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POPULATION DISTRIBUTION AND WATER RESOURCES IN PAKISTAN

Growing population, lack of water resources, the massive amount of water withdrawal, and migration of people from rural to urban areas are creating a water scarcity issues in Pakistan. However, the suitable quantity of water resources is decreasing due to the unsustainable extraction of water resources whereas the land availability for the construction of domestic areas is reducing because of migration of people and urban areas are becoming overcrowded.

Therefore, the aim of present work is to analyse the population distribution in the different province of Pakistan as well as the amount of total blue water, people access to drinking water and water withdrawal activities. To determine the outcomes/results the datasets have been downloaded from various sources i.e. SEDAC (NASA), World pop, Joint Research Centre (JRC-GHS), Gridded Population of the World version 4 (GPWv4) and aqueduct map 2.0. Population distribution and water resources maps have been investigated in the implementation of mapping algebraic approach in the context of Quantum Geographic Information system (QGIS). Classification, overlapping, clipping, masking and other GIS techniques are applied with the help of raster and vectors datasets. By using zonal statistics tool, we examined the number of people living in each province of Pakistan. However, through the overlapping of population density and water resources maps, we derived the outcomes that in which part of the country people are extracting the massive amount of water resources and where people are facing the water scarcity related issues.

Key words: Population, water resources, Pakistan, QGIS.

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Пәкістандағы халық пен су қорларының таралуы

Су қорларының жетіспеушілігі, судың көп мөлшерде алынуы, халықтың ауылдан қалаларға көшіп-қонуы мен ұдайы өсуі Пәкістандағы су тапшылығын тудыруда. Алайда, су қорларының ұтымсыз пайдаланылуы салдарынан күнделікті пайдаланыстағы су қорлары азайып, алүй аумақтарын салу үшін жердің болуы тұрғындардың көші-қонына байланысты азаяды, ал қалалық жерлер толып кетеді. Осылайша, осы мақаланың мақсаты Пәкістанның әртүрлі провинцияларындағы халықтың үлестірілуін, сондай-ақ су бетінің мөлшерін, ауыз суға қолжетімділікті және суды тұтынуды қамтамасыз ету. Нәтижелерді анықтау үшін SEDAC, World Pop, Joint Research Center (JRC-GHS), World Version 4-нің (GPWv4) Gridded Population және акведуктор картасы 2.0 сияқты әртүрлі дереккөздерден жүктелді. Халықты және су бөлу карталарын еркін кросс-платформалық геоақпараттық жүйе (QGIS) контексінде картаға алгебралық көзқарастарды жүзеге асыру кезінде зерделенді. Растрлық және векторлық деректер жиынтығымен жіктелу, бірін-бірі қиып алу, қию, маскировка және басқа да ГАЖ әдісі қолданылды. Зоналық статистикалық құралды қолдану арқылы біз Пәкістанның әрбір провинциясында тұратын адамдардың санын зерттедік. Дегенмен, халықты және судың тығыздығын карталармен толтыру арқылы біз ел халқының бөлігі су ресурстарының үлкен көлемін шығарып, су тапшылығымен байланысты проблемаларға тап болған нәтижелерді алдық.

Түйін сөздер: халық, су ресурстары, Пәкістан, QGIS.

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Распределение населения и водных ресурсов в Пакистане

Нехватка водных ресурсов, огромное количество забора воды, рост и миграция населения из сельских районов в города создают проблемы нехватки воды в Пакистане. Однако подходящее количество водных ресурсов уменьшается из-за нерационального использования водных ресурсов, в то время как доступность земли для строительства домашних территорий уменьшается из-за миграции людей, а городские районы становятся переполненными. Таким образом, целью настоящей работы является анализ распределения населения в различных провинциях Пакистана, а также объема водной поверхности, доступа людей к питьевой воде и водозаборов. Для определения результатов наборы данных были загружены из различных источников, например, SEDAC (NASA), World pop, Объединенного исследовательского центра (JRC-GHS), Gridded Population of the World version 4 (GPWv4) и карты акведука 2.0. Карты распределения населения и водных ресурсов были исследованы при реализации алгебраического подхода к картированию в контексте свободной кроссплатформенной геоинформационной системы (QGIS). Классификация, перекрытие, отсечение, маскирование и другие методы ГИС применялись с помощью наборов растровых и векторных данных. Используя инструмент зональной статистики, мы изучили количество людей, живущих в каждой провинции Пакистана. Однако, путем наложения карт плотности населения и водных ресурсов, мы получили результаты, в которых часть населения страны добывает огромное количество водных ресурсов и где люди сталкиваются с проблемами, связанными с нехваткой воды.

Ключевые слова: население, водные ресурсы, Пакистан, QGIS.

Introduction

The pressure on water resources has been increasing and remains to grow worldwide, driven by rising food and energy demands and increasing standards of living (Vörösmarty, Green, & Lammers, 2000). Global water withdrawals have increased in the last century, which is almost twice the rate of human population growth (Falkenmark, 1997). The proportion of urban populations increased from 43% in 1990 to 52% in 2011, and it is predicted to grow to 67% by 2050 (United Nations, Urban population, development and the environment, 2008). Urbanization is expected to accelerate with population growth and social development in the novel century (Heilig, 2012). Urbanization developments in developing countries mostly differ from previous urban transitions in terms of scale, speed, and morphology, and they should obtain suitable attention and generates extraordinary impacts on environmental systems such as urban heat island effect, water run-off change, biodiversity decrease, and anthropogenic carbon emission (Chen, Cao, & Liao, 2016). Many governments craft policies to encourage urbanization for example, China has recently organised a new urbanization plan, which is expected to boost domestic demand (Bai, Shi, & Liu, 2014). Although extensive study has been conducted on urbanization, the definition of «urban» itself is vague, changing over time and space (Cohen, 2004). Consequently, the content of «urban» area maps vary largely depending on the methodology used and the data source (Friedl, et al., 2010). In 2014 researchers used the 2010 census data, and 2010 parcel data of USA to highlight the population distribution on high resolution gridded population surface they also used the dasymetric and heuristic sampling method with 30*30 m spatial resolution and accuracy has been assessed by National land cover database to produce land cover-based population product and then compared it with high resolution gridded population surface (HGPS) (Jia, Qiu, & Gaughan, 2014).

The scientists adopted the Statistical modelling and areal interpolation method with Land use land cover data (LULC) at 30m spatial resolution, LULC data 1 m resolution and parcel data. However, accuracy assessment performed at block level and validated at parcel level, overall relative error (ORE), mean absolute error (MAE), and root mean square error (RMSE) were used to check the accuracy of prediction. Therefore, Population distribution assessed based on the average population on each dwelling unit 8 models were developed and tested and model 7 (Dasymetric model) produced accurate results than others and produced a map of Um-Alhamam Riyadh, Saudi Arabia. Um-Alhamam ward has an overall area of 4 km^2 and contains 488 blocks and 2839 parcels (Alahmadi, Atkinson, & Martin). Scientists agree that an understanding of population distribution is essential for urban planning and sustainable development studies and for exploring the interrelationship between humans and their environment on diverse spatial scales. Urban planning adopted tasks including new town planning (NTP), urban infrastructure planning (UIP), and urban traffic planning (UTP) must forecast the population size and its development trend based on long-term statistics and then make a foresighted blueprint (Yin, et al. 2015). As urban areas are more vulnerable to be hit by water crises around the world and may impact the vast number of population and economic activities (Hellstrom, Jeppson and Karman, 2000).

The aim of this study is the analysis of population distribution, people access to drinking water, amount of water withdrawal and available blue water in Pakistan. To reach the aim of the study we required several types of datasets such as population data, remotely sensed data, census data. To obtain the population data we adopted distinct sources like World pop, Joint Research Centre (JRC) Global Human Settlement (GHS), Socio-economic Data and Application Centre (SEDAC-NASA-Columbia), Food and Agricultural Organisation (FAO) and water resource datasets have been downloaded by World Resource Institute (WRI).

Materials

Description of the study area

2.1.1. Location and Demography

The Islamic Republic of Pakistan is in the continent of Asia, the coordinates between 30.3753° N, 69.3451° E and it is situated eastern and northern hemisphere with a height of 8,125 m (above sea level. Islamabad is the capital of Islamic Republic of Pakistan, which is located on a latitude of 33.7294° N, and longitude of 73.0931° E. Pakistan shares its borders with four neighbouring countries Iran, China, India, and Afghanistan. In the east of Pakistan is India, which has a 2,912-km border with Pakistan. Iran is in the west of Pakistan, which has a 909-km border with Pakistan. Afghanistan located at the northwest of Pakistan; with a shared border of 2,430 km., China is towards the northeast and has a 523-km border with Pakistan. Pakistan estimated population till January 1st, 2017 was 194.9 million and covers an area of 796,095 km². An administrative unit of Pakistan consists of four provinces (KPK) Khyber Pakhtunkhwa Province, Punjab, Sindh, Gilgit-Baltistan, Baluchistan and four territories (FATA) Federally Administrative Tribal Areas, Azad Kashmir and (ICT) Islamabad Capital (Figure 1).

Figure1 – Representing to the territories and provinces of Pakistan

Ground Water Resources in Pakistan

To know the groundwater resources of Pakistan is important for that research. Ground water resources of Pakistan occur in the Indus Plain, spreading from Himalayan foothills to Arabian Sea, and are deposited in alluvial deposits. The Plain is approximately 1,600 Km long and covers an area of 21 Million hectares and is blessed with widespread unconfined aquifer, which is fast becoming the supplemental source of water for irrigation. The aquifer has been constructed due to direct recharge from natural precipitation, river flow, and the continued seepage from the conveyance-system of canals, distributaries, water channels and application-losses in the irrigated lands during the last 90 years. This aquifer, with a potential of around 50 MAF, is being exploited to an extent of about 38 MAF by over 562,000 private tube wells and about 10,000 public tube wells. It is estimated that, out of a total accessible potential of about 0.9 MAF, 0.5 MAF is already being exploited, thereby leaving a balance of 0.4 MAF that can still be utilized. This creates misconception, as the aquifers are not continuous but are limited to basins due to geologic conditions. It is noted that, in two of the basins (Pishin-Lora and Nari) groundwater is being spoiled, beyond its development potential, creating mining conditions and causing a huge overdraft of groundwater that is threatening to dry up the aquifers in the long term (Majeed, 2010).

Rainfall trends in Pakistan

The inconsistency of rainfall has increased geographically, across seasons, and annually in Asia over the past few decades. Decreasing trends in rainfall patterns along Pakistan's coastal areas and arid plains have also been detected (Houghton, et al., 2007). According to Pakistan Meteorological Department, most important parts of Pakistan experience dry climate. Humid environments prevail but over a small area in the north. The whole of Sindh, most of Baluchistan province, most parts of the Punjab and central parts of Northern Areas obtain less than 250 mm of rainfall per year (Rehman & Shan, 2010). There is no clear altitudinal trend of rainfall, which is covering to the whole country. The researcher selected 30 stations from extreme north to south and east to west and dataset spreads over a period of 30 years (1976-2005). The selected stations have been divided into five dissimilar microclimatic zones (Rehman & Shan, 2010).

Data Collection

The main significance of current work is the collection of spatial data sets and the generation of a complete database for mapping algebra approach. Meanwhile, the main concept is that the information is stored and made available to all potential users, this approach should be followed in other countries worldwide.

The objective is to assess and compare the various population density and water resources maps. To fulfil the objective of the study it is an essential to download dataset for population mapping and to determine the water resources. The datasets downloaded from several sources in which we have SEDAC (NASA-Columbia), World Pop, and FAO. SEDAC (NASA-Columbia) is providing estimates of population density for the years 2000, 2005, 2015, and 2020, created on counts consistent by national censuses and population registers, as raster data to facilitate data integration. The fourth version of SEDAC Gridded Population of the World (GPWv4) is gridded with an output resolution of 30 arc-seconds, or ~1 km at the equator (NASA, 1958). World pop is providing an estimate of the number of people residing in each 100*100m grid cell for every low and middle-income country with Geographic projection WGS84. Through integrating census, satellite survey, and GIS datasets in a flexible machine-learning framework, high-resolution maps of population count and densities for 2000-2020 are produced, along with additional metadata (WorldPop, 2013). FAO is providing the information about the population density was derived from Land Scan 2000-Global Population Database with a spatial resolution of a 5*5 arc and Geographic projection WGS 1984 (FAO, 1975). Aqueduct Global Maps 2.1 data include indicators of water quantity, water variability, water quality, public awareness of water issues, access to water, and ecosystem vulnerability. Aqueduct country and river basin rankings dataset shows countries and river basins average exposure to five of Aqueduct's water risk indicators baseline water stress, inter annually variability, seasonal variability, flood occurrence, and drought severity (World Resources Institute, 1982).

Methodology

Starting from the given background the aim of this research is to examine the utility of mapping algebra approach based on QGIS, in the case of water resources and people of Pakistan. First, different vector and raster layers have been imported with the help of QGIS. Secondly, all the raster layers were clipped for the study area (Pakistan) the Pakistan map has been clipped from global raster dataset by using the processing toolbar. Whereas the Global aqueduct map has been clipped for the study area (Pakistan) and the new vector layer has been created (Layer> create layer> new shape file layer) as well as features have been extracted by using the feature extraction tool from attribute toolbar. Raster layer has been clipped by using the processing toolbar (Processing toolbar > GDAL extraction > clip raster by mask layer). However, the vector layers of Pakistan consist of three different maps depicting the total water withdrawal in cubic kilometre per year, Total blue water in cubic kilometre per year, Access to water in percentage and raster layer showing the population densities in different provinces/regions of Pakistan with the unit of persons per sq. Kilometre. The Total withdrawal is the total amount of water extracted from freshwater sources for human use. The Total blue water for each catchment is the collected runoff upstream of the catchment plus the runoff in the catchment. Access to water measures the percentage of population without access to improved drinking-water sources. Higher values indicate areas where people have less access to safe drinking water and consequently higher reputational risks to those not using water in an equitable way. Therefore, the zonal statistics tool has been used to check the population density of each raster layer, which gives us the results in an attribute table in integers form. Finally, population distributed raster layer has been overlapped and compared with other vector layer of Pakistan to assume about the amount of water withdrawal in different provinces of Pakistan.

Results and discussions

The outcomes derived from the application of mapping algebraic approach with the help of census and other ancillary data are presented now. Results in the form of raster and vector maps are elaborated and discussed. Through mapping algebraic approach, we analysed the population density maps whereas the impacts of population density have been analysed by overlapping with the aqueduct layer.

Aqueduct Global map 2.0

According to the Figure 2 as you can see most of the blue water resources approximately > 100 km³ exist in the northern part of the country and in the north-east of Pakistan the amount of total blue water is about 50-70 km³ while in the north-west of the country the blue water resources are 30-50 km³. When we assess the "blue water" resources towards southern part of the country the given map (Fig.2) showing the scarcity of the resources which is about 10-30 km³, but some southern part reserved > 100 km³ though in the south-western portion of Pakistan the total is about 10-30 km³ whereas, in the south-eastern part of Pakistan the country is also facing the lack of water resources and accessible water are 30-50 km³.

According to the water withdrawal map of Pakistan as in Figure 3 the northern part of the country the total water withdrawal is about 10-30 km^3 per year and in the north-east of the country the water withdrawal is approximate > 100 km^3 per year while in the north-west the water withdrawal is in between 30-50 km^3 per year. Whereas, in the southern part of the country the water withdrawal is 10-30 km^3 per year while in the south-west the water withdrawal is < 10 km^3 per year and in the southeast of the country the water withdrawal is > 100 km^3 per year.

As you can see in Figure 4 higher values indicate areas where people have less access to safe drinking water. According to the given map, each inhabitant in the entire country have low to medium (2-5%) access to safe drinking water.

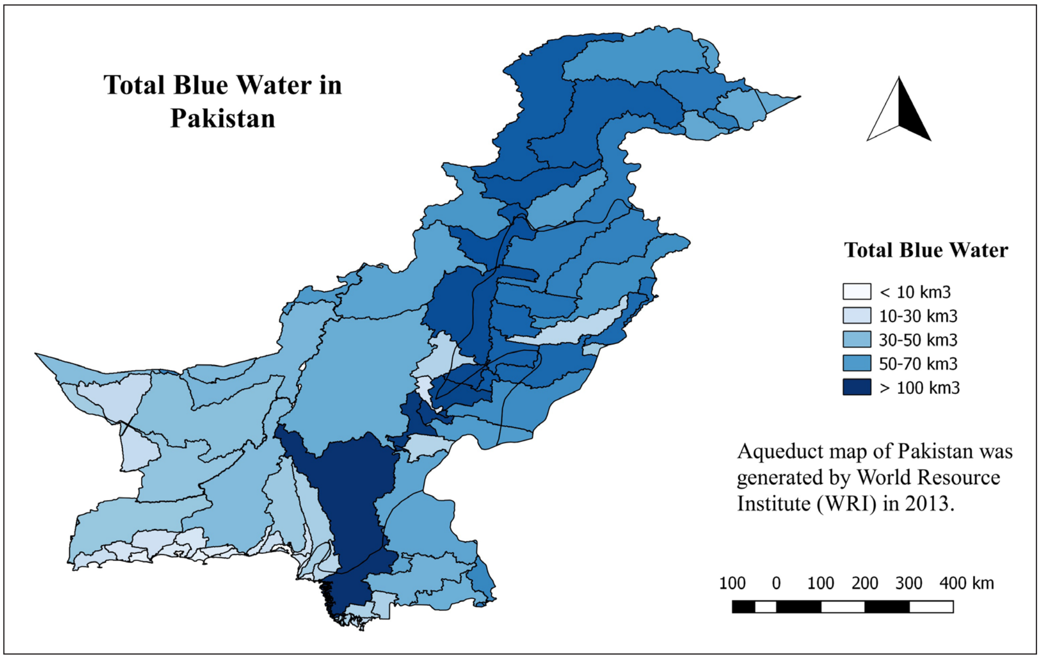

Figure 2 – The map of Pakistan showing the average amount of blue water resources in Pakistan (Source: World Resource Institute WRI)

The outcomes derived from the SEDAC (GPWv4) data sets are explained below. As given Figure 5 showing the population density per person per grid cell (~1km) in different regions/districts of Pakistan. While the assumption made for the year 2020 during this assumption, we predict that most of the population will be settled in the Punjab province which is 31° north and 72° towards eastern part of the country and it is the second largest province by area after Baluchistan. In Punjab, the population will be highly dense which > 1000 Persons per km² is. In the northern areas of Pakistan, which are

35.35°N and 75.9°E, the total population in 2020 will be 1-5 Persons per km². In KPK, (Khyber Pakhtunkhwa) province the total expected population for the year 2020 will be 25-250 Persons per km², which is 34.00°N and 71.32°E. Baluchistan is the largest province of Pakistan with respect to the area forming the southwestern region of Pakistan. Their predictable population for 2020 is 1-5 Persons per km² and the total area is 347,190 km² it lies 27.7 °N and 65.7°E. The Federally Administered Tribal Areas (FATA) is a semi-autonomous tribal region in 33° north and 70° east of Pakistan, consisting of seven tribal agencies/ districts and six frontier regions, and are directly governed by Pakistan's federal government through a special set of laws called the Frontier Crimes Regulations (FCR). The expected population of 2020 for this region is 5-25 Persons per km² and the total area is 27,220 km². Azad Kashmir province is situated in the 32.22°N and 73.28° towards east. The total predictable population of Azad Kashmir province is 25-250 Persons per km² for the year 2020 while the total area is 13,229 km². Sindh is one of the fourth province of Pakistan in the southeast of the country. Sindh is the third largest province of Pakistan by area, which is 140,914 km², and it lies 25.89°N, 68.52°E. The population density of Sindh is 250-1000 Persons per km². Federal capital territory (FCT) Islamabad is the capital city of Pakistan and it is the 10th largest city of Pakistan, which is located in the Pothohar Plateau in the north-eastern part of the country with 33°′N 73°E their expected population for the year 2020 will be > 1000 Persons per km². In the northern areas of Pakistan, which are 35.35°N and 75.9°E, the total population in 2020 will be 1-5 Persons per km² and the total area is 72,971 km².

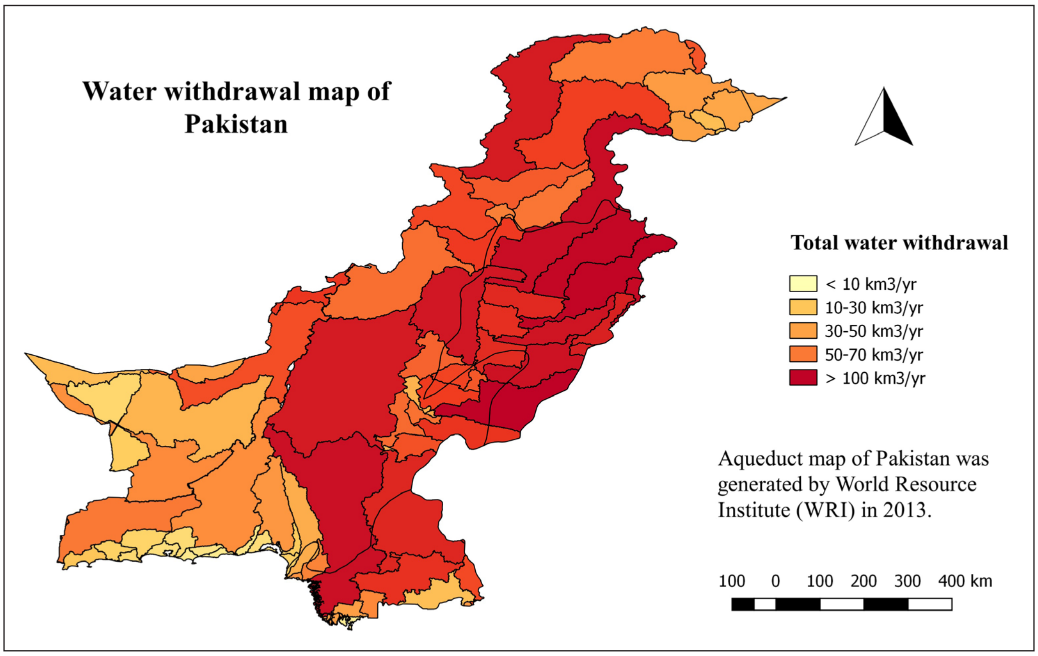

Figure 3 – The map of Pakistan showing the total water withdrawal in Pakistan (Source: World Resource Institute WRI)

Gridded Population of the World (GPWv4)

The outcomes derived from the Figure 6 about dissimilar provinces of Pakistan is that most of the population is living in Punjab province, which is extremely high > 1000 Persons per km². If we assess the population density of northern areas for the year 2015 it is about 1-5 Persons per km². In 2015, Khyber Pakhtunkhwa (KPK) province population density is >1000 Persons per km² but towards the north-west of the (KPK), the population is about < 1 Persons per km². In 2015 Azad Kashmir (AK) province population density is about 25-250 Persons per km². According to the 2015 analysis, the Federally Administered Tribal Areas (FATA) population density is 5-25 Persons per km². The population density of Sindh province in 2015 is 25-250 Persons per km². In 2015, the Baluchistan population density is < 1 Persons per km² and the estimated population density of Islamabad is > 1000 Persons per km² for the year 2015.

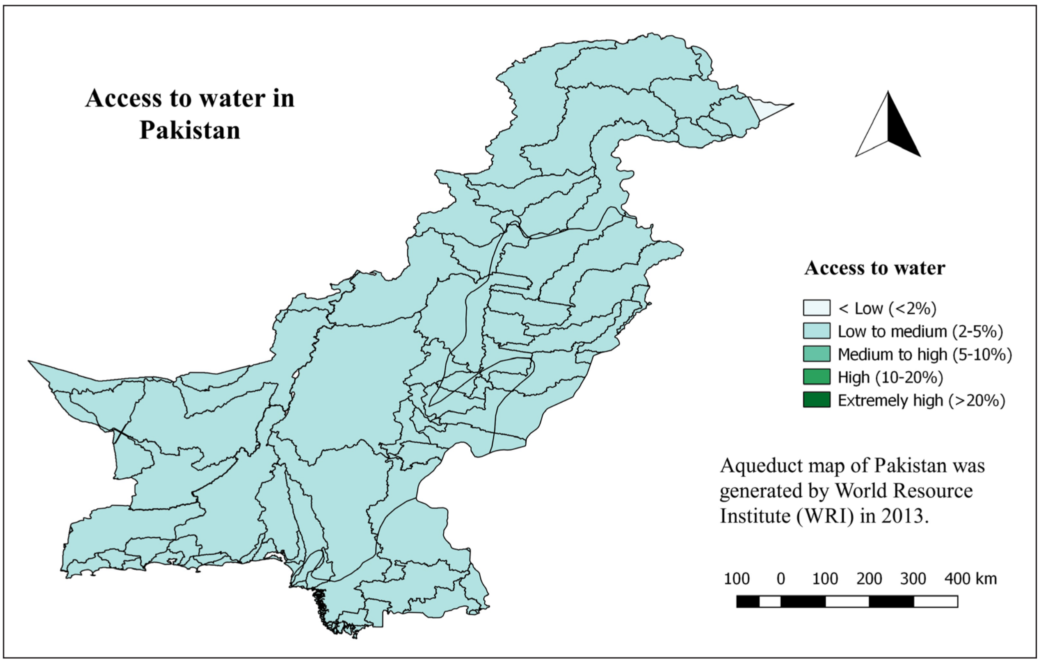

Figure 4 – The map of Pakistan showing the people access to water in Pakistan (Source: World Resource Institute WRI)

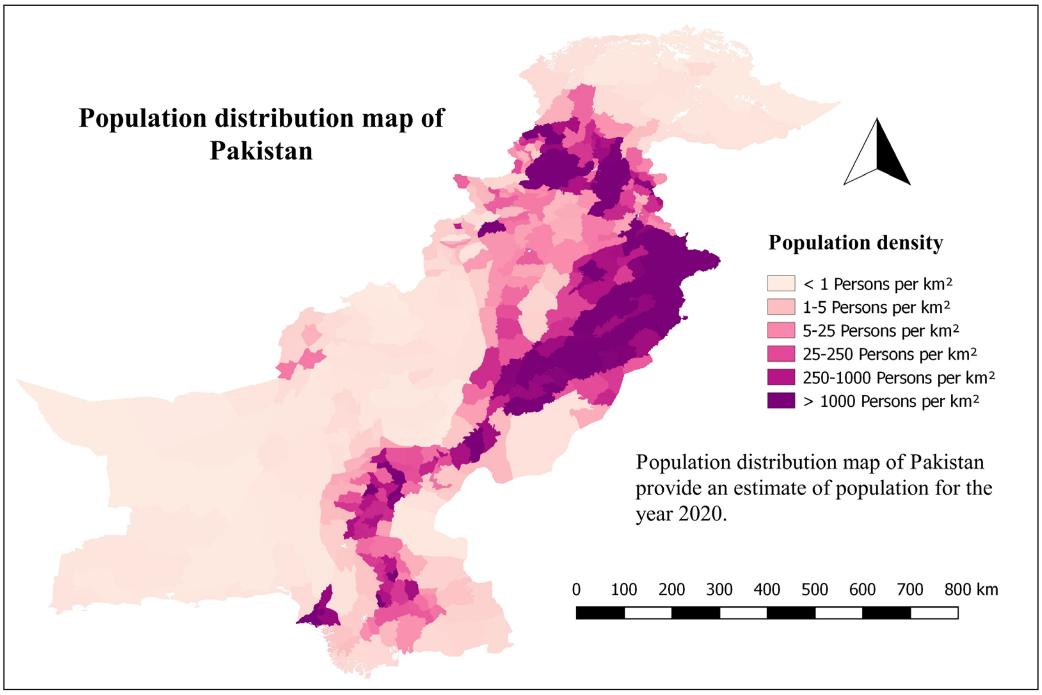

Figure 5 – Population density in different regions of Pakistan for the year 2020 (Source: SEDAC)

The given Figure 7 explaining the outcomes derived for the year 2005 as the population density of Punjab province is > 1000 Persons per km² and in northern areas, the population density is < 1 Persons per km². Whereas the population density of Khyber Pakhtunkhwa (KPK) province has been determined about > 250-1000 Persons per km² and towards the north-west their population is < 1 Persons per km² while the population density of Azad Kashmir (AK) is 25-250 Persons per km². If we look at the population density of Federally Administered Tribal Areas (FATA) it's about 5-25 Persons per km² though the population density of Sindh province is 25-250 Persons per km² and the population density of Baluchistan is < 1 Persons per km². The capital of Pakistan (Islamabad) population density is > 1000 Persons per km².

The given Figure 8 illustrating us the population density for the year 2000. As you can see the population, density of Punjab province is about > 1000 Persons per km² and if we analyse the population density for northern areas their population density is < 1 Persons per km². Although, the population density of Khyber Pakhtunkhwa (KPK) province is about > 25-250 Persons per km² and towards the north-west their population is < 1 Persons per km² while the population density of Azad Kashmir (AK) is 1-5 Persons per km². Whereas, the population density of Federally Administered Tribal Areas (FATA) it's about 5-25 Persons per km², however, the population density of Sindh province is 25-250 Persons per km² and the population density of Baluchistan is < 1 Persons per km² and the population density of Islamabad is > 1000 Persons per km².

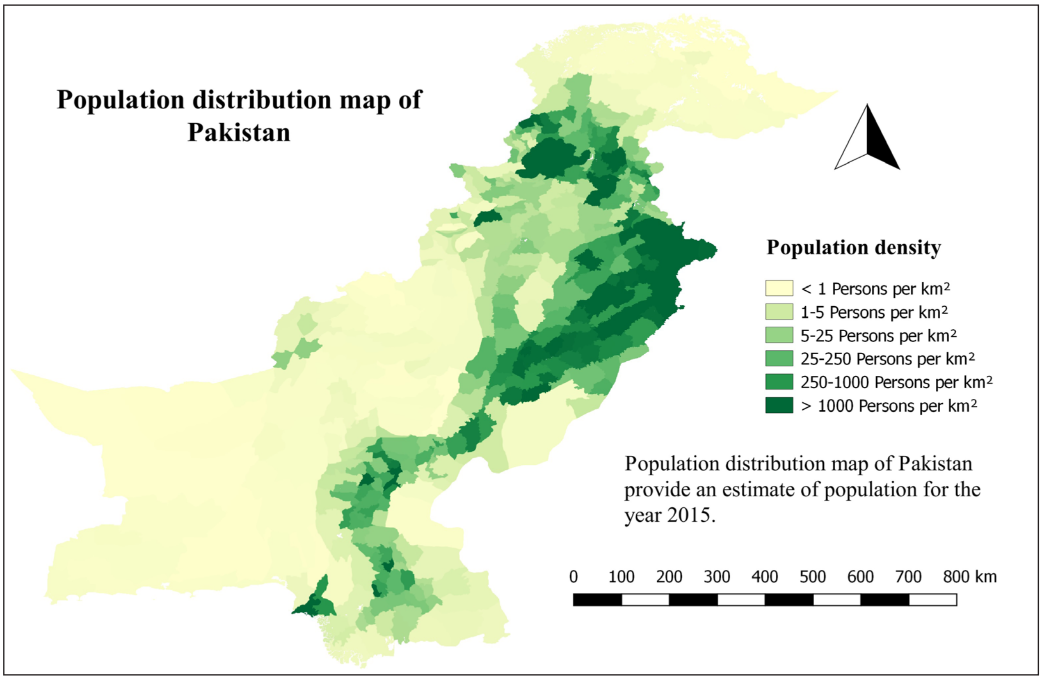

Figure 6 – Population density in different regions of Pakistan for 2015 (Source: SEDAC)

Food and Agriculture Organization (FAO)

Figure 9 has been clipped for Pakistan from the Global dataset of Food and Agricultural Organisation (FAO) and representing the population density for the year 2000. As northern areas which are located 35.35°N and 75.9°E their population density 1-5 Persons per km² while in Punjab province the population density is > 1000 Persons per km² which is 31° north and 72° towards the eastern part of the country. In Federally Administered Tribal Areas (FATA) which is 33° north and 70° east it has a population density < 1 Persons per km², Azad Kashmir 32.22°N and 73.28° towards east their population density is 25-250 Persons per km², and Baluchistan which lies 27.7 °N and 65.7°E with a population density 1-5 Persons per km². Whereas, the population density of Sindh is 250-1000 Persons per km² it lies 25.89°N, 68.52°E. In (KPK) the population density is >1000 Persons per km² but towards north-west the population density in (KPK) is 1-5 Persons per km² and it lies 34.00°N and 71.32°E of Pakistan. In Islamabad, the population density is 250-1000 Persons per km² and it is situated 33°43′N 73°04′E.

World Pop

The given Figure 10 has been directly downloaded from World pop website and it is representing to the population density of Pakistan for the year 2000. According to this figure as you can see the northern areas of Pakistan, which are located 35.35°N and

75.9°E their population density < 1 Persons per km². The population density of Punjab province is > 1000 Persons per km² and it is situated 31° north and 72° towards the eastern part of the country while Federally Administered Tribal Areas (FATA) located 33° north and 70° east it has a population density 1-5 Persons per km². The Azad Kashmir is located 32.22°N and 73.28° towards east their population density is 25-250 Persons per km² and Baluchistan which lies 27.7 °N and 65.7°E with a population density 1-5 Persons per km². Whereas, the population density of Sindh is 250-1000 Persons per km² it lies 25.89°N, 68.52°E. In (KPK) the population density is >1000 Persons per km² but towards the northwest, the population density in (KPK) is < 1 Persons per km² and it lies 34.00°N and 71.32°E of Pakistan. In Islamabad, the population density is > 1000 Persons per km² and it is situated 33°43′N 73°04′E.

Through the implementation of zonal statistics (Raster toolbar > Zonal statistics) given in Figure 11, 12 illustrates the number of people living in each province of Pakistan with respect to different years and provinces.

To make a comparison of population density map with water resources map I choose the water withdrawal map of Pakistan Figure 3 and population density map of Pakistan in 2015 in Figure 6 (Gridded Population of the World (GPW), 2018). While by means of the spatial analyst tools the raster layer has been reclassified and by conversion tools this raster layer has been converted in to polygon (Spatial analyst tools > Reclass > Reclassify), (Conversion tools > from raster > Raster to polygon). To determine the results about the number of Persons per km² and amount of water withdrawal the overlapping technique has been done by using the analysis tools (Analysis tools > overlay > Union). However, the different geographic features have been identified randomly (Feature Identifier) with the help of overlapped population density map and from each province of Pakistan. I obtained five points from raster (Population map) and from vector layer (Water withdrawal map) whereas three points from each territory/region to assess the water withdrawal with respect to the population density of Pakistan. As you can see in a given Figure 13, the Punjab province is highly populated area as compared to the other provinces and territory while the large amount of water is being extracted from that Punjab province.

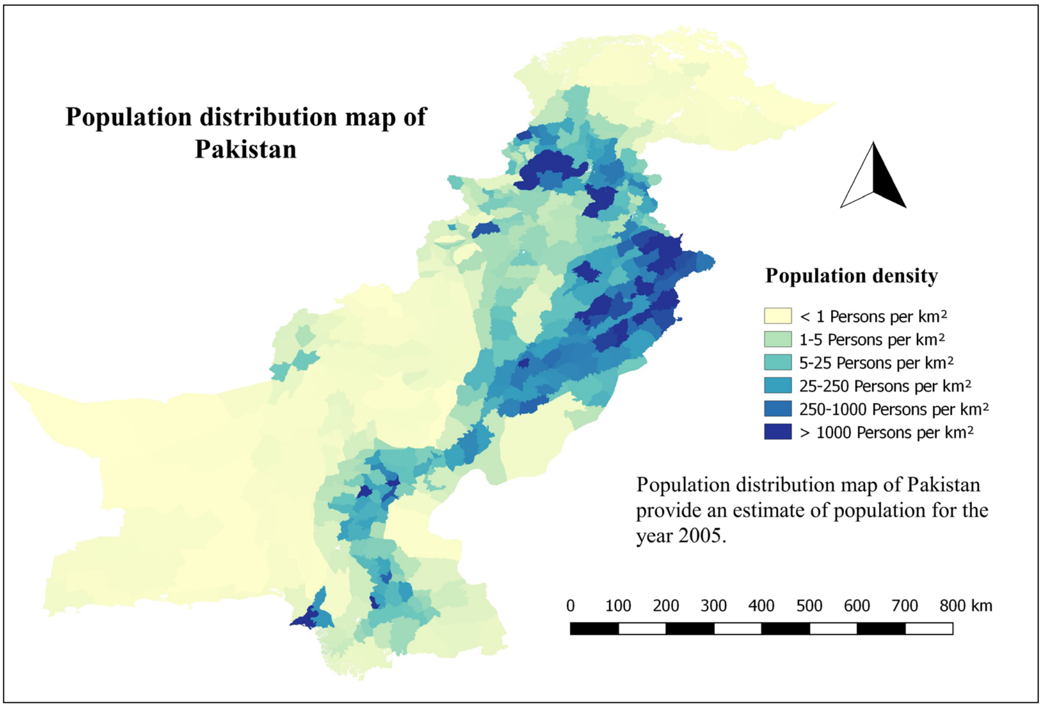

Figure 7 – Population density in different regions of Pakistan for 2005 (Gridded Population of the World (GPW), 2018)

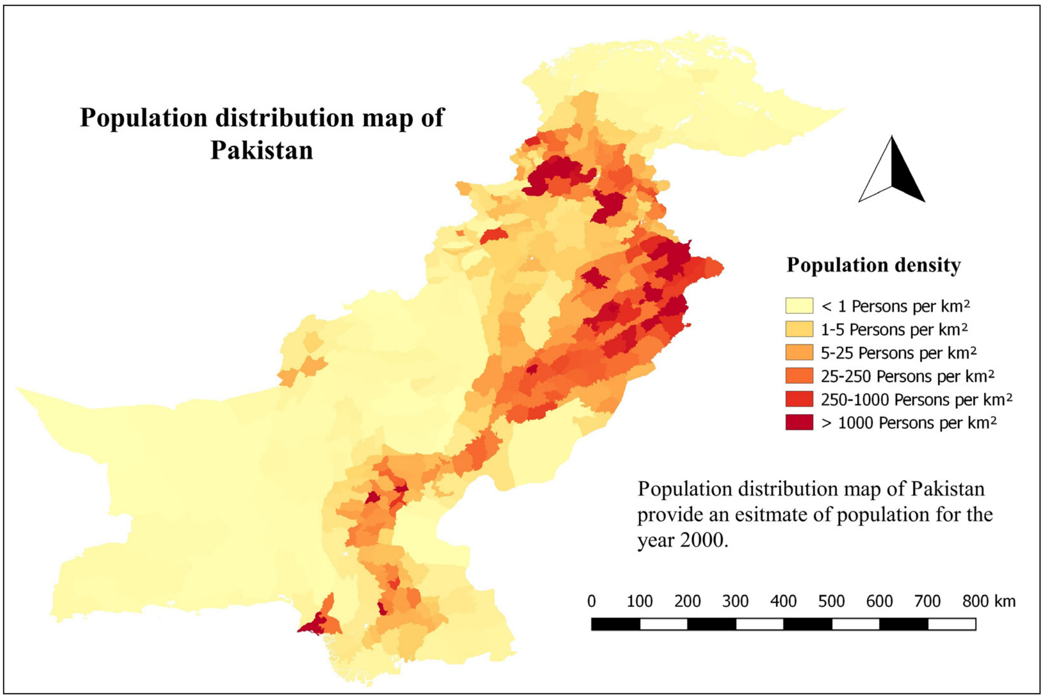

Figure 8 – Population density in different regions of Pakistan for 2000 (Gridded Population of the World (GPW), 2018)

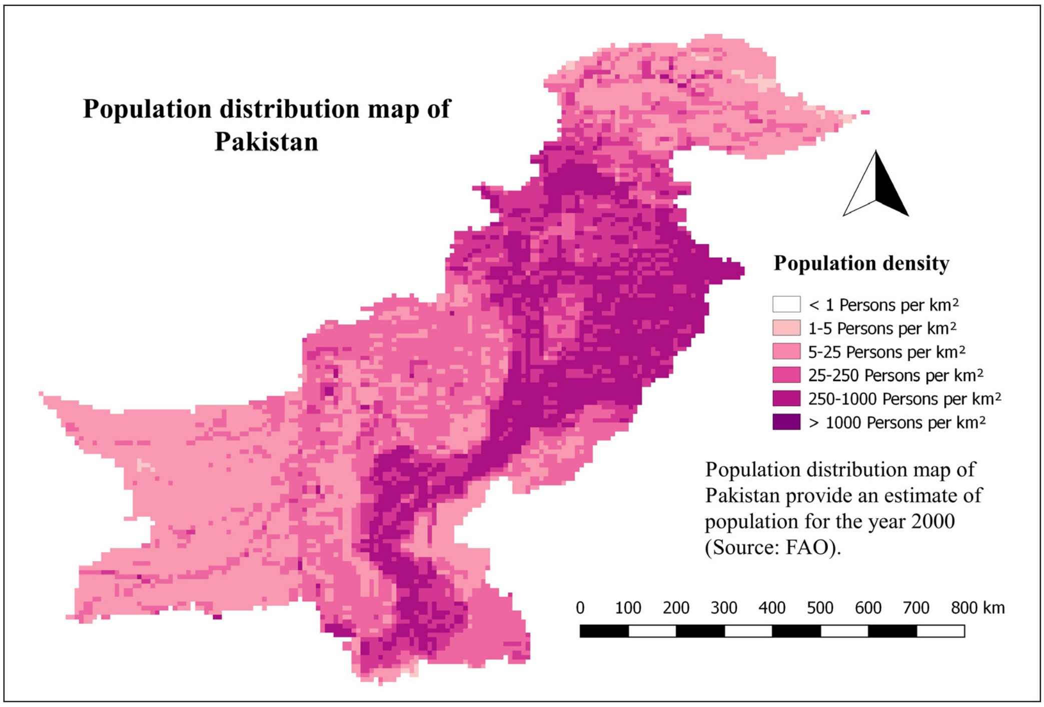

Figure 9 – Population density in different regions of Pakistan provide the estimate of population for the year 2000 (FAO, 2017)

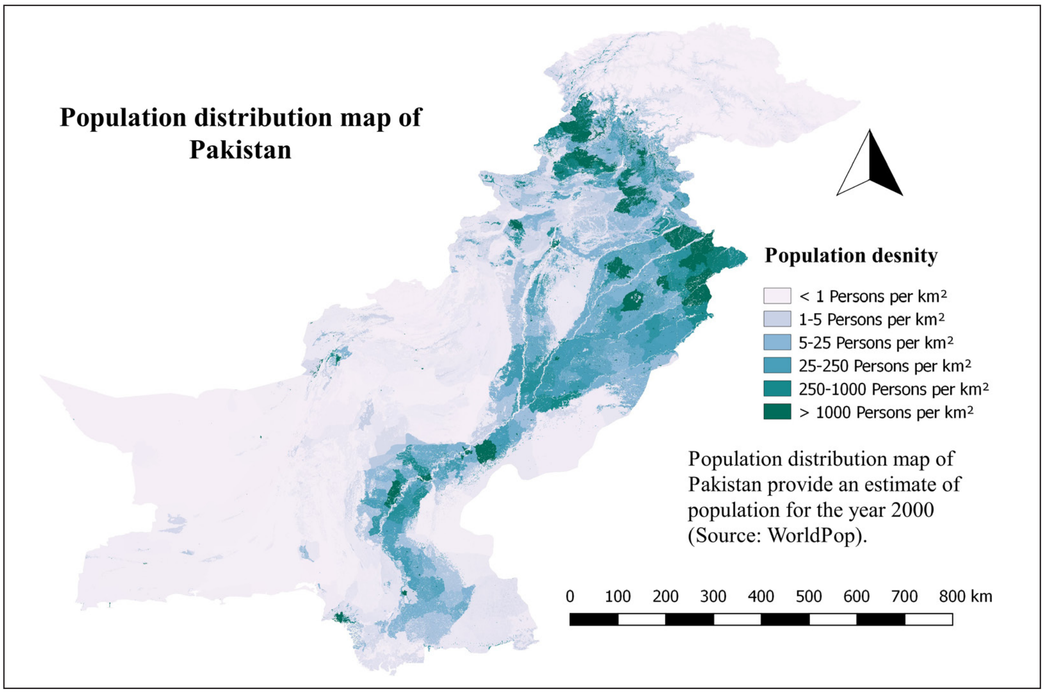

Figure 10 – Population density map of Pakistan for the year 2000 (WorldPop, 2013)

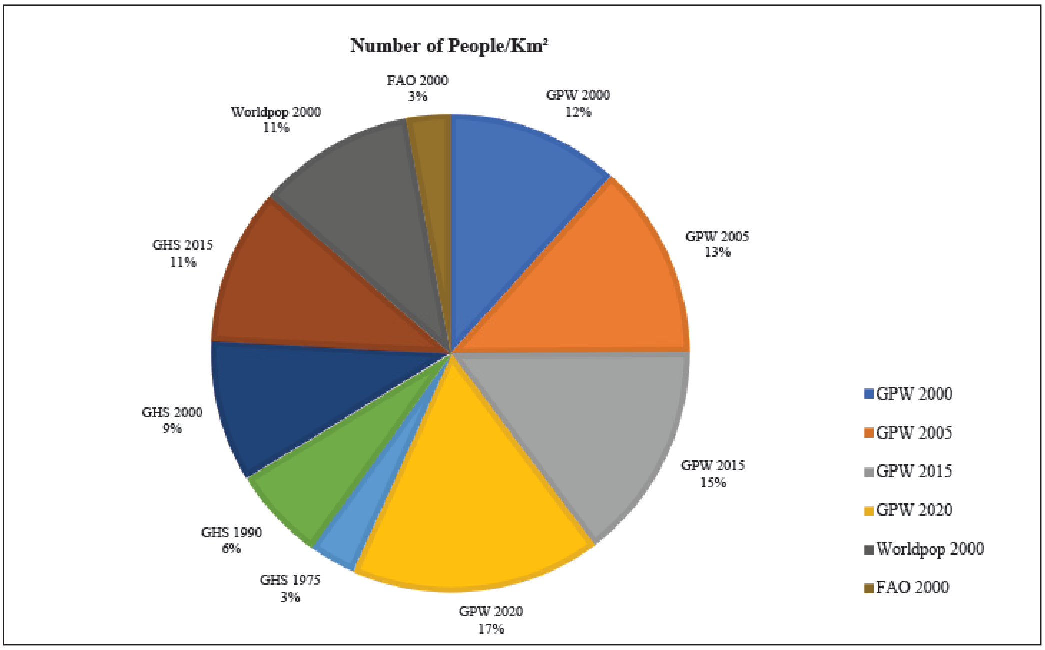

Figure 11 – Depicting the population of Pakistan with respect to years

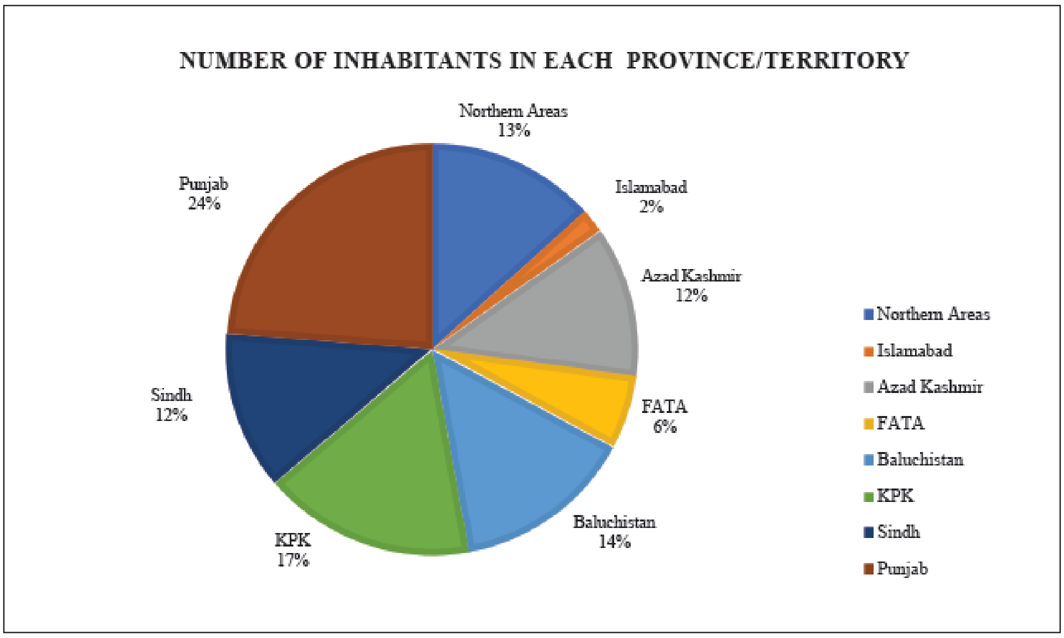

Figure 12 – Representing the provinces of Pakistan

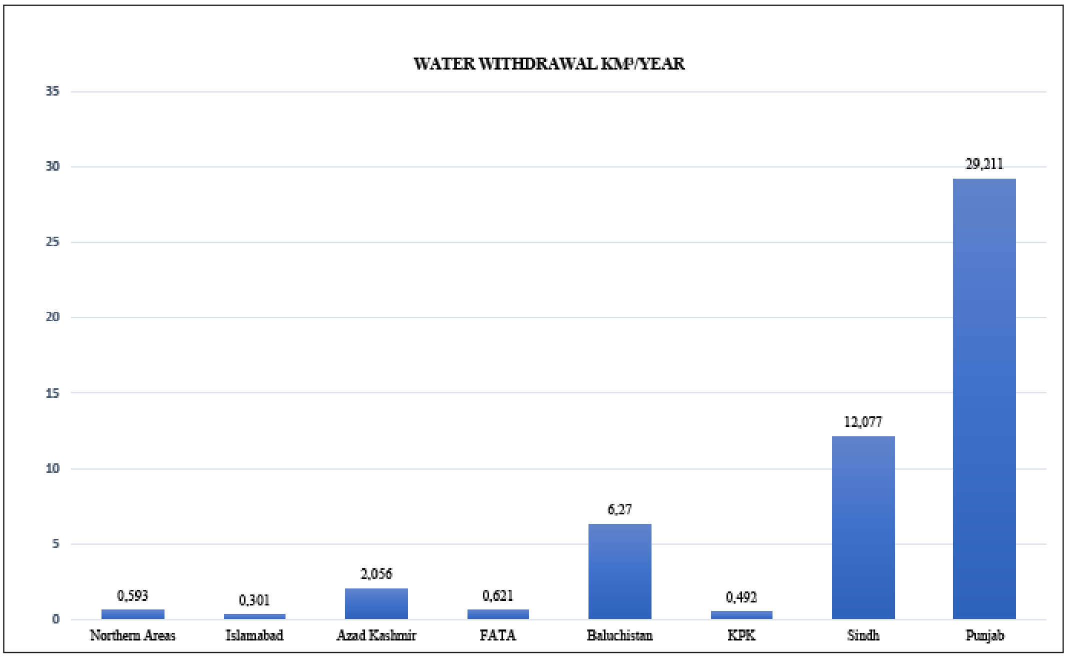

Figure 13 – Representing to the amount of water withdrawal km^3/year

Conclusions

Through overlapping of population density map 2015 (Gridded Population of the World (GPW), 2018) in Figure 6 with water withdrawal layer Figure 3 we derived the outcomes that in which part of the country people are extracting the massive amount of water resources and where people are facing the water scarcity related issues. According to Figure 4 in Pakistan, people have low to medium access to water (2-5%). In Punjab province, the population density is about > 1000 Persons per km² while the water withdrawal amount is > 100 km^3 per year and it is located 31° north and 72° towards eastern part of the country. Whereas, in northern areas, which is located 35.35°N and 75.9°E the population density is < 1 Persons per km² and the amount of water withdrawal is 10-30 km^3 per year. Khyber Pakhtunkhwa (KPK) province lies 34.00°N and 71.32°E their population density is approximate >1000 Persons per km² but towards the north-west of the (KPK), the population is about < 1 Persons per km² and the amount of water withdrawal over there is 30-50 km^3 per year. The Federally Administered Tribal Areas (FATA) is in 33° north and 70° east of Pakistan with a population density 5-25 Persons per km² and water withdrawal amount is 30-50 km^3 per year. Azad Kashmir province is situated in the 32.22°N and 73.28° towards the east with a population density 25-250 Persons per km² and water withdrawal amount is approximate > 100 km^3 per year. Sindh is the third largest province of Pakistan by area, which lies in 25.89°N, 68.52°E while the population density of Sindh is 25-250 Persons per km² and the amount of withdrawal is > 100 km^3 per year. Baluchistan is the largest province of Pakistan with respect to the area it lies 27.7 °N and 65.7°E the population density < 1 Persons per km² and water withdrawal amount are < 10 km^3 per year. Federal capital territory (FCT) Islamabad is the capital city of Pakistan and it lies 33°′N 73°E with a population density > 1000 Persons per km² and the water withdrawal amount is 30-50 km^3 per year. After assessing the population density Figure 12 and water withdrawal capacity Figure 13, we realized that most of the people are living in the Punjab province and extracting the massive amount of water as compared to the other provinces/territory of Pakistan.

Student and researchers who want to apply the same approach discussed here my recommendation is to access the cited literature for comprehensive descriptions of required procedure. Whereas, preplanned dataset strategies can save time and additional struggle as well as producing more meaningful results for monitoring purposes.

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