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Geo-Sequential Analysis Of Juniper Forest Ziarat

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Abstract

The state of Pakistan is showing immersive increase in population over the past few decades. Due to arid and semiarid climatic conditions the country is depriving in forested land. Juniper forest of Baluchistan province is one of few forest of province which contributed in forested land of country but unfortunately is listed in IUCN Red list. Juniper forest the aesthetic beauty and home for wild organisms is pushed backwards due to population growth, urbanization, deforestation, unemployment and climate change. The changes in the forest were monitored through emerging techniques. The present study evaluated the data of two decades from 1999-2009 and 2009-2018. 5 classes were identified in study area namely Water, Barren, Vegetation, Forest and Built up. The technique of Hybrid classification is used using Maximum Likelihood Algorithm. Various health indices like NDVI, MSI and SAVI were also calculated. The health indices result also supported classification data showing a regular decrease in forested land of Ziarat district. The accuracy for classified imageries for year 1999, 2009 and 2018 were 82%, 99% and 96% respectively, giving off the higher kappa values of 0.81%, 0.98% and 0.95% The findings of study indicated constant decrease in forested land and increase in vegetation and Built up class. Barren class was observed to be largest due to low rainfall. Climate change and human interruption are the main culprit in causing an irreversible damage to Juniper forest which if not combated could impose a huge threat in survival of Juniper forest Ziarat. Proper management and conservation strategies are necessary to be incorporated by Government to protect the natural asset.

Keywords: Classification, Health, *Juniperus cupressaceae*, Machine Learning, Indices

1. Introduction

Forest are mentioned as the landscape which comprises of native and natural tree stands, not including the agricultural used trees that can attain height of up to 5m and covers 0.5 hectors area (Kumari & Asok, 2017). Pakistan is situated in southeast region of Asian continent comprises of arid and semi-arid climate. In comparison to world forested land Pakistan only contributes to 4.8% to world forested land which makes up about 4.2 million hectors land according to 2020 World Bank data. This forest percentage of Pakistan is way too less than prescribed forested land by UNDP (United Nations Development Program) which is at least 25% per state.

Balochistan, the largest province of Pakistan occupying 44% of its total land (Fareen et al., 2010). Despite of having the largest land cover, the forest area in this province is very limited. One of the key and lone natural grown forests located in Balochistan is Juniper (*Juniperus cupressaceae*) forest of Ziarat. Ziarat land lies in semi-arid region having bumpy and rocky hills with steep landscape. The Juniper forest of Ziarat falls in the dry temperate region (Champion et al., 1965). Juniper trees provide great recreational site as it filters air, increase humidity, moderates micro climate of the area and increase ground water table by increased percolation and reduces soil erosion (Sarangzai et al., 2012). Ziarat lies in temperate region. The area is cold during winters minimum -9 0 C and pleasant during summers maximum 28 0 C (Holdridge, 1947). Ziarat lies outside of monsoon region so plenty of rainfall which this region receives is in winter season. The summer season is pleasant while winter is extreme. Average rainfall per year is 280-400 mm which mainly occur during winter season in form of snow, rain and hail. Maximum temperature in this area is 28°C in July and August while the minimum temperature is observed to be -9°C in the month of January. The most humid month in Ziarat is December with maximum 67% humidity. (Ali, 1966; Ahmed et al, 1990; Shah, 1978). High wind speed is observed in months of September and October. Soil has limestone which is usually thin and infertile (Sarangzai et al., 2012). Ziarat has world second largest reserve of Juniper. Juniper trees grow in harsh environmental conditions with low rainfall. Due to lesser rainfall only physical weathering of rocks occurs causing a thin layer of soil available for the growth of these trees. This Juniper forest is also mention as "Living Fossils" because these are slow regenerating and drought resistant trees. Some matured trees have the age range of 4000-5000 years (Sheikh, 1985). Balochistan has roughly about 141,000 hectors of pure *Juniperus excelsa* forests, out of which about 86,000 hectors of these are found in Ziarat and Loralai districts (Sheikh, 1985).

These forests provide many medicinal plants, recreational sites and habitat to local flora and fauna. About 90 plant species are utilized as curative agent by the regional people (Saranzai et al., 2010). *Juniper excelsa* is locally used for the treatment of jaundice, tuberculosis, flu, allergies, stomach ache, pain relaxant, antibacterial, treating urinary tract infection and fever (Emami et al., 2011; Saranzai et al., 2012). It is also used in making mood scents and leaves as incense (Achakzai et al., 2016).

The main threat of population growth on natural resource is forest degradation. As population increase, demand increase which imposes burden on resource causing over exploitation. Ziarat valley is facing the forest degradation since ages. But the intensity of deforestation phenomena has intensified since past few decades. The main factors causing forest deprivation are population growth, over grazing, illegal logging, disease and fungal attack and nutrient scares soil prone to erosion. Due to lack of livelihood in district the majority of population depend on forest to meet their basic needs. In winters massive logging for construction and fuel wood occur because of severe cold temperature in the region. Although natural gas is provided to the region but due to low pressure and uncertain supply local's moves back towards forest cutting. The prolonged drought condition in study area and frequent cutting of forest cause pressure on water availability and ground water recharge. Climate change, ground compaction due to deforestation, construction of new infrastructure and conversion of forest land to vegetation to fulfil the growing food demand on population bloom are considered the key points for deforestation. Timely analysis for detection of change in this resource is necessary for the proper analysis, monitoring and management. Ziarat Juniper forest has been enlisted in IUCN Red list of Pakistan as the most threatened ecosystem (Saraengzai et al., 2012). Population growth and urbanization are the main causes of deforestation. The *Pyrofomes demidoffi* (heart rot fungus) attacks on heartwood of *Juniper excelsa* which causes decay of trees. Over grazing and unlawful timber cutting also contributes towards the destruction of the forest. Many natural process like drought, climate change, insect and disease attack are also huge contributing factors for the worsening the forest situation. The cutting of juniper trees is also considered unsustainable for environment as it is extremely slow growing tree specie which takes minimum of 200 years to come to the stage of harvesting (Achakzai et al., 2016).

2. Materials and Methods

Maximum likelihood algorithm was used in supervised classification while K-mean clustering algorithm was used in unsupervised classification. For this study, satellite imageries of two decades (1999-2009, 2009-2018) was acquired from USGS Glovis (United States Geological Survey Global Visualization Viewer) with zero cloud cover using Landsat 4-5 and Landsat 8 OLI. 5 classes were delineated including Water, Forest, Vegetation, Barren and Built up. 200 random points were selected and monitored through Google Earth. Accuracy assessment was also conducted in end to eliminate any error and biasness.

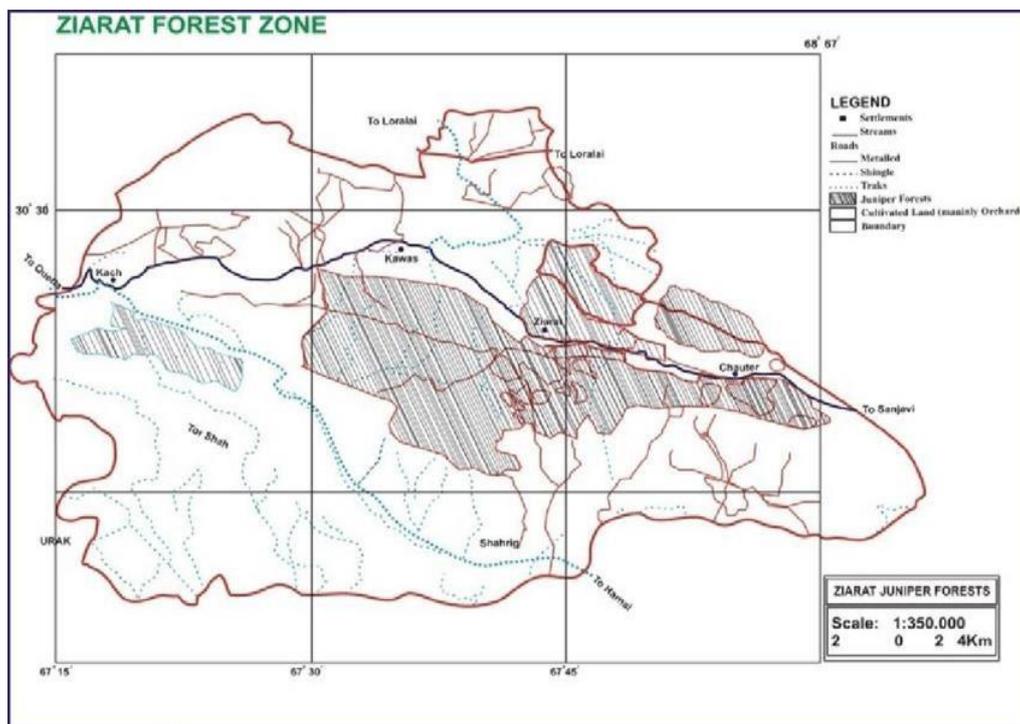


Fig 1. Ziarat juniper forest (Saranzai et al., 2012)

3. Results

Two hundred and fifty-six random points were selected in all 3 satellite imageries (1999, 2009 and 2018). The result of present study showed the accuracy of 1999 82%, 2009 99.22% and 2018 to be 96.88 %. The kappa value of 1999 image is 0.81563, 2009 is 0.9882 and 2018 is 0.9563 which shows the results to be highly accurate (Table 1).

Table 1. Accuracy and kappa value of classified imageries

Landsat image	Accuracy assessment	Kappa value
1999	82%	0.81563
2009	99.22%	0.9882
2018	96.88%	0.9563

The results of LULC change of Ziarat Juniper forest in 1999 indicates the barren land was most dominating class of the Ziarat district by covering 1914 sq.km of area while the recessive class was water which occupied only 1 sq.km area. The forest cover in 1999 image was discovered to be 792 sq.km which was the second dominating class followed by built up covering 14 sq.km area and vegetation cover was observed to be 5 sq. km as shown in fig 2.

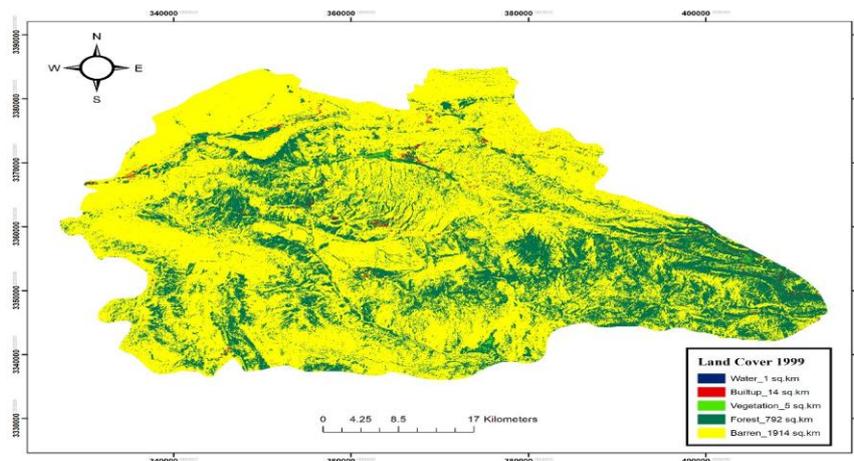


Figure 2. Land Cover Map of Ziarat District for Year 1999

The classification of Landsat image from the 2009 showed increase in the total surface water from 1 sq.km to 2.97 sq.km in 2009 because of breakage of long drought season in Ziarat. The total built up area shrank from 14 sq.km to 5.06 sq.km because of the deadly earthquake of magnitude 6.4 on 28 October 2008 which caused destruction of many houses in Ziarat district killing at least 300 people. The increase in agricultural practices and forest cover was seen 2009 classified image that is 17.80 sq.km of vegetative land and 972.39 sq.km of forest land was increased as compare to previous year. Barren land was also a dominating class in 2009 with total area of 1723 sq.km as shown in the figure 3.

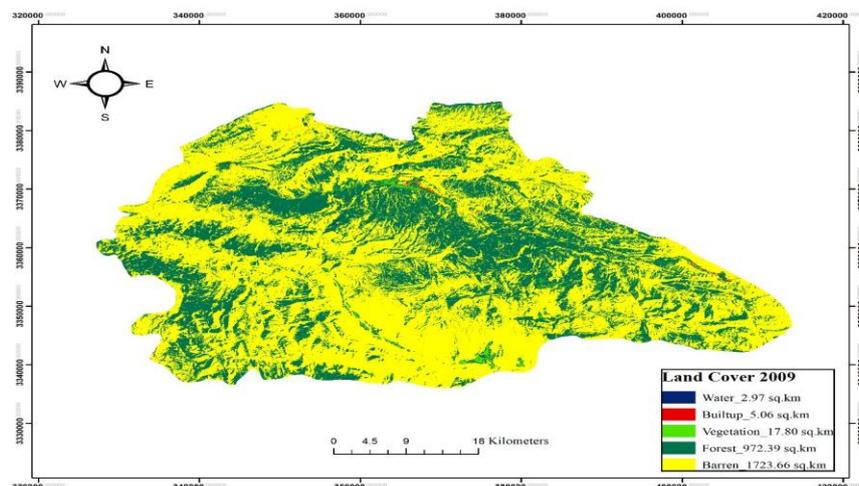


Figure 3. Land Cover Map of Ziarat District for Year 2009

The last classified image was from year 2018 which showed that majority of the study area is barren occupying 1697.02 sq.km area. The increasing trend was seen in built up and vegetation as compare to the previous decade while the total land cover area of forest and water was decreased. The total land cover area of water was 1.07 sq.km, built up was 11.31 sq.km, vegetation was 386.78 sq.km while forest was 625.85 sq.km as shown in figure 4.

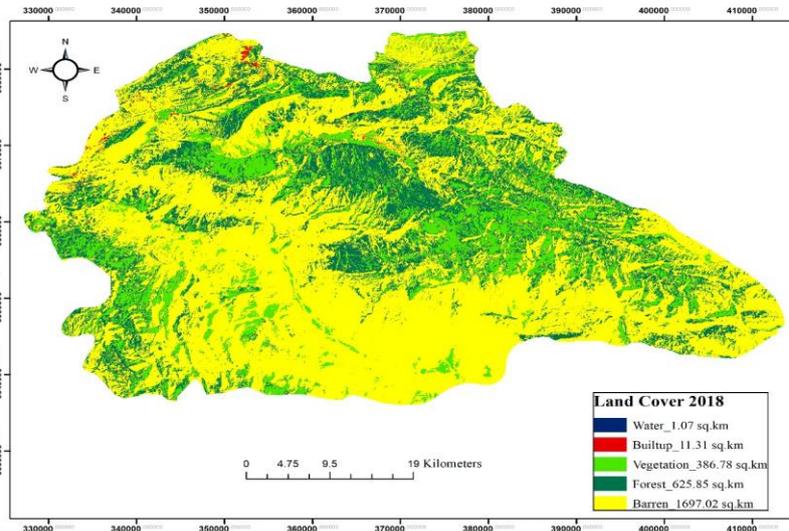


Figure: 4. Land Cover Map of Ziarat District for Year 2018

3.1. Change Analysis

A huge change was detected in various classes of Ziarat district in past 2 decades. All the classes showed changes and intermingled with the other identified classes. From 1999-2009 water class shifted in vegetation, barren and built up but majority area of water class was occupied by vegetation class that is 0.808396 sq.km (Table 2). Vegetation class converted into forest, barren and built up while 11.461386 sq.km converted into barren land. Forest class shifted into barren, vegetation, water and built up. Built up occupied 2.443029 sq.km area from forest class. Barren class converted a little bit into all 4 classes (Fig 5).

From 2009-2018 classified Landsat images showed shifting among all 5 classes but majority of the classes showed increase in this 10 years' time lapse. Vegetation, forest and barren class showed increase in their area that is from 2009-2018 forest increase in area by 418.473678 sq.km, barren class increase by covering the area of 1487.596654, and vegetation land increase by 17.488721 sq.km (Fig 6). These three classes also shifted to other classes as well. 10.023518 sq.km area of barren class converted into built up class while 3.995628 sq.km built up class converted into barren class. Majority of water class converted into vegetation class (Table 3).

Table: 2. Area shifting from 1999-2009

		2009				
		Water	Vegetation	Forest	Barren	Built up
1999	Water	0.009623 sq.km	0.808396 sq.km	0 sq.km	0.049442 sq.km	0.194373 sq.km
	Vegetation	0 sq.km	0.710913 sq.km	0.173514 sq.km	11.461386 sq.km	1.117808 sq.km
	Forest	1.587115 sq.km	2.14106 sq.km	13.341426 sq.km	0.779018 sq.km	2.443029 sq.km
	Barren	0.020082 sq.km	0.002403 sq.km	0.036132 sq.km	670.729578 sq.km	0.018075 sq.km
	Built up	482.214491 sq.km	2.959029 sq.km	4.658524 sq.km	298.734289 sq.km	1226.553028 sq.km

Table: 3. Area Shifting from 2009-2018

		2018				
		Water	Vegetation	Forest	Barren	Built up
2009	Water	0.789673 sq.km	1.654295 sq.km	0.055494 sq.km	0.529141 sq.km	0.002146 sq.km
	Vegetation	0.021476 sq.km	17.488721 sq.km	0.632433 sq.km	0.426066 sq.km	0.002147 sq.km
	Forest	0.236392 sq.km	348.104343 sq.km	418.473678 sq.km	202.376839 sq.km	0.657103 sq.km
	Barren	0.09924 sq.km	22.095629 sq.km	204.596018 sq.km	1487.596654 sq.km	10.023518 sq.km
	Built up	0 sq.km	0.099509 sq.km	0.276888 sq.km	3.995628 sq.km	0.985016 sq.km

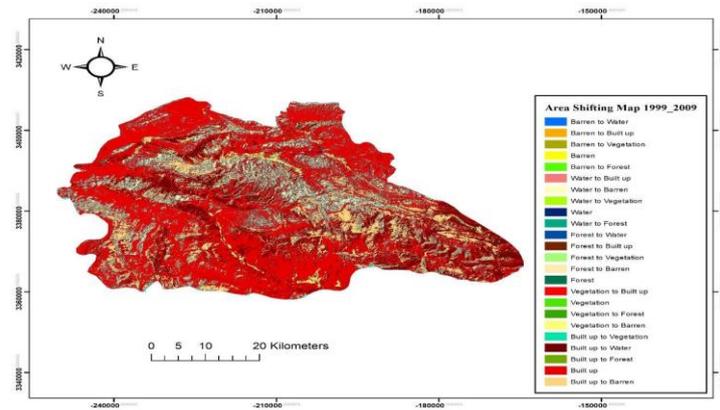


Figure 5. Area Shifting Map of Ziarat District from 1999-2009

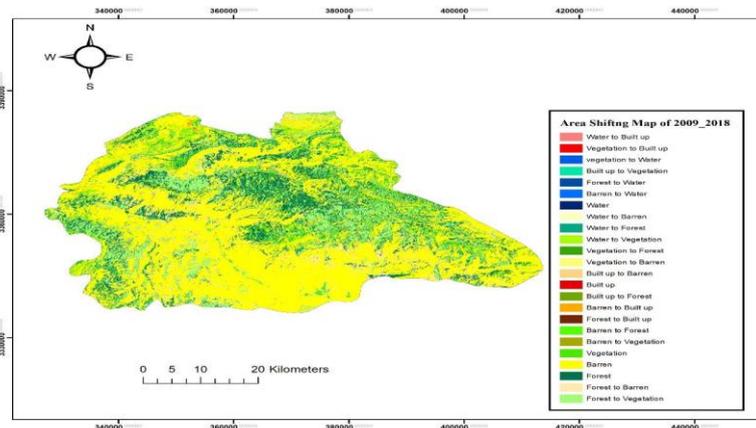


Figure 6. Area Shifting Map of Ziarat District from 2009-2018

3.2. Health Indices of Ziarat Juniper forest

The objective of assessing the health of forest is accomplished by using multi-spectral Landsat image that shows reflectance in visible and infrared light range. To analyse the health status of Ziarat Juniper Forest three vegetative indices was used namely as NDVI (Normalized Difference Vegetative Index), SAVI (Soil Adjusted Vegetative Index), MSI (Moisture Stress Index). These three indices were used to analyse 3 years’ data that is 1999, 2009 and 2018 respectively with the help of ArcGIS software. The spectrum from infrared to visible reflected light from plants were studied to examine the health of forest as different anthropogenic activities and virus attacks like Heart rot fungus and Dwarf milestone has deteriorated the health and coverage of Ziarat Juniper forest. Normalized Difference Vegetation Index (NDVI) NDVI shows the natural vegetation cover and is widely use in analysis. The minimum and maximum values of three years’ data was calculated that is of year 1999, 2009 and 2018.

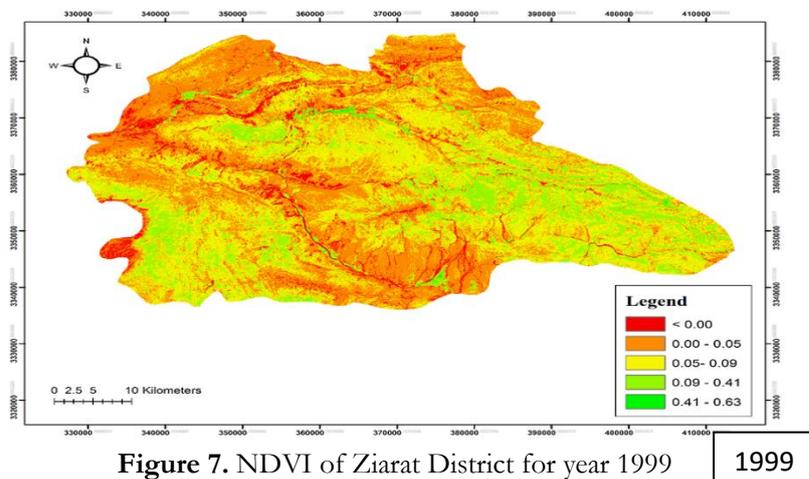


Figure 7. NDVI of Ziarat District for year 1999

1999

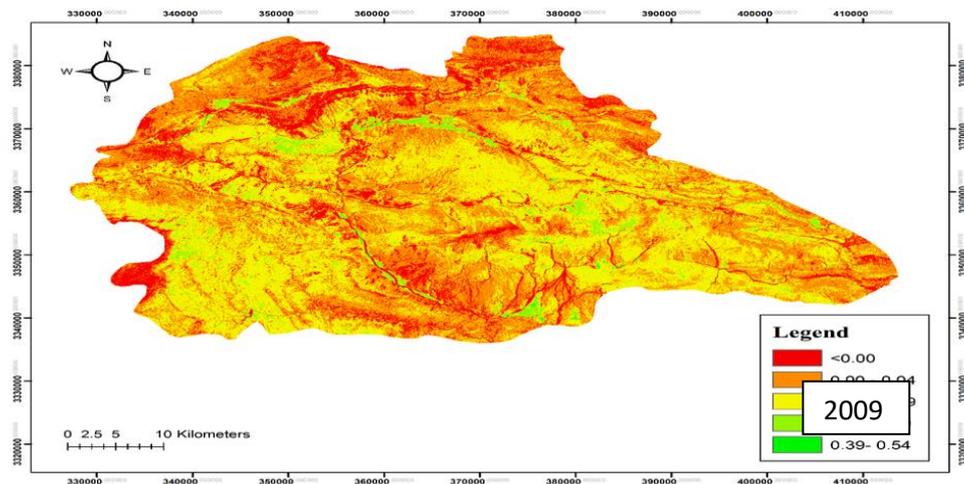


Figure 8. NDVI of Ziarat District for year 2009

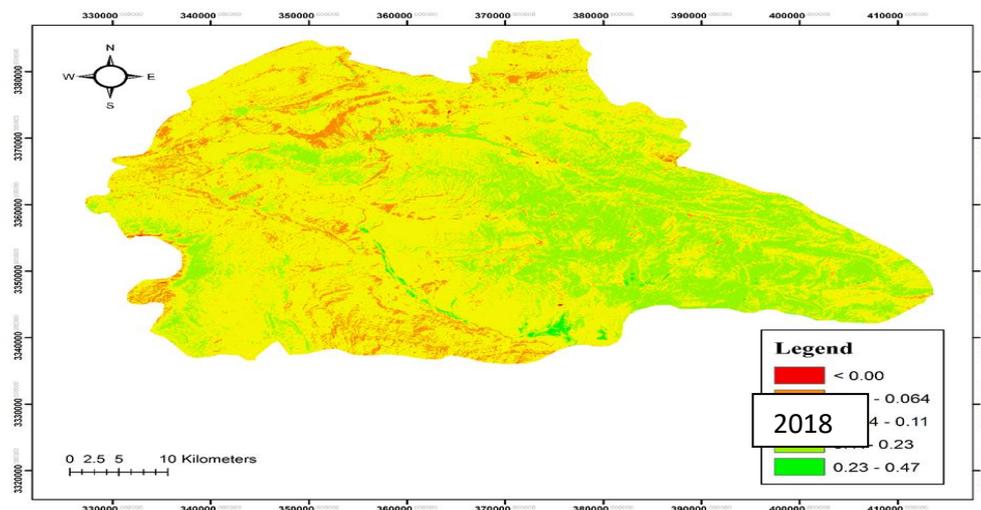


Figure 9. NDVI of Ziarat District for year 2018

NDVI inspect the link between spectral variability and change in growth rate. It measures the canopy by calculating the reflectance in Red and Near Infrared wavelength. NDVI value shows decrease from 1999 till 2018 (Fig 7-9). The highest recorded value of NDVI is 0.63 recorded in 1999 while 2018 results show the value of 0.47 which is far less than 1999. This suggest the change in health of vegetation cover.

The lowest value was found because the reflectance from soil was high. The less vegetative soil produces high value in red band and low value in NR showing low NDVI value. NDVI values vary with the absorption of red light by plant chlorophyll. Diseased and dead plant reflect back the red light resulting in lower NDVI. So the results show the subsequent decrease in the health and density of juniper forest.

3.3. Soil adjusted vegetation index (SAVI)

SAVI shows result for areas where soil is exposed and vegetation is low. It minimizes the effect of top soil on the forest and vegetation. In current study soil factor ($L=0.5$) was considered because of intermediate forest canopy in Ziarat. SAVI gave the same results as NDVI i.e. gradual decrease from 1999 to 2018. The maximum value of SAVI was observed in 1999 to be 0.94 which decreased to 0.70 in 2018. The higher value of SAVI indicates in leaf area which means that in 1999 the forest area of Ziarat was higher than 2018 image.

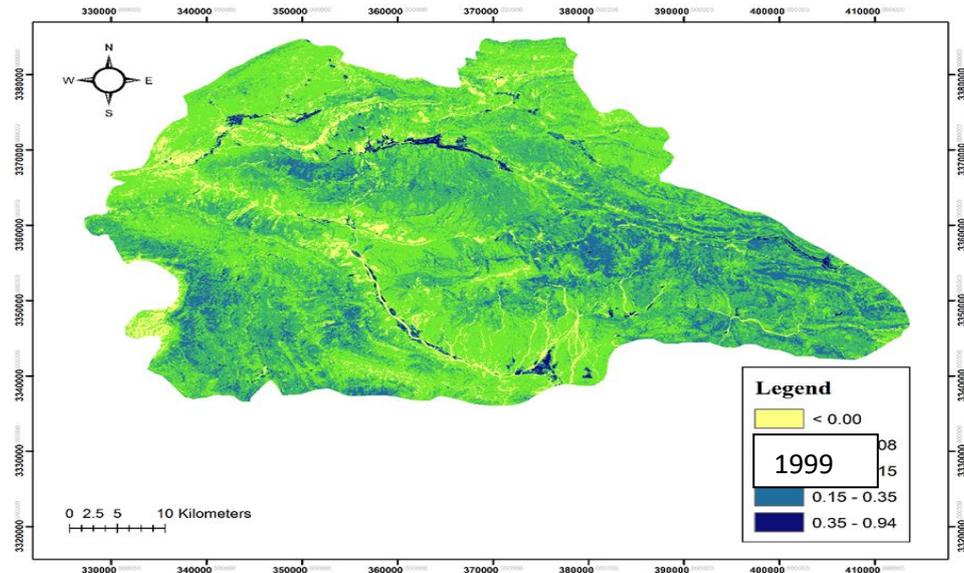


Figure 10. SAVI of Ziarat District for year 1999

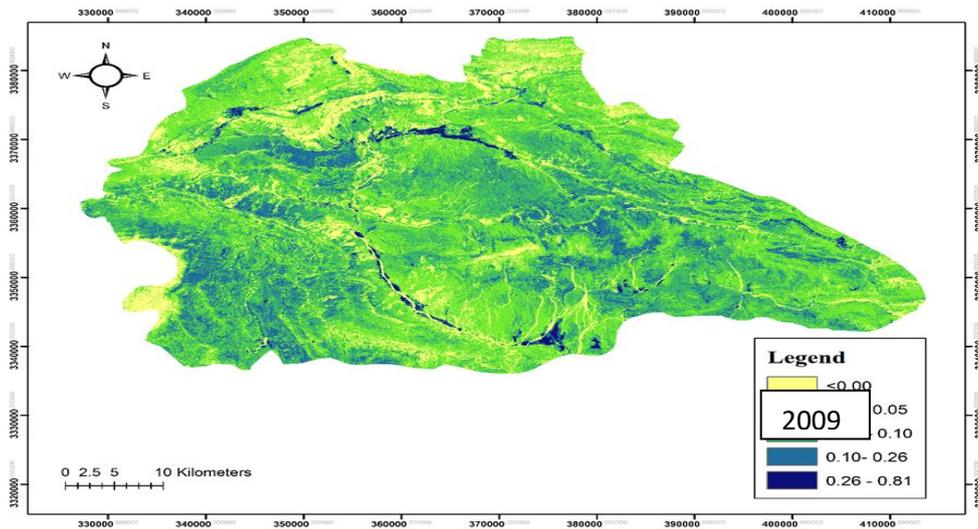


Figure 11. SAVI of Ziarat District for year 2009

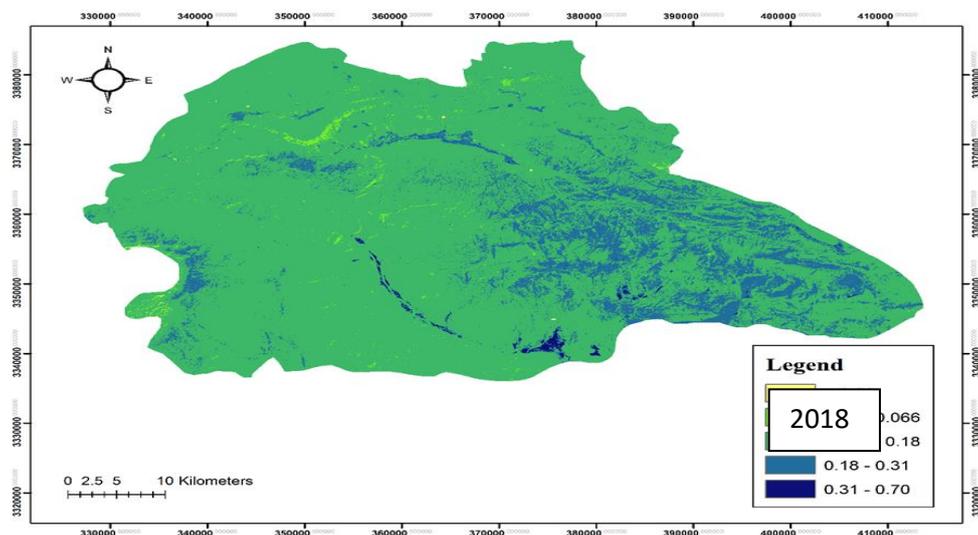


Figure 12. SAVI of Ziarat District for year 2018

3.4. Moisture Stress Index (MSI)

MSI depict the changes in content of leaf water based on near and middle infrared reflection. It is a useful index to calculate the stress of water in the plants. Usually the agricultural land shows lesser MSI value while barren and grassland shows higher MSI value due to water stress. In 2009 highest MSI value (13.4286) was recorded in most of Ziarat Juniper Forest. Majority of the moisture stress was noted in eastern side of study area which is reserved area for juniper forest and south-west region which comprises mainly of barren land and sparse juniper trees. The higher value indicates greater water stress and less water content (Harris, 2015). While in 2018 the moisture stress subsidizes to 4.07143.

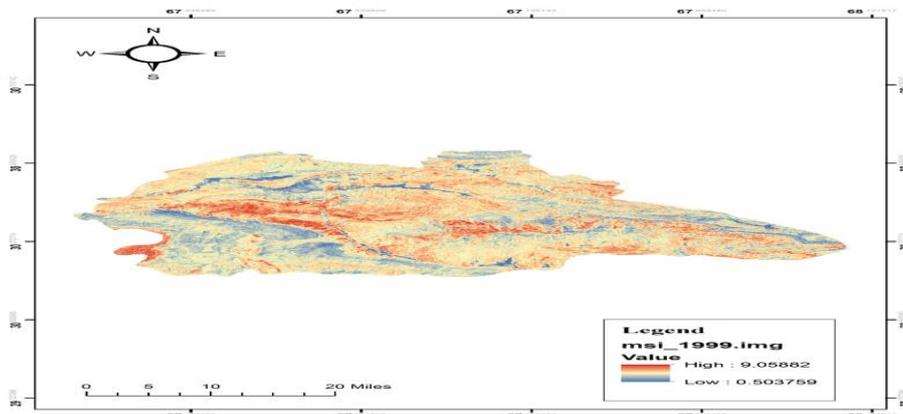


Figure 13. MSI of Ziarat District for year 1999

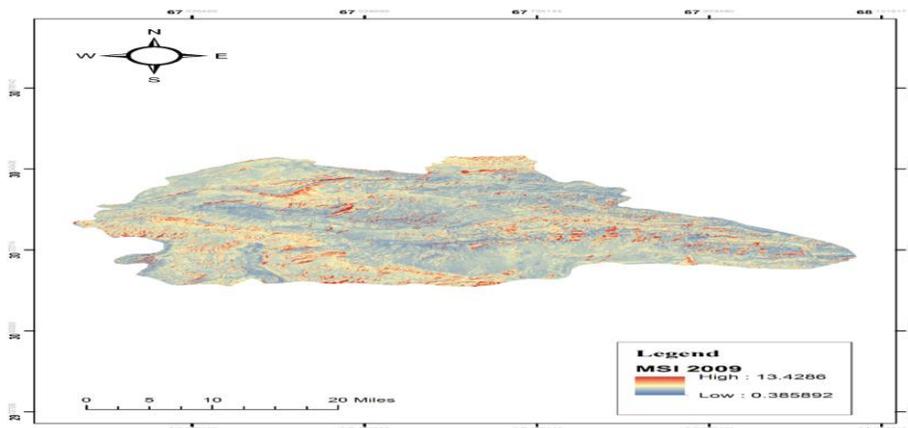


Figure 14. MSI of Ziarat District for year 2009

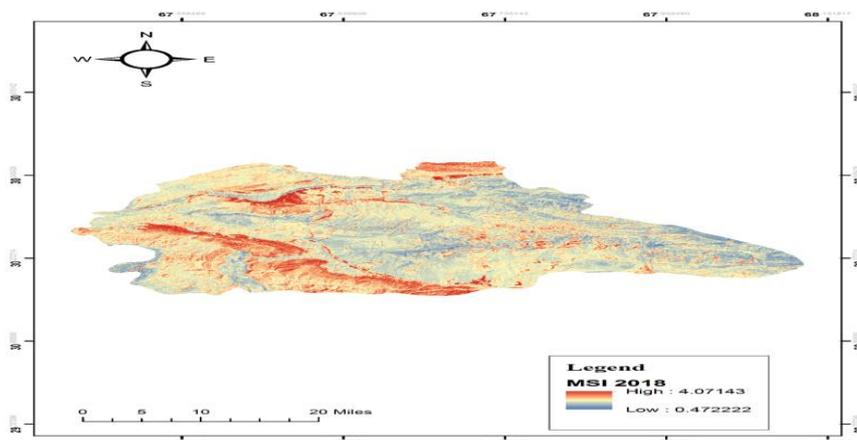


Figure 15. MSI of Ziarat District for year 2018

4. DISCUSSIONS

Approximately all the identified classes showed change and conversion to another class in past 2 decades' interval. The major class observed to be dominating on all three analysed satellite imageries was barren class because of lying in region with low rainfall. Except for the thin juniper forest no other dense tree canopy is found in this region. From 1999-2009 a little bit change occurred in barren class. While from 2009-2018 barren class majority area converted into forest, agriculture and built up. As forest and vegetation showed almost the same wavelength so it possible that some of forest class pixels mixed up with the vegetation class, however the classification of forest was carefully done through google earth engine. Barren class showed subsequent decrease from 70% to 62% from 1999-2018.

Water class was observed to be the most stressed class as compare to the rest of identified classes. It is because Ziarat is a drought prone region with a prolonged drought period from 1998 till 2004. While the year 2009 received subsequent amount of rainfall breaking the drought period increasing the surface water area from 0.03% to 0.07% in 2009. The 2018 analysis showed decrease in water class from 0.07% in 2009 to 0.03% in 2018. Majority of water class showed conversion in vegetation class.

Urban class was most difficult class to identify in classification. As majority of the house top were made of mud and wood which causes the built up class pixel to overlap with barren and forest class. The same issue was also faced by Jallat et al., 2021. The built up class displayed decrease in 2009 image to be 0.18% from 0.51% in 1999. This decrease is because of deadly earth quake experience of 6.4 magnitude in the region causing destruction of majority of house hold. The earthquake caused death of 300 people. While a massive increase of 43% was observed in 2018 due to excessive population growth in the region. The housing and population census of Ziarat district indicated the increase of 20% from 1980 to 2017 (Jallat et al., 2021).

Forest and vegetation class are the most crucial class in the present study. Both classes showed inverse relationship. Vegetation class showed increasing while juniper forest showed decreasing trend from 1999-2018. From 1999-2009 forest and vegetation class showed a little bit conversion in all other classified 3 classes, however forest class showed higher conversion in built up class. The results of forest and vegetation class were almost same as results proposed by Jallat et al., 2021. The current result indicated 7% decrease in total forest area from 1999-2018 which is approximately same as result shown by Jallat et al., 2021. Vegetation class also showed gigantic rise of 13.82% during the same period.

Sarangzai et al. (2013) research showed the unlimited use of juniper and herbs in making herbal medicines for treatment of various diseases. The habitat destruction of these plants and juniper due to over grazing and levelling of land for construction and agriculture and over exploitation of these plants without sustainable management was observed to be great stress causer to the forest. Sarangzai et al., 2013 research emphasizes on conservation and sustainable usage of these medicinal plants.

Secondly the soil composition of juniper forest is also loamy sand type which shows low to moderate water retention and low organic value. Sarangzai et al., 2012 research showed poor correlation between soil texture showing high dependency of forest on soil which is constantly disturbed by livestock, human behaviour and climate change live persistent and prolonged drought. Juniper forest also shows high rate of soil erosion due to clearing of forest and vegetation. Soil formation process is slow in study area because only method of topsoil formation is physical weathering. Jallat et al., 2021 study showed that carbon stock value of soil is higher than the forest in study area because of thin canopy of forest. But the carbon sequestration lowered since past few decades due to forest degradation.

Die-back phenomena in *Juniper excelsa* was also observed in overly matured trees by Sarangzai et al., 2012b. the reasons mentioned were either soil erosion which reduces soil fertility and water percolation resulting in insufficient supply of food to upper branches resulting in their death or the removal of marginal trees which causes trees growing on side fully exposed to the oppressive environmental condition making trees unable to withstand it causing death of upper tree branches commonly known as die-back.

Sarangzai et al., 2013 in another research linked the degradation of medicinal plants found in Ziarat district with the habitat destruction and land clearing due to lesser and no awareness. Gul et al., 2014 research showed positive correlation between deforestation and population gloom. Population increased caused reduction in Batsargai, Gohar and Sasnamana reserved juniper forest of Ziarat because of clearing of forest for population settlement. Among the locals regarding the usefulness of this natural resource.

Majority of the times 1 class mix with another class during analysis because of close spectral values like forest and vegetation which is tough to discriminate that's why other vegetative indices are convenient to eliminate these errors (Atesoglu, 2015).

The occupational opportunities are limited in the study area. Despite of marble mining no other source of income is present which causes residents to drift toward forest logging to fulfil their basic necessities. The linear forecast for the 3 decades till 2048 indicates decrease in forest and increase in vegetation and barren land (Jallat et al., 2021)

Current world population is 7.98 billion is expected to boost up to 12-13 billion in 2100 according to United Nations Population Division published in 2015 (Abel et al., 2016). Similarly, the population of Pakistan is showing the increasing trend of 2.3% per annum (Achakzai et al., 2013). The increasing population, urbanization and industrial bloom on earth makes the natural resources extremely at risk. The amplification of industries, apartments and agriculture has caused immense threat to forest, land and ecosystem leading to soil erosion, water logging and salinity. These unbothered issues intensify into global catastrophe like global warming and climate change which causes threat to survival of human and other organisms (Ray, 2011).

Vegetative indices NDVI is well used index in analysing the vegetative changes occurring in larger area. In current study NDVI is used along with 2 other vegetative indicator SAVI and MSI to strengthen the generated result. Secondly NDVI is affected by non-vegetative features like sunlight angles, shades, topsoil, cloud cover and agriculture. These feature could affect the validity of data that's why some other indices are also used to eliminate such occurring's. The NDVI results indicated majority of study area to be barren. The maximum value of NDVI occurred in 1999 image to be from 0.41-0.63 covering sparse area. According to Bid, 2016 the healthy vegetation shows NDVI value greater than 0.5 but the current study showed maximum NDVI value of 0.63, 0.54 and 0.47 in 1999, 2009 and 2018 respectively. The data evaluate the 46 decrease in forest canopy, conversion of forest into barren and unhealthy and diseased state of forest. Many researches previously done pointed towards the outbreak and fast spread of different fungal and parasitic diseases in juniper forest of Ziarat. Batool et al., 2012 stated that branch snag and root connection is the main cause of transmittance of heart rot fungus among the juniper trees in Ziarat. It was recorded that stem of trees are more prone to damage then branches. Fully fledged trees show resistant toward the infection while the immature ones aging 10-15 years are completely demolished in 3-4 years which is a main threat for the growth of plant. Archeothobium oxycedri (Dwarf mistletoe) and die-back phenomena also damage juniper forest strength and growth (Sarangzai et al., 2012). The major cause of dieback is lack of nutrients in soil which results in inadequate supply of food to upper braches of trees causing their death. Forests result in water recharge. The higher amount of forest results in larger ground water resource of region. As forest decreases ground water resource also reduces resulting in water stress. The NDVI results support the result of hybrid classification which indicates reduction in forest cover. The second possible factor of lower NDVI value is due to needle shape leaves of juniper. NDVI shows positive correlation between chlorophyll and Leaf Area Index (LAI), higher leaf surface area results in high NDVI value. The lesser leaf area might be contributing factor in low NDVI value.

SAVI vegetative index is used to eliminate the impact of soil from the vegetation. It was developing to enhance NDVI. Lower value of SAVI indicates exposed soil while higher value indicates dense canopy. The ranges of SAVI showed pretty much the same result as NDVI where the highest value is observed in 1999 image to be 0.94 which delineate to 0.70 in 2018. This result showed the reduction in juniper forest. The highest SAVI values were observed in the region where agriculture practices are common means in south-eastern and northern region of study area. While the eastern and western region of study area where juniper forest is present showed lesser SAVI ranges indicating thin forest canopy and higher soil covering. SAVI provides a clear data about the actual plant patches present in research area and validates the results of NDVI but it offers universal soil line for all soil types which gives least data about the soil configuration (Rondeaux et al., 1996).

MSI index is used to determine the water stress on the vegetation. MSI also act as drought index as it provides data on water stressed plantation. Usually the water stressed class is area that comes outside of the agricultural land. The high MSI value is shown in 2009 to be 13.4286 however fig 5.1 indicates the highest rainfall in 2009 as compare to 1999 and 2018. Secondly the temperature of the study area remained to be average throughout this period with negligible change which won't be a contributing factor in increased MSI value.

5. Conclusion

The results showed the change in vegetation in the 2 decades' results. Main focus of the study was to analyse juniper forest that decreased 31-29%. Increasing trend was seen in vegetation and built up. While water and barren was decreased. The temperature didn't show any effect on the Juniper forest but water shrinkage and expansion of poor agricultural practices has incorporated a negative impact on juniper forest. The research study would be able to provide data for management and conservation studies

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