(Wu et al.,2008, Galloway and Sneed,2013, amighpey et al., 2024). On the one hand, subsidence is considered an environmental threat that destroys aquifers and soil, and on the other hand, it destroys buildings and structures located on the site. Many subsidence areas have spread to urban areas and caused destruction and damage to ancient monument (Rukayah et al. 2021, Hamouda et al. 2021, Alfare at al. 2014).

Persepolis is a symbol of the splendor and grandeur of ancient Iran. Persepolis is a complex of several palaces nestled in the fertile plain of Marvdasht and at the foot of Mount Rahmat in Fars Province, located in the city of Marvdasht, Iran. Persepolis is located in the north of Marvdasht County, north of Fars Province (northeast of Shiraz). Six and a half kilometers from Persepolis is Naqsh-e Rustam. In Naqsh-e Rustam, there are tombs of kings such as Darius the Great, Xerxes, Artaxerxes I, and Darius II. The Kaaba of Zoroaster is a rectangular stone structure in the Naqsh-e Rustam area.

Unfortunately, excessive use of groundwater resources in the fertile Marvdasht plain for the purpose of agricultural development without considering climate resilience has led to extensive subsidence in this plain, which has led to a serious threat to the health of the ancient monuments located there. In this study, the rate of land subsidence in the vicinity of these historical buildings was examined.

Materials and Methods

Geodetic observations such as radar interferometry, GPS measurements, and precise leveling methods are used to identify and monitor areas affected by subsidence risk. Radar interferometry with wide coverage and high spatial resolution, along with GPS with high temporal resolution, as well as precise alignment observations and high-precision gravity measurements, can be a suitable source for land surface deformation in the region.

In order to investigate the subsidence of the Marvdasht plain, a combination of geodetic observations in the region, including radar interferometry and precise leveling, was used. Radar interferometry was used in two time periods: August 2018 to July 2019 and September 2019 to September 2024.

Results, & Discussion

The results indicate an expansion in the extent and rate of subsidence in recent years. Therefore, the western part of the Persepolis World Base area and the area of the Kaaba of Zoroaster have also entered the subsidence zone at a rate of about 1 cm per year. Also, according to calculations, the changes in the subsidence rate near these ancient monuments are great.

Conclusion

In order to preserve and maintain these ancient monuments, the need to use structural consolidation methods in these historical monuments is something that must be considered. On the other hand, management of groundwater resources exploitation in the fertile plain of Marvdasht, modification of the cultivation pattern and prohibition of cultivation of water-intensive crops for agriculture and methods of artificial aquifer feeding are suggested to stop subsidence in the Mukda region. Also, the use of microgeodetic observations and calculations is suggested to investigate and monitor the deformation of these ancient monuments.

Investigating land subsidence and its changes within the Persepolis and Naqsh-e Rostam Heritage Site

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Persepolis is a symbol of the glory and grandeur of ancient Iran. Persepolis is located next to the Marvdasht Plain and at the foot of Mount Rahmat in Fars Province, located in the city of Marvdasht, Iran. Unfortunately, the excessive extraction of groundwater in the Marvdasht Plain to provide water for agriculture has caused subsidence in this plain. Considering the importance of protecting ancient and historical monuments, it is important to investigate the extent of subsidence of the Marvdasht Plain within the Persepolis and Naqsh-e Rostam World Cultural Heritage Site in order to assess its impact on possible damage to this site. Calculations indicate widespread subsidence of the Marvdasht Plain with a maximum rate of 22.6 cm per year. Also, the results of the calculations indicate the expansion of subsidence of the Marvdasht Plain towards Persepolis and Naqsh-e Rostam in recent years. On the other hand, changes in the subsidence rate near these ancient monuments are significant. In order to preserve and protect these valuable ancient monuments, measures to combat the destructive effects of subsidence on them and sustainable management of the region's groundwater resources are proposed to prevent the subsidence of the Marvdasht Plain.

Keywords: InSAR, subsidence, gradient of subsidence, Persepolis and Naqsh-e Rostam World Cultural Heritage Site.

Introduction

Antiquities and cultural heritage are the identity card of every country. Since antiquities determine the antiquity, history and civilization of every land, the protection of historical and cultural monuments, through a combination of science and art, is essential (Smith, 2020). Iran is also among the first countries to have antiquities and historical and cultural buildings in the world, and has the oldest culture and civilization in the world (Jones & Lee, 2018). Climate change in the world and its consequences in the form of continuous droughts, water shortages, and seasonal floods have cast a shadow over the country's cultural heritage in the past few years.

One of the consequences of climate change has been water scarcity and pressure on groundwater resources. The lack of management of groundwater resources and their uncontrolled extraction has caused widespread subsidence in the world and in Iran