



Spatio-temporal assessment of land use dynamics and urbanization: linking with environmental aspects and DPSIR framework approach

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Abstract

Urbanization is the main force of the global environmental as well as land use land cover changes (LULC). Urbanization is caused by prompt increase in population growth, migration, and urge for employment. In this study, Geographic Information System (GIS) was applied for the analysis and representation of spatio-temporal changes in LULC in Peshawar district and these results were linked with environmental aspects and Driver-Pressure-State-Impact-Response (DPSIR) framework approaches. For LULC classification, the Landsat freely available satellite imageries were used. The analysis revealed that the vegetation cover has increased from 37.8% of the total area to 71.3% during 1990–2020 and this change in vegetation is attributed to the government initiatives of Billion Tree Tsunami afforestation project after 2014 which has substantially decreased the barren land (from 66% in 1990 to 19% in 2020) in southeastern part of Peshawar district. Although, there was reduction in the vegetation cover in the past but due to extensive plantation between 2014 and 2020 resulted rapid increase in vegetation cover in the study area. The results of the present study detected a remarkable increase in built-up area which has increased almost 224.6% from 1990 to 2020. The study area population has increased from 2.12 million during 1998 to 4.26 million in 2017. The DPSIR results revealed that drivers and pressure have adverse effects on the carrying capacity of natural resources which have resulted deterioration of ecosystem. The resulted reduced capacity leading towards land degradation, loss of agricultural land, decline the groundwater level and resulted in pluvial flooding in Peshawar district. Government and environmental protection agency should implement the land use bylaws to reduce the rapid and unplanned urban growth and its negative impacts on natural environment.

Keywords Urbanization · GIS · Spatio-temporal · LULC · DPSIR framework

Introduction

Urbanization is the result of population growth due to natural increase and migration and urge for employment (Li et al. 2018; Jarah et al. 2019; Tombari Bodo 2019) that increase the demands for the settlements and infrastructure which forced the sprawl to merged the rural areas into urban areas

without prior planning (Balha et al. 2020). Urban sprawl is not only the increase in number of people, but it also increases the construction of residential and commercial area, transportation, demand of water supply and industrial activities which ultimately results into the removal of vegetation cover (Aliyu et al. 2017). The increase in all these aspects is directly or indirectly linked with environmental degradation. Population growth and built-up area results in conversion of agriculture land into commercial and built-up area. Urbanization and urban sprawl not only affect the local environment but it also affects the regional and global climate (Mao et al. 2018; Sun et al. 2018).

Urbanization triggers growth of residential area, infrastructure and recreational areas, and other public facilities over an agricultural land around the city (Izakovičová et al., 2017). Remarkable variations in land use land cover changes have been noted worldwide with the passage of time that significantly affected the local, regional and

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global environment (Ibrahim 2017). In ecological research, urbanization is directly linked with population growth, urban expansion, and economic development. Urbanization changed rural and agricultural land as well as trespassing over the vast forests of high productivity (Elmqvist et al. 2015; Parivar et al. 2021). The rapid urbanization has not only placed natural resources under stress and increased food insecurity but has also resulted capacity loss of soil's carbon sequestration as well as resulted vegetation loss. The rapid urban sprawl has adversely affected the environment and climate. The population pressure leads to poor solid waste management, wastewater sanitation, and emission of hazardous gases (Balha et al. 2020; Verma et al. 2019). The population growth results increase in vehicles which is the major source of greenhouse gases (GHGs) emission and consequently affect the climate of the area results in increasing the atmospheric temperature (Rahman et al. 2017).

In developing countries, the urban areas are facing the trends of rapid expansion and land conversion from agricultural to built-up, same is the case in Pakistan. In Pakistan, the total population influx was towards urban centers that has increased urban population from 17.8% in 1951, 32.5% in 1998, to 37% in 2017. In Pakistan, the rapid increase in population with average of 2.4% annually (GoP 2018) leads to conversion of agriculture land into built-up area. A specific strategy to cope with this challenge is two-fold, addressing the needs of both the urban and rural environments (Angelidou et al. 2018). Pakistan has experienced an extensive land use change in the last few years (Samie et al. 2017). The lack of proper land use planning and development activities drive has raised many environmental problems.

In Pakistan, few studies have been reported on the assessment of urbanization and detection of land use changes and monitoring of landscape. GIS and remote sensing play important role to analyze urban sprawl with its influences on environment (AbdelRahman et al. 2020). Different cities of Pakistan have been studied to assess and predict the urban sprawl patterns and urbanization trends using multi-stage remote sensing data; i.e., the Lahore district has been selected to analyze its urbanization trends (Mahboob et al. 2015), Faisalabad (Karami et al. 2018), Quetta (Bazai and Panezai 2020; Khan et al. 2020), and detection of urban expansion and changing land dynamics in Lahore and Bahawalnagar (Aziz et al. 2017; Parveen and Abdul 2019). Similarly, Mahboob et al. (2015) described the LULC changes in the mega city Karachi, Sindh. Many researcher studied the urban sprawl in Islamabad through multi-sensor and multi-temporal data to analyze the population dynamics and population patterns to predict the urbanization (Shah et al. 2021; Yar et al. 2016). Raziq et al. (2016) have investigated and monitor the urban sprawl, land use changes, and population dynamics in Peshawar city.

The occurrence of urban sprawl is more active in Peshawar due to its sharing social and cultural values with Afghanistan as well as more people from other areas of Khyber Pakhtunkhwa migrate here for seeking jobs, education, and health facilities. The population dynamics affect the local natural resources and climate of the area. The Peshawar district recorded highest population growth rate of 3.99% in Khyber Pakhtunkhwa, and the district population has increased from 2 million 1998 to 4.26 million in 2017 (Ullah 2017). In the absence of city planning and proper regulation, the city has been escalating in multi dimensions mainly along road corridors. Peshawar city needs an updated and approved land-use plan, linked to a master-plan for the city. These plans are essential for managing the rapid urbanization process that is underway, and ensuring necessary rural and agricultural zoning. Land-use zoning is especially important for protecting the local agricultural sector and strengthening the residential and commercial base of existing areas (Kamran et al. 2021). Many studies proved that Peshawar district facing the challenge of urban sprawl. Raziq et al. (2016) observed abrupt changes in all LULC classes, particularly in built-up area during 1999 to 2016. Khan et al. (2019b) demonstrated that the urban area is increasing temporally and barren land shows the declining trend in Peshawar district. The study further showed that the water bodies gradually declining from 2.05 km² in 1996 to 1.21 km² in 2016. At the same time, the urban area is rapidly amplified by 94.07%, 117.78%, and 322.65% with 1996, 2003, and 2016 respectively in district Peshawar. Samiullah et al. (2019) and Yar et al. (2016) have been reported increase in the urban land of Peshawar. The main aim of this study is to monitor urban sprawl and analyze the land use changes over the last three decades (1990–2000), (2000–2010), and (2010–2020) beside to find out the relationship of the trends of population dynamics with environmental degradation.

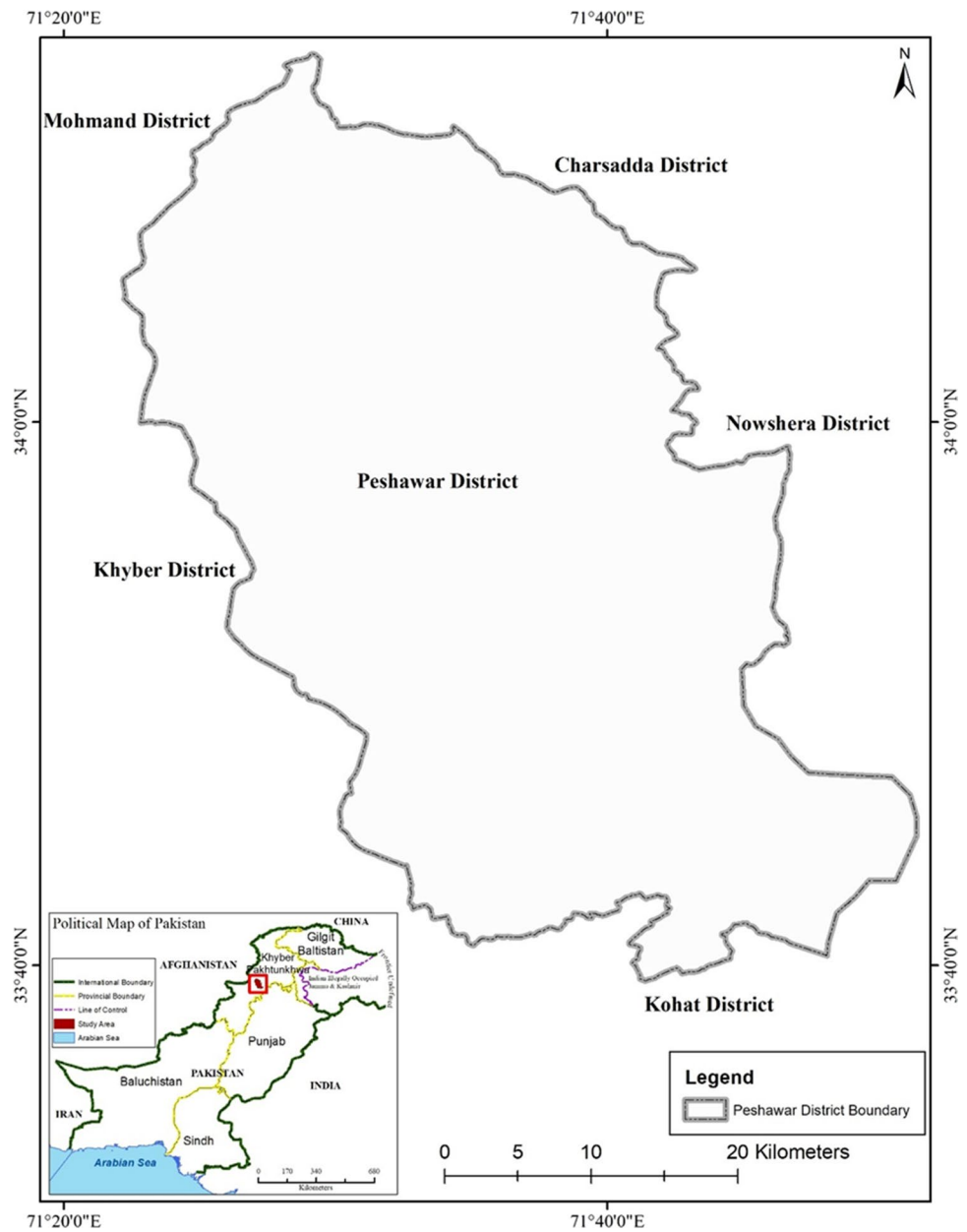
Material and methods

The study area

Peshawar is the largest city and provincial capital of the Pakistan's province Khyber Pakhtunkhwa. The Peshawar district lies in the southwestern side of the Peshawar vale close to the Pak-Afghan border which is approximately 40 km to the West. Peshawar district lies between 33° 44' to 34° 15' north latitude and 71° 22' to 71° 42' east longitude as shown in Fig. 1.

The Peshawar district covers an area of approximately 1216.17 km² which is about 1.69% of the total area of the Khyber-Pakhtunkhwa province. It comprises of 92 Union Councils and 346 neighborhoods/village councils. According to the recent census report of 2017, the total population

Fig. 1 Location of study area



in Peshawar was about 4.26 million, whereas the population density was around 1612.5 persons per km². The population comprises with the urban and rural population which is approximately 1.9 million and 2.2 million, respectively, as

shown in Table 1 (GoP 2017). Peshawar district is considered as densely populated district in Khyber-Pakhtunkhwa (Ullah 2017).

Table 1 Population distribution of District Peshawar (1998 and 2017)

Administrative unit	Population-2017	Population-1998	1998–2017 Average annual growth rate
Peshawar district	4,269,079	2,026,851	3.99
Rural	2,299,037	1,044,035	4.23
Urban	1,970,042	982,816	3.72

Source: GoP 2017

Data types and management

In the current research, the Landsat satellite images for the years 1990, 2000, 2010, and 2020 have been used. Further details of the image processing and classifications are given in the subsequent subsections. The qualitative data for Driver-Pressure-State-Impact-Response (DPSIR) framework was collected from the relevant departments and key persons using focus group discussion, expert opinion, and interviews method.

Landsat image pre-processing

GIS is applied for the analysis and spatio-temporal representation of LULC changes in the study area using Landsat imageries. The assessment of LULC changes in the study area was formulated by implementing supervised classifier

algorithms on each of the four Landsat images selected over almost 30-year period (1990–2020). Table 2 show the details of the images used in this study.

Land use classification

The land use and land cover classification have been performed by acquiring freely available Landsat satellite imageries of different dates. These satellite imageries have processed applying different atmospheric, geometric, and other image enhancement techniques. Image signatures have developed for supervised classifications, and the images were classified in categories namely built-up area, vegetation cover, water bodies, and barren land. Land use changes for the mentioned classes of the selected year were extracted according to the supervised classification. The detailed methodological framework is given in Fig. 2.

These results were then further analyzed for the identification of the temporal variations in the LULC classes using the following equation.

Where,

$$r = 100 \times \frac{A2 - A1}{A1} \times \frac{1}{t2 - t1}$$

- $t1$ is an initial time; $t2$ is the later time
- $A1$ is the class cover at an initial time

Table 2 Landsat data used

Years	Satellite sensor	Spatial resolution	AQ date	(WRS)
1990	Landsat 5 TM	30 m × 30 m	1990–10-08	WRS-2 150/37
2000	Landsat 5 TM	30 m × 30 m	2000–10-19	WRS-2 150/37
2010	Landsat 5 TM	30 m × 30 m	2010–10-19	WRS-2 150/37
2020	Landsat 8	30 m × 30 m	2020–10-10	WRS-2 150/37

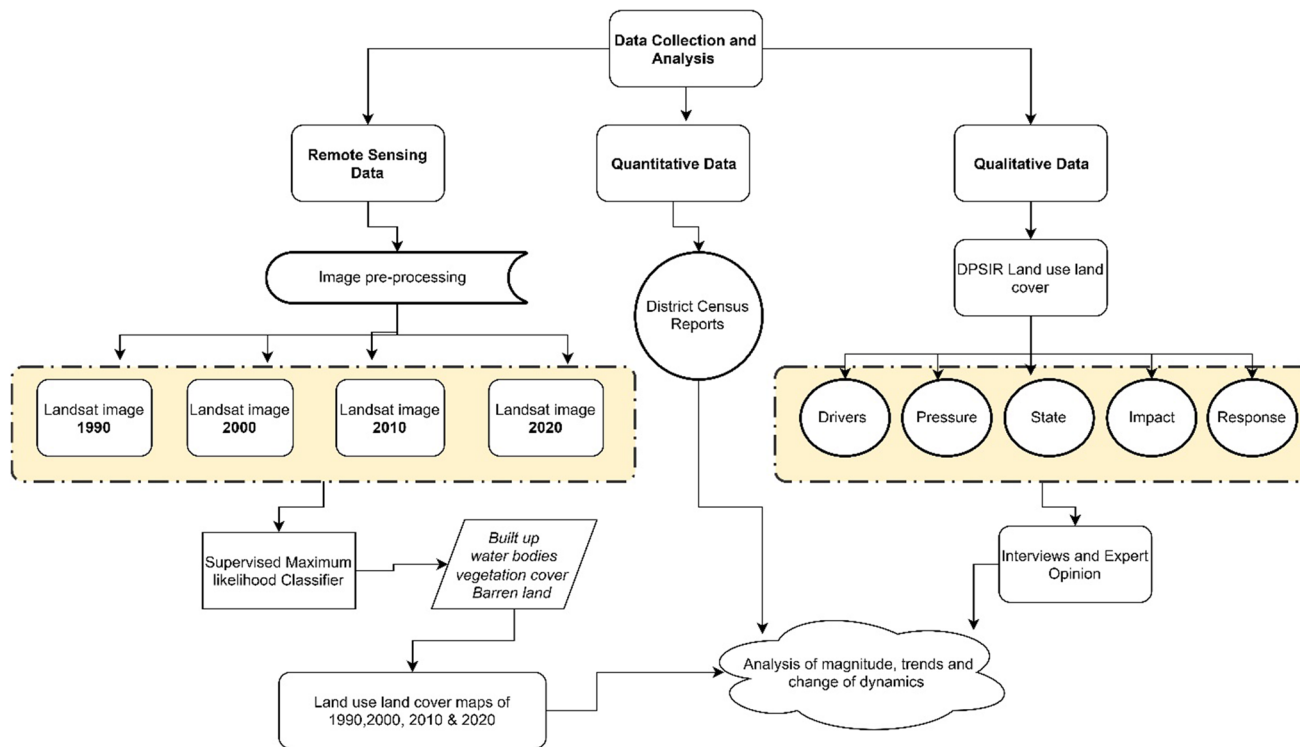


Fig. 2 Methodological framework for the study

- A2 is the class cover at later time

DPSIR data analysis and methods of data collection

Components of the DPSIR framework were identified by means of focus group discussion, expert opinion, and interviews with key persons of the relevant departments. Interview-guided-based approach was conducted for cost benefit analysis of integrated physical, social, natural, and economic factors. Interviews of the relevant experts of different departments like Urban Policy Unit, Peshawar, Peshawar Development Authority, Environmental Protection Agency, Physical Health Engineering Department, Official of the Transport Office Peshawar, and official of the Local Government Department were conducted. A focus group discussion session was conducted involving all the mentioned department

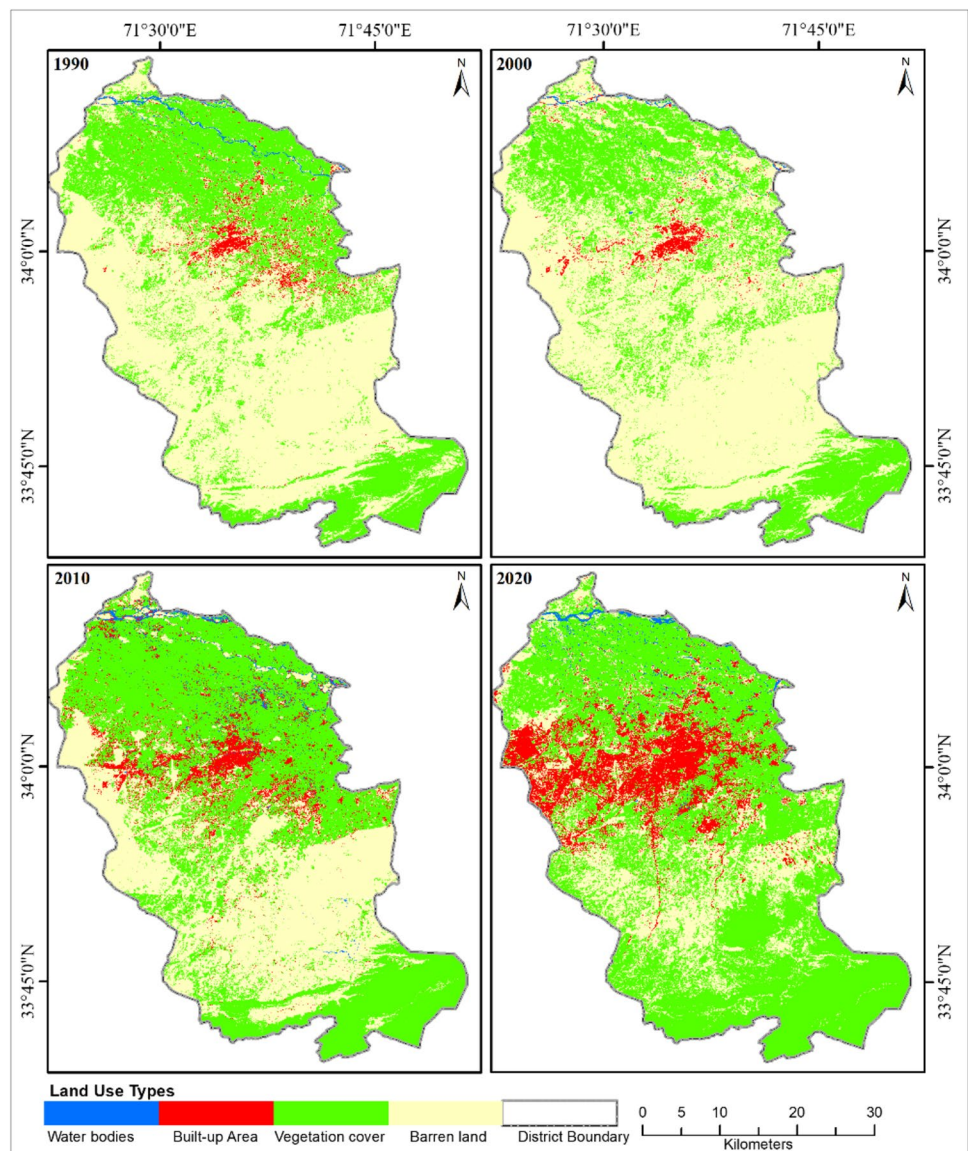
officials, academicians and some experts from the NGO sector. Based on these interview and focus group discussion, the data was compiled and discussed in this research.

Results

Classification of land use changes

As LUCC indicates the change of the land cover activity over the Earth’s surface. As Fig. 3A shows, the built-up is concentrated in the center of the district during 1990. Most of the adjacent areas in the south are barren and having no vegetation areas, while in north of the city, center is mostly vegetation covered area. In the recent years, the study and modeling of land use cover change (LUCC) have attracted

Fig. 3 Spatio-temporal LULC for the year 1990, 2000, 2010, and 2020



growing interest, as it is a complex issue and involves as the driving forces for many environmental problems which alter the physical, chemical, and environmental factors (Aburas et al. 2019, 2021).

The land use for the year 2000 is shown in Fig. 3B. From the results an increase in barren land is observed which was 58.8% in 1990 and increased to 66.4% in 2010. The results further revealed the decline in water bodies from 0.5 to 0.3% in Peshawar district. No significant changes observed during 1990–2000 in the built-up area. In 2000, the barren land is increased grabbing the vegetation cover. The result of the 2010 LULC analysis shows the gradual increase in built-up area in the center and adjacent areas of the Peshawar district. Figure 3 shows that majority of the urban sprawl grows in the center of the district, whereas the area of vegetation cover also observed an increase from 31% in 2000 to 38% in 2010. The water bodies again reached to its covered area which was 0.5% in 1990 that decreased 0.3% in 2000 while again increased 0.5% in 2010. The present situation of urban flux is more challenging task to meet the need of foods, water, shelter, educational, health facilities, to population.

In 2020, the built-up area increased at a higher rate at the vicinity of the city center. It increased from 2.7% in 1990 to 9% in 2020. The current study shows that urban sprawl is occurring at the center of the district with respect to economic development, industrialization, migration, and urbanization. Government, policymakers, and urban planner need careful steps for extension and expansion of city in future to cope with negative impacts of urban sprawl. No major changes observed in water bodies during last ten year (2010–2020) but it is the fact that the urge of resources is getting increased with increase in urbanization, industrialization, and economic growth. A rapid increase in vegetation covered area was observed during 2010–2020.

Overall the study results showed the rapid increase in built-up area during 1990 to 2020. The built-up area was 42.6 km² in 1990, but with the passage of time and migrations, the total built-up area in the Peshawar district increased to 138.3 km² in 2020. The barren land reduced with the passage of time due to its utilization for settlement expansion, expansion of agricultural land to meet the food requirements, and government intervention in the form of afforestation program. Water bodies covered an area of 8.5

km² 1990, 5 km² in 2000, 22 km² in 2010, and 7.6 km² in 2020. The increase in water bodies area in 2010 was the results of 2010 flood where the rivers of Peshawar vale expand their horizons towards the Peshawar district and then again shrink to almost its actual. Table 3 and Fig. 3 show a clear increase in vegetation covered area in 2020. Although, a rapid increase in built-up area was also observed in 2010 and 2020. The vegetation cover was approximately 585.5 km² in the year 1990, whereas it increased to 1105.3 km² of area in 2020.

The rapid and unplanned construction activity transform cities into impervious surface which enhance the chances of surface flow and urban flooding (Rahman et al. 2019). Population dynamic and distribution are closely linked with each other. Land values, livelihood, economic values, and social stratification increases with urbanization (Figs. 4 and 5).

Accuracy assessment

The accuracy assessment was performed after image classification taking 70–100 random samples for each land use class and a total 400 samples for each image. The overall accuracy for the year 1990 was 83.16% with kappa coefficient 0.73, whereas the overall accuracy of the 2000 image classification was 85.91% with kappa coefficient value 0.78 (Table 4). The overall accuracy for the year 2010 was 90.12%, while for 2020 was 91.2%, whereas the kappa coefficient was 0.91 and 0.89, respectively.

Detection of LULC changes during 1990 to 2020

The change in LULC during 1990–2020 calculated in this study, and the results showed 224.6% increase in built-up area of Peshawar district just in a time span of three decades (1990–2020) (Fig. 6). At the same time, the gradual decrease in barren land and water bodies was observed from this study results which is 67.4% decrease in barren land and 10.5% in water bodies (Table 5). Although a decrease in the vegetation cover was also observed during 1990–2000 but the demand for food and government extensive plantation after 2014 resulted a rapid increase in the vegetation covered area. Figure 4 shows the high increase in vegetation cover in the southern parts of the Peshawar district. During the study

Table 3 Land use land cover change in Peshawar district during 1990–2020

LULC classification km ² (%)	Year 1990	Year 2000	Year 2010	Year 2020
Built up area	30.9 (2.7)	42.6 (2.9)	104.01 (6.7)	138.3 (9)
Barren Land	293.8 (58.8)	1071.5 (66.4)	628.47 (40.5)	297 (19)
Water bodies	8.5 (0.5)	5 (0.3)	22.87 (1.4)	7.6 (0.4)
Vegetation cover	585.5 (37.8)	482.9 (31)	792.96 (51.2)	1105 (71.3)
Total	1548.5			

Area shown in the table is in km.² and percentage

Fig. 4 Distribution of land use changes for each category from year 1990–2020

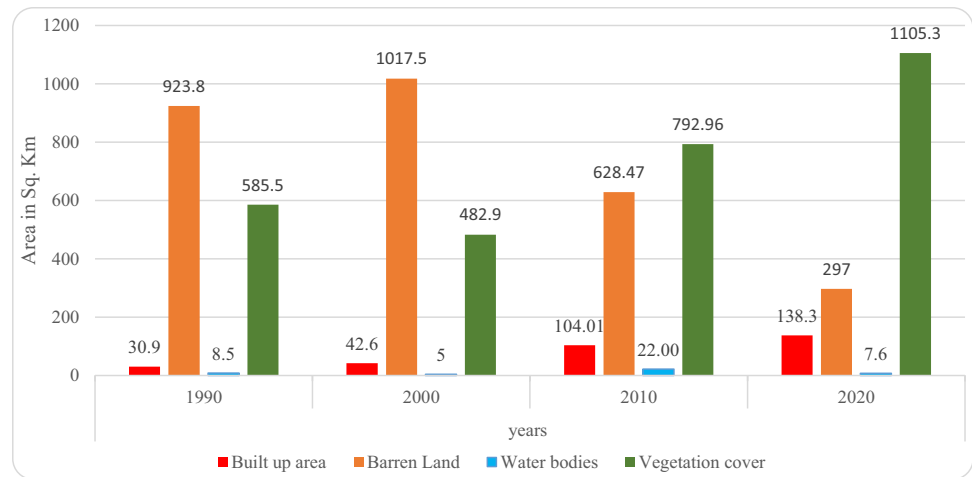


Fig. 5 Trends of Land Use Changes during past three decades (1990–2020). Note that Fig. 10a, b, c, and d trend of land use land cover changes during 1990–2020. The graph (a) trend indicting the rapid increase of built-up area with the increase of population and economic uplift. The graph (b) shows decline in barren land after 2010. The graph (c) indicating the dramatic increase of vegetation cover from 1990 to 2020. The graph (d) shows water bodies during 1990–2020.

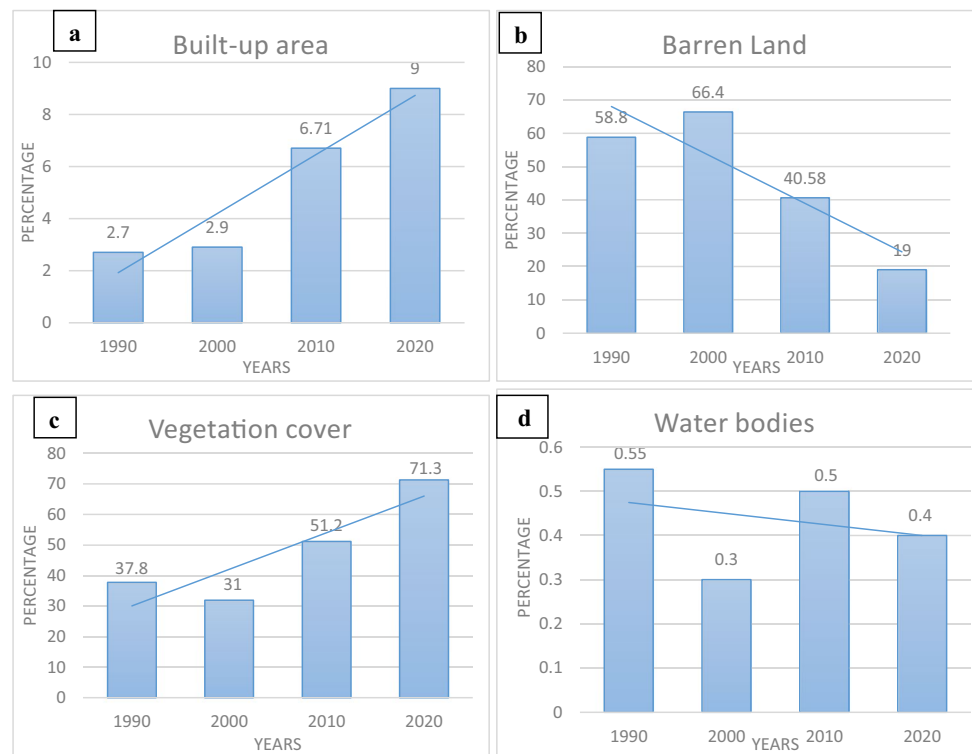


Table 4 Image classification accuracy assessment of the selected years 1990, 2000, 2010, and 2020

Images	Overall accuracy	Kappa coefficient
1990	83.16%	0.73
2000	85.91%	0.78
2010	90.12%	0.91
2020	91.2%	0.89

period, the vegetation covered area increased from 37.8% in 1990 to 71.3% in 2020. This increase in vegetation in the southern and eastern parts of Peshawar district is due to Government initiatives of Billion Trees Tsunami Afforestation Project. A gradual decrease in barren land from 66% (in 2000), 58% (in 2010), and 19% (in 2020) (Table 6).

The rapid population growth, industrialization, and urbanization consequently convert the urban areas into hub of pollution, degradation of ecosystem, and energy

Fig. 6 LULC change detection analysis between last three decades (1990–2020)

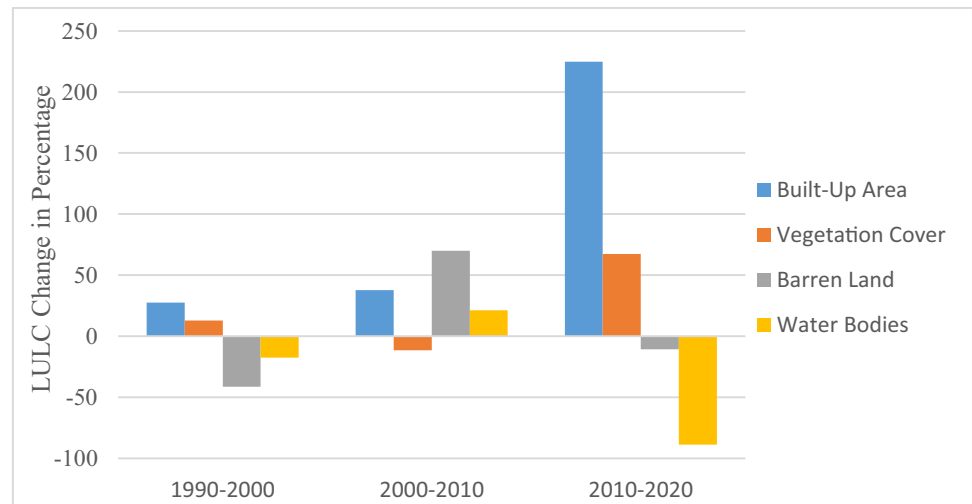


Table 5 Land cover change (percentage) detection during past 30 years (1990–2020)

S. no	Land cover type	Area in km ²		Change (%)
		1990	2020	
1	Built-up area	42.6	138.3	224.64 ↑
2	Vegetation cover	585.5	1105.3	88.77 ↑
3	Barren land	911.8	297	67.42 ↓
4	Water bodies	8.5	7.6	10.58 ↓

Increase in percentage indicated by ↑, decrease in percentage indicated by ↓

consumption. Many scientists reported that urban regions are limited to 2%, but are responsible for > 75% of carbon emission and energy consumption of the total global surface area (Han et al. 2020). The increase in built-up area and urbanization results in the emission of many harmful gases, noise, and liquid waste (Kabir and Khan 2020). The increase in human population is the main cause of the expansion of urban areas to meet their shelter needs. The uncontrolled growth of cities causes the destruction of natural environment and declining biodiversity due to loss of their natural habitat (Wan Mahari et al. 2020).

Table 6 LULC change detection analysis between last three decades (1990–2020)

Land classes	Change detection from 1990 to 2000	Change detection from 2000 to 2010	Change detection from 2010 to 2020
Built up area	27.5 ↑	37.86 ↑	224.64 ↑
Vegetation cover	12.9 ↑	11.5 ↓	67.39 ↑
Barren land	41.2 ↓	70 ↑	10.58 ↓
Water bodies	17.5 ↓	21.2 ↑	88.81 ↓

Increase in percentage indicated by ↑, decrease in percentage indicated by ↓

The dynamic and rapid changes in the land use and land cover ultimately affect the natural environment and act as the environmental stressors. It is the fact that many of environmental changes are interconnected with urbanization and uncontrolled population growth. In Asian countries, the growth rate of urban areas is higher as compared to the rest of the world. It has been reported that in 1900 the urban population was 15% of the total population, whereas the recent statistics show the approximately 50% of the total population are living in urban areas (WWAP 2006). According to United Nation findings, almost 55% of the world's population lives in urban areas now a day, but it is projected that it will increase to approximately 68% by 2050 (Wan Mahari et al. 2020).

DPSIR framework

The concept of DPSIR framework is the collective study of cost benefit analysis of integrated physical, social, natural, and economic factors. This framework key drivers, pressures, states, and impacts that resulted from the process of land use change. Components of the framework were identified by means of focus group discussion, expert opinion and interviews with key persons of different relevant departments (Provincial Disaster Management Authority, Agriculture

department and Urban Unit) based on the interview-guided approach (Kitchin 2000). Respondents were selected based on their expertise, legislative knowledge, environmental protection planning, and development and urban policy.

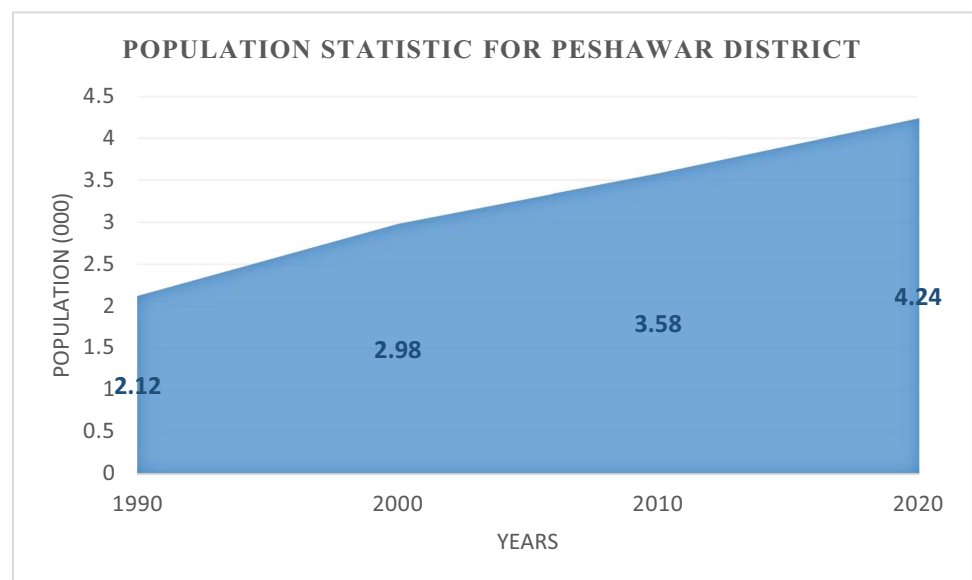
Drivers

One of the major driving forces for the unplanned land use changes is the population explosion. This can be easily quantified with the suitable available data. Total population in Peshawar district was 2.12 million in 1990 which increased to 4.26 million in 2020 (Fig. 7). Due to rapid population growth, 224.6% increase in built-up area was observed during 1990–2020. Urban expansion is directly linked with population growth which ultimately results in built-up area expansion to meet the need for housing. High population growth resulted in agriculture intensification and land fragmentation due to high demand for food and land for residential purposes. In Khyber-Pakhtunkhwa, the Peshawar district is the largest city of the province and main center of economic activity. Easy access to main market, transportation facilities, province capital, jobs, economic hub, availability of education, and health facilities are some of the drivers which are responsible for the population influx towards Peshawar district. Kertész et al. (2019) stated that land degradation is the major driving forces due to land use changes. Many unplanned LULCC like deforestation and alternation of vegetation cover resulted into degradation of land, which leading to adverse changes at global level. Many researchers concluded that extension of rural centers, road construction, reduction in water resources, and human population dynamics are responsible for land degradation (Batunacun et al. 2019).

Pressure

The population growth puts pressure and results into unplanned rapid development. It inserts pressure on agriculture and agriculture intensification occurs to meet the demand for food. Population growth also results land fragmentation and reduced farm holdings. One of the drivers of land use change is the low farm land holding for selective nature. These factors put the pressure on natural resources and also compelled for intensifying the land for economic benefits. Urbanization resulted in the high population density which leading towards intensification of natural resources of the area. The competition for the resources puts the pressure and deteriorates the quality of natural resources; i.e., the soil fertility declining with the intensification of agricultural practices and high volume of water extraction results in low water table. The results of this study indicate the gradual decline in water bodies. Khan et al. (2019a) conducted a study in Peshawar, and their study results showed that the water table has depleted due to increase in built-up area. Pressures are usually higher on urban centers for more affluent society triggering for economic growth for basic needs. Land use change development is according to the demands and wants of people which sometimes beyond the carrying capacity of the resources. In another study, Qasim et al. (2013) discussed that agriculture intensification occurred due to the expansion of urban area to encounter the availability of land for population. As a result, a large area of agriculture land was transformed into different classes which exert pressure on land to meet the demand grains (Rasool et al. 2016).

Fig. 7 Population statistic (1990–2020)



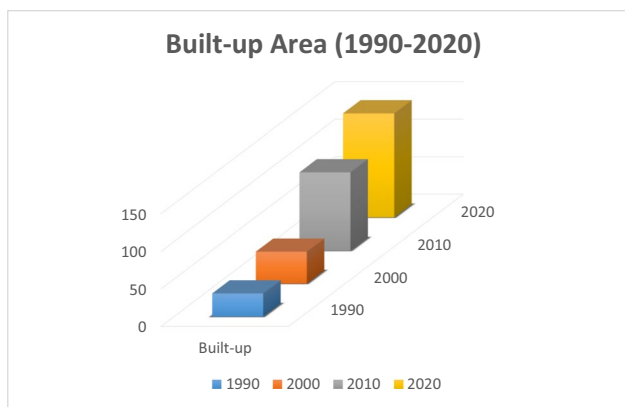
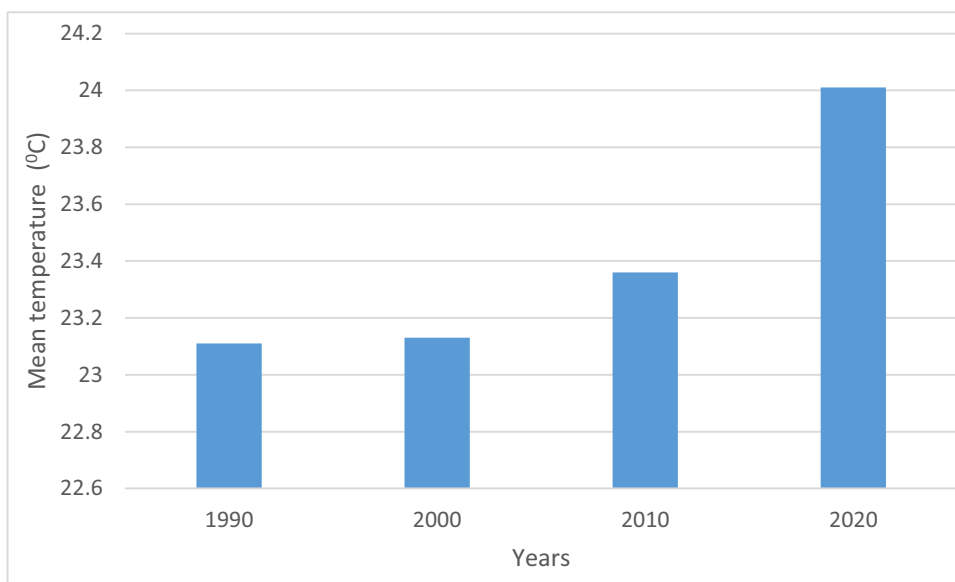


Fig. 8 Built-up area of Peshawar district (1990–2020)

State

Rapid development and changing land dynamics pressurized the state of natural resources and systems in the area. Peshawar facing the rapid increase in built up area with increase of population and economic development (Fig. 8). Due to urbanization, the land use is the major source of degradation, i.e., conversion of agriculture land into built-up area, forest into built-up, agricultural, and horticulture. Population dynamics adversely affect the water resources and vegetation. The soil fertility is declining due to compaction and agriculture practices meet the demand of food. Further, the increase built-up area increases the impervious surfaces which causes surface flow and deplete groundwater in Peshawar. Urbanization and increasing built-up area escalate the surface runoff, decrease infiltration to recharge the groundwater aquifers, and often result into pluvial flooding in Peshawar district. Khan et al. (2022) conducted a study

Fig. 9 Mean temperature for Peshawar district (month of October)



on the impact of soil sealing on pluvial flooding in Peshawar and concluded that rapid population growth has resulted expansion in built-up area, urban sprawl, and infrastructure expansion that resulted more impermeable surfaces and consequently intensified the surface runoff as well as pluvial and flash flooding.

Impact

In long term, the drivers and pressures having negative impacts on the resources (land, soil fertility, and water) which ultimately leading towards declining in crop productivity, increasing surface and air temperature, increase drinking and sanitation issues and pollution. The consequences of reduced staple crops productivity will be increasing the food security and hunger in population. In the study, a significant correlation between built-up area and temperature was observed (Fig. 9). Altieri et al. (2014) stated that the unplanned expansion of built-up area adversely affect the natural cycles (water cycle, carbon cycle and nitrogen cycle), systems, and their functions. The land use changes significantly affecting the local environment (humidity, wind direction, and temperature) which may alter the regional climate, availability of water (Wang et al. 2015), and alternation in ecosystems (Foley and Kistemann 2015). Climatic conditions also trigger the natural hazards and destruction. Land use changes increase deforestation and convert the vegetation cover into built-up area, which facilitate the natural disasters and global warming.

Response

Responses are the actions taken by individual, society, and government departments for the better future, land use

planning, and encountering the unplanned land use changes. Government should practice the legal coding and zonation for different sectors and activities. At national and provincial level, planning is vastly concerned with allocation of resources and achieving some urban goals. So, proper planning and management of resources should be focus by top management at decision making level. The DPSIR framework of land use dynamics is shown in Fig. 10.

Relationship between land use changes and environment

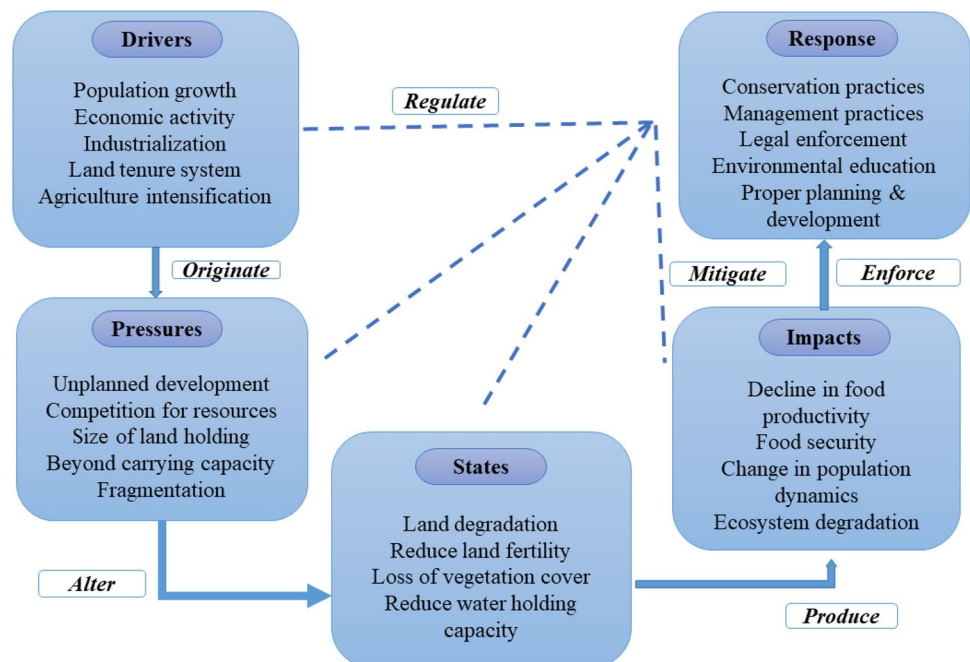
Hassan et al. (2016) discussed the relationship between land use/land cover changes due to population growth and socio-economic development. Globally, the consumption of energy, water, and other resources has increased along with substantial loss of agriculture land, forest cover, ecosystem degradation, and biodiversity loss. The changes in land cover and land use with population growth can alter the condition and health of the environmental resources. The people of rural areas tend to move towards urban centers for economic opportunities that is the main cause of increase in population in urban areas. Kidane Bahir and Alemu (2015) suggested that less than 70% of vegetation cover induces a risk of soil degradation, flood, and other natural disasters. The change in land-use significantly contributes to degradation, fragmentation, and loss of biodiversity. Urbanization greatly affects the local and regional environment, which eventually alter the global climatic changes.

Urban areas with high population growth and without planning are the most susceptible to external shocks and

stresses (including climate change) (Fang et al. 2020). The increase in urban infrastructure leads to degradation of fragile ecosystems as well as large populations having socially or economically marginalized. In population, the impacts are felt by vulnerable people such as poor communities because of their high exposure to hazards and lower ability to adapt and respond (physical and financial limitation). The increase in urbanization leads to environmental pollution that have direct impacts of climate change that are twofold such as storms, typhoons, and heat waves, diminishing agricultural land due to rapid and unregulated land-use change. Increasing conversion of cultivated land to built-up area has serious consequence for provincial food security and agriculture-based revenue generation (Sajan 2020). Agricultural productivity is also threatened by changing agriculture land into built-up area which leads to increase in temperature as well as environmental pollution issues.

Peshawar is one of the fastest growing lands, and the development has resulted in the loss of natural vegetation and fertile agricultural land. Land expansion brought changes in land use and resulted in the reduction of productive agricultural land and detrimental to agriculture loss and food security. Land use changes negatively affect by excessive fragmentation of vegetation cover (such as intensive fertilization, irrigation, and mechanization). (Silva et al. 2018). Unplanned changes and population growth extremely exposed to natural climatic hazards such as flood, drought, and heat waves. Generally, the alternation in land changes at large scale results in severe global climatic changes.

Fig. 10 DPSIR framework for land use dynamics



Discussion

The current study focused on the land use change and urbanization impacts on environment in Peshawar district using the GIS, remote sensing, and DPSIR framework approach. The land use land cover change (LUCC) has attracted growing interest in recent research, as it is a complex issue and many environmental problems (Aburas et al. 2019, 2021). Peshawar is the largest city and capital of Khyber Pakhtunkhwa. The study results showed fluctuations in different land use classes in last three decades (1990–2020), but overall, the built-up areas observed a rapid increase and the same was observed from other studies conducted in Peshawar (Raziq et al. 2016; Khan et al. 2019b; Yar and Huafu 2019; Ahmad et al. 2021; Yar et al. 2022). All these mentioned studies conducted in Peshawar focused either on only land use land cover change, i.e., (Raziq et al. 2016) or conducted research on land use change impact on a specific problem like Khan et al. (2019b) conducted research on the land use change impact on land surface temperature and agricultural crop productivity in Peshawar district. Similarly, Ahmad et al. (2021) focused on the impact of land use cover change on water quality and associated health risk in Peshawar district, while Yar and Huafu (2019) conducted their research on the land use change impacts on agricultural land. Similarly, another research conducted by Yar et al. (2022) discusses the land use change impact on groundwater in Peshawar district. The current research is different in all aspects from the previous land use land cover research conducted in Peshawar district as it not only focused on land use change impacts on environment but apply the DPSIR framework in the study area.

The results showed that the vegetation cover decreased in 2000 and the barren land increased as compare to 1990. This increase in barren land and decrease in vegetation was due to the history extreme drought in South Asian region including Khyber Pakhtunkhwa during 1998–2002 (Rahman et al. 2021). The built-up area was 2.7% in 1990 which increase to 9% in 2020. This increase in built-up area is surging other problems in Peshawar district which needs government intervention and proper planning to mitigate its negative impacts. The increase in built-up area and paved surfaces have depleted the ground water level and been discussed by other researchers (Khan et al. 2019a; Rahman et al. 2019; Yar et al. 2022). This increase in built-up area is encroaching on the fertile food producing area in Peshawar district, and the same is observed in other studies (Yar and Huafu 2019). To meet the requirement of food, the agricultural activity expanded over the barren land in the study area. Furthermore, the barren land was converted to vegetation covered area due to government intervention in the form of Billion Tree Tsunami Program.

The urban sprawl in Peshawar district is the result of the rapid population growth where population in 1998 was 2.12 million which doubled in 19 years and reached 4.26 million in 2017 (GoP 2017). The rapid population growth and urbanization consequently convert the urban areas into hub of pollution and environmental problems, while these urban areas are responsible for > 75% of the global carbon emission and energy consumption (Han et al. 2020). The increase in human population is the main cause of the expansion of urban areas to meet their shelter needs. The increase in built-up area and urbanization results in the emission of many harmful gases, noise, and liquid waste (Kabir and Khan 2020).

Conclusion

The present study concluded that in Peshawar district, rapid unplanned urbanization occurs. In Peshawar district, the built-up area has almost increased 224.6% in last three decades (1990–2020). The built-up area increases the impervious surfaces causing many environmental hazards, such as flood, increase surface temperature and decline the level of groundwater. The hazard and human-induced changes adversely affect the natural ecosystem. The natural and rapid growth in population is the significant factor in the urbanization. The rural to urban migration due to availability of resources in Peshawar is the key contributing factor in urban sprawl. In the present study, the analysis indicates the gradual decline in the barren land and water bodies which is 67.4% and 10.5%, respectively, in the study area. During the study period (1990–2020), the population growth was recorded from 2.12 million to 4.26 million. The current study links the land use changes with human–environment indicators. It is suggested to develop health, education, and economic facilities in other cities of Khyber Pakhtunkhwa to control the population influx towards Peshawar. Furthermore, the government should fully implement the land use regulations to reduce the threat of rapid built-up area increase and its negative impacts on environment. This study is a pioneering step in linking urbanization and land use changes with environmental aspects based on DPSIR framework approach in Peshawar as well as in Khyber Pakhtunkhwa province. This study identified the urbanization drivers, pressure, state, its impacts, and response for sustainable urban development. The research findings endorsed the policy implementation and prior planning to control the unplanned development.

Author contribution Saba Yousafzai: writing of article, Rashid Saeed: data collection, Ghani Rahman: designing of methodological framework, Sidra Farish: literature review.

Data availability All freely available data sources were used.

Declarations

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