
RESEARCH ARTICLE

Assessing the Impact and Coping Measures of Urban Flash Floods in Quetta during Monsoon 2022

Tanveer Hussain ¹

Scholar in Department of Disaster Management and Development Studies, University of Balochistan.

Article Info

Abstract

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The research study was carried out to assess the impact and coping measures of flash floods in Quetta City during Monsoon 2022. A combination of both qualitative and quantitative research methods was used as part of the "After-Only" research design. Primary data sources included a survey of the affected areas in Quetta City and interviews of officials from various departments. Secondary data sources involved records from relevant departments, newspapers, journals, and internet. The random sampling technique was adopted during the survey, and thematic analysis of total sample size of 390 was carried out. The findings have revealed that unchecked urbanization and construction in waterways amplified the damage caused by flash floods in Quetta in 2022. The empirical evidence and survey conducted in the affected areas highlighted a deficiency in the implementation of existing regulatory measures. In order to mitigate the effect of any future flash flood, existing regulatory mechanisms are required to be implemented in true letter and spirit, which should include reclaiming encroached waterways, planning for rehabilitation of affected households to suitable locations, and detailed urban planning to cater for the expansion of Quetta City.

¹ The author is a scholar in Department of Disaster Management and Development Studies, University of Balochistan. He is a Graduate of National Defense University, Islamabad. The Author can be reached at tanveerawan1612@gmail.com

Introduction

Due to climate change, Pakistan is becoming more prone to flood disasters¹. In recent years, Balochistan, the largest province of Pakistan, has seen a surge in devastation caused by floods. Flash floods also pose significant threats to urban areas, leading to the loss of lives, damage to infrastructure, and disruption of socio-economic activities. Flash floods are mostly hit with little or no warning; therefore, they can be very dangerous. Quetta, the capital of Balochistan, has experienced the adverse effects of flash floods during Monsoon 2022, which were intensified by rapid unplanned urbanization², construction in waterways, and inadequate urban regulations. The research evaluates the impact of flash floods on Quetta City during Monsoon 2022. Effort is being made to investigate the intricate relationship between urban planning, development practices, and regulatory frameworks vis-à-vis flash flood vulnerabilities of Quetta City to suggest mitigation measures.

During the Monsoon 2022, Quetta experienced unprecedented urban flash floods, which exposed its vulnerability. In addition to natural causes, the issue was pronounced due to the unchecked urban expansion and construction in waterways. Quetta City's expansion is primarily due to urban migration and population growth³, which is increasing its vulnerability to flash floods. This study proves significant in assessing the causes and shortfalls in policy making and urban planning. This study contributes to enhance preparedness against any future flash floods by offering strategy to urban planners and policy makers. This also adds to the available knowledge on the relation between urban planning and

¹ Friederike EL Otto, Mariam Zachariah, Fahad Saeed, Ayesha Siddiqi, Shahzad Kamil, Haris Mushtaq, T. Arulalan, et al. "Climate change increased extreme monsoon rainfall, flooding highly vulnerable communities in Pakistan." *Environmental Research: Climate*, Vol. 2, No. 2 (2023): 2-19.

² Muhammad Haroon Bazai, and Sanaullah Panezai. "Assessment of urban sprawl and land use change dynamics through GIS and remote sensing in Quetta, Balochistan, Pakistan." *Journal of Geography and Social Sciences (JGSS)*, Vol. 2, No. 1 (2020): 31-55.

³ Ibid.

flash flood vulnerabilities. This research can also raise the public awareness about the consequences of unregulated urban growth of Quetta City amid flash flood susceptibility.

The objectives of this study are: -

- To assess the impact of flash flood on Quetta City during the Monsoon 2022.
- To analyze the role of urban planning and development practices in mitigating the impact of flash floods.
- To evaluate the effectiveness of existing regulatory measures in managing flash flood vulnerabilities in the urban context.

The study will address the following research questions: -

- How did the Monsoon 2022 flash floods impact Quetta City in terms of human lives, infrastructure, households and livestock?
- How does rapid urbanization contribute to increased flash flood vulnerabilities in Quetta?
- How did construction in waterways contribute to the effect of flash floods?
- Does the existing urban planning and development practices mitigate the flash flood susceptibility?
- How effective is the current regulatory framework in managing and mitigating flash flood disaster in Quetta City?

This study has designated Quetta City as its research area due to its vulnerability to flash floods. For data collection, primary and secondary sources were utilized in addition to survey results and discussions with related officials.

Literature Review

This section explains the arguments and opinions of accredited scholars on the research problem, summarizing information from relevant publications and articles. We have adopted a systematic approach to conduct a comprehensive review of the relevant literature. The available literature was also reviewed on the effect of urbanization vis-à-vis regulatory measures to check the clearance of waterways, especially in the context of Balochistan in general and Quetta in particular. After a comprehensive review of the available literature, gaps in the study have been identified. After identifying the research gaps in the available literature, a hypothesis has been formulated along with its variables.

Scholars around the globe are considering the impact of climate change in various domains. There is a consensus among the researchers that the upsurge in frequency and level of extreme weather events is linked with climate change⁴. From available records since the 1960s, a rise has been seen in the number of flood disasters. Moreover, from the 1990s on, climate change has caused a significant number of flash floods⁵.

In various climate models, they agree that flash floods are going to increase as the world is getting warmer and the rainfall intensity is going to increase⁶. Some of the scholars are of the view that, due to advancements in methods of communication and reporting mechanisms, knowledge of disasters is known to everyone in the world. Therefore, all trends seem to be going upwards.

⁴ A. Kermanshah, S. Derrible, and M. Berkelhammer. "Using climate models to estimate urban vulnerability to flash floods." *Journal of Applied Meteorology and Climatology*, Vol. 56, No. 9 (2017): 2637-2650.

⁵ Chris Zevenbergen, Adrian Cashman, Niki Evelpidou, Erik Pasche, Stephen Garvin, and Richard Ashley, *Urban Flood Management* (London: CRC Press, 2010), <https://doi.org/10.1201/9781439894330>.

⁶ Eve Gruntfest and John Handmer, "Coping with Floods," in NATO Science Partnership Subseries: 2 (ASEN2, volume 77) (London: CRC Press, 2001).

However, in recent past, this trend is noticeable as shown in Figure 1.⁷

Number of Flood Disasters Worldwide

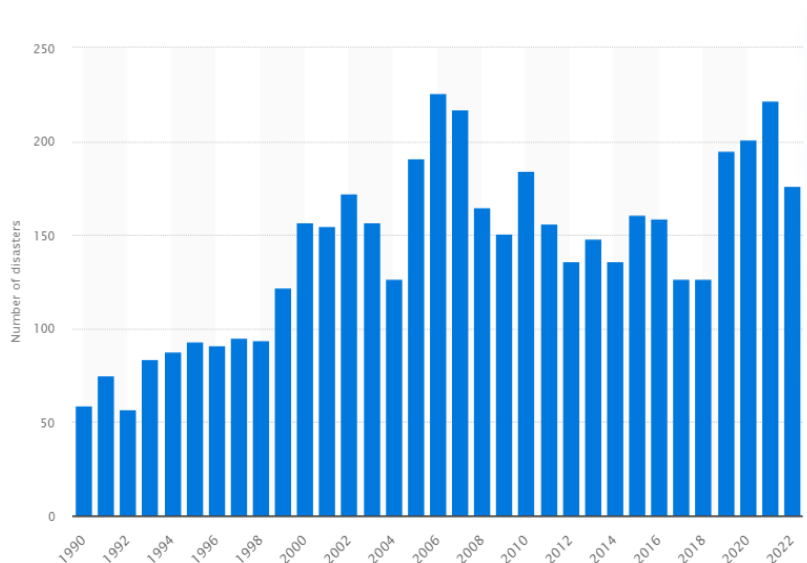


Figure 1: Number of Flood Disasters Worldwide from 1990 to 2022.

Impact of flash floods is assessed on basic three factors which are the degree of inundation, water level rising rate and flow. The damages caused by flash floods are classified as direct damages, indirect damages, secondary damages and intangible damages. The direct damages are those which affect property, infrastructure, and income crops, whereas indirect losses include the loss of businesses and services. Secondary effects are on the people who are dependent on the output of lost property, services and crops. Intangible effects are on the environment, aesthetics and social well-being⁸. Flash floods in urban areas have a direct link with urbanization. Many flash flood areas are developed due to urbanization and inadequate

⁷ Zevenbergen and Ashley, “Urban flood management”

⁸ Grunfest and Handmer, “Coping with flash floods”, 12.

drainage system⁹. In order to cope with flash floods, we should adopt an approach that identifies risk and vulnerability. Zekai Şen has defined floods as volume of runoff following an intense rainfall event within a given drainage basin, which is determined by two key factors: the intensity of the rainfall itself and the characteristics of the drainage area. There are a few characteristics of drainage areas which are important in this regard. These include slopes, areal extent and cross-sectional ground variations along the main waterway¹⁰.

Urban flash flooding is considered a very fatal disaster in urban areas, particularly the cities which are located in arid regions. In arid regions, migration to urban areas results in the growth of urban settlements. This phenomenon also triggers an increase in urban expansion towards available land in the peripheries. Flash floods, among the other disasters, are a more frequent and fatal hazard. Moreover, major damage is reported in developing countries, especially in urban areas. GIS techniques are now being used to predict the flash floods¹¹. The heavy rainfall-induced flash floods are becoming the deadliest and most expensive weather-related disasters in urban areas due to population hubs, inadequate water drainage systems, and impermeable surfaces¹².

Hemmati, et al. developed a framework that enables city planners to channelize urbanization through merging non-structural mitigation plans, urban planning guidelines, and socio-economic incentives. Urbanization poses flash flood risks which can be

⁹ Grunfest and Handmer, "Coping with flash floods", 12.

¹⁰ Zekâi Sen. *Flood Modeling, Prediction and Mitigation*. Cham, Switzerland: (Springer International Publishing, 2018).

¹¹ Bassma Taher Hassan, Mohamad Yassine, and Doaa Amin. "Comparison of urbanisation, Climate change, and drainage design impacts on urban flash floods in an arid region: case study, New Cairo, Egypt." *Water*, Vol. 14, No. 15 (2022): 2430.

¹² Kermanshah and Berkelhammer. "Using climate models", 2650.

addressed with detailed planning and mitigation measures using land-use regulations¹³.

In the recent past, the shifting of population from rural to urban areas is on the rise. World Urbanization Prospects (2018), issued by the UN Department of Economic and Social Affairs¹⁴, shows that in 1950 the world's urban population was 30 %. In 2007, the ratio of urban areas increased to more than half of the world population. In 2018, the urban area percentage increased to 55%. This trend is likely to hit 68% by 2050 (Figure 2). In developing countries, the rate of migration from rural to urban areas is significantly higher¹⁵.

Rural and Urban Population in the World

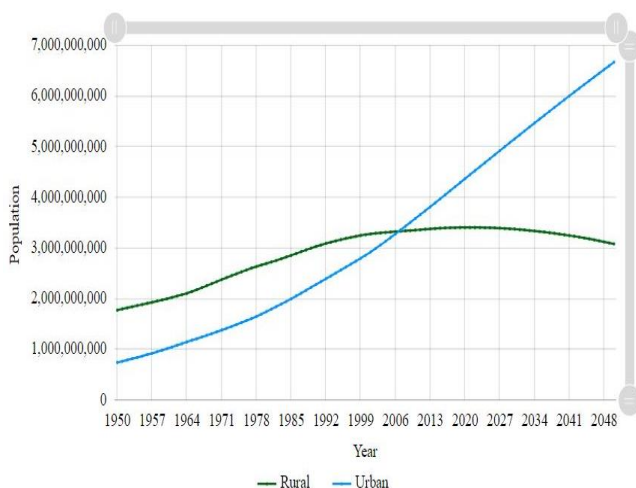


Figure 2: Rural and Urban Population in the World.

¹³ Mona Hemmati, Hussam N. Mahmoud, Bruce R. Ellingwood, and Andrew T. Crooks. "Shaping urbanisation to achieve communities resilient to floods." *Environmental Research Letters*, Vol. 16, No. 9 (2021): 2-13.

¹⁴ United Nations, Department of Economic and Social Affairs, Population Division, World Urbanization Prospects: The 2018 Revision, Online Edition (2018), accessed December 13, 2023, <https://population.un.org/wup/Download/>.

¹⁵ Andrew M. Hamer, and Johannes F. Linn. "Urbanization in the developing world: patterns, issues, and policies." *Handbook of regional and urban economics*, Vol. 2 (1987): 1255-1284.

Urbanization is likely to increase soon, especially in the developing Asian countries. Urbanization is accelerated by the rapid globalization and expansion of local economies. This concentration in the cities is likely to increase the number of affected people to any disaster¹⁶. Most urban cities in developing countries combine drainage systems with sewerage systems. These have a relatively low capacity for discharge of water. These are designed without considering the intersection with the natural routes of flashfloods. This increases the vulnerability of the sewerage system to flash floods. Additionally, a severe negative effect occurs when heavy rainfall and increased wastewater discharge in dense populations lead to sudden overflows in the drainage system¹⁷.

Balochistan has seen an increase in flood disasters where losses and damage to humans, livestock, and crops were beyond recovery. As supported by Şen (2018) that due to longer return period or scarcity of precipitation, in dry and semi-dry counties, flash floods are more disastrous. Moreover, it is difficult to predict about the flash floods as they occur for a short duration and in small regions¹⁸. Different scholars have explored various dimensions about these disasters in Balochistan. Ainuddin et al. (2010) has debated about the need for local involvement during any disaster and highlighted the need of decentralization of disaster management institutions in Balochistan, Pakistan¹⁹.

In October 2020, the Provincial Disaster Management Authority (PDMA) Balochistan issued “Disaster Risk Management Plan District Quetta, Balochistan”²⁰, which identifies floods as a

¹⁶ Zevenbergen and Ashley, “*Urban flood management*”

¹⁷ Hassan and Amin. "Comparison of urbanization", 2430.

¹⁸ Şen, Zekâi. “Flood modeling, prediction and mitigation”.

¹⁹ Syed Ainuddin, Daniel P. Aldrich, Jayant K. Routray, Shabana Ainuddin, and Abida Achkazai. "The need for local involvement: Decentralization of disaster management institutions in Baluchistan, Pakistan." *International Journal of Disaster Risk Reduction*, Vol. 6 (2013): 50-58.

²⁰ Disaster Risk Management Plan District Quetta, Balochistan, accessed December 13, 2023, <https://cms.ndma.gov.pk/storage/app/public/plans/October2020/16fgsfRYJtFvzWK85g9O.pdf>.

disaster risk for Quetta District. It also covers the details of various aspects related to other disasters, however; it does not elaborate on the need to clear waterways, encroachments to nallah and urban planning to mitigate the impact of any future floods.

Quetta Master Plan was a major reason behind related problems in Quetta City. The research finds that the major problem faced by Quetta City is improper urban planning. Due to lack of planning, the city remained underdeveloped and exposed to natural disasters. The city was not planned to house 2.59 million people which are currently residing in the city. This has created a huge burden on the city's infrastructure and resources. Moreover, mismanagement of the city is further increasing congestion within the urban areas. The main cause of this mismanagement is due to disturbance of rural-urban ratio, which has further deteriorated the master plan²¹.

Mostly, it is evident that urban problems are because of mismanagement, faulty planning and lack of coherent urban policies. Local government and administration of the city have been entrusted to carry out land-use planning to systematically address adverse effects of urbanization. There are a number of technical tools available for planners. Geographical Information Systems (GIS) are becoming widely used tools for decision-making. It can integrate data and present it clearly and concisely. GIS also helps local governments in better management of rapid urban growth²².

The recent floods in Balochistan were in year 2007, 2010, 2012 and 2022²³. Despite the experience of previous floods and

²¹ Zain Uddin Kasi, Syed Ainuddin, Abdul Rahim and Jamal. "Evaluation of Quetta Master Plan from the Lens of Disaster Risk Reduction: A Case of Quetta Master Plan." *Pakistan Study Centre*, Vol. 14, No. 2 (2021): 160-177.

²² Masakazu Ichimura "Urbanization, urban environment and land use: Challenges and opportunities." (Asia-Pacific Forum for Environment and Development, Expert Meeting, 2003): 1-14.

²³ Kiyya Baloch. "Balochistan's Flood -- Not So Natural a Disaster." *The Express Tribune*, September 28, 2022. <https://tribune.com.pk/story/2378871/balochistans-flood-not-so-natural-a-disaster>.

repeated warnings, unexpected was the unpreparedness of the provincial government, especially at district administration level. However, no assessment of flash floods in Quetta after the Monsoon 2022 was carried out by any scholar.

In most cases, flash floods become more dangerous when there is a blockage in the waterways. A study gives the example of the small village of San Carlos Minas, which has a population of 1000 and is in the State of Córdoba, central Argentina. A heavy rainfall obstructed the water from a stream, resulting in a flash flood that wiped out the village²⁴. In the longer run, unless any construction is done without planning, it will make the residents unsafe against floods. Sustainable urban development planning must be oriented towards long-term goals²⁵. Planners should utilize knowledge about the environmental consequences of different solutions. We should avoid encroachments of natural landscape, soil resources and ecosystem. After the advancements of modern mapping techniques, urban planners must utilize these to mitigate the effects of any disaster. There is a requirement to change from flood protection and adapt to flood risk management techniques²⁶.

Research Gap

The scholars have explored various dimensions of flash floods in depth, including general pattern, risk reduction measures by the communities especially in urban context, role of various departments in mitigation measures and related effects of urbanization. Effects of urbanization are also explored by various scholars. However, the recent flash flood assessment of Quetta City in the context of unchecked urbanization and waterway construction needs further elaboration. As a result, mitigation measures will play

²⁴Carlos EM. Tucci, "Urban flood management"(World Meteorological Organization: 2007).

²⁵ Petter Naess, "Urban Planning and Sustainable Development." *European Planning Studies*, Vol. 9, No. 4 (2001): 503-524.

²⁶ Zevenbergen and Ashley, "Urban flood management".

an important role in risk reduction in Quetta City. This research is crucial in achieving the same goal.

Hypothesis

Unchecked urbanization and constructions in waterways are responsible for increase in losses and damages caused by flash floods in Quetta City during Monsoon 2022.

The research entails exploring independent variables (unchecked urbanization and constructions in waterways) in context of Quetta city as it is rarely debated by the academia. The dependent variable (losses and damages caused by flash floods) has been focused more by various domains, however, the co-relation, as intended to be researched by the scholar, has not been deliberated upon in depth in context of Quetta City.

Research Methodology

This section covers the research design used to assess the impact of flash floods in Quetta during the Monsoon 2022. A combination of both qualitative and quantitative research method was used to plug the existing gap in knowledge. As the “after-only” design is being widely used for impact assessment studies, this research is also developed on examination of literature including previous scholarly work, survey and experimental evidence.

Study Area

The research study was carried out within Quetta City (Figure 3)²⁷, especially the areas hit by flash floods during the Monsoon 2022.

²⁷Quetta City Google Map, accessed on December 8, 2023, <https://www.google.com/maps/place/Quetta,+Balochistan/@30.1701805,67.0186888,11z/data=!3m1!4b1!4m6!3m5!1s0x3ed2de34ca7faae9:0x4696d44c4b6ff19718m2!3d30.1798398!4d66.9749731!16zL20vMG44NGs?entry=ttu>

Google Map of Quetta, Balochistan



Figure 3: Map of the Study Area – Quetta, Balochistan

Quetta, capital of Balochistan province, has seen unprecedented urbanization. Quetta is 5,500 feet above sea level. The famous Bolan Pass is a natural gateway to Quetta Valley. In a geological survey of Quetta, Shah (1975) explained that Quetta valley is a lengthy depression nestled between the Murdar Ghar Mountain to the east and the Chiltan Mountain to the west. To the north, it is overshadowed by the Takatu Mountain peak, while to the south, it splits into two narrow valleys due to the presence of Landi's intervening hillocks. The eastern branch of the valley bends slightly eastward and connects with the Spizand-Ismail Khan valley in the south, while the western branch concludes at Lak Pass. Beyond Quetta's western boundaries, a gap exists stretching from Samungli to Balleli, facilitating its connection with the Karanga Lora Valley to the west²⁸.

²⁸ S. H. A. Shah, "The Structure of Quetta Valley", (Vol 7) (Geological Bulletin, Paper 6, 1975) accessed December 11, 2023, <http://nceg.uop.edu.pk/GeologicalBulletin/Vol-7-8-1975/Vol-7-8-1975-Paper6.pdf>

Data Collection

Primary data sources included survey of the affected areas in Quetta City and discussion with officials and policy makers of various departments. To collect the data, a questionnaire in Urdu was used for better comprehension of the respondents. The first part focused on the respondent's profile. The second part comprised of 10 questions, highlighting their perception about flash floods, urbanization, constructions in waterways, relief efforts and future preparedness. Interactions were carried out with concerned officials of the PDMA, Commissioner and Deputy Commissioner Quetta, Irrigation, Revenue and Regional Meteorological Center, Quetta. Their focus was on assessing and identifying shortfalls in existing urban planning and regulatory measures. Secondary data sources involved records from relevant departments, newspapers, journals and internet.

Sampling

Random sampling technique was adopted during the survey. As per Census 2023²⁹, number of Households in Quetta District are 145,850 with an average household size of 8.32. Household heads of the affected areas of flash floods who are defined as main person for decision making in a family were selected as the sampling unit of this study. Opinion of a total of 390 respondents was sought from affected areas in the form of a questionnaire by employing Arkin & Colton formula³⁰.

$$n = \frac{NZ^2 \times P \times (1 - P)}{Ne^2 + \{Z^2 \times P \times (1 - P)\}}$$

n = sample size = 383 \approx 390

²⁹ Census 2023, accessed December 24,2023, <https://www.pbs.gov.pk/>

³⁰ Herbert Arkin, and Raymond R. Colton. *Tables for statistician*. (Barnes & Noble, 1963).

N = Number of Households (145,850)

Z = confidence level (95 % = 1.96)

P = degree of variability (50 %)

e = sampling error (50 %)

The golden rule for calculation of sample size as described by R. Kumar in his book *Research Methodology* that the greater the sample size, the more accuracy you will achieve in the findings which will reflect 'true' result³¹; however, due to limitation of time and resources, only minimum standard was achieved during the survey.

Research Analysis Tools

Thematic and content analysis was used during the research. The primary data was analysed using thematic analysis in which trend of unchecked urbanization and construction in various waterways was analysed along with identifying shortfalls in planning and policy making. On the other hand, content analysis was used to analyse secondary data obtained from previous scholarly work, open sources including internet. Predominantly, manual techniques were used for compilation of data.

Findings and Analysis

This section discusses the assessment of the flash flood's impact on Quetta City during the Monsoon 2022, based on the analysis of empirical evidence and data collected from primary and secondary sources. This also highlights the fact that how rapid urbanization intensified the flash flood vulnerabilities in Quetta, especially construction in waterways which amplified the effects of flash floods. It also includes evaluation of existing regulatory measures in

³¹ Ranjit Kumar. *Research Methodology: A Step-by-Step Guide for Beginners*. 3rd ed. New Delhi: Sage. 2011.

managing flash floods vulnerabilities of Quetta and role of urban planning in mitigating its impact.

Impact of Flash Floods on Quetta City during the Monsoon 2022

PDMA Balochistan issued a Daily Situation Report on 7 November 2022³² after the completion of the joint survey. There were 39 deaths due to flash floods (10 males, 17 females and 12 children) and 46 injured (18 males, 17 females and 11 children). The Monsoon 2022 caused damage to 10 bridges in and around Quetta City. 8050 houses were destroyed, and 10200 houses were partially damaged. Moreover, 2336 livestock deaths were also reported. Most of this damage was on the outskirts of Quetta, near and around waterways. Most affected people were poor families occupying mud houses. Figure 4³³ shows the condition of these houses and families after the flash floods.

Damaged Houses after Heavy Monsoon Rainfall in Quetta



Figure 4: Residents clear debris of damaged houses after heavy monsoon rainfall.

³² PDMA Balochistan Daily Situation Report, November 7, 2022, accessed December 15, 2023, <https://www.pdma.gob.pk/pdma-daily-situation-reports>

³³ Residents clear debris of a damaged house due to a heavy monsoon rainfall on the outskirts of Quetta on July 5, 2022, *Geo News*, July 6, 2022, accessed December 17, 2023, <https://www.geo.tv/latest/426314-quetta-declared-disaster-struck-as-balochistan-rains-kill-13>

In addition, 1000 kilometers of roads were damaged due to flash floods³⁴.

Bypass Road towards Hanna Lake after the Flash Floods



Figure 5: Bypass Road towards Hanna Lake after the flash floods

Figure 5³⁵ shows the bypass road towards Hanna Lake in devastated condition after the flash floods. The waterway was reclaimed by the gushing water. It is a typical example of construction in waterways where roads were constructed alongside waterways by using the space available inside the Nallah. The waterways and typical nallahs of Quetta City have become narrow in breadth after heavy encroachments. Therefore, whenever there is heavy rain, the roads turn into running nallahs.

³⁴ The Planning and Development Department Government of Balochistan, Balochistan Flood Recovery Plan 2022, https://www.undp.org/sites/g/files/zskgke326/files/2023-10/balochistan_flood_recovery_plan_2022.pdf

³⁵ Bypass Road towards Hanna Lake after the flash floods, *Global Times*, accessed December 18, 2023, <https://www.globaltimes.cn/Portals/0/attachment/2022/2022-08-27/06fd1a46-b3f5-400a-b8e2-499682fe5965.jpeg>

This situation is clearly depicted in Figure 6³⁶, where the running water is strong enough to damage everything.

Situation of Flash Floods on Roads in Quetta



Figure 6: Individuals trying to rescue persons from a car on a flooded road in Quetta.

Meteorological Data Analysis

From 2006 to 2022, rainfall in millimeters (mm) was analyzed and compared with the Monsoon 2022, as requested from Regional Metrological Centre, Quetta. Comparison of only four months (June to September) was carried out as the research was limited to Monsoon rainfall impact. The analysis revealed that during the Monsoon 2022, Quetta received unprecedented rainfall especially in July and August 2022, which was 55 mm and 156 mm respectively (Figure 7)³⁷. The data also shows that rainfall never crossed the 50 mm mark in any month except June 2007 (61 mm) and this intensity was repeated after a long time in the Monsoon 2022. As already pointed out, urban flash floods become lethal disasters in cities

³⁶Some people seen trying to rescue persons from a car stuck on a flooded road in Quetta, *The News*, August 14 2022, accessed December 18,2023 <https://www.thenews.com.pk/print/982214-six-more-killed-as-rains-add-to-balochistan-swoe>

³⁷ Regional Metrological Centre, Quetta, Monsoon Rainfall Data, 2006-2022.

located in arid regions, as any major rainfall events after long period hits the expansion of city in ignored waterways.

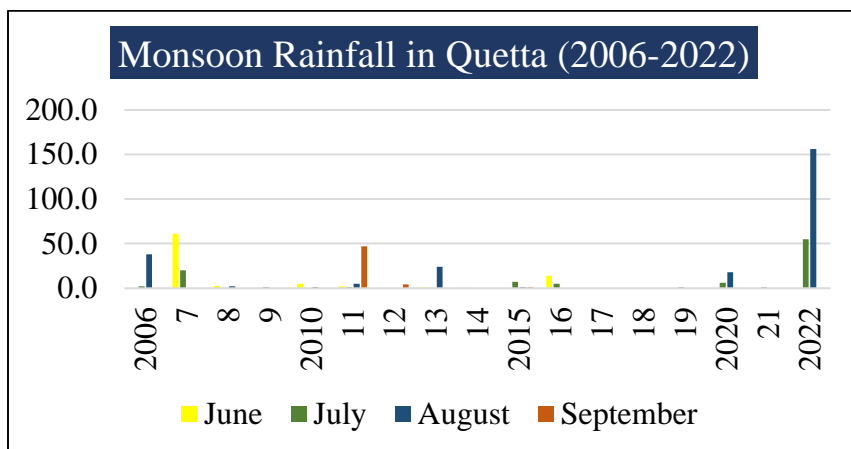


Figure 7: Monsoon Rainfall in Quetta (2006-2022)

Moreover, the identified two months of heavy rainfall in Monsoon 2022 (July and August) were further analyzed for daily rainfall in Quetta. In Figure 8³⁸, daily rainfall record pointed out that 59 mm and 37.2 mm per rainfall was recorded on 25 and 26 August 2022 respectively. This volume of water was destined to reclaim its waterways.

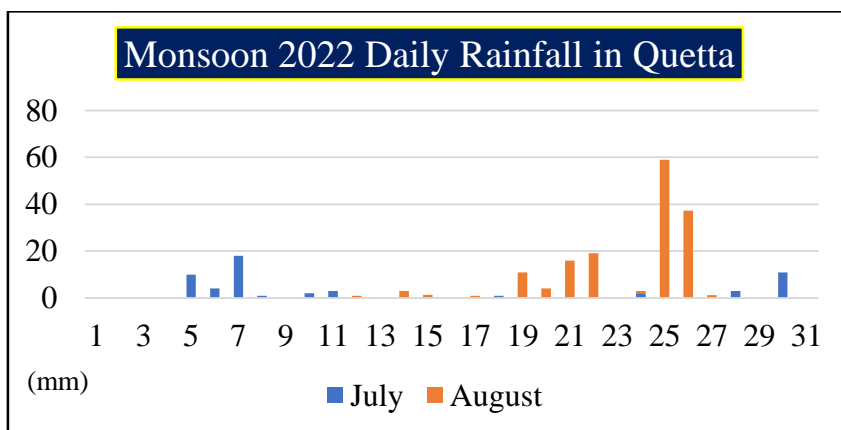


Figure 8: Monsoon 2022 Daily Rainfall in Quetta

³⁸ Ibid.

Major Waterways in Quetta

As per chapter 3 of Balochistan Irrigation and Drainage Authority Act, 1997³⁹, power and duties of Irrigation Department includes maintaining irrigation, drainage, storage reservoirs and flood control infrastructure in the province. It is also responsible for the planning, designing, construction and improvement of irrigation, drainage, storage reservoirs and flood control system. In Quetta Valley, there are 15 major waterways (flood nallahs) that have massive encroachment issues. The Table 1⁴⁰ shows their length and capacity:

Table 1: Flood Nallahs (Waterways) in Quetta

S#	Flood Nallah	Length (Kilometers)	Discharge (Cusecs)
1.	City Nallah	9	7000
2.	Durrani Nallah	4	3200
3.	Pashtoon Abad / Shin Ghar Nallah	10	2600
4.	Kar Khasa / Brewery Nallah	5.1	5600
5.	Hanna/Urak Nallah	47	30500
6.	Sara Ghurgai Nallah	18.74	10500
7.	Sara Khulla Nallah	18.5	16800
8.	Takhtani / Ghaus Abad / University Nallah	9	4000
9.	Hori Nallah / Kharoat Abad Nallah	6.68	3200
10.	Eastern Bypass Nallahs	16	2000
11.	Mustafa Abad Nallah	3.5	2000
12.	Karim Abad Nallah	3	1500

³⁹ Balochistan Irrigation and Drainage Authority Act, 1997, accessed December 19,2023, <https://irrigation.balochistan.gov.pk/acts-rules-regulations/>

⁴⁰ Irrigation Department, Government of Balochistan, Waterways in Quetta, 6 December 2023.

13.	Bangulzai Nallah	2.5	1800
14.	Badeni Nallah	3	3600
15.	Sariab Lora	52	18000

The Irrigation Department carried out demarcation of flood nallahs along with Board of Revenue Staff. Afterwards, joint reports were submitted to Senior Member Board of Revenue (SMBR). The department prepared demarcation maps identifying the major encroachments in these waterways. Two critical flood channels (Hanna and Kar Khasa) were identified for anti-encroachment drive. However, implementation could not be fruitful till now. Figure 9⁴¹ shows the flow of these flood nallahs in Quetta Valley.

Flood Nallahs in Quetta Valley

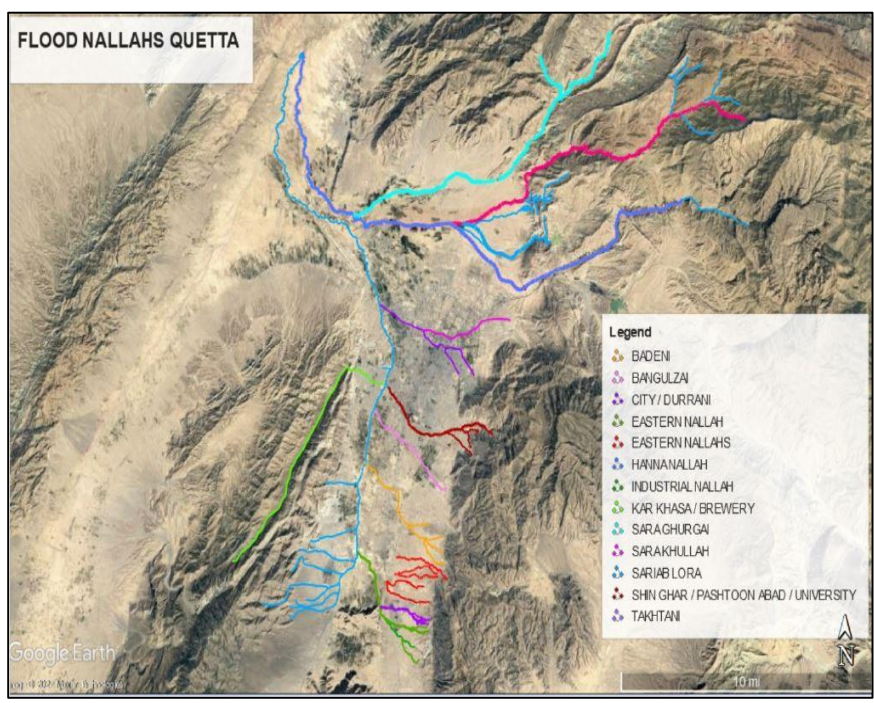


Figure 9: Flood Nallahs in Quetta Valley

⁴¹ Flood Nallahs Quetta Map, prepared by Irrigation Department, Government of Balochistan.

The researcher also approached the Revenue Department for their assessment about the impact of flash floods in Quetta and coping measures. The department also identified the construction in waterways as the main reason for damages caused by flash floods. According to the officials, they notified a committee on June 27, 2023, comprising Deputy Commissioner (DC) Quetta, Executive Engineer (XEN) from the Irrigation Department, XEN from Metropolitan Corporation Quetta, Settlement Officer, and others. The TORs (term of references) of the committee were to identify the encroached waterways in Quetta District, their Google mapping and suggesting way forward. As per the official of the Revenue Department, at more than 40 locations, encroachments in major waterways are occupying around 62 acres waterways land. The areas in Quetta where major encroachments in waterways have been identified include Eastern and Western Bypass, Hazarganji, Saryab, Mariabad, Hazara Town, City Nallah, Smaungli Road, Issa Nagri, Satellite Town and Qambrani Road. However, apparently, due to lack of synergy among various departments, clearance of encroachment is still awaited. Moreover, no plans are made for settlement of evicted families from encroached areas.

Effect of Urbanization

Balochistan is Pakistan's largest province by area, with the lowest population density per square kilometer. According to the 1951 Census, Balochistan's population was only 11.6 million, with only 12.4% urban proportion. However, as per Census 2017, population increased to 12.3 million with urban proportion to reach 27.6 %⁴². It is likely that urban ratio is further increased over the years. Census data of 2023 is still not officially released by Pakistan Bureau of Statistics. As per the news published in *The Express Tribune* on 22 August 2023⁴³, decision made in the Council of Common Interest's meeting regarding Balochistan's digital census results of 2023 was

⁴² Census 1951, accessed December 24, 2023, <https://www.pbs.gov.pk/>

⁴³ "Balochistan census results challenged", *The Express Tribune*, August 22, 2023, accessed December 24, 2023, <https://tribune.com.pk/story/2431931/balochistan-census-results-challenged>

challenged in the Supreme Court. As per the petition, the population of Balochistan was reported to be 21.7 million but it was reduced to 14.89 million in approved results. Figure 10 shows the percentage of rural and urban population from 1951 to 2017, indicating the move of rural population towards cities.

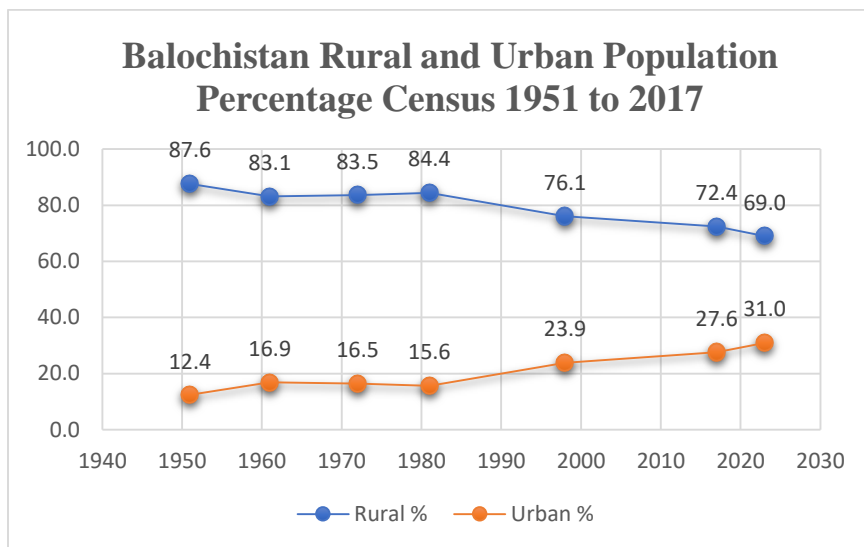


Figure 10: Balochistan Rural and Urban Population Percentage Census 1951 to 2017.

Quetta District is the most populous district of Balochistan, with a population of 2.59 million⁴⁴, as per Census 2023. According to Gallup Pakistan Analysis of Census 2023 Results⁴⁵, Quetta has seen the highest increase in population with 0.33 million, followed by Khuzdar and Panjgur. Figure 11 shows an increase in the population of Quetta District from 1981 to 2023. As Pishin & Killa Abdullah were also counted in Quetta District thus previous census data has been excluded in this analysis.

⁴⁴ Census 2023, accessed December 28,2023,<https://www.pbs.gov.pk/>

⁴⁵ Gallup Pakistan Analysis of Census 2023 Results Islamabad, October 20, 2023, December 24,2023,<https://gallup.com.pk/post/35479>

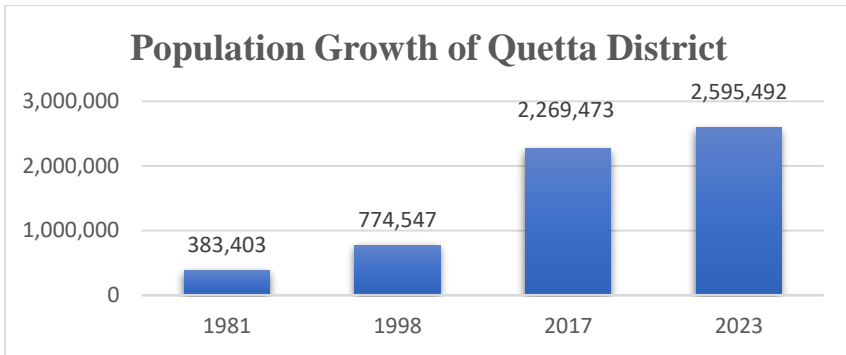


Figure 11: Population Growth of Quetta District from 1981 to 2023.

With the increase in population, mainly due to rural to urban migration and rapid growth rate, the number of households in Quetta also shows a remarkable increase. Presently, as per Census 2023 results, the number of households is 145,850. The construction of new houses was not regularized by the various departments. The density per kilometer of Quetta District increased with occupation of low-lying areas and along banks of waterways especially towards outskirts of the City. Moreover, the new construction was also not that reliable to withstand any disaster. Figure 12 shows the comparison of Pacca, Semi Pacca and Kacha household units as extracted from Census 2023. This surge in new constructions gave rise to unplanned urbanization, leading to encroachment of waterways and banks of nullahs.

Comparison of Structural Strength of Household in Quetta District

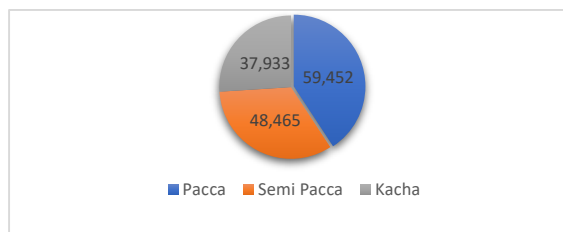


Figure 12: Comparison of household units, Quetta District (Census 2023)⁴⁶.

⁴⁶ Census 2023, accessed December 28, 2023, <https://pbs.gov.pk/>

Google Earth provides satellite view with timeline; therefore, it was used to analyze new constructions inside waterways. Only two areas are discussed in succeeding paragraphs for brevity. In Figure 13, Google Image comparison of Ameenabad and Raisani Town at Western Bypass from 2002 and 2023 explains the phenomenon of unplanned urbanization where restriction of waterways is evident.

Google Image comparison - Western Bypass from 2002 to 2023

Google
Image
2002



Google
Image
2023

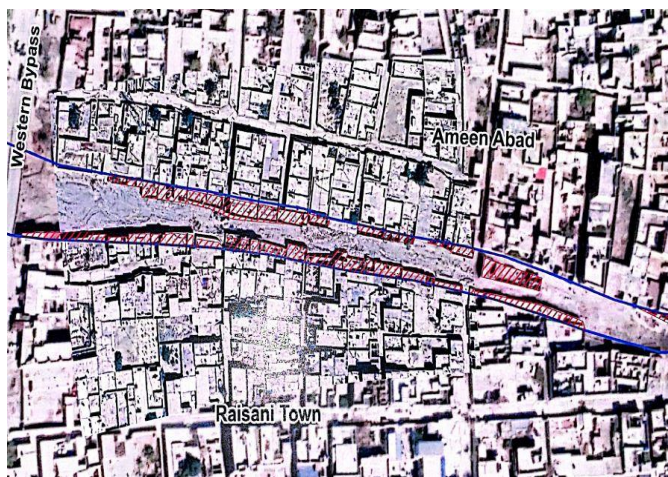


Figure 13: Google Image comparison of Ameenabad and Raisani Town at Western Bypass from 2002 to 2023.

As per the discussion with officials of Revenue and Irrigation Departments, more than 40 places have been identified where these encroachments restricted the waterways. Figure 14 shows how number of households expanded towards waterways and the unplanned urbanization occupied even inside the nallahs near Hazarganji.

Google Image comparison of Hazarganji from 2002 to 2023

Google
Image 2002



Google
Image 2023

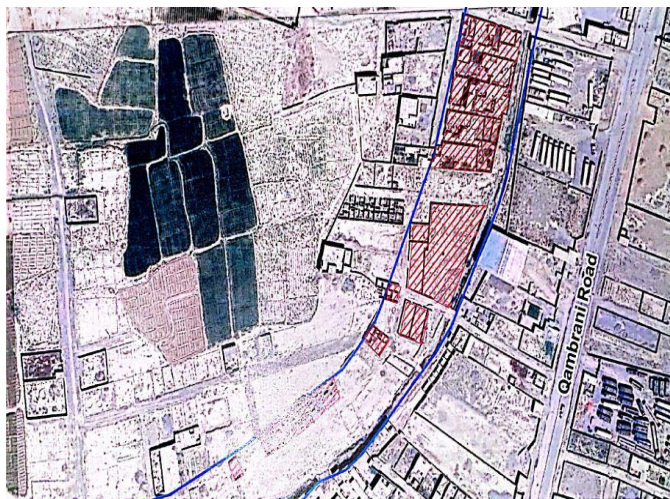


Figure 14: Google Image comparison of Hazarganji from 2002 to 2023.

Contingency Plans of PDMA Balochistan

PDMA was established in 2007 under the National Disaster Management Ordinance 2006. Provincial Disaster Management Commission (PDMC) is headed by the Chief Minister as Chairman. Its mandate under NDM ACT 2010 includes formulation and implementation of provincial disaster risk management policy/plans and review the development plans of provincial line departments to ensure that prevention and mitigation measures are integrated therein⁴⁷. The in-charge at the DDMA level is DC Quetta, and the in-charge at the divisional level is the commissioner for all types of disaster-related activities. In 2012, PDMA issued the Monsoon Contingency Plan, 2012.⁴⁸ with an aim to manage monsoon emergencies by putting in place requisite mitigation measures and a well-coordinated and integrated response. Its objectives included to enhance the effectiveness and timeliness of emergency response to ensure that emergency response is coordinated through the clarification of goals, strategies, roles and responsibilities to anticipate and overcome difficulties to strengthen response coordination between Provincial Government Departments, District Administration and humanitarian organizations. This plan categorized the districts into 5 categories i.e. very low, low, medium, high and very high districts. This plan identified Quetta as a medium-risk district.

This plan was reactive in nature as no prior planning was carried out to identify risk involved in case of heavy rainfall. After the disastrous flash floods of Quetta and other parts of Balochistan, Contingency Plan for Monsoon 2023 was issued by PDMA⁴⁹. This plan categorized all the districts in 3 categories low, medium, and high-risk districts. Quetta is placed as high risk after the Monsoon

⁴⁷ NDMA Act, 2010, accessed December 21,2023, <http://www.ndma.gov.pk/storage/NDMA-Act/NDMA-Act.pdf>

⁴⁸ Balochistan Monsoon Contingency Planning, 2012, accessed December 25,2023, <https://www.pdma.gob.pk/plans-policies-sops-circulars/plans>

⁴⁹ Provincial Monsoon Contingency Plan, 2023, accessed December 26,2023, <https://www.pdma.gob.pk/natural-hazards/flooding>

2022. This plan also lacks identification of low-lying areas or constructions in waterways. It is not covering aspect to shift the vulnerable population to some pre-planned areas after the weather warning.

In November 2008, District Quetta, Balochistan, issued the Disaster Risk Management Plan. The Quetta District was the specific target of this plan. Section 2 of this plan correctly identifies floods as a potential risk for Quetta. Two Union councils of District Quetta were recognized prone to threat of flood and settlements on banks of nallahs which flow through the city. But it was opined that history had not any significant and relentless effects of the flood. However, in this plan, it was pointed out that mitigation and preparedness is required to be evolved while the implementation is to be monitored locally at the Union Council level to reduce the impact of the flood’s disasters. However, the community level did not implement any measures, allowing urbanization to continue infiltrating the waterways.

Findings of Survey and Analysis

In the succeeding paragraphs, perception of the affected community and officials from relevant departments is presented as assessed from the survey conducted in the study area. The primary purpose of the Urdu-translated questionnaire was to accept or reject the null hypothesis (H0).

Profile of the Respondents

Composition of Respondents by age	Descriptive Statistics
	390
Over 50 Years	75
Between 41-50 Years	151
Between 31-40 Years	130
Between 21-30 Years	34
Below 20 Years	0

Composition of Respondents by Qualification	
Primary	7
Middle	27
Matric	55
Intermediate	96
Graduate	116
Masters	89

Table 2: Descriptive statistics of the respondents about their age and qualification

Source: Survey Data, 2023

The sub-section describes the age composition and education qualification of the respondents. The average age of the respondents is around 42 years (Table 2). Moreover, the age composition of the respondents varies from 23 years to 59 years. This indicates that all respondents are experience enough to give their point of view about the asked questions. Their educational qualifications range from primary to master`s. Mostly under matric respondents were above 50 years age who were unable to study due to financial constraints but had requisite knowledge and experience about the questions related to flash floods in Quetta.

Overall Results of Survey

During the survey, respondents were asked 10 questions in the form of two choices (Yes and No). A summarized response is given in Figure 15. Though the survey does not reflect public perception of the complete population, it gives perception of people about flash floods in Quetta and their thinking about reasons behind losses and damages occurred during the Monsoon 2022. Besides local population from affected areas, surveys also include assessment of randomly selected officials from concerned departments. The basic conclusions which can be drawn from the data given below, that all the respondents agreed about the construction in waterways as major cause of losses and damages during the Monsoon 2022 in Quetta.

Secondly, the majority of them also opined that urbanization is not being regularized by the Government.

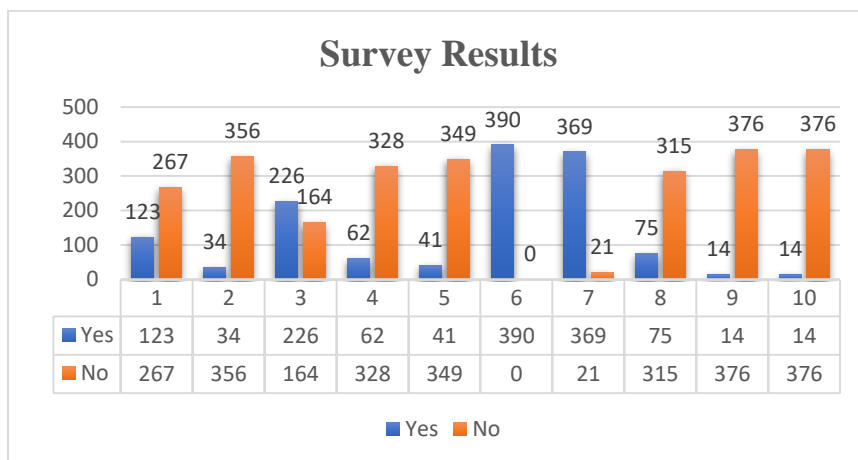


Figure 15: Tabulated Survey Results from Respondents *Source: Survey Data, 2023.*

Serial

Survey Questions

1. Did the frequency of flash floods increase in Quetta in recent past?
2. Does the urbanization of Quetta is being regulated by the Government?
3. To your knowledge, are there regulations and ordinance available for safety and risk reduction against flash floods?
4. If yes, are these regulation and ordinances effective?
5. Did you receive any warnings against flash floods?
6. Does the construction in waterways is major cause of losses/ damages?
7. Will the effect of flash floods be minimized if encroachments in waterways are removed?

8. Are the communities well prepared to respond to any future flash floods?
9. Are you satisfied with relief and rescue efforts post monsoon flash floods?
10. Has the community/ the Evacuation Centre received any assistance?

Perception of the Respondents

In Question 1, regarding frequency of flash floods, 68.4 % (267 respondents) were of the view that Quetta is receiving heavy rainfall coupled with flash floods.

Question 2 asked respondents whether the government is regulating Quetta's urbanization. 356 respondents (91.2%) reported that the Balochistan government failed to regulate urbanization in Quetta, which led to multiple issues, including land misuse. People's knowledge of existing regulations and ordinances for safety and risk reduction against flash floods in Quetta, as well as their effectiveness, was the focus of questions 3 and 4. According to 226 respondents (57.9%), there were laws available, but 42.1% were unaware of them. Moreover, the majority of people (84.2%) agreed that these rules and regulations were ineffective. In response to Question 5, 349 individuals (89.5%) reported that their community did not receive any warnings against flash floods. Contrary to that, the Metrological Department issued heavy rains warnings, but these were not specific for any community or people living inside and along nallah banks. The reason behind unawareness of affected people can be attributed to our national psyche that unless we are pushed by the administration, we do not pay any heed to warnings. The secondary sources also show that these heavy rains warnings were repeatedly available on news channels, social media and print media.

In Question 6 & 7, respondent view was sought regarding construction in waterways as major cause of damages and minimizing effect if these encroachments are removed. 390 (100 %)

and 369 (94.7 %) respondents agreed to these questions respectively. It is evident from the results that the people do understand the issue and the solution, yet they turn a blind eye when it comes to acting on this principle and implementing these rules.

Question 8 was aimed to assess the preparation of the communities against flash floods. Despite disaster in Quetta due to the flash floods 2022, the response of communities shows that 315 individuals (80.7 %) believe that their communities are not well prepared for future. This demonstrates the ineffectiveness of PDMA and DDMA plans in preparing communities for potential disasters. This also highlights the reactionary mindset of our departments and communities.

In Question 9 and 10, people's opinion was asked about their satisfaction about relief and rescue efforts post monsoon flash floods and receipt of any assistance by the affected people. Response from the majority of the respondents (96.5 %) showed that affected people are not satisfied with relief and rescue efforts. Moreover, assistance is also not directed towards affected communities.

Conclusions and Recommendations

After comprehensive discussion on the research topic, the argument is clear from the rainfall analysis from 2006 to 2022 that during the Monsoon 2022, Quetta received unprecedented rainfall especially in July and August 2022, which was 55 millimeters (mm) and 156 mm respectively. Moreover, daily rainfall data illustrates that 59 mm and 37.2 mm per rainfall were recorded on 25 and 26 August 2022 respectively. This was unparalleled rainfall in a short period of time which ultimately reclaimed waterways which were encroached over decades. 15 major waterways (flood nallahs) in Quetta Valley were identified, which have massive encroachment issues. Anti-encroachment drive of two critical flood channels (Hanna and Kar Khasa) was started; however, implementation could not be fruitful till now. The findings of the survey as well as the discussion with officials identified that construction in waterways was the main reason for damages caused by flash floods. After the flash flood

disaster of Monsoon 2022, around 40 locations with encroachments of 62 acres waterways land were marked by relevant departments. These include Eastern and Western Bypass, Hazarganji, Saryab, Mariabad, Hazara Town, City Nallah, Smaungli Road, Issa Nagri, Satellite Town and Qambrani Road. However, apparently due to lack of synergy among various departments, encroachment clearance has not given desired results.

Balochistan, despite being a province with the lowest population density per square kilometer, has seen a surge in urban population growth. In 1951, the population of Balochistan was only 11.6 million with only 12.4 % urban proportion. However, as per Census 2017, population increased to 12.3 million with urban proportion to reach 27.6 %. Quetta District is the most populous district of Balochistan with a population of 2.59 million as per Census 2023. According to Gallup Pakistan Analysis of Census 2023 Results, Quetta has seen the highest increase in population with 0.33 million.

Urbanization was the main reason for the increase in number of households. These new constructions were not regularized by the any department. As the available land decreased, these expansions were done at the cost of waterways. Google Image comparison of different areas of Quetta City, especially outskirts, from 2002 and 2023 shows the phenomenon of unplanned urbanization where restriction of waterways is obvious.

PDMA Balochistan and DDMA Quetta prepared the Monsoon Contingency Plans; however, no clear strategy was given to mitigate the impact of flash floods. The Disaster Risk Management Plan of District Quetta was also issued in November 2008 which correctly identified floods as potential risk for Quetta, particularly two union councils and settlements on banks of waterways. However, no measures were taken at community level resulting in further deterioration of waterways.

The survey conducted in the study area was aimed to get perception of respondents through a questionnaire. 390 respondents

were randomly selected to record their opinion on ten questions related to flash floods. The results of the survey rejected the Null Hypothesis (H_0).

The findings revealed that Quetta City's unplanned urbanization has increased its vulnerability to flash floods, primarily due to waterway construction. Poor planning in expansion of city and non-implementation of available regulatory measures led to the disaster caused by flash floods in the Monsoon 2022. The relatively poor population did not consider natural flood waterways and constructed weak houses in the danger areas which were destroyed by flash flood. Due to rapid urban growth mainly due to migration, coupled with poor planning, areas vulnerable to flash floods were occupied being less expensive. The relevant departments were neither able to check these encroachments nor evaluate the damages in a disaster. No planning was done to project the water level in traditional nallahs of Quetta Valley and mitigate its effects.

The findings and methodology of this study could be used by future researchers to craft a guideline to assess the flash flood effects in different nallahs of Quetta Valley that are vulnerable to similar conditions. Moreover, the drainage system of Quetta City should also be linked to any future study where heavy rains cause flooding of roads, streets and low-lying areas.

To mitigate the impact of flash floods in Quetta and to protect the population from future flash floods, following recommendations are proffered: -

- To cope with the increasing vulnerabilities of Quetta to flash floods, a technical assessment for available waterways and drainage systems is required. Future development planning should be carried out in the light of that assessment. Although waterways have been narrowed due to unplanned urbanization, encroachments must be removed from critical areas so that flash floods do not damage the population in future.

- Planning is of utmost importance to mitigate the impact of flash floods. It should include an assessment of shortfalls in the existing planning process, and development plans should account for Quetta's drainage system while calculating the maximum flow level of existing waterways. The urbanization towards the outskirts of the city should be regularized and land usage in flood prone areas to be avoided at all costs.
- The impact of recent flash floods on infrastructure, especially roads and bridges, point out flaws in planning. Construction of roads in waterway beds should not be permitted at any cost. The XEN should not approve any design which does not provide protection against flash floods.
- The concerned departments need to revisit the implementation mechanisms. As the PDMA has already given each district's responsibility to the DDMA under the respective DC, therefore, we recommend that DC Quetta lead all mitigation initiatives.
- The Irrigation Department should demarcate the historic flood waterways of Quetta Valley and land should be reclaimed phase wise. This will be a difficult task but synergy of efforts of various departments under PDMA can bring better results. At least 6 feet dredging of waterways is required to maximize flow capacity and remove accumulated soil.
- Relocation of population from encroached areas is likely to be a challenging task. However, they need to be relocated and compensated as their life saving are destroyed in flash floods. They also need to be educated not to occupy low lying areas as flash floods will return sooner or later.
- Due to advancements of technology, weather warnings are received well in time, but no one pays any heed.

Coordination meetings under PDMA should commence on receiving such warnings which should be followed by quick implementation.

- Unauthorized land usage is the major weakness in the study area. Land use policy is considered the most important feature in any development, especially urban planning. The Revenue Department procedures are required to be effective to check unauthorized use of land. Quetta Master Plan needs to be implemented for safety of its population. Moreover, new constructions should be checked for their strength and design to withstand flash floods.
- Quetta, being the capital city, attracts the rural population as evident from recent the census analysis. Unless other areas are developed by Balochistan Government, surge in urbanization cannot be controlled. The other hubs should be planned and developed accordingly.
- The Monsoon Contingency Plans of PDMA and Disaster Risk Management Plan of District Quetta require revision to include flash floods vulnerable localities and measures to mitigate its impact. The identifications of restriction in waterways, impact areas and contingency plans for relief and rescue should be included by DDMA. Communities should be taken on board, especially keeping in mind the impact of flash floods 2022. Instead of a reactionary approach, a proactive strategy should be adopted in planning and preparation.
- Finally, the awareness and training of communities is of paramount importance. Only resilient communities can prepare themselves against any disaster. Unless the population is on board, no plan can be successful. The people of the area should be taken into confidence by an effective awareness campaign. Implementation Committees should be formed by DDMA to oversee the execution phase of all

planning. We must not forget the lessons learned from past mistakes to prevent future flash flood disasters in Quetta, as they could wreak havoc and destroy lives and infrastructure.