Analyzing the Relationship between Electrical Consumption by Pumping and Water Induced Land Deformation to Understand Water Security

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Introduction

Water security implies sustainable use leading to sustainable availability of clean and safe water to cover socioecological systems needs now and in the future.

Water availability changes can be reflected in land surface deformation (d) in alluvial or basin-fill aquifer systems [1,2].

Water use can be estimated by the energy consumed by pumps (e) for extracting water [3, 4].

This study analyzes water security by comparing trends in *e* and *d* over time and space in the sprawling region of Cochabamba, Bolivia.

Methods

We integrate InSAR data with pumping energy consumption records from an extensive well network. Statistical analysis identifies 4 trends in energy consumption (increasing, decreasing, stable, and no consumption) and 3 in ground deformation (uplift, subsidence, and no significant change) from 2018 to 2022.

By combining these trends, we define 4 water security scenarios: Water Security (WS), Threatened Water Security (TWS), Water Insecurity (WI), and Reversible Water Insecurity (RWI) (Fig. 1).

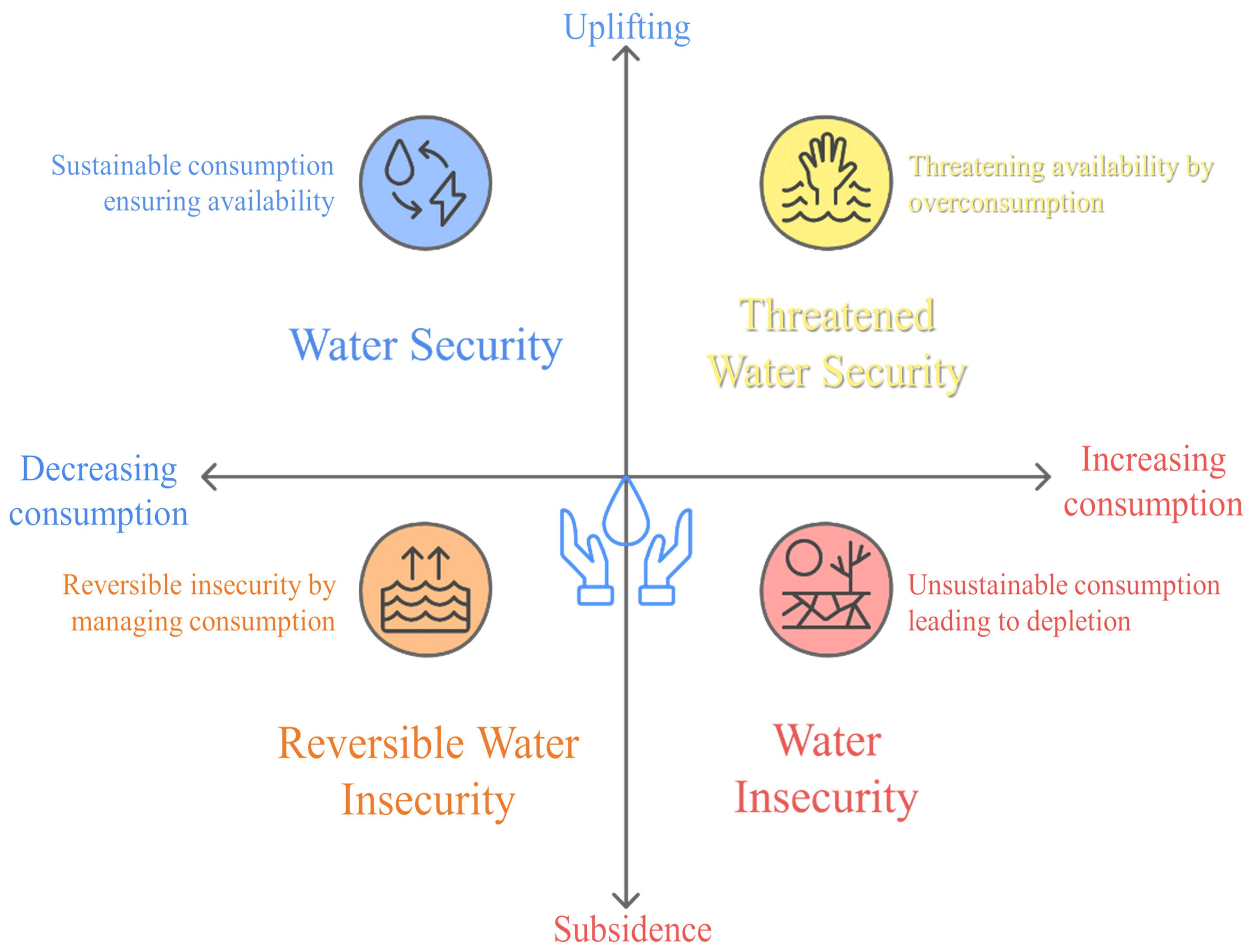

Figure 1. Theoretical water security scenarios based on (*e*) and (*d*) trends.

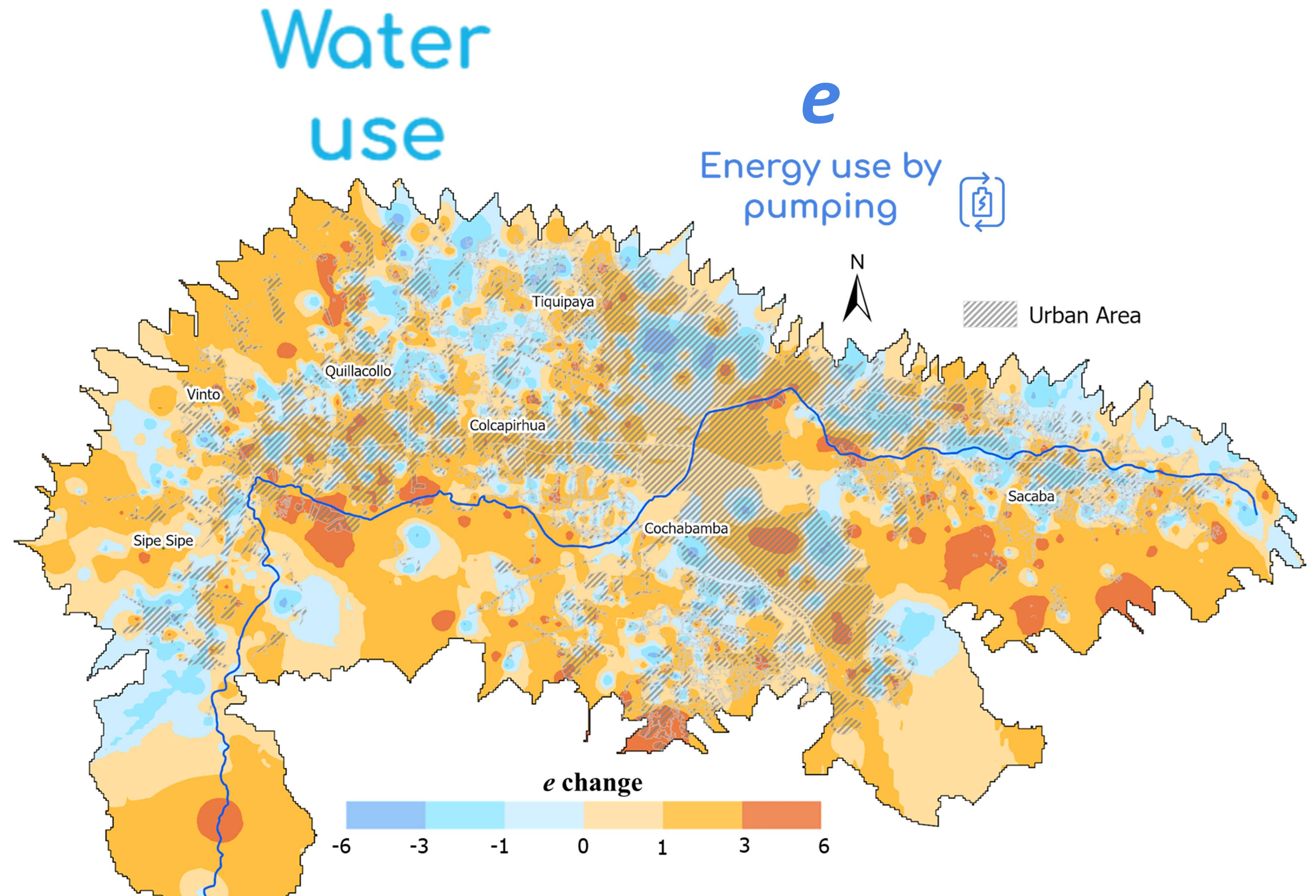

Figure 2. Spatiotemporal trends in *e* from 2018 to 2022. Blue indicates a decreasing trend and orange an increasing trend in *e*. The values correspond to the slope of the standardized monthly *e* over time multiplied by a hundred and spatially extrapolated, representing the change of *e* over time, with more color intensity showing larger changes.

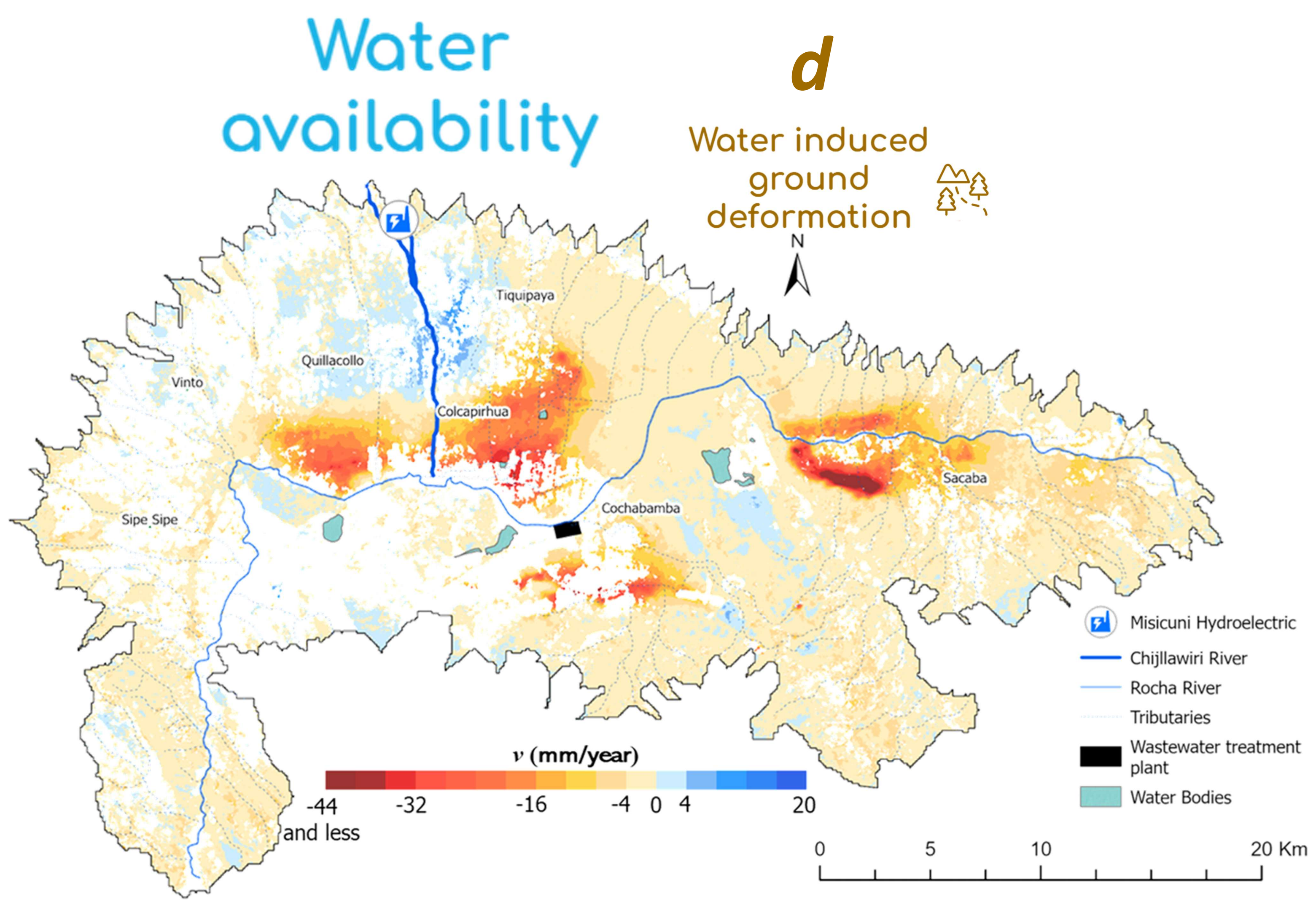

Figure 3. SBAS displacement velocity geocoded map. The map shows the average displacement velocity from 2018 to 2022 (*v*, mm/year) depicting areas of subsidence (yellow to red) and uplifting (blue) in the alluvial fan of Cochabamba. The map highlights the Misicuni Hydroelectric and the Chijllawiri River in the major area of uplifting.

Water (in)security in Cochabamba 2018 - 2022

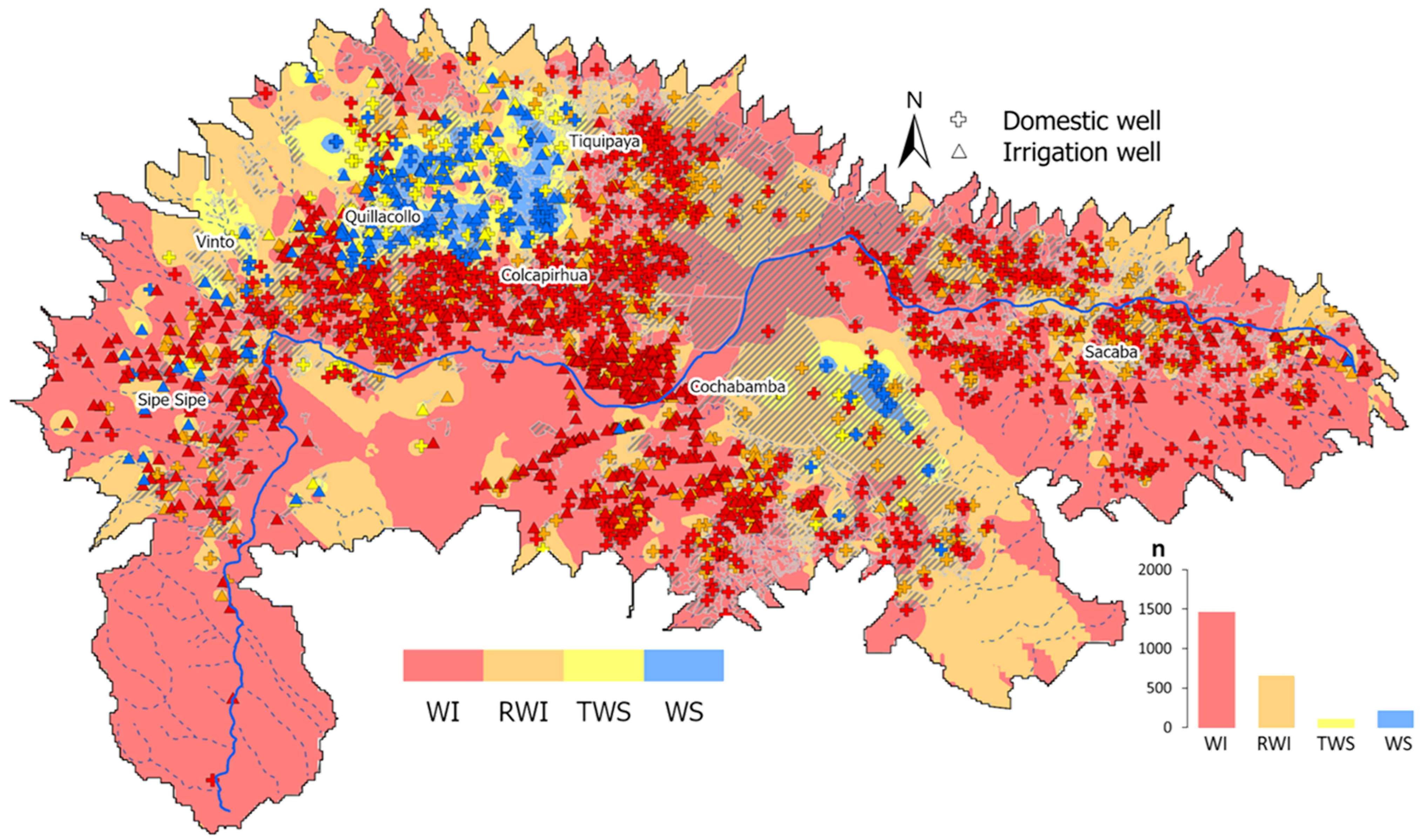

Figure 4. Spatial distribution of wells (irrigation as triangles and domestic as crosses) by water security scenario. The color of each well and area corresponds to each of the four scenarios: Water Insecurity (WI), Reversible Water Insecurity (RWI), Threatened Water Security (TWS) and Water Security (WS). The base layer corresponds to the spatially extrapolated values of each scenario.

Results

Most wells indicate both unsustainable water use and subsidence, implying Water Insecurity across Cochabamba.

Water Insecurity is driven by predominant domestic groundwater use and an increasing trend in energy consumption by pumping and in the number of wells.

Water security can be understood as the sustainable balance between water use and water availability over time.

Conclusions

This study demonstrates the potential of InSAR-derived ground deformation and pumping energy consumption as cost-effective and scalable groundwater monitoring tools, providing spatial and temporal insights into potential water security trends.

Water Insecurity predominance emphasizes the urgency of rethinking groundwater management in Cochabamba, with a focus on collaborative, efficient, and sustainable water supply systems.

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