Available online at www.jrors.ir

Journal Of Radar and Optical Remote Sensing

JRORS 2 (2021) 23–32

The Role of Anthropogenic Effects in Subsidence of Normanshir-Fahraj Plain

Samad Fotoohi[a*], Hossain Negaresh[b], Roghayeh Delaram[c], Masoud Sistani Badooei[d]

[a]*Ph.D. in Geomorphology, Department of Physical Geography, Faculty of Geography and Environmental Planning, University of Sistan and Baluchestan, Iran*

[b]*Ph.D. in Geomorphology, Department of Physical Geography, Faculty of Geography and Environmental Planning, University of Sistan and Baluchestan, Iran*

[c]*Ph.D. Candidate in Geomorphology and Environmental Management, University of Sistan and Baluchestan, Iran*

[d]*Ph.D. Candidate in Geomorphology and Environmental Management, University of Sistan and Baluchestan, Iran*

Received 08 February 2021; Revised 20 April 2021; Accepted 15 May 2021

Abstract

The role of humans in anthropogenic erosion and geomorphological changes of its natural environment is very important. Its most important role in recent decades is the use of surface and groundwater resources, which has been clearly shown as the destructive effects of excessive use of groundwater. Therefore, the need for water resources has caused the withdrawal of these very valuable resources from the underground aquifers of the country, whether allowed or not, and is facing the risk of land subsidence. The construction of the dam was another destructive effect that played an important role in blocking the aquifer nutrition. Normanshir-Fahraj plain is one of the plains in the country which has been directly affected by dam construction and uncontrolled abstraction of groundwater. After the dewatering of Nesa Dam, we were witnessed many environmental and water crises downstream of the alluvial fans of Fahraj and Normanshir.
The need for drinking water, irrigation of date orchards and other uses has led to high groundwater abstraction. Also, the subsidence is calculated using radar data Sentinel 1 satellite for 6 months about 10 cm, which is high. Therefore, it is necessary to pay attention to landslide risk management as well as to avoid secondary hazards such as the destruction of walls and buildings, road lines and the transfer of energy and infrastructure by the relevant governorate.

Keywords*:* Anthropogenic, Land Subsidence, Sentinel 1, Radar Interference, Normanshir-Fahraj Plain

[*] Corresponding author Tel: +98-9177312688.
Email address: samadfotohi@yahoo.com.

1. Introduction

A set of Ggeomorphological changes that occur by humans in nature is called anthropogenic, which is divided into several main categories including agricultural activities, mining, transportation, the energy industry, ground-water abstraction m, etc. These effects range from the smallest type of activity (which may be digging up grassroots or small scratches on a piece of rock) to the largest and most extensive activities (such as creating metropolises) showing the spread of direct human influence in nature (Falsoleiman et al., 2015). Anthropological hazards as one of the disorders caused by human function can disrupt the processes of maintaining ecosystem integrity (Woods, 2007). Landslide is one of the environmental hazards that threaten most of the plains of Iran today.

Land subsidence is a morphological phenomenon that occurs under the influence of the forward movement of the earth and the cause of this phenomenon can be natural (such as dissolution of karstic formations underground) or human (such as uncontrolled extraction of groundwater, drilling) tunnel and metro (Sharifikia, 2012). In the developing world, many rural communities are located in water-scarce areas, where there is an unequal distribution of hydrological and economic resources (Jamali et al., 2020: 2). Due to climate fluctuations and successive droughts in recent years in Iran and the need to estimate the water required for different uses and groundwater abstraction from different aquifers, subsidence has a long history and most plains in Iran are exposed to this phenomenon. Numerous studies have been conducted in the world and most of the cities of Iran and their secondary dangers have been mentioned. In this research, the amount of groundwater utilization, which is more than the amount of nutrition and groundwater level decline, has been mentioned as the main cause of subsidence. Landslides cause extensive damage to residential areas, including buildings, bridges, infrastructure, and agricultural land, the permanent destruction of aquifers, etc., using radar techniques to Identify and warn, damages can be reduced. Therefore, various researches have been done using this technique, some of which are mentioned.

Karimi et al. (2013) using Polsar images and radar interferometry method, studied Tehran subsidence in the period 2009 to 2010 and calculated the amount of subsidence from 1 to 25 cm. Mirshahi et al. (2013) used Terra SAR-X images to calculate the rate of land subsidence and compared the TSX and ENVISAT radar data with each other to express the ENVISAT data more accurately. Roozban et al. (2016) estimated the subsidence of Rafsanjan plain with about 28 cm with the Sentinel 1 images. Other researches include Kuhsar et al. (2014) in Yazd-Ardakan, Babaei et al. (2015) in Qazvin, Rafiei and Sedighi (2015) in Naftshahr, Babaei et al. (2015) in Qazvin plain, Roozban et al. (2016) in Rafsanjan plain, Sharifi Kia (2012) in Nogh - Bahrman, Mottaqi (2008) in Kerman, Ismaili (2009) in Kerman - Zangiabad, Sharifi Kia (2009) in Zarand, Kuhsar Et al. (2014), Amighpi (2009) and Alemi (2002) in Ardakan and Yazd plains, Pakdaman et al. (2014) at Imam Khomeini, Jalini (2017) and Heshmati (2012), Kagawa and Foruno (2010) airports Plain of Canto, Japan, and Book et al. (2012) in Venice pointed out that the results of all the above studies show the ability of the radar interferometry method to measure the degree of deformation and displacement of the earth's surface with centimeter accuracy.

Therefore, the use of remote sensing tools has partially solved such problems. In the last two decades, the radar interferometry technique has been used as an efficient and effective tool in the study of phenomena that cause deformation of the earth, and very valuable results in the field of geomorphology using This technique is obtained. Radar Interferometry (InSAR) has been one of the most accurate and cost-effective remote sensing methods to detect ground-based displacements. In addition, in this method, by using satellite data and its reproducibility, monitoring of this phenomenon in the desired location can be done easily and at the lowest cost (Sharifikia, 2012).

As mentioned, subsidence is one of the silent and intangible hazards that cause a lot of long-term damage, including primary damage (such as cracks in the ground) and secondary damage (such as cracking of walls and houses and destruction of infrastructure). Brings. Normanshir-Fahraj plain is also involved in this risk due to the uncontrolled abstraction of groundwater and the purpose of this study is to investigate the impact of human activities on land subsidence and also to provide a suitable model

for land use in this area. In this study, an attempt is made to investigate the extent of land subsidence using the radar interference measurement method and to determine the relationship between them by studying human activities in the plain.

2. Research Methods

In this study, which has been investigated by remote sensing method and GIS, the radar data of the Sentinel-1 satellite in a period of six months have been used to investigate the amount of land in the study area (Table 1). The reason for choosing the six months period is that the amount of groundwater abstraction in this area is very high due to the need for water and agriculture, and the sign of this abstraction is very tangible. In selecting radar data for software processing, data with the lowest spatial baseline is selected, as well as for radar interference from SNAP software designed to work with the Sentinel-1 data, and almost all major radar data processing such as geometric corrections and supports radiometry, has used. This satellite performs imaging operations without being affected by weather conditions in the C-band range with a wavelength of 5.6 cm. The study area was also located in IW2 and Burst 4-7, which were isolated from the total data.

Table 1. Details of data used by Sentinel-1 satellite in the research

Master Data	Slave Data	Polarization	Bperp (meter)	Btemp (Days)	Model coherence
2019-07-04	2019-12-31	VV	0.02	180	0.84

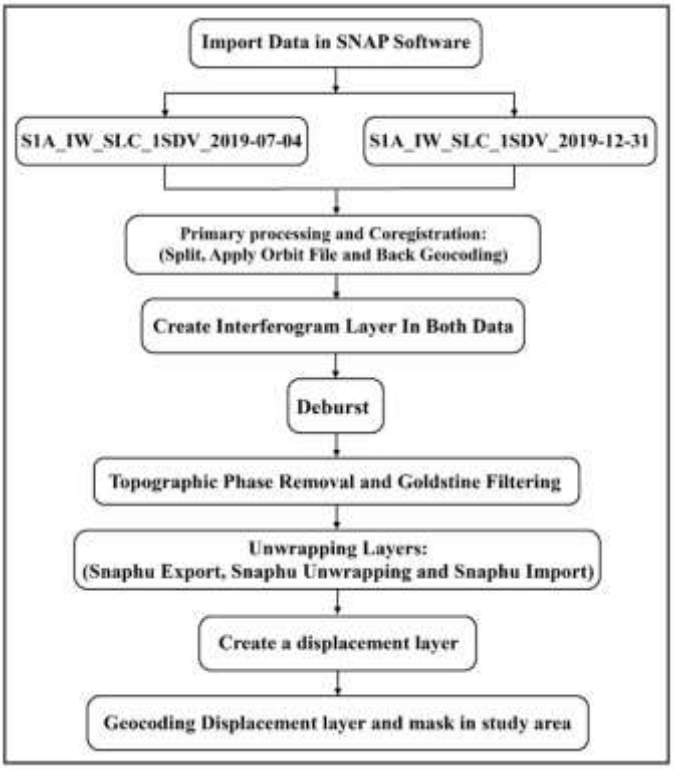

Figure 1. Innovative method: Flowchart of Dinsar data processing

2.1. Study Range

The study area is located in the east of Kerman province and the cities of Bam, Fahraj, and Regan. In terms of absolute position, this region is between 58° 33′ 04″ to 58° 56′ 33″ east longitude and 28° 45′ 41″ to 29° 05′ 05″ latitudes. Also, in terms of climatic conditions, it is located in hot, dry, and desert areas, which will lead to more water needs. The average height of this plain is about 500 meters (Fesharaki, 1978) and the access roads to the study area are through 35 km of Bam-Zahedan road (Figure 2).

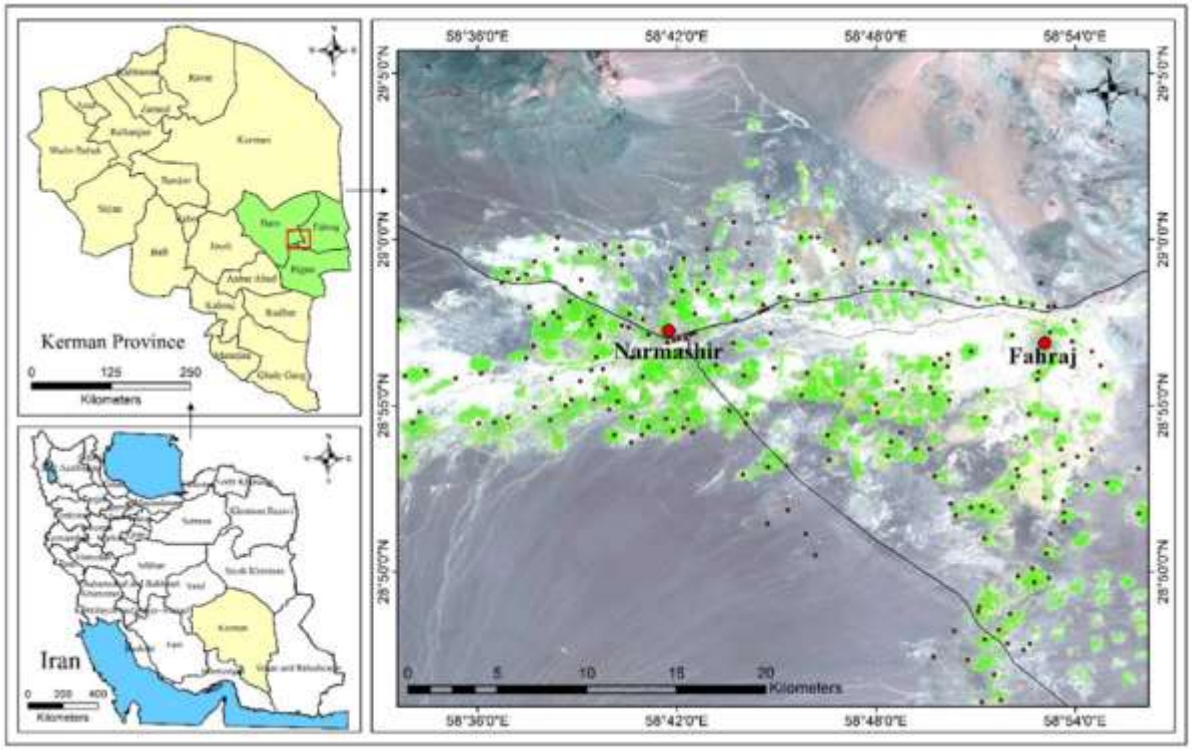

Figure 2. Geographic location of the study area

2.2. Analysis of Research Findings

In this study, the DInSAR radar interference technique has been used to investigate the rate of land subsidence. The role of human factors in this phenomenon is of primary importance and based on what has been determined based on field evidence and remote sensing, the research has been done. It should be noted that the effect of climate change, as well as the role of human factors and anthropogenic geomorphological changes, has played a major role in land subsidence in this region, which is discussed below for various reasons.

Normanshir-Fahraj plain aquifer due to geological, climatic conditions (entry of many floods into the alluvial surface of the region and groundwater recharge), cognitive and geomorphological sediment until recent years have significant surface and groundwater resources and since this region is marginal It is located south of Lut Desert and downstream of a huge alluvial fan. Due to the high altitude difference between its southern heights and the northeastern part of the region, it has had severe hydrogeomorphological effects in previous geological periods, so it has good porosity due to its location in Lut desert. It had a basement where many aqueducts were dug on the surface of this alluvial

fan and its water was used for various purposes such as drinking and irrigating agricultural lands. So that from the south to the north and from the west to the east of the region, the granulation of sediments has become finer and the topographic conditions have also played an important role in this. In terms of geological studies, the center of Narmanshir plain is composed of fine alluvial grains of sand, sand, and silt, and the margin of the plain is composed of coarse elements of rubble, sand, and gravel (Zare, 2008) which is located at the base of a large alluvial fan and in and its surface is dug with many aqueducts (Figure 3). In recent years, due to the role of humans and their manipulation of nature and water resources in the study area, we were witnessed of many hydrological and water resources degradation.

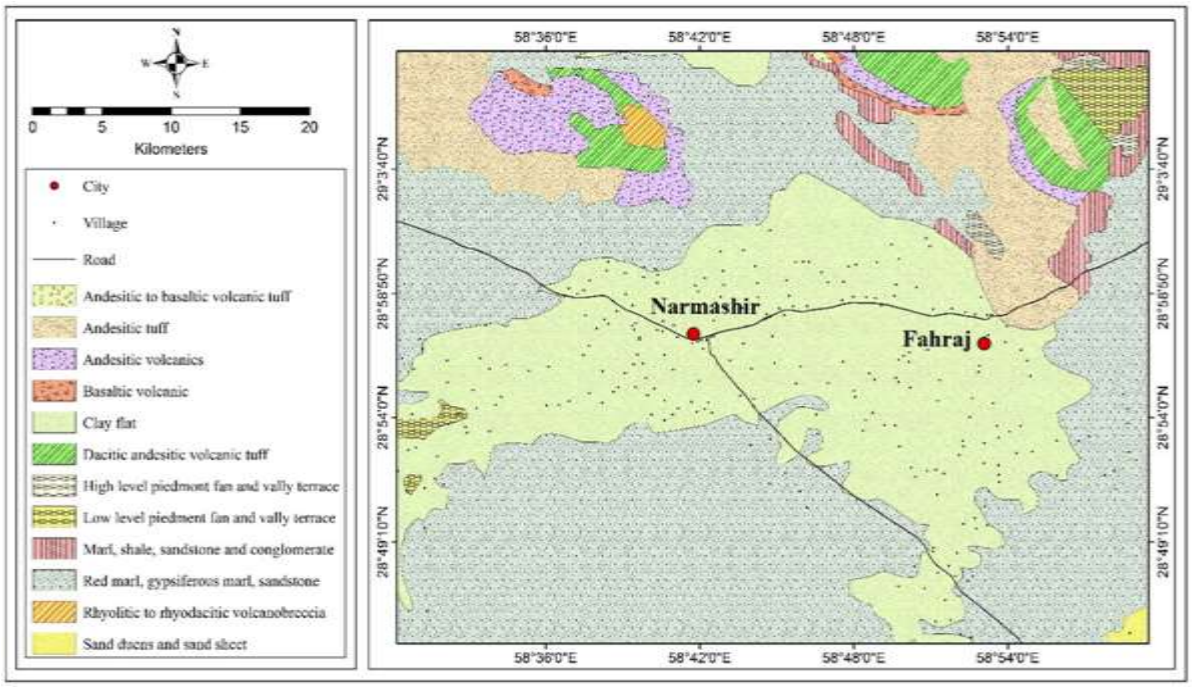

Figure 3. Geology map of the study area

Therefore, in recent years, due to the construction of Nessa Dam, the feeding of alluvial fans leading to this plain has stopped and its aqueducts, which were the source of power for aquifers and gardens and other agricultural, industrial, and drinking uses, have dried up (Figure 4).

Therefore, the construction of Nessa Dam has had many negative and destructive effects in this area. In addition to preventing the inflow of water from the Nessa River to feed the downstream aquifer of the alluvial fan and the overflow of its aqueducts, as well as the destruction of the environment around the Fahraj and Normanshir rivers, it has also affected human and agricultural consumption. Inevitably, it has forced the indigenous people of the region to use groundwater instead of surface water. Since the population of the region is very large and in addition to drinking and animal husbandry, there are many agricultural lands and date orchards, so to meet this need, many deep and semi-deep wells have been dug and constructed in this plain, legally and illegally. These wells extract large volumes of groundwater to meet these needs. The result of this uncontrolled abstraction of groundwater is the risk and phenomenon of land subsidence in the region, which in the near future, we will be witness of more tangible effects and dangers of subsidence. Now, to show the deterioration of the situation in the region and to determine the area of subsidence, radar data from the Sentinel-1 and radar differential interferometry methods have been used only in a period of six months. The diagrams below show the interference layer and the filtered and non- unwrapped phase layer, both of which are georeferenced.

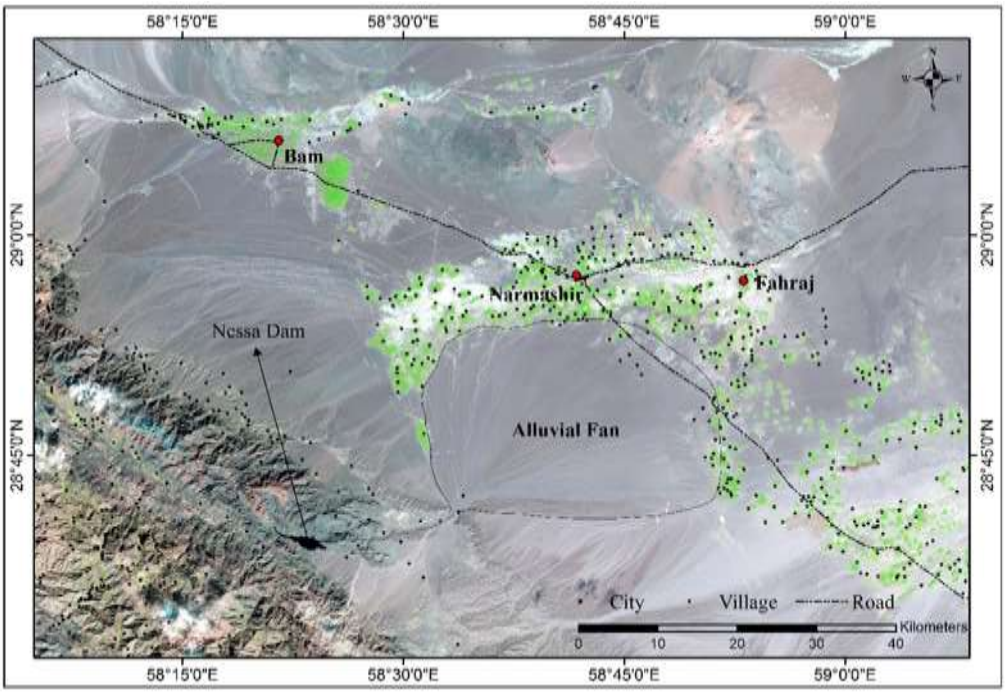

Figure 4. Geographic location of the Nesa Damin study area

As can be clearly seen in the map above, the fringes resulting from land subsidence in the area of groundwater abstraction are well represented. In addition, subsidence areas have a direct relationship with villages and date orchards and agricultural lands in the study area. Also, due to the changes in these date orchards and the surrounding agricultural lands, there is a sharp and maximum difference in the phase layer in the map, which is not related to land subsidence and is only the result of changes in the leaves of date trees and agricultural lands. Another important point is that all the villages followed by all the wells dug in the surface of the Geological Formation of the clay plateau (according to Figure 3) in which the aquifer of the region is located.

Following the processing of radar data in SNAP software, the filtered phase layer is first unwrapped and then the displacement layer is prepared, and finally, the georeferencing and the final map are prepared. It should be noted that in performing the above operations and in order to work accurately and as a result prepare a low error map, the digital elevation model (DEM) with a resolution of 30 meters ASTER sensor has been used externally in SNAP software. Therefore, the volume of processed output data is very high and the accuracy of the layers is very high. Figure 7 also shows the final displacement map in georeferenced form.

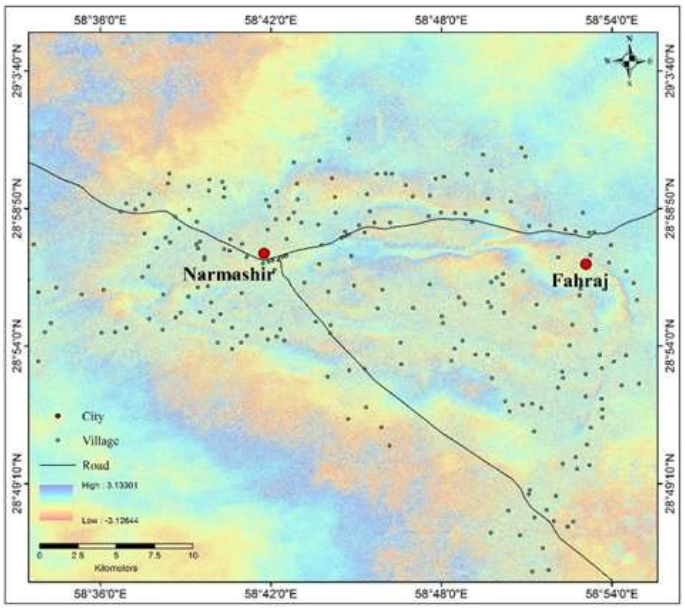

Figure 5. Topographic phase removal map of area

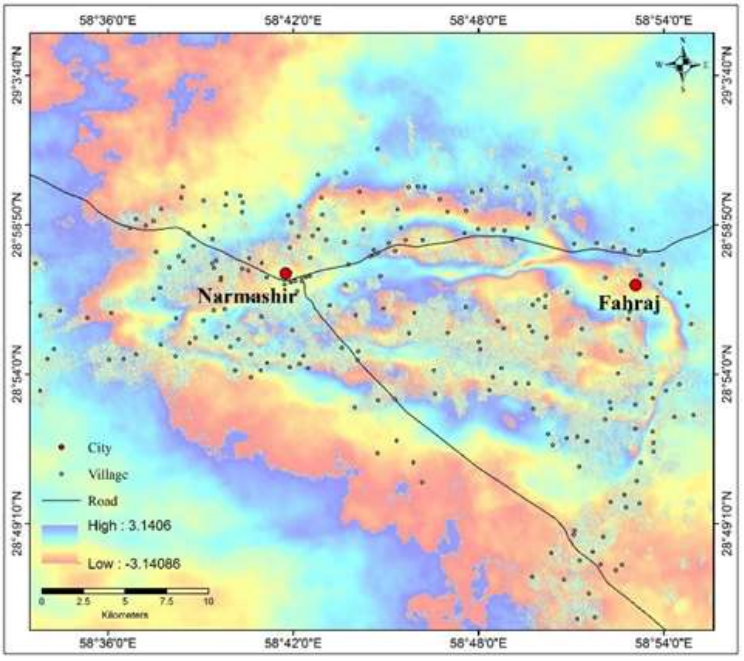

Figure 6. Goldstein phase filtering map of area

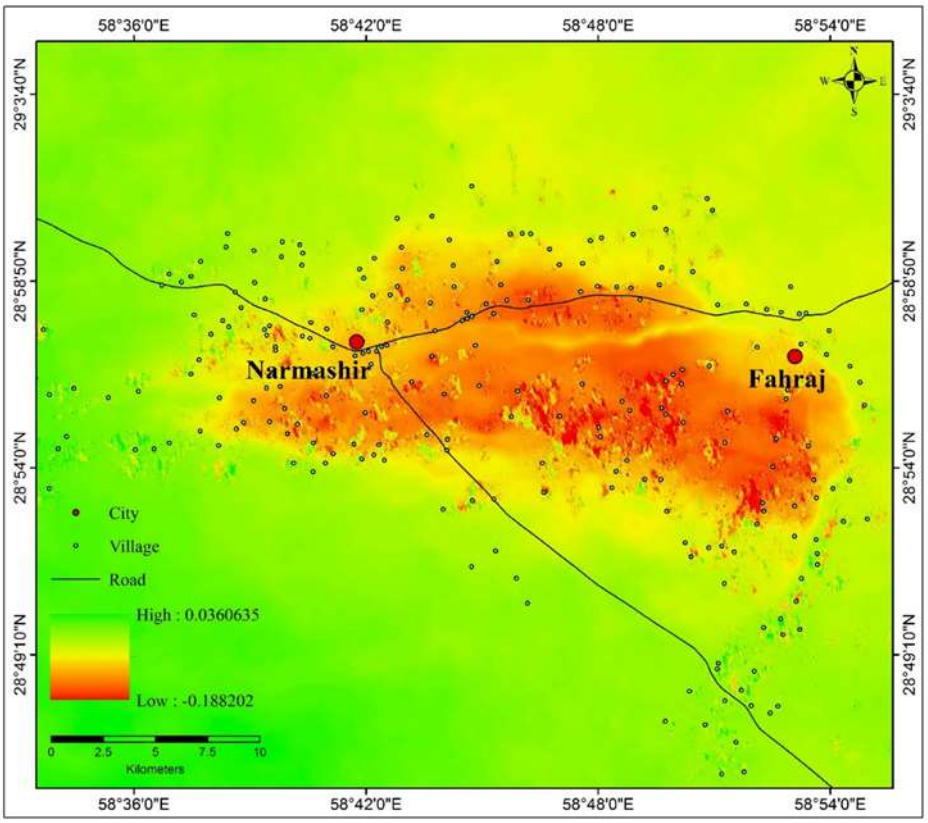

Figure 7. Land subsidence map

According to the vertical displacement (VV) map, the output obtained using the DInSAR technique is the maximum phase change related to orchards and fields. By taking into account these gardens and surrounding lands, which are the result of surface changes, on average in the Normashir Fahraj plain, we will be witness of 10 cm of landslide during 6 months, which is a very high number and an alarm for the officials of this region to manage. Groundwater abstraction as well as management, control, and efficiency of Nessa Dam. Because, if the necessary measures are not taken to supply the required water for drinking, agriculture, and animal husbandry from Nessa dam and control the amount of groundwater abstraction, we will be witness of aquifers destruction and many water problems as well as primary and secondary risks of land subsidence in the region. Therefore, it seems necessary to allocate sufficient water resources from the Nessa Dam in order to meet the water needs and water rights of the region's environment in the downstream areas. It should also be noted that due to the traditional irrigation conditions in the region, there is no proper transmission system to reduce the loss of incoming water to orchards and agricultural lands. Recent droughts in the country and the urgent need for water resources are more important and deserve much attention.

Unfortunately, the phenomenon of land subsidence, which has occurred in recent decades due to lack of surface water and uncontrolled abstraction of groundwater, has caused many problems for agricultural lands, residential areas, roads, and water supply canals (Salehi, 2013) and other infrastructure facilities in Iranian aquifers and many Piezometric wells water level drop shows a high correlation with land subsidence (Dehghani et al., 2015; Ahmadi et al., 2018) that finally after the completion of aquifer resources, damages such as unemployment and migration leads to farmers and causes social, economic and political crises. The present study, like other research by researchers on

land subsidence and the indiscriminate use of groundwater resources for agricultural, industrial, drinking, and other uses directly related to land subsidence in various regions, reveals the fact that, in the not too distant future with the depletion of aquifer resources, the country has many problems in the field of water supply that the relevant authorities must consider the necessary measures and take action before the incident and environmental and land cover changes can be due to human exploitation. Considered natural resources to provide their resources (Jamali et al., 2019).

3. Conclusion

What has been evaluated and studied in this study is the role of human intervention in geomorphological changes or in other words anthropogenic changes and due to the important role of humans in changes in nature, anthropogenic studies have been very important in this research. One of these changes in land subsidence is due to the uncontrolled abstraction of groundwater, which has been studied in the present study. The study area is Normanshir-Fahraj plain located in the east of Kerman province and located in Bam, Fahraj, and Regan cities, which in terms of climatic conditions is in the range of hot, dry, and desert climate, which in recent years due to the construction of Nesa dam and groundwater abstraction from its plain aquifer has subsided, which due to climatic conditions and water and agricultural needs, this amount of abstraction is much higher than the national average. To prove this hypothesis, using the radar data of the Sentinel 1 satellite, which was received at a time interval of six months, the amount of land subsidence and the area under subsidence in this area have been identified and calculated by radar differential interferometry. The results of data processing in SNAP software show that in this short period, 10 cm of subsidence has occurred, which is a very high number and shows that the amount of groundwater abstraction by wells drilled in the area was extremely high. Therefore, the role of human activities in this region that cause adverse effects in nature can be clearly seen in this study. Since the construction of dams is mainly aimed at regulating river water to prevent hazards such as floods and minimize damage, but unfortunately in most dams, this law is not observed and has played the role of closing the river water, which has created much more risks. In the study area, Nessa Dam has acted in this way and has created many problems and dangers in its downstream, which can be attributed to such things as the destruction of the region's environment due to not giving water rights to its downstream rivers, destruction, and drying of aqueducts in the surface of the drilled alluvial fan pointed to the forced withdrawal of groundwater, followed by subsidence, and other problems and secondary hazards. Therefore, in order to reduce the risk of land subsidence in Normanshir-Fahraj plain, it is necessary to think of necessary measures that can be used to reduce the harvest and use of groundwater, water needed for agriculture, livestock, drinking, and other uses through dam water sources. Groundwater supply and harvesting should be minimized, and in order to waste this surface water, it is necessary to build a proper transmission system. There is also a need to regenerate groundwater resources through aquifer feeding and bring the region back to its natural balance.

References

Ahmadi, N., Mousavi, Z., & Masoumi, Z. (2018). Study of subsidence of Khorramdareh plain using radar interferometry technique and its hazards. *Remote Sensing and GIS, 10*(3), 33-52.

Amighpi, M., Arabi, S., & Talebi, A. (2009). Investigation of subsidence of Yazd plain using radar interference measurement and accurate leveling. *Journal of Earth Sciences*, 20th year, 157-163.

Babaei, S. S., Mousavi, Z., & Roustaei, M. (2016). *Measurement of subsidence rate in Qazvin plain using radar interferometry technology between 2003 and 2010*. National Geomatics Conference.

Bock, Y., Wdowinski, S., Ferretti, A., Novali, F., & Fumagalli, A. (2012). Recent subsidence of the Venice Lagoon from continuous GPS and interferometric synthetic aperture radar. *Research Letter, 13*(3), Q03023, doi: 10.1029/2011GC003976 ISSN: 1525-2027.

Dehghani, M., Karmi, M., Hosseinizadeh, S. M., Sharifi, S. M., & Farhang, A. (2015). Investigation of

subsidence of Dindarloo plain with InSAR technique and its evaluation by water table decrease by Kriging method. *2nd Specialized Congress of Earth Sciences, Tehran*.

Fall Soleiman, M., & Hajipour, M. (2015). Spatio-temporal analysis of anthropogenic hazards of mines in Iran. *Journal of Spatial Analysis of Environmental Hazards, 2*(2), 51-33.

Fesharaki, P. (1978). Geographical distribution of agricultural products in Bam and Normanshir units (settlements of South Lut catchment basin). *Geographical Research*, (16), 1-18.

Jalini, M., Sepehr, A., Rashki, A., & Lashkaripour, GH. R. (2017). Analysis of Landslide Phenomena and Evaluation of Edaphic Factors Affecting the Morphology of Gaps Case Study of Neyshabour, The *First International Conference on Natural Hazards and Environmental Crises in Iran, Solutions and Challenges, Ardabil*.

Jamali, A. A., & Kalkhajeh, R. G. (2019). Urban environmental and land cover change analysis using the scatter plot, kernel, and neural network methods. *Arabian Journal of Geosciences, 12*(3), 100.

Jamali, A. A., & Kalkhajeh, R. G. (2020). Spatial Modeling Considering valley's Shape and Rural Satisfaction in Check Dams Site Selection and Water Harvesting in the Watershed. *Water Resources Management, 34*(10), 3331-3344.

Kagawa, A., & Furuno, K. (2010). Land subsidence monitoring system in the southeast part of Kanto groundwater basin, Japan. *IAHS-AISH publication*, 339-344.

Karimi, M., Ghanbari, A. A., & Amiri, Sh. (2013). Measuring the Risk of Urban Landslides from the Landslide Phenomenon (Case Study: District 18 of Tehran). *Journal of Geographical Spatial Planning, 1*(3), 37-56.

Mirshahi, F. S., Valadon zoj, M. J., Dehghani, M., & Hashemi Aminabadi, S. M. (2013). Measurement of land subsidence using radar interferometry technique using TerraSAR-X images.

Pacheco, J., Jorge, A., Eduardo, R., Moises, A., Vsevolod, Y., & Gil, O. (2006). Delimitation of ground failure zones due to land subsidence used gravity data and finite element modelling in the queretaro valley, Mexico. *Engineering Geology, 84*.

Parsasyrat, L., & Jamali, A. A. (2015). The effects of impermeable surfaces on the flooding possibility in Zarrin-Shahr, Isfahan Municipal Watershed. *J Appl Environ Biol Sci, 5*(1), 28-38.

Rafiei, J., & Sedighi, M. (2016). Determination of subsidence based on radar interference (Insar) in Naftshahr oil field, *National Geomatics Conference*.

Roozban, A., Ismaili, A., & Motaq, M. (2016). Investigation of land subsidence using differential radar interferometry (DInsar) using sensor images, SENTINEL *2nd National Conference on Spatial Information Technology Engineering, Khajeh Nasiruddin University*.

Salehi, R., Ghafouri, M., Lashkaripour, Gh., & Dehghani, M. (2013). Investigation of subsidence of South Mahyar plain using radar interferometry method. *Iranian Journal of Irrigation and Water Engineering, 3*(11), 57-47.

Sharifikia, M. (2012). Determining the extent and amplitude of land subsidence using radar interference measurement (D-INSAR) method in Nogh-Bahrman plain. *Journal of Spatial Planning and Planning, 3*(16), 77-55.

Sheikhi Koohsar, Z., Al-Modarressi, S, A., & Sarkargar Ardakani, A. (2014). Determining the amount and extent of land subsidence using radar differential interferometry in Yazd Ardakan plain. *21st National Geomatics Conference*.

Turani, M., Aq Atabai, M., & Roustaei, M. (2015). Study of subsidence in Gorgan city using radar interferometry method. *Journal of Spatial Planning*, 117-128.

Woods, A. M. (2007). *Quantifying the Relationship between Anthropogenic Disturbance and Biotic Integrity in the Adirondack Park*. Thesis of Environmental and Forest Biology, University of New York.