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Evaluating urbanization impact on stressed aquifer of Quetta Valley, Pakistan

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ABSTRACT

This research is focused on the land use/land cover (LU/LC) changes impacts on the groundwater table and urbanization trend of Quetta valley for a period of 10 y. The land cover changes are occurring locally, regionally, and worldwide, which results in the expansion of urbanization trend and groundwater table depletion. Population growth leads to fast change in land use patterns, which increases the demand for basic needs. Urbanization and climatic impacts on depleting groundwater resources in Quetta need to assess and find a scientific solution using applications of the latest software. This study investigated the land cover changes in three categories, which were barren land, vegetation, built-up area by using maximum likelihood classification (MLC). Water table depletion was defined in five ranges from very low to very high by using the Kriging Method. It is inferred that the built-up area was increased the most in the last 10 y, that is, 2008–2018 as compared to other classes. The City area groundwater has been observed most of the depletion from 2008 to 2018. The selected Union Councils/Towns of Quetta District coming in the study area were City, Cantonment, Baleli, Kuchlak, Kachi Baig, Hanna, Shadenzai, and Saraghurgai were separated in polygons according to their boundaries to get the population density of each area. The Quetta city was found to be the most populated. It is imperative to inspect the land use change, water levels of current functional pumping wells, and population growth rate annually for its present management and future planning.

Keywords: Land use/land cover; Groundwater table; Urbanization; GIS; Remote sensing; Quetta; Pakistan

1. Introduction

Undoubtedly, water is essential for all living organisms [1]. Nowadays, people are consuming water for different purposes like drinking, agriculture, irrigation, waste disposal, industry, etc. [2]. Many countries are now facing the challenge of water demand due to rapid population growth, including Pakistan [3], India [4], Japan [5], Kenya [6], and Bangladesh [7].

Pakistan has plenty of surface water (128,300 million m^3/y) and groundwater (50,579 m^3/y) resources but the water storage per capita reduced from 5,600 to 1,000 million m^3/y due to mismanagement and contamination [8,9]. Pakistan Council of Research in Water Resources (PCRWR) has concluded that 84%–89% of water resources had been contaminated, which is an alarming situation in Pakistan for people's health and groundwater contamination [10]. The Rechna Doab, sub-catchment of Indus River basin in Pakistan, groundwater is declining every year and if the same scenario exists during the next 25 y, 10 m groundwater level will be decline. Rechna Doab lower parts the surface

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water is limited which will not only decline the groundwater level up to 10–20 m but will also salinize the water which will cost the groundwater pumping very difficult for farmers [11].

Quetta city rapid urbanization pattern impacted water table depletion which causes an interruption in water supply and as a result more tube wells/borehole connections are being set up locally which has increased the use of water and now made drinking water challenging in many areas. Consequently, the households fulfill their water demands by calling water tankers, which cost extra expenses. Groundwater decline in Quetta was first noticed in 1989 when a decline of 0.25 m/y was observed. The groundwater monitoring system was expanded in 1987 and at present Water and Sanitation Authority (WASA), maintains 10 automatic level recorders and several dozen monitoring wells [13].

Worldwide, many countries are affected by the land cover changes and urban growth rate but in Asia, the situation is very complicated [13]. Countries like Pakistan [14], China [15], India [16], Bangladesh [17], and Iran [18] are facing a rapid change of land use/land cover (LU/LC) due to the urban growth rate. Rapid urban development is becoming a threat to vegetation because it is reducing vegetation areas inside and around the cities [19].

Remote sensing is very helpful to recognize the vegetation and land cover changes [20]. Using remote sensing and GIS for LU/LC changes detection in few parts of southwestern Nigeria over 16 y duration from 1986 to 2002 concluded that the disrupted forest affected the large area of LU/LC in that area. The images were classified using the Maximum Likelihood Classification (MLC) method. It was observed that due to urbanization growth and economic affairs, the current land resources affected [21].

About one-third of Pakistan's current population is urban. However, that figure will rise to nearly 50% by 2025 [22]. The Islamabad, the capital city of Pakistan, the LU/LC changes relationship with urbanization were detected on satellite images from 1982 to 2012 by using GIS and remote sensing techniques. From this study, it was concluded that due to rapid urbanization and deforestation there was an increase in the built-up area, an agricultural area, and water body classes of LU/LC which has a broader impact on nature and the environment [23].

Due to rapid urbanization in the Quetta District, the demand for water is increasing and people are using different ways to fulfill the demand for water, for example, from tube wells, and boreholes which resulted in depletion of water level up to an alarming situation [24].

This research is an attempt to assess the LU/LC changes impacts on groundwater table level and urbanization trend of Quetta valley over a period of 10-y. Satellite images are classified and processed to quantify the LU/LC changes, which highlight an increase in urbanization in the central region of the Quetta valley. Rapid unplanned urbanization impacts could be severe for local natural resources like groundwater. The water table level differences and population density of Quetta valley (study area) were observed by collecting data from different departments, that is, WASA, Public Health Engineering (PHE), irrigation, PCRWR, election commission, and Bureau of Statistics.

2. Study area

2.1. Location description

Quetta, the capital of Balochistan province and comes in the top ten biggest cities of Pakistan. It is located between four mountains. Quetta, a rapidly growing city, lies between latitudes 30°–03′ N and 30°–27′ N and longitudes 66°–44′ E and 67°–18′ E.

The study area includes Union Councils/Towns which are central City, Cantonment, Baleli, Saraghurgai, Hanna, Kuchlak, Kachi Baig, Shadenzai extends to both east and north sides. The study area has a high population density due to Afghan refugees and rural people to urban area migration. The area extends from Kuchlak to the north of Takatu mountains, Shadenzai to interfering mound of Landi at the south, Chiltan mountain on the west, and Koh-i-Murdaar mountain to east (Fig. 1). Quetta is a trade center and commercial hub for the main trade route with Afghanistan and now has acquired global significance due to China–Pakistan Economic Corridor (CPEC) and soon linking Quetta with Gwadar port through railway to cater to future economic activities [25].

After the 1935 earthquake, Quetta city was designed for just 50,000–80,000 people. Till 1947, Quetta was a small town and people used to call it small London [26]. However, rapid population growth in terms of rural-urban migration increased the population growth. In 1980s, Afghan refugees helped to grow the slum area. New housing schemes in different areas increased the new settlement and it continues which turned Quetta into a populated city [27]. In 2017 census, Quetta has a population of over 1 million with Pashtun and Baloch majority, and Hazara minority with small other groups of community which give the city a multicultural feel [28]. Quetta is a groundwater-dependent city. A rapidly growing population, increasing groundwater depletion and changes in land use are considered the biggest challenges in this city.

2.2. Climate, geology, and hydrogeology

The Quetta valley has a semi-arid and continental climate characterized by summer and cold winters. Both the temperature and rainfall vary from season to season, the warmest month with the highest average temperature of the year is July (35°C) and the coldest month with the lowest average temperature of the year is January (–3.4°C). The average annual temperature is 15.8°C in Quetta. The average annual rainfall is 244 mm in Quetta. The month with the highest number of rainy days is March (6 d). Months with the lowest number of rainy days are June, September, October, and November (1 d) [29]. Fig. 2 shows the high average rainfall value 56.7 mm in January while 0.3 mm in September of last decade (2008 to 2018).

Quetta valley is situated at the height of 1,676 m above the sea level, while surrounding hills; it rises to 3,000 m. Quetta shape is bowl like and surrounded by the mountains, in which gaps between mountains are for roads and railway tracks. The northern Takatu Mountains lead towards Chaman Spin Boldak border with Afghanistan. The gap in Mashlak hills in the west lead toward Noshki to Zahidan border with Iran. The Chiltan hills gap through Lak passes in the south lead toward Mastung which opens the routes toward Kalat and Bolan Pass. The Zarghoon and Murdar hills in east–north lead toward Punjab through Loralai and Barkhan, respectively [30].

In terms of geography, Quetta District is mountainous and the terrain elevation varies between 1,254 and 3,500 m above sea level. The Mashlakh, Chiltan, Murdar, and Zarghoon are regarded as an important mountain ranges. The valley of Quetta is surrounded by the mountains of Murdar, Chiltan, Takatu, and Zarghoon in which gaps between mountains are for roads and railway tracks. The northern Takatu Mountains lead toward Chaman Spin Boldak border with Afghanistan. The gap in Mashlak hills in the west lead toward Noshki to Zahidan border with Iran. The Chiltan hills gap through Lak passes in the south lead toward Mastung which opens the routes toward Kalat and Bolan pass. The Zarghoon and Murdar hills are located in the east–north and lead toward Punjab through Loralai and Barkhan, respectively [31]. Quetta is included into the Upper High Lands areas of Balochistan.

The depletion of the groundwater table is also a serious concern, which is depleting an alarming rate due to which Quetta city is facing a shortage of water and will no longer rely on groundwater. The city of Quetta is overgrowing while the water resources are limited and cannot sustain the demand for the existing population, agriculture, industry, and nature for a long.

3. Data source and methodology

The topographic thematic map was used, which includes the study area boundary of Quetta city, Pakistan with a scale of 1:50,000, sourced from USGS earth explorer website. The satellite images of Landsat 7 Enhanced Thematic Mapper Plus (ETM+) and Landsat 8 Operational Land Imager/ Thermal Infrared Sensor (OLI/TIRS) of 30 m multispectral data resolution were downloaded of December 2008 and November 2018. The ground truth data for LU/LC classes were in the form of reference points taken from the Global Positioning System (GPS) of 2008 and 2018 separately, used for the image classification and accuracy assessment.

The groundwater samples of 2008 and 2018 were all collected from WASA and PHE departments based on the location of the pumping wells. The data were available for

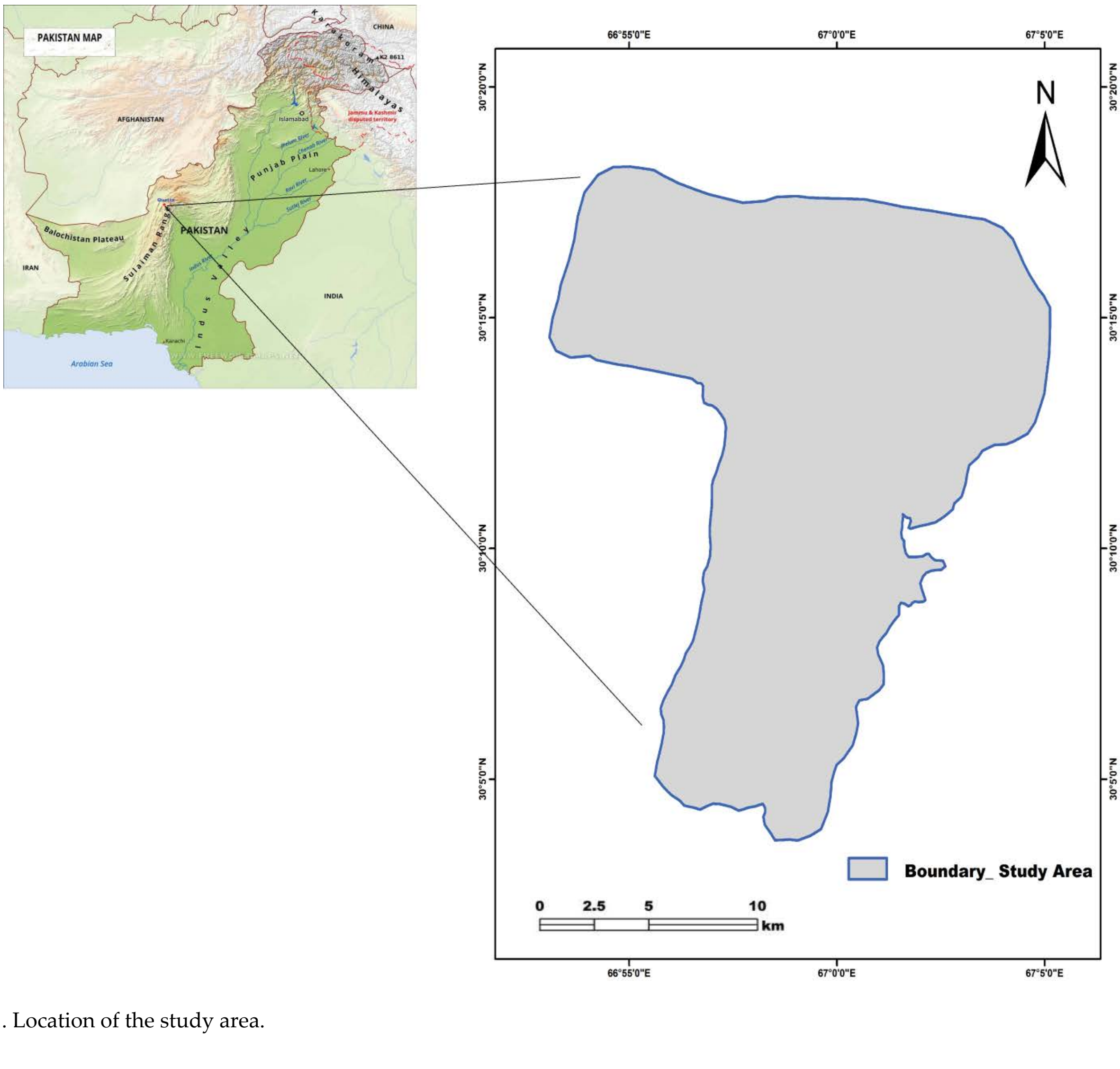

Fig. 1. Location of the study area.

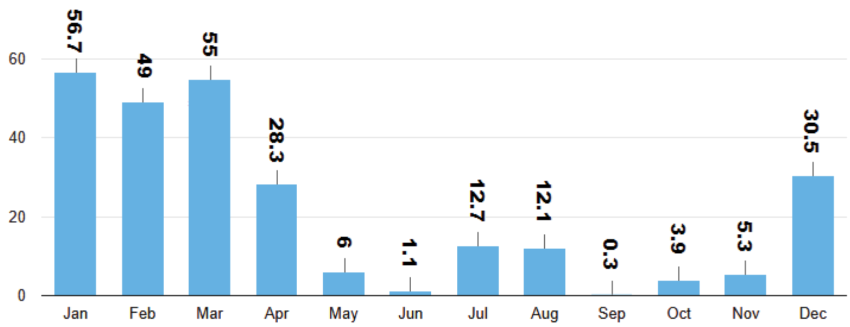

Fig. 2. Annual average rainfall (mm) at Quetta valley of last 10 y from 2008 to 2018 (Source: Pakistan Meteorological Department).

water from 131 pumping wells, out of 162 wells that were functional in 2008 and 2018. The data was used to identify the water table levels of different towns of the study area.

The maps of Quetta District Union Councils and Quetta city wards/towns were received from Deputy Commissioner, Quetta city office to get the exact boundaries according to the study area. The population of 2008 and 2018 data was collected from Election Commission of Pakistan regional office Quetta as well as Pakistan Bureau of Statistics regional office Quetta to find the population density of the study area.

3.1. Digital image pre-processing and supervised MLC

The satellite images pre-processing is essential before the change detection of classes to get the result according to the ground truth. The Digital Elevation Models (DEMs) (2008 and 2018) were classified using ArcGIS software. The polygon shapefile data layer of the study area boundary was added according to satellite images coordinate system to pre-process the image through mask extract (Spatial Analyst Tool of ArcGIS) by cropping the required area in order to define the study area boundary and to assign the different spectral signatures of different LU/LC classes. MLC is the most widely used method. Among them, MLC is considered the most accurate classification scheme [32].

The supervised MLC method was used by taking around 120–150 training samples of each LU/LC classes. The training sample numbers differed from each of the classes of LU/LC in color according to the class identity and discrepancy. The defined classes were barren land, vegetation, and built up area as depicted in Fig. 3.

3.2. Post-classification

The post-classification was done based on ground truth for the precision of LU/LC classes for the accuracy and elimination of errors. The comparison of the classification results with ground truths, the correction, and modification were made. The maps of 2008 and 2018 were compared a complete result of the classified class change was obtained.

3.3. Accuracy assessment

Accuracy assessment of each of the classification types was done to get accurate change detection. It is a very important and pivotal part of image classification for precision. It was done to compare the ground truths vs. the change results. Accuracy assessment of each classification is important if the data is helpful for change detection analysis. In this research, accuracy assessment was done for the year 2008 and 2018 maps by considering ground truth data.

3.4. Water table level detection by Kriging method

In total 131 functional pumping well data of 2008 and 2018 in excel file were transferred to ArcGIS shapefile of study area boundary using x and y coordinates. The Kriging method (interpolation) of the spatial analyst tool in ArcGIS was used to find the water table levels for the study area. A Kriging method is a geoprocessing tool that interpolates a raster surface from points using Kriging. The Kriging method has been found to be very useful for data analysis as it can control the statistical properties as well as it can create different maps like simple, prediction, probability, quantile, and ordinary. The Kriging method may be ordinary or universal depends upon the type of input information. The ordinary method is useful for developing interpolated maps while the universal method is useful for calculating probabilities. The water table level interpolation map of the study area was distributed into five different elevation zones. Each map of 2008 and 2018 of the study area were processed by using the Kriging method to find the difference in water table levels. The 2008 study area map water level ranges from less than 300 ft to more than 376 ft and the 2018 study area map water level ranges from less than 500 ft to more than 800 ft.

3.5. Population density of the study area

The source maps (un-georeferenced sourced layer) in which Union Council boundaries were cleared were translated into ArcGIS for georeferencing by adding control points to the referenced map coordinate layer of the study area boundary. The points were selected on the source data to enter the x and y coordinates (INPUT X and Y) as per referenced shapefile of the study area to lay it on the exact coordinates of the study area. After that, each of the Union Council boundaries, polygon shape was made and area was calculated by opening the study area layer attribute table from the context menu and another field of the area on the right side of the attribute table was added. By clicking on the

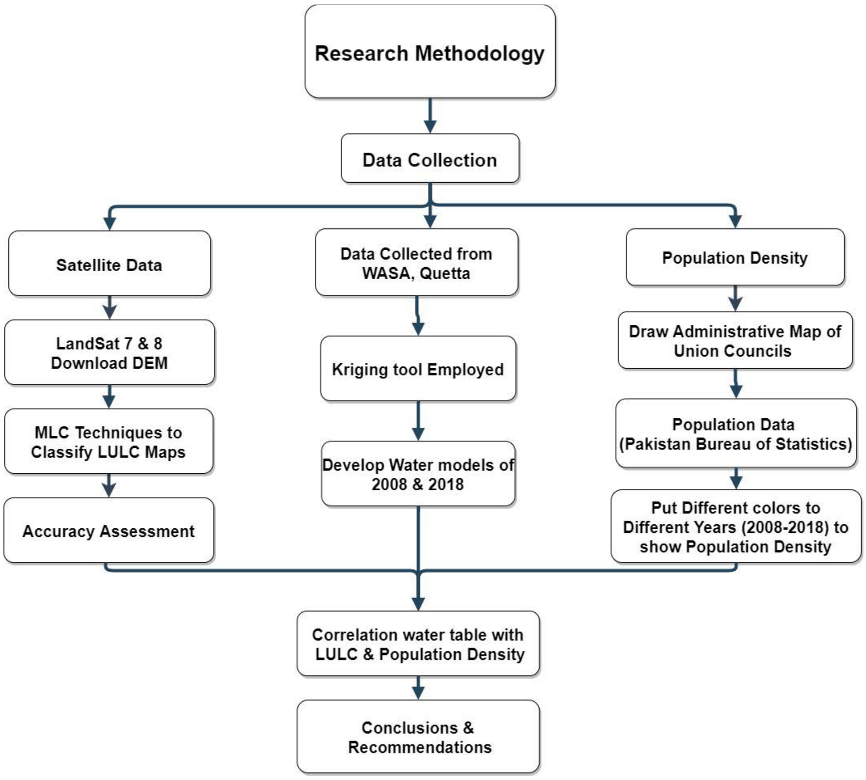

Fig. 3. Flowchart of the research methodology.

area field name, the entire column was selected, and then by the right click, the "calculate geometry" was selected from the context menu. In calculate geometry option, the field of area was selected in the property with GCS: WGS 1984 coordinate system and unit of a km^2. After setting all these properties by clicking on OK, the area of each Union Council polygon was calculated out of the study area. Population density of 2008 and 2018 was calculated by dividing the population (persons) by area (km^2) of each of the Union Council coming in the study area.

4. Results and discussions

4.1. LU/LC classification

It was observed that overall, there was 94% accuracy in the supervised classification of LU/LC changes detection (Fig. 5). The study area was divided into three LU/LC categories which were barren land, vegetation, and built-up area. The LU/LC classification of 2008 and 2018 is shown in Fig. 4. From 2008 to 2018, overall changes in the LU/LC classes differ with built up area experiencing the most increase and the barren land undergone the most decrease in the study area as shown in Table 1. The table shows that in 2008 the built-up area was 62.50% while in 2018, it was 77% and barren land in 2008; it was 14% while in 2018 it was 10.55%. Similarly, the vegetation was 23.50% in 2008 whereas in 2018 it was 12.45%. LU/LC changes are very complex and sometimes they are interlinked as one LU/LC class change can also expense the other LU/LC class. This study result also agrees with the result of the other study at Quetta, Pakistan that due to the urbanization growth rate the land cover changes increased on built-up area, which causes the depletion of water table level in urban areas and also reduced the vegetation [33].

After the classification, the accuracy assessment was performed for each class to estimate the changes and get an accurate result as the resulting data is for change detection. Therefore, it is very important to check the accuracy of every individual class. The results of 2008 and 2018 are compared with the satellite images of Landsat ETM+ for which the ground truth data likely consider. Overall, accuracy is collected by dividing the sum of the correctly classified sample units by the total number of the units. It is observed that, there is 94% accuracy in the supervised classification of LULC changes detection. This shows that these accuracy methods give highly accurate images than the MLC maps. These accuracy assessment methods are very important for the land use change modeling maps [34].

4.2. Groundwater table depletion

The study area was defined in five ranges of groundwater level based on functional pumping wells data as shown in Fig. 6. The ranges were categorized as very low, low, medium, high, and very high. The study area in 2008 water level range starts from less than 300 ft and ends to more than 376 feet with the intervals of the 25 ft differences in between the ranges. The study area in 2018 water level starts from less than 500 ft and ends to more than 800 ft with intervals of 100 ft in between the ranges. Fig. 6 shows that as compared to 2008, the depletion is increased

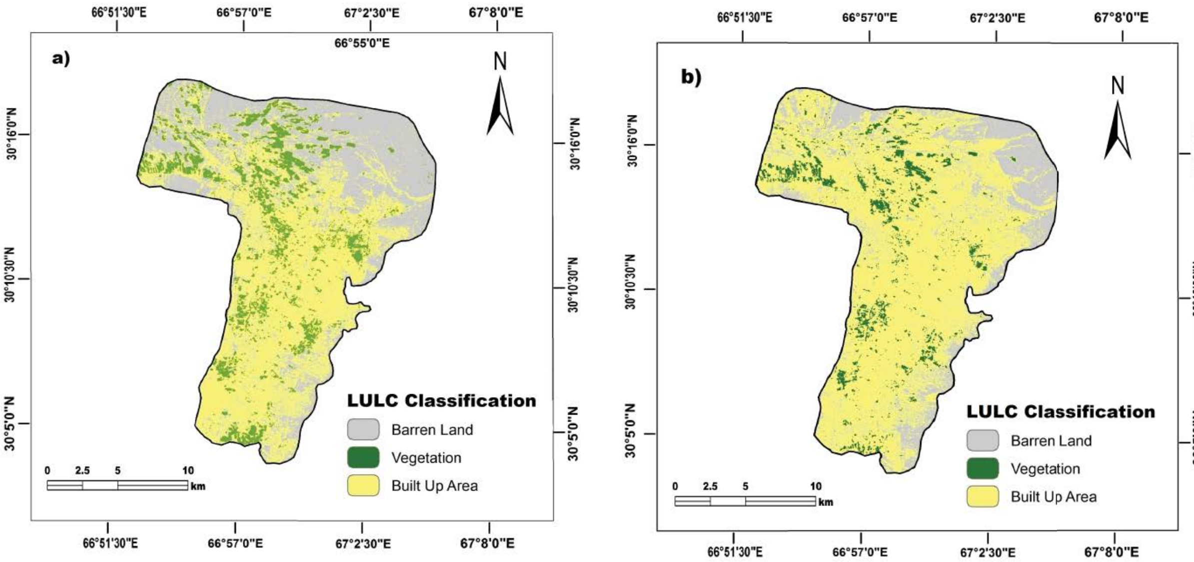

Fig. 4. Land cover changes classification of study area: (a) 2008 and (b) 2018.

Table 1
Land cover class covered area and percentage of study area (a) 2008 and (b) 2018

(a)			(b)		
Land cover class	Area (km²)	Percentage	Land cover class	Area (km²)	Percentage
Barren land	52.52	14%	Barren land	39.60	10.55%
Vegetation	88.23	23.50%	Vegetation	46.73	12.45%
Built up area	234.57	62.50%	Built up area	288.99	77%
Total	375.32	100%	Total	375.32	100%

in 2018 in all the parts of the study area. In Fig. 6, on the basis of the Union Councils/Towns of the study area it's shown that the graph bar of city area is affected the most in this span of 10 y whereas the Hanna area was affected the less due to little difference of water table level in between the 10 y. The previous study on the groundwater level of Quetta, Balochistan is evidence of this research study due to the increasing population growth rate and water supply-demand. The people are using different ways to get the water supply like tube wells, and boreholes, etc. which results in depletion of water table level to an alarming situation [12]. Also, [35] showed in their study that due to climatic changes in the future, that is, temperature increase and precipitation decrease at Quetta city there will be a scarcity of water and depletion of water table level.

4.3. Population density, area, and land cover classes

The selected study area was divided into the Union Councils/Towns to get the population density of 2008 and 2018 as shown in Fig. 8. The Union Councils/Towns area of Quetta District coming in the study area were City, Cantonment, Baleli, Kuchlak, Kachi Baig, Hanna, Shadenzai, and Saraghurgai. In Fig. 8, the population density legend was labeled from the lowest to the highest value. It has

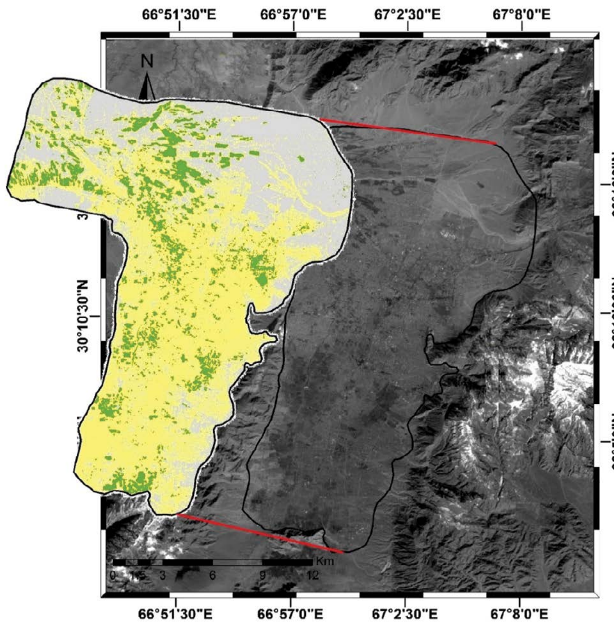

Fig. 5. Comparison of classified and satellite image for accuracy assessment.

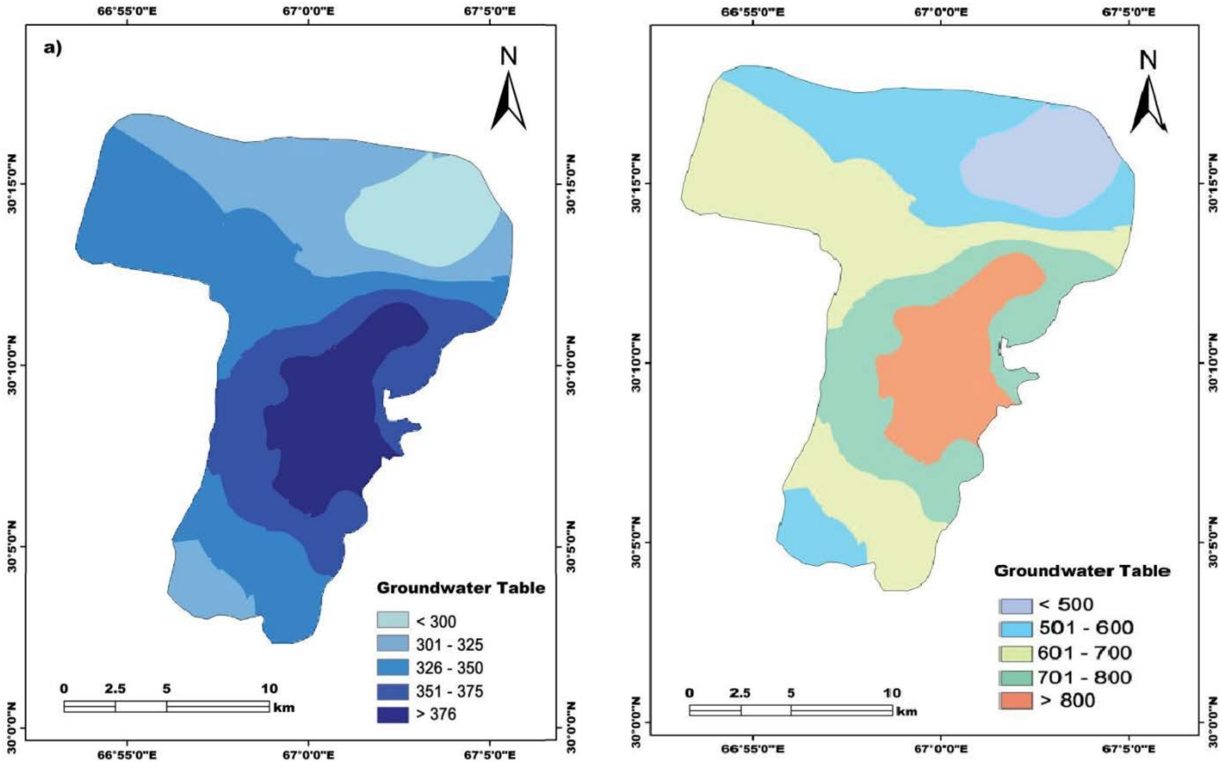

Fig. 6. Water table level ranges of study area: (a) 2008 and (b) 2018.

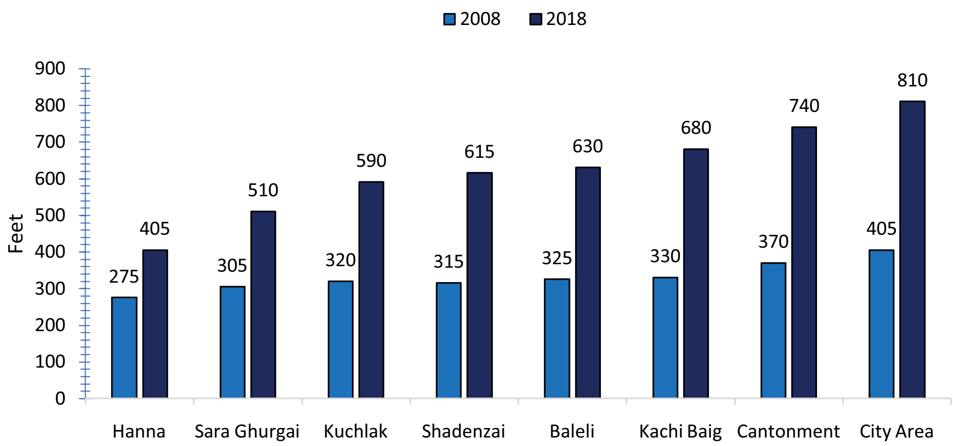

Fig. 7. Water table level of study area Union Councils/Towns (2008 and 2018).

shown that Saraghurgai was the least populated area and City was the most populated area from 2008 to 2018, which shows that there was an intensity in the growth rate at City area from the last 10 y of the research. In Table 2, the population density was calculated with the area and persons of each Union Council/Town coming in the selected study area, that is, Quetta valley. The population density was arranged in ascending order with respect to the Union Councils/Towns. The land cover classes, that is, built-up area, vegetation, and barren land was also compared in percentage with a population density of each Union Council/Town of 2008 and 2018 as shown in Table 3. It was observed that built-up area was increased in the study area due to population growth rate; vegetation was decreased with average and barren land was decreased in each area of the selected study area between 2008 and 2018. The previous profile report of Quetta District prepared by the Planning and Development Department of Balochistan Government in collaboration with UNICEF in 2011 is authentication of this research that the population was increased up to 62.5% by applying the annual growth rate (4.13%) to 1998 census [36]. The Pakistan Emergency Situation Analysis report in 2015 of Quetta District results also resembled with this study that population density with annual growth rate of 4.13% of the Quetta

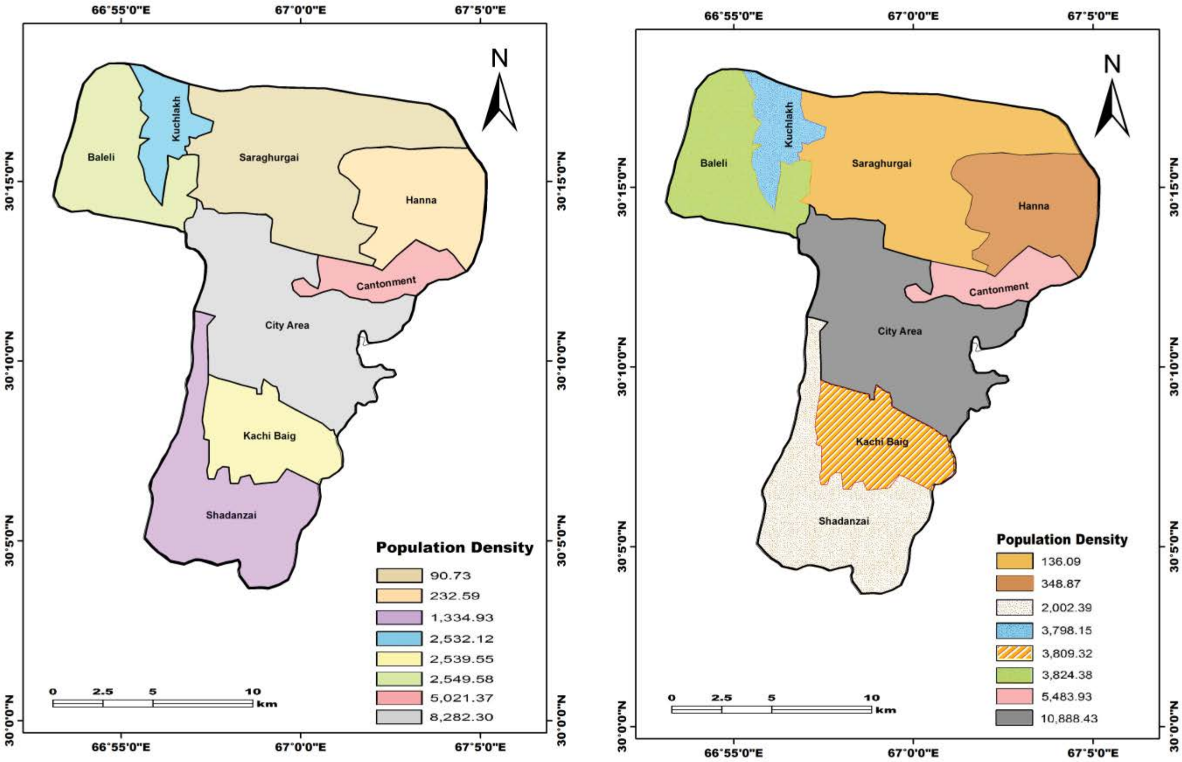

Fig. 8. Population density map of study area Union Councils: (a) 2008 and (b) 2018.

District in 1998 census was increased to 99% in 17 y till 2015 and same result per we have witnessed in 2017 census of Pakistan [37].

4.4. Relationship between LU/LC changes with water table and urban pattern

This study examined the relationship and future predictions between LU/LC changes with water table level and urban pattern from a total area of 375.32 km^2 of the study area and found that due to change in urbanization pattern the land use changes occurred which have increased the built-up area and decreased the barren land and vegetation as shown in Table 1. This increase in built-up area has affected the water table level. It was observed that due to population growth rate and rural to urban migration the groundwater level depleted in many areas of study area as shown in Fig. 6. LU/LC changes are complex mainly due to the urbanization growth rate. The land cover changes increased the depletion of water table level in urban areas and reduced the vegetation in the buildup areas of the city [33]. Population pressures are involved in creating environmental and hydrological issues such as to increase in solid waste production, a decline in water quality and quantity, and urban nonpoint runoff [37].

Urbanization patterns also have a connection with population density as the population will increase the change in LU/LC will also occur. As it is shown in Table 3, that due to an increase in population density (persons/km^2) the land cover classes are also differentiating from 2008 to 2018. With the results and analysis, it is now obvious that there is a relationship between LU/LC changes with groundwater table and urbanization pattern and in near future due to the rapid population growth rate there will be a wondrous change in LU/LC pattern with serious impact on groundwater level. LU/LC changes are really complex mainly due to the urbanization growth rate. The land cover changes increased the depletion of water table level in urban areas and reduced the vegetation in the buildup areas of the city [9]. The research explored that land cover areas with a high population density are less vulnerable to groundwater contamination infiltration but more stress on limited water resources [38].

Table 4 shows that the population density increases in every Union Council/Town because of the population increase in the next 10 y till 2028. The City area population density has increased from 10,888.43 person/km^2 in 2018 to 13,566.42 person/km^2 in 2028. This urbanization growth is due to the refugees, and rural people migrated to the valley, natural population increase, occupying barren land, urban areas geographical expansion, and conversion of small rural areas into small urban settlements. The provision of water supply, sanitation, and drainage are some of the significant entities of processes of urbanization and extremely effect resources of water and increases the pressure on urban hydrology [39]. As per the fact, the Quetta valley population is growing very fast which needs to be controlled to provide adequate facilities to everyone. It can be concluded that groundwater depletion is drastic, and the problem is getting graver due to many factors such as refugees, indiscriminate water mining, rapid urbanization, less precipitation, and increased population. The population of

Table 2
Area, population, and population density of the study area during 2008 and 2018 (Population Source: Election Commission of Pakistan)

Union Council/Town Name	Area (km^2)	Population 2008 (person)	Population density 2008 (person/km^2)	Population 2018 (person)	Population density 2018 (person/km^2)
Sara Ghurgai	86.19	7,820	90.73	11,730	136.09
Hanna	41.52	9,657	232.59	14,485	348.87
Shadenzai	57.26	76,438	1,334.93	114,657	2,002.39
Kuchlak	16.22	41,071	2,532.12	61,606	3,798.15
Kachi Baig	32.29	82,002	2,539.55	123,003	3,809.32
Baleli	41.55	105,935	2,549.58	158,903	3,824.38
Cantonment	16.80	84,359	5,021.37	92,130	5,483.93
City area	83.49	691,489	8,282.30	909,075	10,888.43

Table 3
Population density, groundwater table and land use/land cover classes gain/lost difference between 2008 and 2018

Union Council/ Town Name	Area (km^2)	Population density difference between 2008 and 2018 (person/km^2)	Groundwater table difference between 2008 and 2018 (feet)	Land cover class percentage difference between 2008 and 2018 (%)		
				Built-up area	Vegetation	Barren land
Sara Ghurgai	86.19	+45.36	–130	+27	–12	–15
Hanna	41.52	+116.28	–205	+20	–1	–19
Shadenzai	57.26	+667.46	–270	+20	–15	–5
Kuchlak	16.22	+1,266.03	–300	+30	–10	–20
Kachi Baig	32.29	+1,269.77	–305	+10	–9	–1
Baleli	41.55	+1,274.80	–350	+26	–6	–20
Cantonment	16.80	+462.56	–370	+11	–7	–4
City area	83.49	+2,606.13	–405	+10	–8	–2

Increase carries positive sign while decrease carries negative sign.

Table 4
Current and future population density expansion scenario of study area 2028

Union Council/ Town Name	Area (km^2)	Population 2008 (person)	Population density 2008 (person/km^2)	Population 2018 (person)	Population density 2018 (person/km^2)	Population 2028 (person)	Population density 2028 (person/km^2)
Sara Ghurgai	86.19	7,820	90.73	11,730	136.09	16,130	187.14
Hanna	41.52	9,657	232.59	14,485	348.87	20,413	491.64
Shadenzai	57.26	76,438	1,334.93	114,657	2,002.39	156,876	2,739.71
Kuchlak	16.22	41,071	2,532.12	61,606	3,798.15	84,141	5,064.18
Kachi Baig	32.29	82,002	2,539.55	123,003	3,809.32	166,904	5,168.90
Baleli	41.55	105,935	2,549.58	158,903	3,824.38	212,933	5,124.74
Cantonment	16.80	84,359	5,021.37	92,130	5,483.93	99,987	5,951.60
City area	83.49	691,489	8,282.30	909,075	10,888.43	1,132,661	13,566.42

Population density of 2028 is based on population and annual population growth rate of Quetta district Census 2017.

Quetta city is growing speedily while the water resources cannot meet and maintain the demand of the existing population of the city [40].

The built-up area is increased while the vegetation and barren land are decreased in each of Union Council/Town of the study area between 2008 and 2018. As in Table 5.3, the built-up area of the City is 75% in 2008 while it is 85% with an increase of 10% in 2018. Similarly, the vegetation and barren lands are 20% and 5% in 2008, respectively, while decreased to 12% and 3% in 2018, respectively (Table 5).

The Union Councils like Sara Ghurgai, Hanna, and Shadenzai are less populated as compared to the other areas because these areas are far from the urban center where the people like to live more due to facilities than in these

Table 5
Comparison of population density and land cover classes percentage of the study area 2008 and 2018

Union Council/ Town Name	Population density (person/km²)		Land cover percentage 2008 (%)			Land cover percentage 2018 (%)		
	2008	2018	Built-up area	Vegetation	Barren land	Built-up area	Vegetation	Barren land
Sara Ghurgai	90.73	136.09	20	35	45	47	23	30
Hanna	232.59	348.87	25	5	70	45	4	51
Shadenzai	1,334.93	2,002.39	60	30	10	80	15	5
Kuchlak	2,532.12	3,798.15	30	30	40	60	20	20
Kachi Baig	2,539.55	3,809.32	70	25	5	80	16	4
Baleli	2,549.58	3,824.38	35	35	30	61	29	10
Cantonment	5,021.37	5,483.93	75	17	8	86	10	4
City area	8,282.30	10,888.43	75	20	5	85	12	3

areas which in result have not disturbed the vegetation and barren land.

The comparison of two classified images explained that over 18 y of the period the forest reserve has decreased by 46.12% and the built-up area increased by 3.09% due to anthropogenic activities and rapid change in the ecosystem. The LULC occur which can be managed if human activities, subsistence farming, illegal logging, sustainable forest management are supervised in a proper way [41].

5. Recommendations

It is recommended that any observed changes in climatic trends should be incorporated in watershed management practices, whether that is in the context of an increasing or decreasing temperature or precipitation. The private tube wells and illegal residential boreholes are the reason, which is affecting the groundwater level significantly and, in the future, it will be alarming if serious steps are not taken by the administration to control the depletion. The administration must ban the illegal tube wells and installation of new tube wells. It is also recommended to develop sound conceptual and quantified models that explicitly link climate variability and change, population growth, and water demand in the Quetta city. Urban aquifer recharges techniques must be implemented to enhance the water table.

6. Conclusions

This study illustrates that Quetta valley is facing various environmental issues due to unplanned urban area extension, over groundwater exploitation, and high migration rate toward this urban center. The observed changes differ in each LULC class by keeping continual changes of increase and decrease over 10 y of the period, that is, 2008–2018. The built-up area with the highest percentage increased extensively in the last 10 y (62.50% in 2008 and 77% in 2018), which has reduced the vegetation and the barren land. The built-up area with the highest percentage increased extensively in the last 10 y, which has reduced the vegetation and barren land. The City area is the most populated dense area in which the population density is 8,282 person/km² in 2008 and increased to 10,888 person/km² in 2018 due to which the City area of Quetta valley is bearing more burden of population and required a lot of basic needs and facilities for the community living there. The climatic impact is significant in the local rainfall pattern in the last two decades which has affected the hydrological cycle and groundwater recharge.

This research work has fewer limitations about the availability of water table data of the entire valley and high-resolution DEM to classify LULC in detail.

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