Imaging Land Subsidence Induced by Groundwater Extraction over NCR using RADAR Interferometry

A DISSERTATION

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by

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ABSTRACT

The groundwater exploitation induced land subsidence is a well-known phenomenon and has been documented in places like Tokyo, Jakarta, Tehran, and Mexico. Delhi- the capital of India, is the fifth most populous city in the world, with a population density of nearly 30,000 people per square mile. Like other global megacities, Delhi is also facing the looming groundwater crisis due to urbanization and illegal pumping and is considered as a critical zone by the government of India. The rapid extraction of groundwater and supporting physiography and hydrogeology of this region makes it prone to land subsidence.

In this study, we demonstrate the results of the Interferometric Synthetic Aperture Radar (InSAR) time series analysis of the NCR Delhi region using Persistent Scatterer Interferometry (PSInSAR). By constructing single-master interferograms derived from Sentinel-1 ascending and descending SAR datasets acquired between 2014 and 2020, we computed the time series of land subsidence in the region. The interferometric processing was done using SNAP followed by time-series analysis using Stanford Method for Persistent Scatterers (StaMPS). To remove the tropospheric error, a phase-based linear correction was applied using the TRAIN toolbox. Line of Sight velocities are then decomposed into the vertical and east-west direction to visualize the uplift and deformation more clearly. Finally, the results were compared with in-situ groundwater observation wells to study the correlation between the two.

Our analysis identifies three distinct subsidence features in National Capital Region (NCR). The maximum deformation exceeding 18 cm/year is found in Kapashera which is located near Indra Gandhi International Airport. Faridabad also shows a high deformation rate of 9cm/year. The study founds that A total area of approximately 11 sq. km was found to undergo continuous deformation since 2014. It included Kapashera (Delhi -Haryana border), Dwarka, and Sanjay Gandhi Memorial Nagar in Faridabad.

The in-situ groundwater well data provided by Central Ground Water Board (CGWB) India is not consistent and has many gaps. However, the careful data analysis of some of the wells followed by spatio-temporal interpolation provides an estimate of the depth to the groundwater level. The groundwater depletion rates show an agreement with the trend of land subsidence. Furthermore,

the results signify that the areas with high subsidence rates show a high groundwater depth in Delhi NCR during 2014-2017.

The study area is further divided into different levels of risk of ground movement using the hazard and vulnerability approach. Seven evaluation indices were selected to estimate the risk. The results indicate that high-risk zone covers 50 sq. Km of the study area, which generally exhibits higher inundation depth and lower elevations. It includes Bijwasan, Samlkha, Kapashera, Sadh Nagar 1, Bindapur, and Mahavir enclave from Delhi; Dundahera, Sector 22A, and Block C from Gurgaon; and Pocket A, B, C of Sanjay Gandhi Memorial Nagar, from Faridabad. The findings of this study can be further used by government agencies to formulate new policies against over-exploitation of groundwater, especially in the areas undergoing subsidence.