Estimation of specific yield of hard-rock aquifers in Upper Cauvery River basin region in India by application of AMBHAS-1D groundwater model

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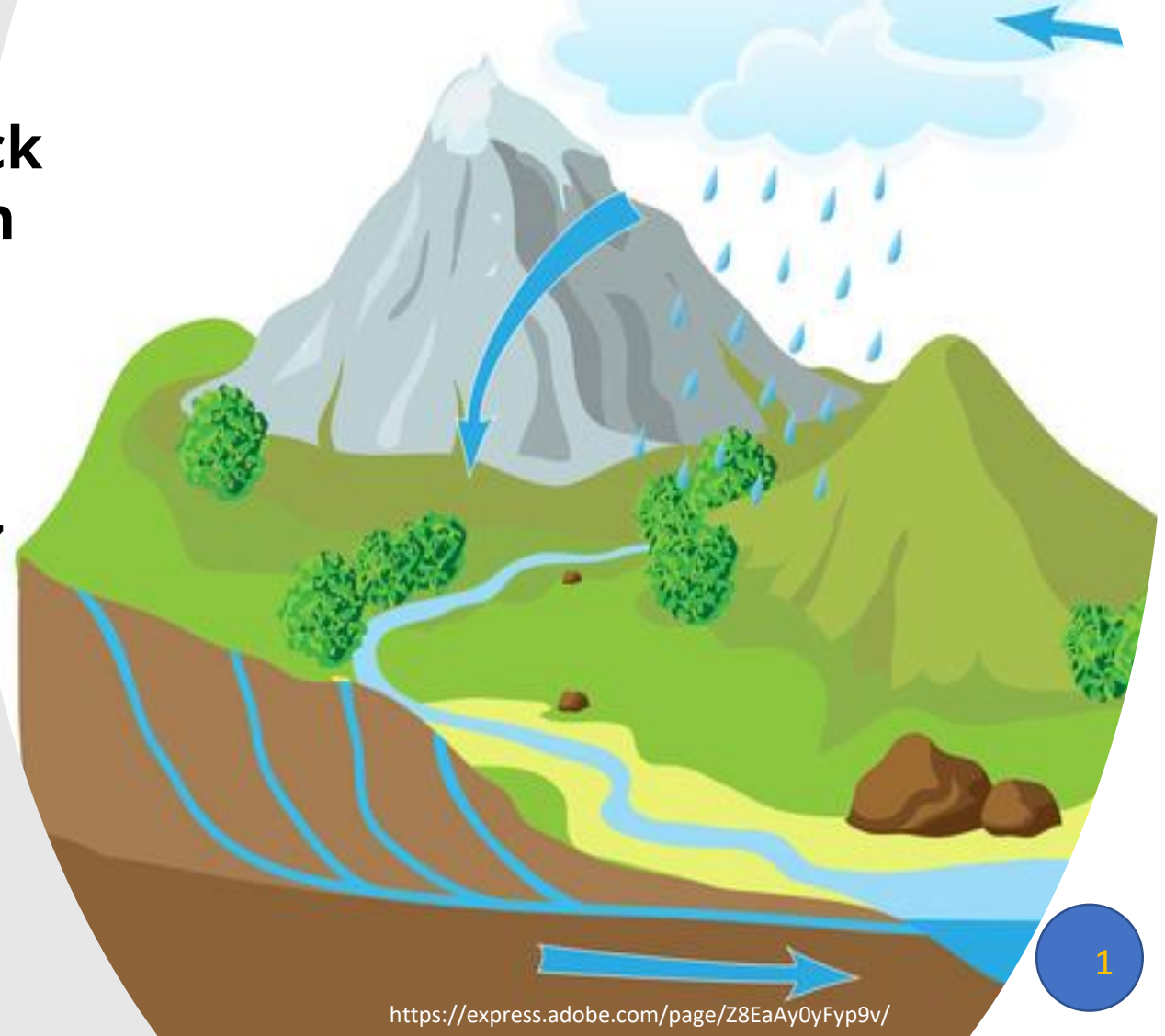

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Introduction

- Specific yield (Sy) is a key parameter in hydrology and water management, as it allows quantification of the available water resources of unconfined aquifers.
- Specific yield is volume of water that an aquifer releases from or takes into storage per unit aquifer area per unit change in water-table depth.
- Assessment of specific yield is crucial for an effective groundwater management in hard-rock aquifers in semi-arid regions, especially southern India :
  - Dependence on groundwater for irrigation
  - High heterogeneity of aquifer properties in the region

Sy Estimation

- Field Methods- pumping test and slug test [Ramsahoye and Lang (1961)]
- Geophysical techniques- MRS and ERT [Legchenko et al. (2006)]
- Water table fluctuation methods [GEC (2015), Subash et al. (2017)]

Motivation

- Estimated specific yield maps is an extremely important aquifer parameter which is used in groundwater and land-surface models for various hydrological studies.
- Water table fluctuation based models are more efficient and economic when studying larger areas
- Existing water table fluctuation-based approaches are not feasible for zero draft scenarios.
- Requirement of an alternate approach to account for discharge which was more dominant process to affect groundwater fluctuations in 1970s and 1980s.

Data Sources

Groundwater levels : Monthly groundwater level at 167 wells locations maintained by Department of Mines and Geology, Karnataka, India. Gaps in the data are filled using linear interpolation.

Rainfall Data : Daily rain-gauge measured data from Department of Economics and Statistics (DES), Karnataka, India is aggregated to monthly time scale. Each groundwater well location is linked to nearest rain-gauge location.

Simulation period : 1980-1990

Assumption : No groundwater withdrawal during the period

Study Area

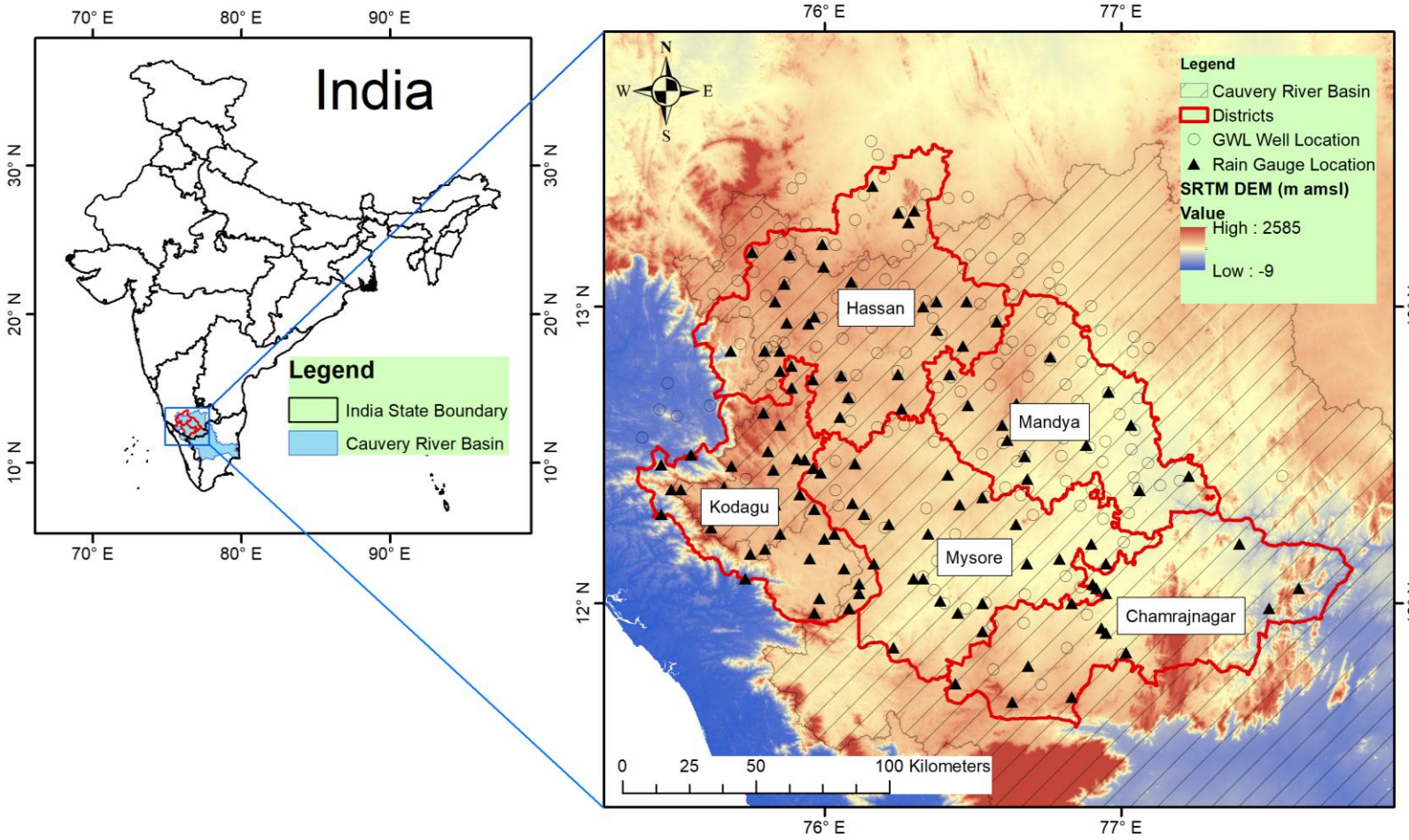


Fig. 1: Upper Cauvery river basin and Hassan, Mandya, Kodagu, Mysore, and Chamrajanagara districts of Karnataka in the region

Model

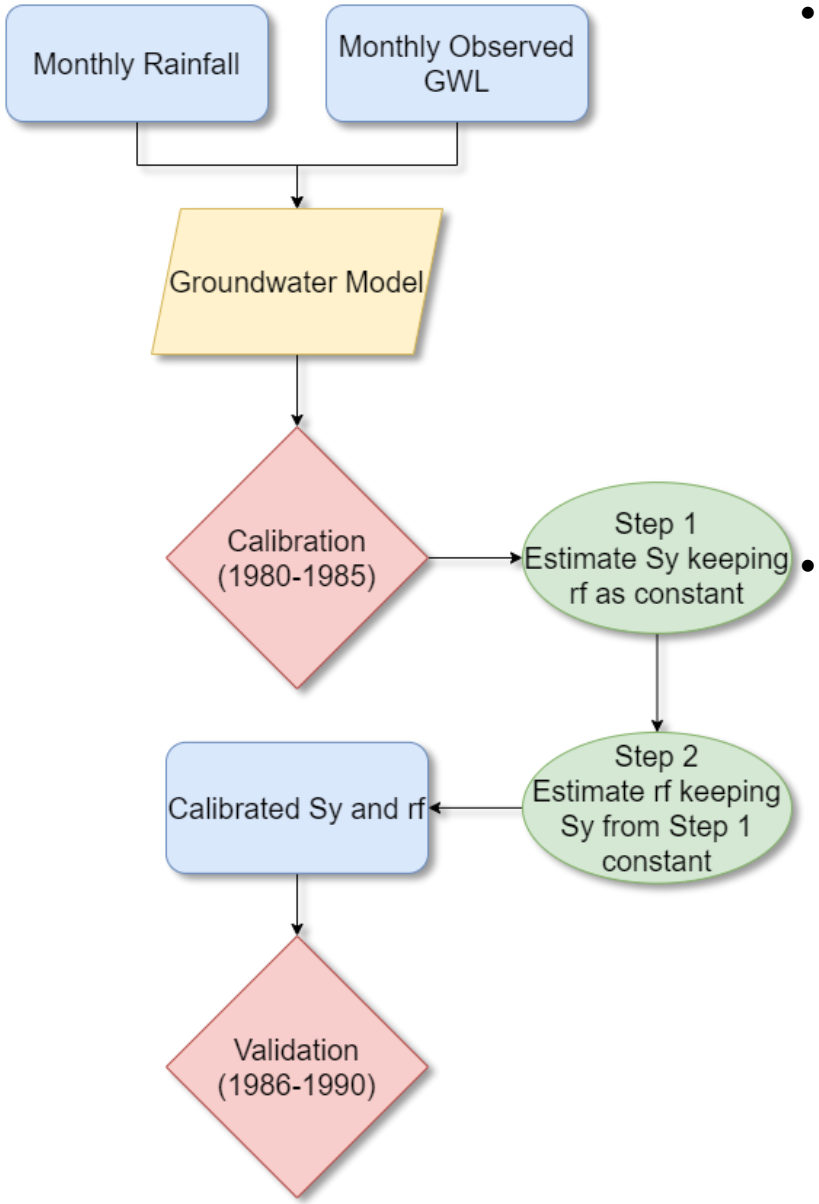
- AMBHAS-1D model is used for study (Subash et al., 2017)
- Physically based lumped model for unconfined aquifers based on Park and Parker (2008) equation :

$$\frac{dh}{dt} = \frac{-1}{Sy}\lambda h + \frac{r_f}{Sy}R - \frac{1}{Sy}D_{net}$$

where, h represents the groundwater level (L), t is time (T), S_y is specific yield of aquifer system (-), λ is the discharge constant (-), R is the rainfall (LT^{-1}), r_f is the recharge factor (-) and D_{net} is the net groundwater draft (LT^{-1}).

- The model runs at monthly time scale
- Model has an in-built optimization module which is used for calibration
- D_{net} for the simulation period from 1980-1990 is considered to be zero.

Methodology



- Recharge factor (r_f) was allowed to vary across years but keeping it in a range from 2 to 12 % and s_y range from 0.1 to 2% based on literature. (Collins et al., 2020)
- Nash-Sutcliffe Efficiency (NSE), RMSE and R^2 between observed and simulated groundwater levels are used to test the applicability of estimated specific yield values.

Results

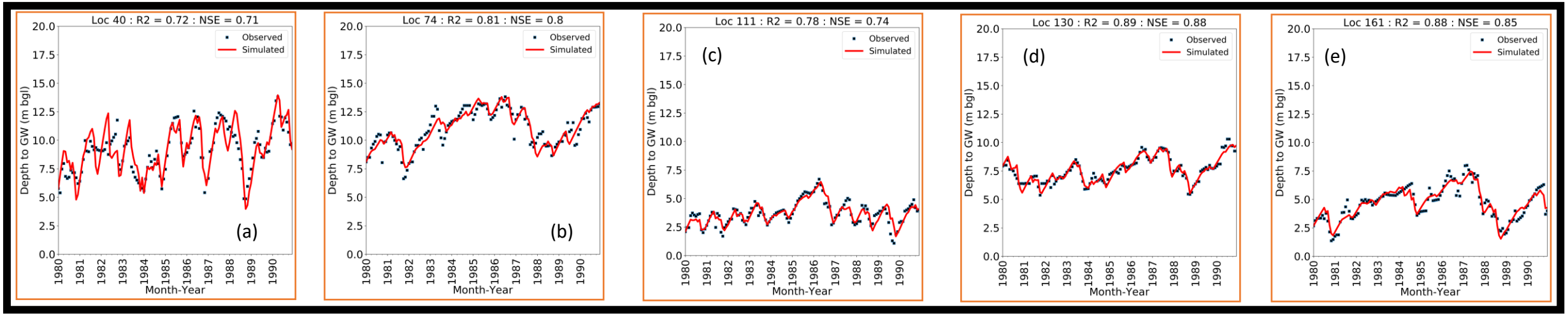


Fig. 2: Comparison of Simulated and Observed GWL at various well locations (a - e)

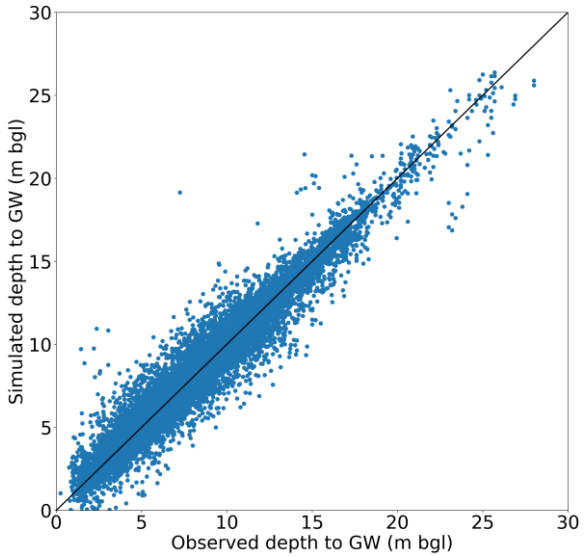


Fig. 3: Scatter plot of simulated and observed GWL at all well locations combined

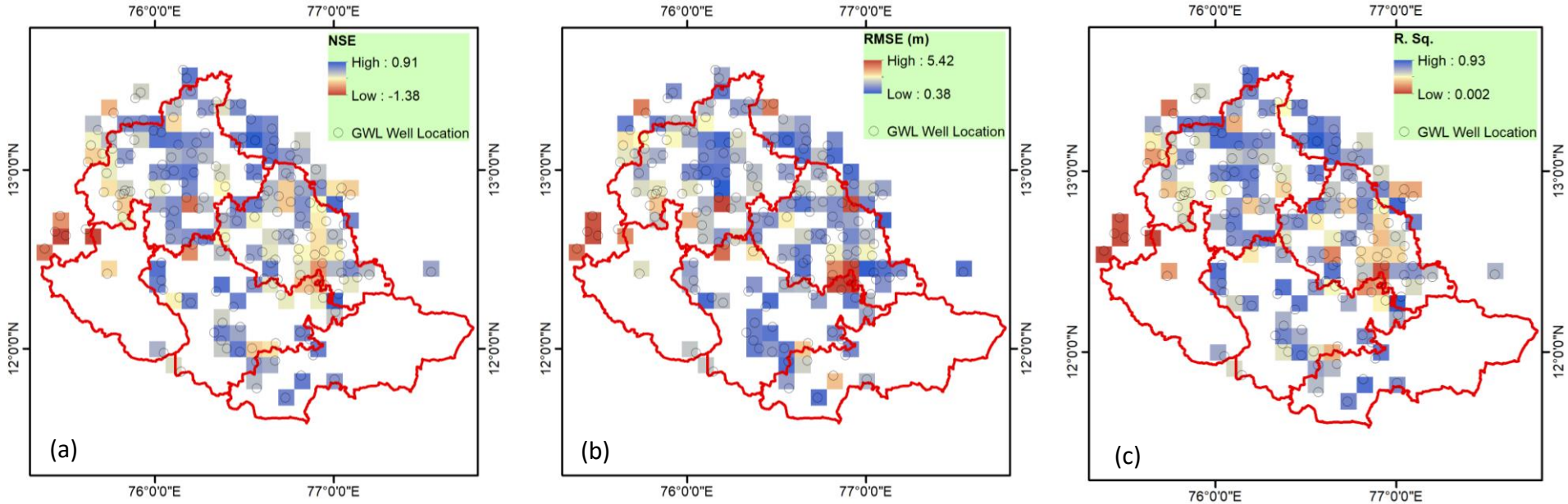


Fig. 4: (a) NSE (b) RMSE and (c) R^2 of estimated GWL using estimated specific yield

Results and Discussion

- Specific yield map for the region is prepared using the Inverse Distance Weighting interpolation scheme.
- Despite being granitic gneissic rock in general, high variability in the estimated specific yield is observed.
- High variability can be associated with degree of fracturation, long-term rainfall trends, variation of water level and topographic impacts.
- Major area of Hassan, Chamrajnagar and Mandya districts of Karnataka state have very low estimated specific yield (<=0.5%) indicating poor fracturing in those regions.
- Clusters of relatively high specific yield (>1%) are observed in south western part of Mysore district and Mysore city depicting weathered upper zone.
- Estimates depth averaged specific yield values for shallow water tables which are representative of upper bounds of specific yield values because of weatherd upper zone.

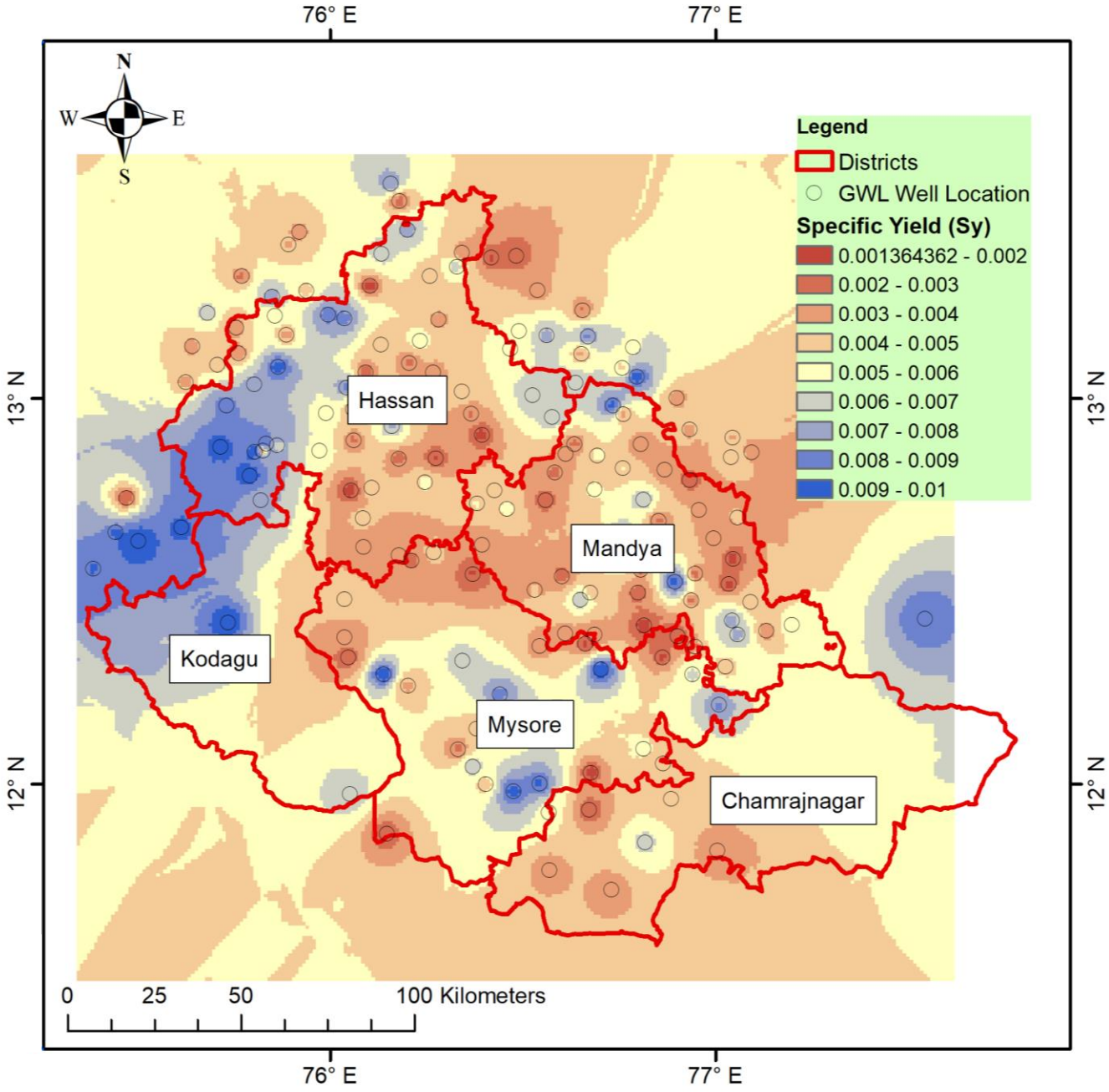


Fig. 5: Estimated specific yield values interpolated using Inverse Distance Weighting (IDW)

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