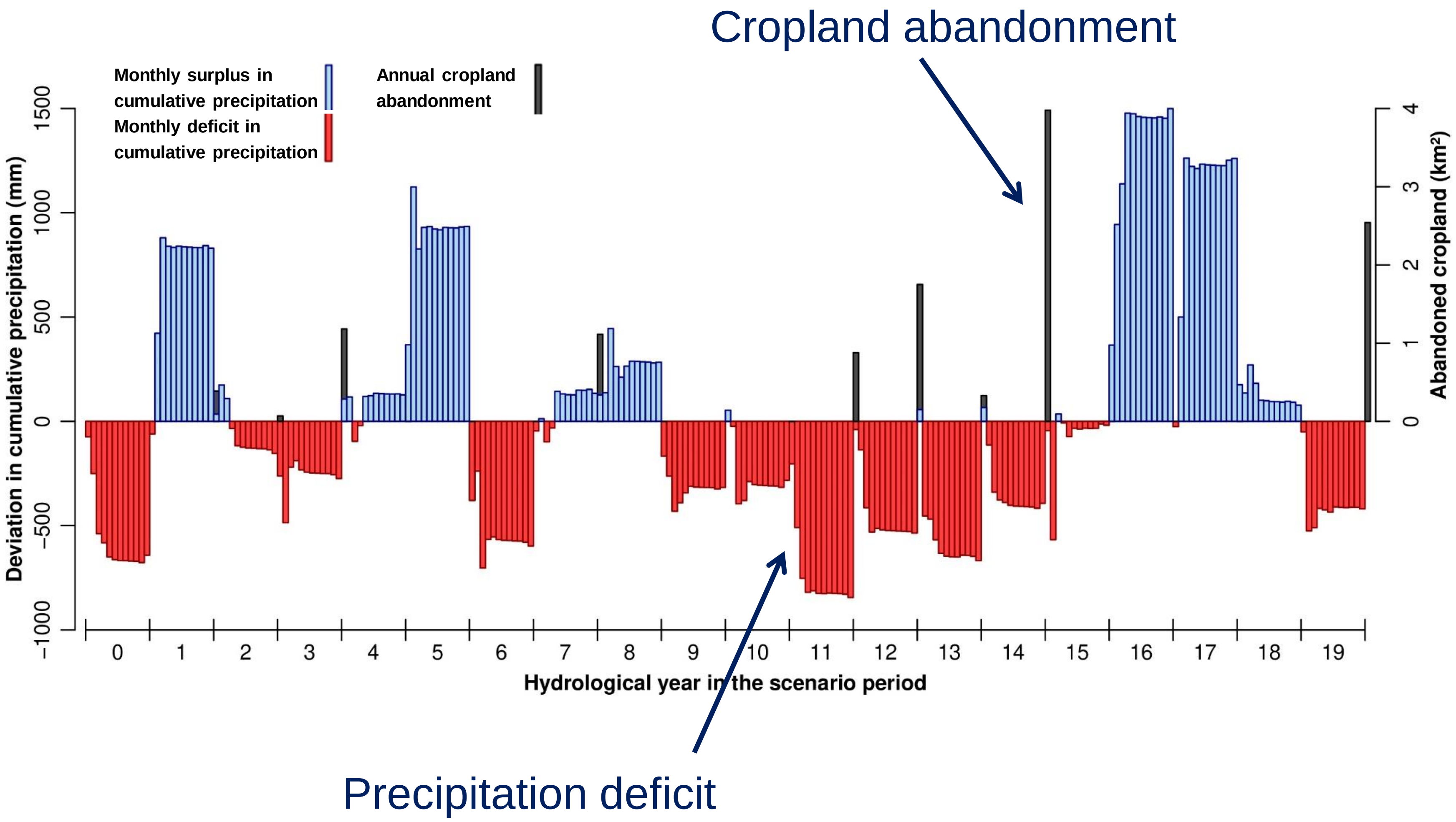
start year ...annual predictions… year 19

Wagner, Kumar, Fohrer, **2022,** *in revision*

Water availability affects water stress

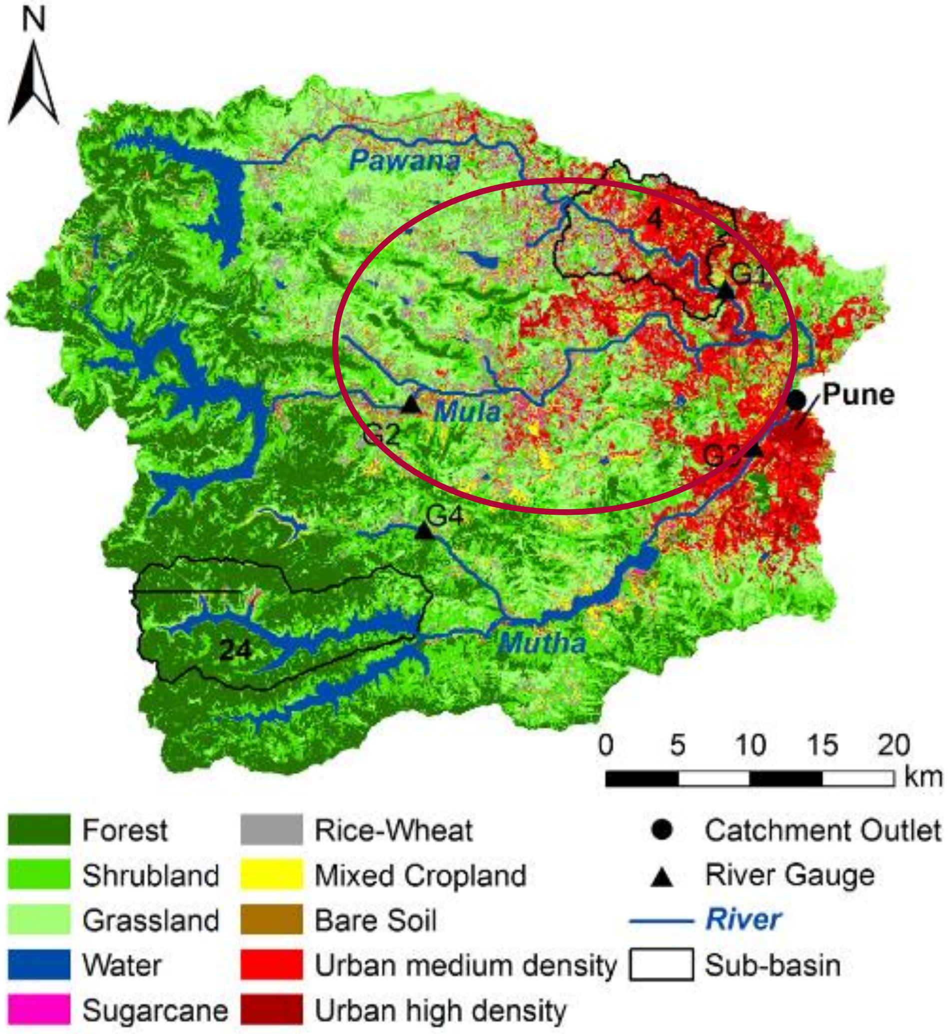


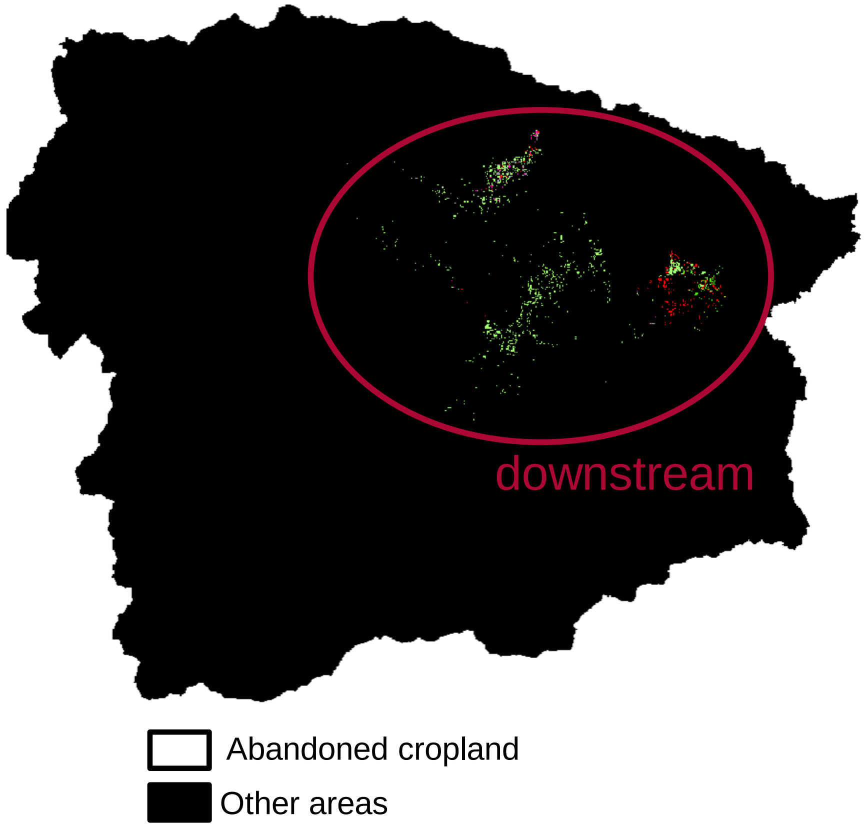
When is cropland abandoned?



Abandonment: Dry years, increasing pressure on land

Where is abandoned cropland located and how is it used in the following years?





Land use of abandoned areas at scenario end:

- Grassland: 51%
- Shrubland: 4.8%
- Urban: 18.0%
- Recultivated: 26.2%

+ water availability
+ pressure on land

Conclusion

Advancing the modeling of land use and land cover change impacts on water resources by:

- Implementing dynamic land use and land cover changes
- Coupling land use and hydrologic models for an integrative assessment of changes in water resources, advantages:
    - Feedback effects and management decisions
    - Integrated assessment e.g. cropland abandonment
- Many more opportunities for model enhancement