Determination of Groundwater Shortage in Afghanistan using GRACE data and the Evolution of Vadose Zone in Kabul City using SAR data

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The country of Afghanistan over the last two decades, has faced an acute shortage of the precious groundwater resource. Some of the significant reasons are hydroclimatic or anthropogenic, but the very definite one that tops it all is the ignorance and the mismanagement of the surface water system. The monthly groundwater storage variation has been calculated from April 2002 to October 2021 using the Gravity Recovery and Climate Experiment (GRACE) dataset for five major river basins of Afghanistan, including Kabul, Amu Darya, Northern, Hari Rud and Helmand river basins. The seasonal groundwater storage anomaly reveals a comparatively gentle negative trend in the Amu Darya and Northern rivers basins than the rest. Consequently, the trends estimated in Kabul, Hari Rud and Helmand basins are dramatically decreasing. Hydroclimatic influence for groundwater storage was compared with the Standardized Precipitation Index (SPI-12 months). Though the SPI values have shown a wet period from 2013 to 2017, the groundwater is declining continuously. Analysis of the Groundwater Storage Abstraction (GWS_{abs}) has been carried out for the entire country. The estimated GWS_{abs} trend (2003-2021) gives a maximum value for the Northeast and Southwest parts of the country. One of the hidden crises of extensive groundwater consumption is land subsidence. The study focused on the evolution of the vadose zone, resulting in land deformation in Kabul City. The resultant land displacement is determined using Sentinel-1 data in the most populated city of Afghanistan (Kabul). The time-series analysis shows two-phase of displacement. In phase I (2015-2017), there is a common gentle trend (-20.66 mm/year in Upper Kabul aquifer and -18.54 mm/year in Lower Kabul aquifer), but in Phase II (2018-2020), a high negative trend (-151.34 mm/year in Upper Kabul and -145.32 mm/year in Lower Kabul) was observed. The vertical displacement was estimated at a maximum value of -202 mm for Kabul City between June 2016 and August 2020. Overall, the entire country is experiencing a severe groundwater decline, but the most dominant ones are the southern and western parts of Afghanistan, causing the not-so-obvious crisis such as land subsidence. This study states that strong policy and regulations change is required to sustain groundwater resources in the country.

Keywords: GRACE; InSAR; Land Deformation; Groundwater abstraction (GWSabs); GWSD; ^{G}WS

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