Research Article

Spatio-Temporal Expansion of Built-Up Areas and its Impact on Farmland and Food Security of Peshawar Valley, Pakistan

Sajjad Ali[1]*, Atta ur Rahman[1] and Sher Ali[2]

[1]Department of Geography, University of Peshawar, Khyber Pakhtunkhwa, Pakistan; [2]Department of Economics, Islamia College University, Peshawar, Khyber Pakhtunkhwa, Pakistan.

Abstract | The study emphasizes the spatio-temporal expansion of built-up areas and its impact on farmland and primary crop production of Peshawar valley, Pakistan. The build-up needs to be with more significant planning to avoid any inconvenience among agricultural land and infrastructure. Built-up is necessary; however, it is worth mentioning to feed 11.23 million people in the district. The region's land is the most fertile and productive in the Khyber Pakhtunkhwa province. Data were taken from the Agricultural Bureau of Statistics from 1990 to 2020, and the satellite imageries of the region were acquired from the United States Geological Survey (USGS). ARIMA technique is employed to get the forecasted values regarding Acreage, Yield, and Production of crops till 2050 in Peshawar valley. Remote sensing (RS) and geographic information systems (GIS) were used to analyze the satellite imageries. The analysis showed a persistent increase in built-up areas from 1990 to 2020 as the built-up area increased by 57090 hectares. However, the barren land indicates a decreasing pattern of growth, decreasing by 102452 hectares in Peshawar valley. The analysis disclosed a consistent increase in the Production of crops. On the other hand, the per capita share of inhabitants in crop production showed a decreasing trend from 1990 to 2020, attributed to the rapid increase in population. The prediction showed that the per capita share of inhabitants in major crop production would decrease further. In 2050, the study area will be unable to feed its inhabitants due to the rapid increase in population and the built-up environment.

Received | July 13, 2022; **Accepted** | August 05, 2022; **Published** | September 26, 2022
***Correspondence** | Sajjad Ali, Department of Geography, University of Peshawar, Khyber Pakhunkhwa, Pakistan; **Email:** sajjadaligeography@gmail.com
Citation | Ali, S., A.U. Rahman and S. Ali. 2022. Spatio-temporal expansion of built-up areas and its impact on farmland and food security of Peshawar Valley, Pakistan. *Sarhad Journal of Agriculture,* 38(4): 1260-1272.
DOI | https://dx.doi.org/10.17582/journal.sja/2022/38.4.1260.1272
Keywords | Spatio-temporal, Built-up area, Gis/Rs, Arima and food security

Introduction

The theme of this study is to examine the pattern of land use land cover and its possible impacts on crops acreage, Production, and per capita share of the residents in major crops production of Peshawar valley. As the built-up area is increasing rapidly at the cost of prime agricultural land, if the land use transformation remains constant, it is impossible for the existing cultivated land to feed the increasing inhabitants of Peshawar valley by 2050. Land-use conversion is a universal phenomenon (Rahman *et al.*,

2016). The green belts and bare soil are being converted into built-up areas (Ali *et al.*, 2020). Worldwide, land-use conversion resulted in a high population growth rate (Yar *et al.*, 2016). In 1950, the world population was 2.5 billion, which increased to 6.08 billion in 2000. In 2020, the number of inhabitants boosted to 7.79 billion; further, it is expected to increase to 9.76 billion by 2050. In 2020 out of the total area of the world, the arable land was 29 percent (Fontaine *et al.*, 2009; Fenta *et al.*, 2017). Of the total arable area, the habitable land was 71 percent (Zhang *et al.*, 2007). In comparison, the suitable size for farmland was 50 percent of the habitable world (Backman and Tianen, 2002; Ali *et al.*, 2019). Globally, the increase in population is attributed to an increase in the built-up areas (Wu *et al.*, 2011). In third world nations, the expansion of built environment is more common than demographic growth, due to a lack of precise land-use policies and implementation (Cabus *et al.*, 2003; Bomans *et al.*, 2011). The increase in built environment resulted in to decline in the fertile farmland, especially in developing regions (Hermosilla *et al.*, 2018). The consistent and rapid land-use conversion at the cost of farmland led to food insecurity in third-world countries (Happe *et al.*, 2008). In the Urima city of Iran, 13950 hectares of agricultural land and bare soil is modified into the built environment from 1996 to 2011(White *et al.*, 2015; Beckers *et al.*, 2018).

Similarly, China lost 15000 hectares of farmland from 1977 to 2001(Geist and Lambin, 2002; Bousqet and Le-Page, 2004). The change in built-up areas in Urima city Iran and China were due to the high population growth rate (Ewert *et al.*, 2005; Bianchi *et al.*, 2006) The economy of Pakistan depends on the agricultural sector (Rahman *et al.*, 2016). In 2000 more than 50 percent of residents of the country were engaged in this sector (Khan and Ali, 2019; Ali *et al.*, 2019; 2020). The rapid change in the built environment snatched the farming occupation from most of the farmers in the country (Rahman and Khan, 2012). In 1976 the built-up area in district Lahore was 58977 hectares increased to 99173 hectares in 2009. In comparison, the cultivated land declined from 95838 hectares in 1976 to 63384 hectares by 2009 (Riaz, 2010). Similarly, in district Multan, the built-up area was 2.7 percent in 2000, enhanced to 7.3 percent by 2016. Although the cultivated land covered 85 percent area of the district in 1976 decreased to 79 percent in 2016 (Sajid *et al.*, 2020).

The consequences of a built environment on food security were more pronounced, and their severity is expected to further increase with time (Rahman *et al.*, 2019). In addition, to food security, environmental circumstances such as aridity, increasing temperature, pollution, drought, and floods have been the leading consequences of the built environment. This study focuses on food security. Many studies were conducted on the impacts of the built environment on food security across the country. Khyber Pakhtunkhwa is the smallest province, having an area of 101741 km^2 in the country. However, it ranks third in terms of economy and population in the country.

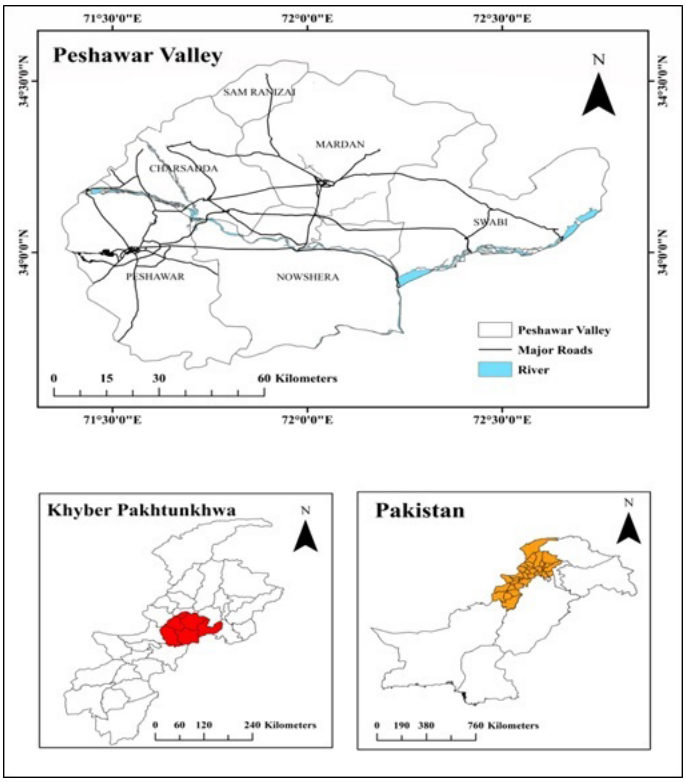

Figure 1: *Location of the study area.*

The valley of Peshawar consists of five administrative districts: Peshawar, Mardan, Nowshera, Charsadda, and Swabi. The study area is over 7705 km^2 and constitutes about 14.1 percent of the KP province (Figure 1). In 1998 the number of residents in Peshawar valley was 6.42 million, with a population density of 895 persons per square kilometer. The number of dwellers boosted to 11.23 million, with a density of 1565 persons per square kilometer in 2017. The share of the population is 30 percent of the entire residents of the KP province. Relatively, the study area is bounded on the South by the Attock-Cherat ranges; the Malakand hills form the Northern boundary. On the West, the study area is bounded by Khyber hills, while the river Indus flows through their East and South-East. However, the river Kabul

is considered the primary water source in the study area. Geographically, the study area is sited from 330 45′ to 340 30′ North latitudes and 710 22′ to 720 45′ East longitudes (Figure 1).

The study's novelty lies in the statement that most developing countries' populations are increasing in abundance. With time this significant increase in population intensifies the pressure on natural resources. The increasing population needs to be satisfied with more and more needs. Means to grow more food and provide shelter put on agricultural land. Buildings and infrastructure take place on farmland, and barren land is disturbed too. The valley of Peshawar is one of the region's most growing valleys with respect to the population. Therefore this study aimed to examine the impact of built-up area on agricultural land.

Peshawar valley is one of the most fertile lands of the provence. Improper built-up will leads to the lose of fertile land (more suitable land to agriculture). Such conversion of agricultural land to built-up will cause threat to food security. This study will expose the impact of built-up area on farm land and threat to food insecurity due to lose of agricultureal land. Technological advancement and inventions have reduced the treathning effects by increasing productivity per acre. However, proper policies regarding towards built-up may increase the smooth supply of food by saving agricultural land in the vally. This study consribute to literature that fresh statilite snaps are taken and analysed to examine the lose of agricultural land; and the variation in food garins production in the valley of Peshawar. Morever, forcasting has been done for food grains in the valley to update about the future food garin supply of the valley. In the best of my knowledge this the comprenensive study to predict food grains supply in futre in comparision of built-up area. This is the first that use land use land cover analysis of Peshawar vally. Per capita share of the inhabitance of the valley Peshawar in major cops production.

Materials and Methods

To get the objective of the study, secondary data sources were consulted. The secondary data sources were accessed to get data about population numbers from the Population Census Organization, Peshawar, cropped area, and Production of major crops acquired from the Agriculture Bureau of Statistics, Peshawar. The satellite imageries of the study area were taken from the USGS, a ten-year break, i.e., 1990, 2000, 2010, and 2020 Landsat satellite.

The data about population, cropped area, Yield per hectare, and Production of major crops were presented in tables and charts. The satellite imageries obtained from USGS were imported to Arc-GIS for georeferencing, digitization, and mosaicking of different bands of satellite imageries to get the area of interest. The image enhancement tool is used to increase the visualization of the satellite imageries from 30×30 to 15×15 meters. The supervised classification follows the image enhancement technique. The study area is divided into four land use classes: Built-up area, Barren land, Waterbodies, and Vegetation cover. The imageries of different years were compared to detect the pattern of the built-up regions in Peshawar valley from 1990 to 2020.

Similarly, the cropped area and Production of major crops (Wheat, Maize, and Sugarcane) were processed in MS-Excel in the form of statistical charts and tables. The ARIMA (Auto Regressive Integrated Moving Average) model is practiced to forecast the area, Production, and Yield of the wheat crop. In most of the past studies, the ARIMA modeling was employed by Wahid *et al.* (2017), Ali *et al.* (2019), Khan *et al.* (2016) etc. literature suggested that in the data type like of the present study, ARIMA is the most compatible techniques.Furthermore, the prediction of population, cropped area, and Production for 2050 were assessed by using Auto-Regressive Integrated and Moving Average (ARIMA) model. Worldwide the ARIMA, model is preferred for future forecasting. Food security was analyzed from the study area's per capita share in major crop production from 1990 to 2050.

Results and Discussion

Land use land cover statistics indicate that Peshawar valley occupied an area of 7705 square kilometers. The area covered by the study region is 14.1 percent of the total area of the Khyber Pakhtunkhwa (KP) province. The analysis found that the study area's built environment is consistently increasing. The increase in built-up areas is at the cost of barren land.

In 1990, out of the total area, the area under built environment was 38496 hectares, which increased to 52252 hectares in 2000, and the area under the built

environment further boost-up to 69565 hectares in 2010. Similarly, the built-up areas in 2020 further increased and marked the figure 95586 hectares in the study area. The analysis discloses that in Peshawar valley, the built environment gained an area of 57090 hectares from 1990 to 2020, with an increase of 1903 hectares annually (Table 1). Moreover, the analysis further reveals that Peshawar valley's built-up areas showed a consistent positive growth pattern from 1990 to 2020. The horizontal expansion in the built-up area needs to replace by vertical expansion in the shape of multi-story buildings.

Table 1: *Peshawar valley, temporal changes in land use land cover, 1990-2020.*

Land use land cover	Area in ha 1990	Area in ha 2000	Area in ha 2010	Area in ha 2020	Change in area 1990-2020 (ha)
Built-up area	38496	52252	69565	95586	+57090
Barren land	343083	303994	269039	240631	-102452
Vegetation cover	372022	394237	406646	413040	+41018
Water bodies	16977	20095	25328	21321	+4344

Source: Extracted from Landsat, 1990 to 2020.

Similarly, the vegetation cover occupied an area of 372022 hectares in 1990, increased to 394237 hectares in 2000, and the area under vegetation cover further increased to 406646 hectares in 2010. It reached the maximum value of 413040 hectares in 2020 in the fertile Peshawar valley. The analysis of land use land cover concluded that in Peshawar valley, the vegetation cover gained an area of 41018 hectares from 1990 to 2020, an increase of 1367 hectares per year. The analysis further showed that the vegetation cover showed a positive growth trend in the study area from 1990 to 2020. The increase in vegetation cover is necessary to feed the residents of Peshawar valley. The physical expansion in a built-up area is to be on bare soil to save the fertile agricultural land.

Whereas the area occupied by the bare soil was 343083 hectares in 1990 and declined to 303994 hectares in 2000, the area under bare ground further decreased to 269039 hectares in 2010 and reached the lowest figure of 240631 hectares by 2020 in Peshawar valley. The area lost by the bare soil is 102452 hectares at a rate of decrease of 3452 hectares per anum in the fertile valley of Peshawar (Figure 4). The analysis of barren land reveals that the bare soil showed a decreasing growth pattern in the study area from 1990 to 2020 (Figure 2a, b, c, d). The overall land use and land cover analysis disclose that the pressure on bare soil increases due to the population growth rate in Peshawar valley. To cover the increasing population's diversion trend in demand and supply for food and shelter put pressure on land distribution. The barren land is persistently converted into built-up areas and vegetation cover from 1990 to 2020. Similarly, agricultural land is converted into buit-up.

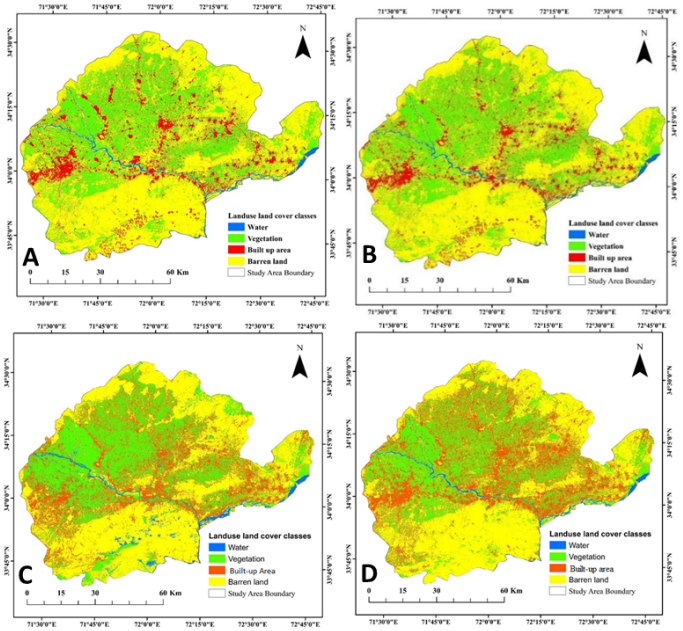

Figure 2: *Land use land cover, 1990 (A); land use land cover, 2000 (B); land use land cover, 2010 (C); land use land cover, 2020 (D) Peshawar valley.*

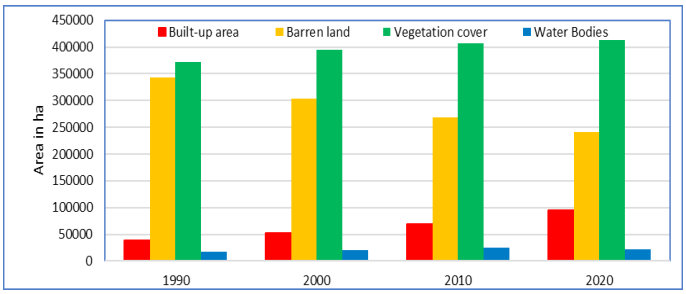

Figure 3: *Peshawar valley, temporal changes in land use land cover, 1990-2020.*

Results and Discussion

Impact of built-up areas on food security

The analysis concluded that the built-up area is persistently increasing in the study area at the cost of engulfing bare soil. Food security refers to the per person share in cultivated area and their production from 1990-2050 in Peshawar valley. The analysis reveals that the rapid increase in population reduced the per person cultivated land and the per capita share in the Production of major crops (Wheat,

Maize and Sugarcane). The facts and figures from 1991 to 2020, regarding the area and Production of major crops acquired from the agricultural bureau of statistics Peshawar, and for the future projection of cropped area, their production and Yield per hectare of major crops from 2021-2050 the modern approach of ARIMA model is applied.

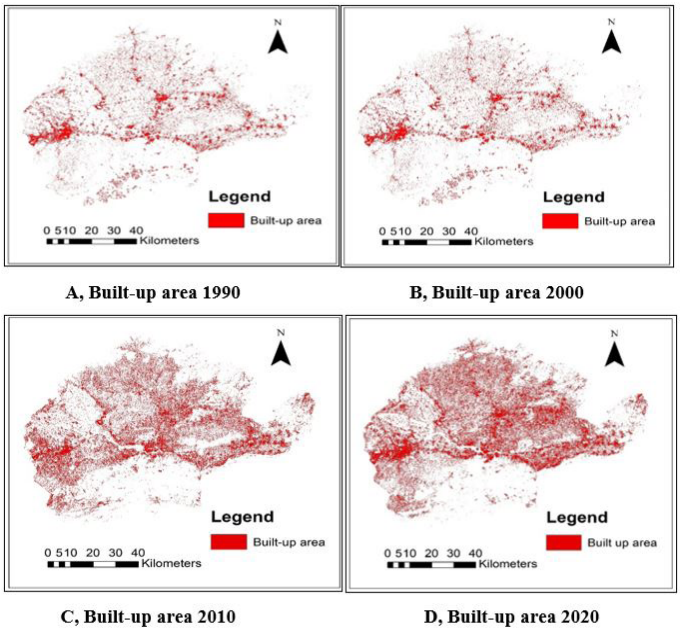

Figure 4: *Peshawar valley, temporal changes in built-up area, 1990-2020.*

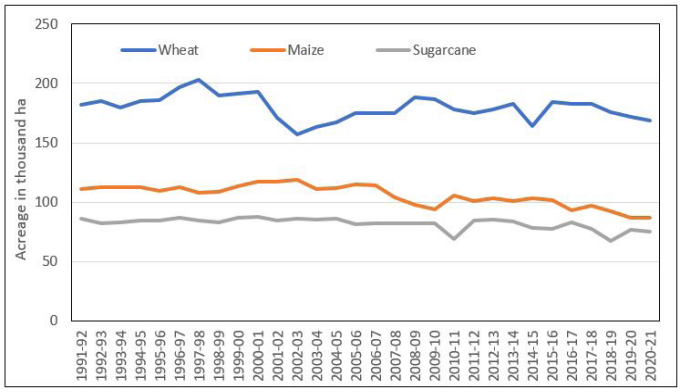

Figure 5: *Peshawar valley, acreage in ha (000) of wheat, maize and sugarcane, 1990-2020.*

Temporal changes in wheat acreage, yield, and production

Wheat, the well-reputed staple cereal crop of the country, belongs to the family of Rabi season. The wheat originated from the (Triticum) grass and grew worldwide in varied climates. Wheat belongs to the Rabi crops, mainly sowing from October to November and harvesting from April to May in plain areas. Wheat is a critical source of sugar, protein, carbohydrate, fibers, minerals, and fats.

Acreage: The land occupied by the wheat crop in 1991-92 was 182 thousand hectares. The rapid demographic expansion increased the demand for grain. To cope with grain requirements, the area under wheat crop in 1997-98 rose to 203 thousand hectares. This was the most significant area under wheat crop during the investigation hours in Peshawar valley. The rapid increase in the physical infrastructure engulfed the farmland in the fertile valley. This increase in the built-up atmosphere reduced the cultivated land for wheat in the fertile valley of Peshawar. The ground under the crop reduced to the lowest value of 157 thousand hectares in 2002-03. To gratify the food amenities of growing inhabitants, the area for the harvest again increased to 187 thousand hectares by 2009-10 in the heart valley. Moreover, in the year 2020-21, the area under wheat crop decreased to mark the figure of 169 thousand hectares in the study area (Table 2).

Table 2: *Peshawar valley, acreage in ha (000) of wheat, maize and sugarcane, 1990-2020.*

Years	Population (Million)	Wheat	Maize	Sugarcane
1991	5.05	182	110.80	86.3
1992	5.30	185	112.79	82.5
1993	5.55	180	112.66	83.3
1994	5.80	185	112.88	84.3
1995	6.05	186	109.77	84.9
1996	6.30	197	112.36	87.1
1997	6.55	203	108.20	84.9
1998	6.80	190	108.85	83.3
1999	7.05	191	113.70	86.5
2000	7.30	193	117.17	87.6
2001	7.55	171	117.10	84.5
2002	7.80	157	118.70	85.7
2003	8.05	163	110.70	85.4
2004	8.30	167	112.10	86.3
2005	8.55	175	114.90	81.6
2006	8.80	175	114.49	82.2
2007	9.05	175	104.17	82.4
2008	9.30	188	97.83	82.4
2009	9.50	187	93.87	82.3
2010	9.80	178	105.38	69.0
2011	10.05	175	101.17	84.5
2012	10.30	178	103.37	85.6
2013	10.55	183	100.54	83.8
2014	10.80	164	103.12	77.9
2015	11.05	184	101.46	77.6
2016	11.30	183	93.03	83.0
2017	11.55	183	96.62	77.5
2018	11.80	176	92.43	67.7
2019	12.05	172	87.14	77.0
2020	12.30	169	87.10	75.1

Source: Agriculture bureau of statistics Peshawar; GoP, 2017.

Yield: Production per unit area is referred to as Yield. In 1991-92, the Yield per hectare of grain was 1.76 tons per hectare in the fertile valley. The Yield per hectare increased with time with the introduction of modern machinery, hybrid seeds, fertilizers, insecticides, and pesticide sprays in the farming sector. The yield per hectare was further enhanced to 2.01 tons in 1997-98 in the heart valley. Moreover, in 2002-03 the per hectare production multiplied to 2.15 tons in the study area (Table 3). In the final year of 2020-21 investigations, the Yield per hectare reached 2.17 tons in Peshawar valley.

Production: The Peshawar valley is well-known for growing wheat in the province of Khyber Pakhtunkhwa after Punjab. In 1991-92 the Production of grain was 321 thousand tons. The wheat output increased to the highest figure of 429 thousand tons in 1997-98 in the study area. This was the largest figure for grain production from 1990-2020 in Peshawar valley. Similarly, in 2002-03 the wheat crop delivered 337 thousand tons of grain to the residents of the fertile valley of Peshawar. With the movement of hours, the area under the crop was reduced. Hence the grain production declined. In 2020-21 the total grain production in Peshawar valley was 367 thousand tons (Table 3).

Table 3: *Peshawar valley, production in tons (000), wheat, maize and sugarcane,1990-2020.*

Years	Population (Million)	Sugarcane	Sugarcane yield (Tons/ha)	Maize	Maize yield (tons/ ha)	Wheat	Wheat yield (tons/ha)
1991	5.05	3984	46.11	132	1.19	321	1.76
1992	5.30	3831	46.42	131	1.16	328	1.76
1993	5.55	3886	46.57	136	1.20	320	1.78
1994	5.80	3945	46.73	164	1.45	330	1.78
1995	6.05	3974	46.76	183	1.67	340	1.82
1996	6.30	4082	46.84	193	1.72	305	1.54
1997	6.55	3973	46.76	173	1.60	429	2.01
1998	6.80	3925	47.05	182	1.68	383	2.01
1999	7.05	4089	47.27	189	1.66	375	1.96
2000	7.30	4098	46.68	199	1.70	406	2.01
2001	7.55	4015	47.45	206	1.76	365	2.13
2002	7.80	4138	48.19	212	1.79	337	2.15
2003	8.05	3966	46.37	205	1.86	353	2.16
2004	8.30	4085	47.27	216	1.93	357	2.14
2005	8.55	3731	45.71	226	1.97	379	2.17
2006	8.80	3932	47.81	248	2.17	381	2.18
2007	9.05	3865	46.84	287	2.76	378	2.15
2008	9.30	3743	45.38	284	2.91	416	2.21
2009	9.50	3605	43.74	291	3.11	413	2.20
2010	9.80	3148	45.50	338	3.20	387	2.17
2011	10.05	3932	46.50	316	3.11	348	1.98
2012	10.30	4073	47.54	351	3.39	353	2.21
2013	10.55	3995	47.61	339	3.38	405	2.12
2014	10.80	3782	48.52	335	3.25	349	2.06
2015	11.05	3503	45.10	381	3.75	379	2.13
2016	11.30	3926	47.22	333	3.58	391	2.16
2017	11.55	3674	47.35	349	3.62	399	2.17
2018	11.80	3266	48.29	340	3.68	382	2.16
2019	12.05	3665	47.53	323	3.71	376	2.18
2020	12.30	3596	47.86	322	3.70	367	2.17

Source: Agriculture bureau of statistics Peshawar; GoP, 2017.

Food security: Food security refers to the per capita share of inhabitants in major crops Production during the investigation hours. In 1991-92, the per person share in the production of wheat was 71 kilogram (Kg) in Peshawar valley. The per capita share of the residents in grain production reduced to 62 kg in 2000-01. The analysis reveals that in 2010-11 due to rapid land-use modification, the per capita share in grain production further decreased to 44 kg. Moreover, in 2020-21, the analysis further concluded that the percentage of inhabitants in wheat production reduced to 33 kg due to the enormous increase in population in the study area. The analysis of ARIMA discloses that the per capita share of wheat further declined to 19 kg in 2050-51. The research tells us that the per capita share in wheat production decreased by 52 kg from 1990 to 2050 in the fertile valley of Peshawar (Table 3).

Prediction: The ARIMA (Auto Regressive Integrated Moving Average) model is practiced to forecast the area, Production, and Yield of the wheat crop. In most of the past studies, the ARIMA modeling was employed by Wahid *et al.* (2017), Ali *et al.* (2019), Khan *et al.* (2016), etc. literature suggested that in the data type like of the present study, ARIMA is the most compatible techniques. It is clear from the results that in 2021-22 the wheat crop occupied 186 thousand hectares of land and delivered 402 thousand tons of grain to the inhabitants of the study area. The analysis reveals that in 2021-22 the per person availability of wheat was 33 kilograms in the study area. However, in 2030-31 the area on which to be wheat grown will be 181 thousand hectares and will provide 420 thousand tons of grain to the residents of Peshawar valley (Table 4).

The increase in production is ascribed to the practice of modern devices in farming, but their per capita share shows a decreasing trend in Peshawar valley. Similarly, in 2050-51 the area under wheat crop will be reduced to 179 thousand hectares, and their output will be 461 thousand tons in the fertile valley of Peshawar. It is concluded that wheat production increased per hectare, but the per capita share decreased from kilogram in 1990 to 19 kilogram in 2050-51 in Table 4.

Temporal changes in sugarcane acreage, yield and production

In the study area the wheat crop was followed by the sugarcane in importance. The sugarcane belongs to the family of Kharif crops. The crop's season starts from April to May, and the spell of their crushing was practiced in December to march in the province. The product of sugarcane are brown sugar (Gur) and white sugar. In 1999-2000 the area under sugarcane reported was 0.1 million hectares and delivered 4.9 million tons of sugar and 0.2 million tons of Gur to the inhabitants of Khyber Pakhtunkhwa province (Ali *et al.*, 2020).

Table 4: *Peshawar valley, acreage in ha (000) of wheat, maize and sugarcane, 2021-2050.*

Years	Sugarcane	Maize	Wheat
2021	38.58	86.25	186.79
2022	35.55	85.48	184.76
2023	36.87	84.65	183.55
2024	36.93	83.83	182.83
2025	35.25	83.01	182.39
2026	37.40	82.19	182.13
2027	35.16	81.38	181.97
2028	36.31	80.56	181.88
2029	36.12	79.74	181.82
2030	34.98	78.92	181.79
2031	36.52	78.11	181.76
2032	34.74	77.29	181.75
2033	35.71	76.47	181.74
2034	35.38	75.65	181.74
2035	34.62	74.84	181.74
2036	35.70	74.02	181.74
2037	34.30	73.20	181.73
2038	35.10	72.38	181.73
2039	34.70	71.57	181.73
2040	34.19	70.75	181.73
2041	34.93	69.93	181.73
2042	33.83	69.11	181.73
2043	34.47	68.30	181.73
2044	34.05	67.48	179.68
2045	33.72	66.66	179.68
2046	34.20	65.85	179.68
2047	33.34	65.03	179.68
2048	33.84	64.21	179.68
2049	33.43	63.39	179.68
2050	33.21	62.58	179.68

Source: Predicted from ARIMA model.

Acreage: The analysis reveals that in 1991-92 the area occupied by sugarcane was 86.3 thousand hectares. With time, due to the expansion in built-up, the crop area reduced to 83.3 thousand hectares by 1998-99. The land under the crop further reduced to 82.3 thousand hectares in 2009-10. Similarly, in 2010-11 the area under sugarcane further decreased and marked the lowest figure of 69 thousand hectares in the heart valley of Peshawar (Table 2). Subsequently, the demand for sugar in the study area increases with the growing number of inhabitants. To increase sugar amenities, the cropped area increased to 83 thousand hectares in 2016-17. Whereas, in 2020-21, the area under the sugarcane crop reduced to 75.1 thousand hectares in Peshawar valley.

Production: The Production of sugar in 1991-92 reported was to be 3984 thousand tons in the fertile valley of Peshawar. Likewise, in 1998-99, the sugarcane crop delivered 3923 thousand tons of sugar to the market of Peshawar valley. Similarly, the application of modern machinery, pesticides, insecticides, fertilizers, and hybrid seeds increased the overall Production to 3731 thousand tons in the heart valley of Peshawar by 2005-06. However, in 2010-11 the sugarcane production reduced to the figure 3148 thousand tons by 2010-11 in the heart valley is attributed to the least Acreage under the sugarcane crop (Table 3). Whereas the sugarcane production in 2020-21 reached the figure 3596 in the fertile valley of Peshawar.

Yield: The per hectare production of the sugarcane crop in 1991-92 was 46.11 tons. The per hectare production was enhanced by applying modern agricultural tools and hybrid seeds. The analysis reveals that in 1995-96 the Yield of sugarcane increased to 46.76 tons per hectare in the fertile valley. With the movement of hours in 1999-2000, the per hectare production was boosted by 47.27 tons in Peshawar valley (Table 4). Though, in 2009-10 the per hectare yield decreased to 45.76 tons, attributed to land use transformation. Additionally, the per hectare production decreased by 43.74 tons in 2009-10. Moreover, in 2020-21 the per hectare production of sugarcane crop increased to the figure of 47.86 tons in the heart valley (Table 4).

Prediction: The prediction of the ARIMA model illustrates that in 2021-22 the sugarcane crop will occupy 38 thousand hectares of land and delivers 1795 thousand tons of sugar to the inhabitants of the study area. Similarly, in 2030-31 the area on which the crop will be applied will be 34 thousand hectares and will provide 1648 thousand tons of sugar to the residents of Peshawar valley. The increase in per hectares output is ascribed to the application of recent technology in farming, but the per capita share of sugar is decreased. Similarly, in 2050-51 the area for the crop will be further reduced to 33 thousand hectares, and their Production will be 1560 thousand tons of sugar (Table 5).

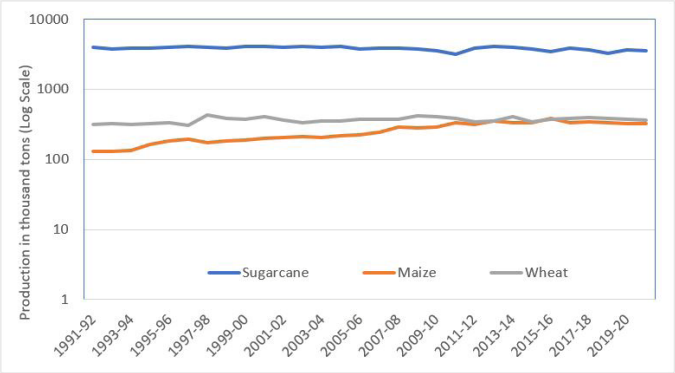

Figure 6: *Peshawar valley, production in tons (000) of wheat, maize and sugarcane, 1990–2020.*

The statistics of ARIMA illustrate that area under sugarcane crop will be decreased from 38 thousand hectares in 2021-22 to 33 thousand hectares by 2050-51. It means that the fertile valley of Peshawar will lose about 5 thousand hectares of area under sugarcane crop during the forecasted years in Peshawar valley. The analysis concluded that the sugarcane crop would be unable to gratify the increasing demand of growing inhabitants in Peshawar valley (Table 5).

Food security: The analysis reveals that in 1991-92, the per capita share of inhabitants in sugar production was 873 kilograms (Kg). Similarly, in 2000-01 the per person share decreased to 637 kg in the study area. The analysis further discloses that in 2010-11 the percentage per person in sugarcane production further reduced to 358 kg. Moreover, the per capita share of the residents further decreased and reached the figure of 326 kg per person by 2020-21. The analysis of ARIMA forecasting that in 2050-51 the per capita share of inhabitants in sugar production will be reduced to only 66 kg. The comprehensive study concluded that the per capita share in sugarcane production decreased by 807 kg from 1990-2050 in the fertile valley of Peshawar (Table 5).

Temporal changes in maize acreage, yield, and production

The maize crop is locally called the corn crop or

Makkai. The Makkai crop is a member of the Kharif crop and is grown from April to June and cut from October to November in Pakistan. The area under the maize crop in 2000 was 0.54 million hectares and provided 0.83 million tons of corn to the inhabitants of the Khyber Pakhtunkhwa province. Corn flour consists of 70 % carbohydrates, 10 % protein, and a small extent of fats (Ali, 2017).

Acreage: The analysis reveals that the area occupied by the maize crop in 1990 was 110 thousand hectares in the heart valley of Peshawar. With time, the valley's population increased so many times, leading to increased corn demand. Therefore, the area under the maize crop increased to 117 thousand hectares in 2000. The analysis further discloses that in 2005 the area occupied by maize crop reduced again to 114 thousand hectares in the study area. Moreover, the increasing trend of the built environment reduced the cultivated area for corn to 105 thousand hectares in 2010 in the Peshawar valley. In 2015, the maize was applied to 101 thousand hectares (Table 2).

The analysis reported that the caltivated land share of corn's crop decreased during the period from 1990 to 2020. The lowest area for maize crops reached the lowest figure of 87 thousand hectares by 2020 in the fertile valley of Peshawar. The area lost by the maize crop was 23 thousand hectares during the study hours from 1990 to 2020 in the study area, at the rate of loss of 790 hectares per anum (Table 3).

Table 5: *Peshawar valley, production in tons (000) of wheat, maize and sugarcane, 2021-2050.*

Years	Population (million)	Maize	Maize yield (tons/ha)	Sugarcane	Sugarcane Yield (tons/ha)	Wheat	Wheat yield (tons/ha)
2021	12.76	323	3.73	1795	46.53	402	2.15
2022	13.23	318	3.72	1678	47.20	404	2.18
2023	13.70	343	4.06	1712	46.45	406	2.21
2024	14.17	338	4.03	1742	47.18	408	2.23
2025	14.64	341	4.10	1638	46.48	410	2.25
2026	15.10	358	4.36	1763	47.16	412	2.26
2027	15.57	354	4.35	1634	46.49	414	2.27
2028	16.04	363	4.50	1711	47.14	416	2.29
2029	16.51	375	4.70	1667	46.51	418	2.30
2030	16.98	372	4.71	1648	47.12	420	2.31
2031	17.45	383	4.91	1699	46.53	422	2.32
2032	17.91	391	5.06	1427	47.10	424	2.33
2033	18.38	391	5.12	1662	46.55	426	2.34
2034	18.85	403	5.33	1666	47.08	428	2.36
2035	19.32	408	5.45	1611	46.56	431	2.37
2036	19.79	411	5.55	1680	47.07	433	2.38
2037	20.25	422	5.76	1612	46.58	435	2.39
2038	20.72	425	5.87	1651	47.06	437	2.40
2039	21.19	431	6.02	1616	46.59	439	2.41
2040	21.66	440	6.22	1608	47.04	441	2.42
2041	22.13	443	6.34	1627	46.60	443	2.43
2042	22.60	450	6.51	1591	47.03	445	2.45
2043	23.06	458	6.70	1607	46.62	447	2.46
2044	23.53	461	6.84	1601	47.02	449	2.49
2045	24.00	469	7.04	1572	46.63	451	2.51
2046	24.47	476	7.23	1607	47.01	453	2.52
2047	24.94	480	7.39	1555	46.64	455	2.53
2048	25.40	488	7.60	1590	47.00	457	2.54
2049	25.87	494	7.79	1559	46.65	459	2.55
2050	26.34	499	7.93	1560	46.98	461	2.56

Source: Predicted from ARIMA model.

Production: The Production of the maize crop reported was 132 thousand tons by 1991 in the study area. Similarly, the analysis concluded that the Production of the crop in 2000 was 199 thousand tons. In 2005 the maize crop provided 226 thousand tons of corn to the market of Peshawar valley. Similarly, in 2010 the maize crop offered 338 thousand tons of corn to the population of the fertile valley. The analysis further discloses that as the area under maize crop was consistently decreasing, contrarily the Production per hectares was increasing with the practice of modern technology in the agriculture sector. In 2015 the Production of corn in the fertile valley was 381 thousand tons. Furthermore, the analysis indicates that the Production per hectare of crop further boosted and reached the highest figure of 322 thousand tons by 2020 in the study area (Table 2).

Yield: The yield per hectare of corn in the study area was 1.19 tons in 1991. The analysis describes that the yield per hectare increases with time in 2000, the yield per hectare reported was 1.70 tons. The use of current-age technology in the farming sector enhanced the yield per hectare of corn; hence, in 2005, the Production of corn increased to 1.97 tons per hectare. Similarly, in 2010 the production of corn per hectare reached 3.25 tons per hectare, which is approximately double that of 1991 in the study area. Moreover, the analysis discloses that in 2015 the per hectare production of corn further increased to 3.75 tons per hectare. The research further concluded that in 2020 the per hectare production of maize boosted to 3.70 tons per hectare in the fertile valley of Peshawar (Table 3).

Prediction: The ARIMA model statistics reveal that in 2021 the area under maize crop will be 86 thousand hectares and will deliver 323 thousand tons of corn to the resident of the study area. The analysis reveals that in 2030 the area on which the maize to be grown is 78 thousand hectares and will provide 372 thousand tons of corn. Correspondingly, in 2050 the area on which the maize crop is raised will be reduced to 62 thousand hectares, and their output will be 499 thousand tons of corn in the heart valley of Peshawar (Figure 7).

The analysis concluded that the production per hectare of corn is increasing. However, the per capita share in corn production is consistently decreasing in the study area from 2021-2050. The increase in per hectare corn production is due to the practice of modern tools in the agricultural sector. In contrast, the decrease in per capita share is attributed to the high population growth rate in the study area. The ARIMA model concluded that the area lost by the maize crop is 24 thousand hectares during the forecasting years from 2021 to 2050 in the heart valley. If the conversion rate remains till 2070 at the current speed, then the agriculture sector will be unable to cope with the food requirements of a growing population in Peshawar valley (Table 5).

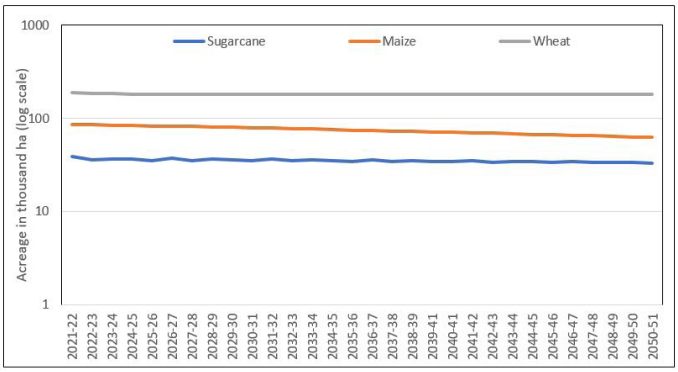

Figure 7: *Peshawar valley, acreage in ha (000) of wheat, maize and sugarcane, 2021-2050.*

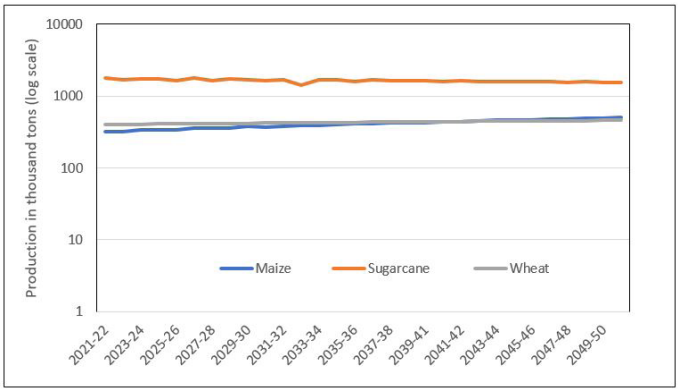

Figure 8: *Peshawar valley, production in tons (000) of wheat, maize and sugarcane, 2021-2050.*

Food security: The per capita availability of corn in 1991 was 36 kilogram (Kg) in the fertile valley of Peshawar. In 2000 the availability per person of corn enhanced to 38 kg in the heart valley. The share of dwellers in the production of corn increased to 48 kg in 2010, attributed to the application of modern tools like new machinery, hybrid seeds, and fertilizers (Table 4). The rapid increase in inhabitants resulted in a decrease of per capita share in corn production from 48 kg in 2010 to 36 kg in 2020 in the fertile valley of the province. The prediction of the ARIMA model illustrates that in 2050 the per person share of inhabitants in the production of maize will be further

reduced to 26 kg in the study area. The analysis further concluded that the per person share in corn production decreased by 10 kg from 1990 to 2050 in Peshawar valley (Table 5).

Conclusions and Recommendations

The area covered by the Peshawar valley is 7705 sq. km. It is about 14.1 percent of the province's total area of Khyber Pakhtunkhwa. In 1990 the population of the study area was 5.17 million, with a density of 286 individuals per square kilometer. The number of residents increased to 12.8 million, with a density of 1720 persons per sq. km. The ARIMA model forecasted that the population will increase to 26.34 million with a density of 3671 persons per sq. km in Peshawar valley. The rapid increase in inhabitants is attributed to the built-up areas. The analysis discloses that in 1990 the built-up area was 38496 hectares, which increased to 52252 hectares in 2000; the area further increased to 95586 hectares by 2020 in Peshawar valley. Moreover, the analysis concluded that the area gained by built-up area is 57090 hectares, an increase of 1903 hectares per year in Peshawar valley. The increased built-up area reduced the barren land and per person share in cultivated land.

In 1990 the barren land was 343083 hectares, decreased to 269039 hectares in 2000, and the area under bare soil further reduced to 240631 hectares in 2020. The barren land is converted into vegetation cover and the built-up regions to gratify growing inhabitants' food and shelter. The area under vegetation cover was 372022 hectares increased to 413040 hectares in 2020 in Peshawar valley. Similarly, in 1990 the per capita share of residents in major crop production such as wheat, maize, and sugarcane were 71, 36, and 873 kilograms (Kg). The per-person share of inhabitants in the mentioned crops reduced to 33 kg of grain, 26 kg of corn, and 326 kg of sugar by 2020 in the heart valley. The deficit per person share in major crop production was 38 kg of grain, 10 kg of corn, and 547 kg of sugar from 1990 to 2020 in the study area. The ARIMA analysis reveals that the loss per person share is 807 kg of sugar and 52 kg of grain from 1990 to 2050 in Peshawar valley.

Based on the results of the present study, the built-up area increased more than double during the last thirty years (30), with an increase of about 1903 hector per year. If this increase continues, it will hurt the agricultural land. The fall in agricultural land will directly affect agricultural Production over time and result in food insecurity. Therefore, this study suggested that proper planning should be adopted to save agricultural land and ensure a smooth food supply. Barren land may be used for built-up to avoid any inconvenience. In the recent past, agricultural technological development helped the economies to feed their inhabitants. But, if economies take care of the built-up with suitable policies and technological development, the prosperity of the societies could be improved, and food insurity can resolve.

In the present study the imageries of landset is used whose resolution is 30 by 30 meter which was available easily on USGS site. If spot imageries were openly available then the land use land cover analysis will be more accurate and appropriate. It is suggested for future researchers that if they use more accurate imageries and any advanced forcasting technique than ARIMA may get more efficient results.

Novelty Statement

The current research highlighted he use of farmland and its impact on food supply. Mass conver-sion of farmland into buildings and infrastructure is a challenge to feed the growing population most particularly in developing countries. High population growth rate attributed to land use dy-namics and it adversely affect fertile land. Such used of fertile land for infrastructure adversely af-fect agricultural production which is a challenge for policy makers to feed the growing population. it can be a threat to the future generation.

Author's Contribution

Sajjad Ali: GIS analysis, methodology development, data collection and analysis, preparation of questionnaire, drafting of research paper.
Atta ur Rahman: Development of spatial database and analysis, reviewing and editing of the research paper.
Sher Ali: Literature collection and review, data collection and preparation of questionnaire.

Conflict of interest
The authors have declared no conflict of interest.

References

Ali, S. 2017. Expansion of built-up areas and its impact on agricultural production of Tehsil Takht Bhai, Mardan. M.Phil. thesis submitted to the Department of Geography University of Peshawar, Pakistan

Ali, S., Rahman, A., and Ali, S., 2019. Impact of built environment on land use of rapidly growing tehsil Takht Bhai, District Mardan. Sarhad J. Agric., 35(3): 966-975. https://doi.org/10.17582/journal.sja/2019/35.3.966.975

Ali, S., Sadiqa, A., Ali, S., and Parveen, S., 2020. Impact of poverty and population increase on environmental degradation: A comparative study of Pakistan and India. Rev. Appl. Manag. Soc. Sci., 3(2): 169-176. https://doi.org/10.47067/ramss.v3i2.51

Backman, J.P.C., and Tiainen, J., 2002. Habitat quality of field margins in a finnish farmland area for bumblebees (Hymenoptera: Bombus and Psithyrus). Agric. Ecosyst. Environ., 89(1–2): 53–68. https://doi.org/10.1016/S0167-8809(01)00318-8

Becker's, V., Becker's, J., Vanmaercke, M., Van Hecke, E., Van Rompaey, A., and Dendoncker, N., 2018. Modelling farm growth and its impact on agricultural land use: a country scale application of an agent-based model. Land, 7(3): 109. https://doi.org/10.3390/land7030109

Bianchi, F.J.J.A., Booij, C.J.H., and Tscharntke, T., 2006. Sustainable pest regulation in agricultural landscapes: A review on landscape composition, biodiversity and natural pest control. Proc. R. Soc. B Biol. Sci., 273(1595): 1715–1727. https://doi.org/10.1098/rspb.2006.3530

Bomans, K., Dewaelheyns, V., and Gulinck, H., 2011. Pasture for horses: An underestimated land use class in an urbanized and multifunctional area. Int. J. Sustain. Dev. Plann., 6(2): 195–211. https://doi.org/10.2495/SDP-V6-N2-195-211

Bousquet, F., and Le Page, C., 2004. Multi-agent simulations and ecosystem management: A review. Ecol. Model., 176(3–4): 313–332. https://doi.org/10.1016/j.ecolmodel.2004.01.011

Cabus, P., and Vanhaverbeke, W., 2003. The economics of rural areas in the proximity of urban networks: Evidence from Flanders. Tijdschr. Econ. Soc. Geogr., 94(2): 230–245. https://doi.org/10.1111/1467-9663.00251

Ewert, F., Rounsevell, M.D.A., Reginster, I., Metzger, M.J., and Leemans, R., 2005. Future scenarios of European agricultural land use: I. Estimating changes in crop productivity. Agric. Ecosyst. Environ., 107(2–3): 101–116. https://doi.org/10.1016/j.agee.2004.12.003

Fenta, A.A., Yasuda, H., Haregeweyn, N., Belay, A.S., Hadush, Z., Gebremedhin, M.A. and Mekonnen, G., 2017. The dynamics of urban expansion and land use/ land cover changes using remote sensing and spatial metrics: The case of Mekelle City of northern Ethiopia. Int. J. Remote Sens., 38(14): 4107–4129. https://doi.org/10.1080/01431161.2017.1317936

Fontaine, C.M., and Rounsevell, M.D.A., 2009. An agent-based approach to model future residential pressure on a regional landscape. Landsc. Ecol., 24(9): 1237–1254. https://doi.org/10.1007/s10980-009-9378-0

Geist, H.J., and Lambin, E.F., 2002. Proximate causes and underlying driving forces of tropical deforestation. Bio Sci., 52(2): 143–150. https://doi.org/10.1641/0006-3568(2002)052[0143:PCAUDF]2.0.CO;2

Government of Pakistan (GoP), 2017. District census report, 2017. Federal Bureau of Statistics, Islamabad

Government of Pakistan, 1973. District census report of Peshawar, 1973; 1982;1999 and 2017. Population Census Organization, Statistic division, Islamabad, Pakistan.

Government of Pakistan, 1983. District census report of Mardan, 1973; 1982; 1999 and 2017. Population Census Organization, Statistic division, Islamabad, Pakistan.

Government of Pakistan, 1999. District census report of Charsadda, 1973; 1982;1999 and 2017. Population Census Organization, Statistic division, Islamabad, Pakistan.

Government of Pakistan, 2017. District census report of Nowshera, 1973; 1982; 1999 and 2017. Population Census Organization, Statistic division, Islamabad, Pakistan.

Happe, K., Balmann, A., Kellermann, K., and Sahrbacher, C., 2008. Does structure matter? The impact of switching the agricultural policy regime on farm structures. J. Econ. Behav. Organ., 6(2): 431–444. https://doi.org/10.1016/j.jebo.2006.10.009

Hermosilla, T., Wulder, M.A., White, J.C., Coops, N.C., and Hobart, G.W., 2018. Disturbance informed annual land cover classification maps

of canada's forested ecosystems for a 29-year landsat time series. Can. J. Remote Sens., 44(1): 67–87. https://doi.org/10.1080/07038992.2018.1437719

Khan, A., and Ali, M., 2019. Impact of Built environment on groundwater depletion in Peshawar, Pakistan. J. Himalayan Earth Sci., 52(1): 86.

Khan, M.K., J.Z. Teng, M.I. Khan and M.O. Khan. 2019. Impact of globalization, economic factors and energy consumption on CO2 emissions in Pakistan. Sci. Total Environ., 688: 424-436. https://doi.org/10.1016/j.scitotenv.2019.06.065

Nasreen, S., 2006. Monitoring of surface water, ground water and soil in Peshawar basin against time the 3rd dimension KP, Pakistan. A Ph. D. thesis submitted to the Centre of Excellence in Geology. University of Peshawar.

Rahman, A., 2007. Environmental impacts of Chashma right bank canal on the land use and agricultural resources of D.I. Khan District, Pakistan. Ph.D. thesis submitted to the Department of Geography, Urban and regional Planning, University of Peshawar, Pakistan.

Rahman, A.S., Parvin, G.A., and Shaw, R., 2016. Impact of urban expansion on farmlands: A silent disaster 7. Urban Disasters and Resilience in Asia. Elsevier, N. Y., 11(2): 91-112. https://doi.org/10.1016/B978-0-12-802169-9.00007-0

Rahman, A., and Khan, A.N., 2012. Ex post impact evaluation of Chashma right bank canal on land use in D.I. Khan District, Pakistan. Arab World Geogr., 15(2): 139-162.

Rahman, A., Khan, A., Haq, N., and Shaw, R., 2019. Soil sealing and depletion of groundwater in rapidly growing Peshawar City District, Pakistan. In Urban Drought. Springer, Singapore. pp. 289-309. https://doi.org/10.1007/978-981-10-8947-3_17

Rahman, A., Khan, A., Haq, N., Samiullah., and Shaw, R., 2019. Soil sealing and depletion of groundwater in rapidly growing Peshawar city district, Pakistan. In: Ray B., Shaw R. (Eds) urban drought. Disaster risk reduction (Methods, Approaches and Practices). Springer, Singapore. pp. 289-309. https://doi.org/10.1007/978-981-10-8947-3_17

Riaz, O., 2010. Impact of population growth on urban expansion in Lahore, 1951-1998. Ph.D. Thesis submitted to the Department of Geography, University of the Punjab, Lahore, Pakistan.

Sajid, M., Mobeen, M., Aziz, T., Kanwal, N., Rehman, A., and Rauf, R., 2020. Impact of land use change on agriculture production of Multan District. J. Sci. Introd., 32(6): 705-710.

Wahid, B., A. Ali, S. Rafique and M. Idrees. 2017. Global expansion of chikungunya virus: Mapping the 64-year history. Int. J. Infect. Dis., 58, 69-76. https://doi.org/10.1016/j.ijid.2017.03.006.

White, R., Engelen, G., and Uljee, I., 2015. Modeling cities and regions as complex systems from theory to planning applications. MIT Press. Sustainability, 6(9): 5853–5875. https://doi.org/10.7551/mitpress/9780262029568.001.0001

Wu, J., Fisher, M., and Pascual, U., 2011. Urbanization and the viability of local agricultural economies. Land Econ., 87(1): 109–125. https://doi.org/10.3368/le.87.1.109

Yar, P., Rahman, A., and Samiullah. 2016. Spatio-temporal analysis of urban expansion on farmland and its impact on the agricultural land use of Mardan City, Pakistan. Life Environ. Sci., 53(1): 35-46.

Zhang, W., Ricketts, T.H., Kremen, C., Carney, K., and Swinton, S.M., 2007. Ecosystem services and dis-services to agriculture. Ecol. Econ., 64(2): 253–260. https://doi.org/10.1016/j.ecolecon.2007.02.024