



PIDE Monograph Series No. 6, 2021

URBAN RESILIENCE AND ITS IMPACT ON ELECTRICITY PROVISION

in Karachi, Islamabad and Peshawar

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PAKISTAN INSTITUTE OF DEVELOPMENT ECONOMICS (PIDE)

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Acknowledgements

This study is commissioned by K-Electric, Karachi to the Pakistan Institute of Development Economics (PIDE), Islamabad. We are grateful to Islamabad Electric Supply Company (IESCO) and Peshawar Electric Supply Company (PESCO) for providing information required in completing this study.



Executive Summary

Rapid urbanisation places pressure on existing infrastructure facilities and the carrying capacity of cities. Pakistan has one of the highest population and urbanisation growth rates in the world. Urban resilience is the capacity of cities to act efficiently so that their residents and workforce, especially the vulnerable people endure the stresses or shocks they encounter in their everyday lives. Literature suggests that in cities that are less resilient and have weak governance systems, it is difficult for various utilities to perform efficiently.

This study explores urban resilience across three cities in Pakistan - Karachi, Islamabad and Peshawar; and examines the linkage between the operational (transmission and distribution losses, safety systems, outages etc.) and commercial (recovery rates) performance of a utility and the urban resilience of the city.

We find the Federal capital Islamabad relatively more resilient as compared to Karachi and Peshawar. Although quite close, resilience in Karachi is slightly better than in Peshawar due to greater economic vibrancy and lesser poverty incidence as compared to Peshawar. Greater resilience of Islamabad, relative to Karachi and Peshawar, is also reflected in the performance of Islamabad Electric Supply Company (IESCO).

However, Karachi is different from the other two cities because of weak governance and fragmented institutional structure. Though all three cities are suffering from the impact of urban sprawl, its impact on Karachi is relatively greater in absolute terms, and started much earlier as compared to urban sprawl in the other two studies. That's why deeper and has its impact on the efficient working of various utilities - gas and electricity etc.

From an electricity utility perspective, IESCO is facing less challenges as compared to both Peshawar Electric Supply Company (PESCO) and K-Electric. However, the nature of the challenges is different in both K-Electric and PESCO. K-Electric is a privatised entity operating in a regulated environment. It has to deal with umpteen number of organisations in Karachi for approvals. It faces delays in tariff determination, delays in the disbursements of Tariff Differential Claims, and delays in receivables from the government departments.

Theoretically, it should have been relatively easier for K-Electric as a privatised company, to make investment decisions to upgrade or replace distribution infrastructure, but the company still needs regulatory approvals from NEPRA. K-Electric, despite all challenges/ hurdles, is improving its performance via building consumer trust through various initiatives such as 'Project Sarbulandi' and upgradation of existing distribution infrastructure across the city. Whereas, PESCO's (state-owned company) main challenges are human resources constraints and lack of capital, and delays in disbursements of public funds for the upgradation of existing infrastructure, which is old and damaged. 'Sarbulandi' type projects should also be adopted in high-loss areas, not only in PESCO but also in other distribution companies in the country.

Safety hazards from a utility perspective are common in all three cities as a result of illegal or informal housing, expansions, encroachments and urban resilience is found to be directly correlated with safety. Better planned cities enable safer service provision as in Islamabad while IESCO is also more vigilant and keeping a daily progress report on the identification and removal of safety hazards. This practice should also be scaled up by PESCO and K-Electric as literature suggests more monitoring always leads to better outcome. Support of civic and law enforcement agencies is compulsory for curbing these safety hazards.

A city economy depends on reliable electricity services. Thus, building the resilience of electricity systems is crucial for human welfare and economic growth. In such an environment, a utility company must have the financial capacity for timely periodic maintenance and to remain prepared for absorbing the effects of dangerous events in an efficient manner. Besides, without the support of relevant government departments/ city authorities, it is not possible for the utility company to work efficiently.

1.Preamble

Pakistan has one of the highest population and urbanisation growth rates in the world. Globally, it is the sixth most populous country. In the last three decades, the urban population has increased three folds, while the number of urban areas has increased from 468 in 1998 to 624 in 2017 (Hussnain et al, 2020).

Rapid urbanisation places pressure on existing infrastructure facilities and the carrying capacity of cities. Urbanisation is a complex socio-economic process that transforms the built environment, converting formerly rural areas into urban settlements, while also shifting the spatial distribution of a population from rural to urban areas.

According to the World Bank, urbanisation in Pakistan, in general, is messy and hidden as cities are expanding beyond administrative boundaries to include ruralopilises_ densely populated rural areas and outskirts not officially designated as cities. Similar findings are shared by an urban scholar, Reza Ali. According to him, 70% of Pakistan's population is non-rural, that is, living in concentrated areas in or around some urban centres (cited from Abdul and Hai, 2020).

Urban resilience is the capacity of cities to act efficiently so that their businesses, institutions, residents, communities and workforce, especially the vulnerable people endure the stresses or shocks they encounter in their everyday lives because of climate change, urbanisation or globalisation. The word resilience means “the persistence of relationships within a system” and “the ability of these systems to absorb the changes of state variables, driving variables, and parameters” (Abdul and Yu, 2020).

Sustainable Development Goal (SDG) 11 says “Make cities and human settlements inclusive, safe, resilient and sustainable.” That is, we need to build modern, sustainable cities. For all of us to survive and prosper, we need a new, intelligent urban planning that creates safe, affordable and resilient cities with green and culturally inspiring living conditions for all. In other words, to increase the resilience of cities to absorb shocks and unforeseen events.

The 5.7 per cent of land under forest cover is much below the recommended benchmark of 25 per cent, often leads to urban flooding in cities like Karachi, Lahore, Peshawar and many other cities in the country, disrupting human lives, property and existing infrastructure. This demands effective strategies to build resilience to deal with such a situation (Shahid, 2020).

In Pakistan, rapid urbanisation is not accompanied by equivalent investment in new and existing urban spaces. This puts an extra burden on existing city systems, creating social/ ethnic tensions, undermining their resilience and creating concerns for their sustainability (Mahendra and Seto, 2019). For instance, Karachi, among the world's top ten largest cities often faces power challenges, water shortages, transport problems, rising informal settlements, environmental issues, urban flooding and poor waste management issues. The situation in other cities is not different.

The resilience of cities may be contextualised in the performance of its public service delivery such as the provision of energy services as they are critical to liveability in urban spaces. It is perhaps due to a lack of urban resilience that despite sizable reforms in the country's energy sector, the delivery of reliable electricity services still remains a challenge. Even none of the current proposals for reforming urban electricity markets has a deeper analysis on its back resulting in little faith in their workability. This necessitates that the performance of electric utilities, for quality electric service delivery may be understood in the context of overall city governance. This can be achieved in two ways: either by comparing utilities of different nature (e.g., electric, water, and gas) with the same city governance context or by comparing similar utilities in different city governance contexts. This study chooses the latter option.

The first objective of the study is to compare urban resilience across three major cities, Karachi, Islamabad and Peshawar. How it impacts the provision of electricity services in these three cities? The study examines the linkage between various operational (transmission and distribution losses, safety systems, outages etc.) and commercial (recovery rates) performance of a utility and urban resilience of the city. The second objective is to draw lessons from IESCO, PESCO and K-Electric regarding safety hazards related to electricity utility for each other and for other distribution companies. Safety hazards that arise because of urbanisation or its consequences, e.g., urban sprawl. The study highlights possible policy actions to enhance resilience in Pakistani cities and a resilient electricity system to cope with urban challenges.

Research Questions:

- What is the state of urban resilience in Pakistani cities? How is it affecting the quality of electricity services?
- Is Karachi less resilient than Islamabad and Peshawar?
- How are IESCO (in Islamabad), PESCO (in Peshawar) and K-Electric (in Karachi) dealing with urban sprawl issues in particular, safety hazards?

Hypothesis:

1. H0: Pakistani cities are resilient to absorb the impact of rapid urbanisation, thus, there is no issue of service delivery, safety in electricity systems and in the collection of payments by electricity distribution companies.
H1: Rapid urbanisation leads to the expansion of slums/ informal settlements in Pakistani cities creating issues of service delivery. Illegal extensions /encroachments create safety hazards and hinders in reducing losses and in collection of payments by electricity distribution companies.
2. H0: Karachi urban dynamics is similar to Islamabad and Peshawar.
H1: Karachi urban dynamics is different from Islamabad and Peshawar due to relatively greater economic vibrancy and relatively more troubled spots because of various socio economic, governance and political reasons.

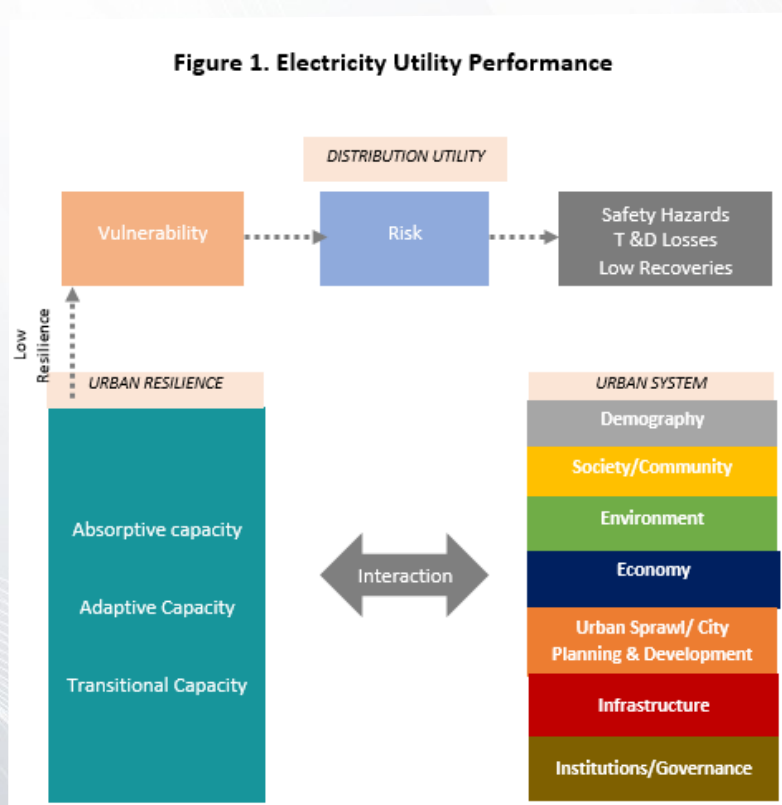
¹<https://www.dawn.com/news/1574424>

The study is organised in five sections. Preamble is followed by conceptual framework and methodology. Section 3 will discuss city profiles and will estimate and compare urban resilience across three cities using various indicators. Section 4 will relate urban resilience with utilities performance and discuss their coping strategies. Section 5 is conclusion.

2. Conceptual Framework and Methodology

Rapid urbanisation creates several serious challenges for cities. For instance, water shortages, lack of sanitation facilities, traffic woes, lack of affordable housing and unreliable electricity supplies. Therefore, the provision of electricity services or the performance of an electricity utility cannot be studied in isolation, especially in cities expanding horizontally and vertically. There are several other factors (economic, social, institutional, governance, community) at play affecting utility performance. For electricity distribution utilities, sometimes it is a trade-off between affordability and reliable supplies; as these companies have to create a balance between their financial sustainability and arranging investments to expand and improve utility services to urban poor residing in informal settlements like slums. This challenge is often aggravated by property rights issues that define many informal or illegal urban settlements. Often these settlements and expansions create safety hazards, sometimes within and sometimes beyond the control of the utility company.

Urban governance plays a critical role in coordinating the activities of various components of the energy system and minimising safety hazards. Urban governance refers to how government at various levels and other stakeholders, plan and manage urban areas_ cities (UKAID, 2016). Literature suggests that in cities that are less resilient and have weak governance systems, it is difficult for various utilities to perform there efficiently.



Each urban space may have its ecology which suggests that while lessons can be learned, there is no panacea or universal governance solution to ensure cities' liveability and prosperity (White, 2019). Even within the same country, cities may be subject to different social, economic, political and institutional reality making them a candidate for differential treatment. And so are the utilities performing in these city systems, these can't be treated equally.

²Electricity utility is a company in the electric power industry that engages in all or only one aspect of the electricity supply chain, that is, generation, transmission and distribution. These utilities include privately-owned, publicly-owned, cooperatives or nationalised entities.

³The selection of sub-indicators is dependent on the availability of data; there is no systematic compilation of city databases in Pakistan.

For example, Karachi offers great poverty reduction potential which facilitates informal land markets resulting in an urban sprawl of unparalleled magnitude in the country (WB, 2018). This together with poor governance, institutional fragmentation hampers the quality of public service delivery, reduces the city's resilience and raises concerns over the sustainability of this urban space – sometimes called 'civic emergency' (Abbas, 2021).

Literature suggests that utility performances do not take place in a vacuum and can only be assessed in the light of utility characteristics and the contextual variables or the city environment in which it operates. Utility's own characteristics may be realised as various measurable attributes such as utility ownership, size of the network, safety systems, reliability in supplies, profitability, operational and commercial efficiency.

Context on the other hand is a multidimensional concept comprising various complex indicators. Among those important in an urban context may be the following: infrastructure planning and development; demographic characteristics; urban sprawl characteristics; social/ community and economic landscape; environment; and governance and institutional settings (Figure 1).

A city is a complex system composed of natural systems, social systems, and structural systems. Each system itself is important. For comparative purposes, various urban resilience indicators and utility characteristics would be used. The conceptual framework can better be understood via Figure 1. The framework is adapted from Zhang et al (2020), with several modifications. Urban systems are interlinked and are the key systems affecting urban abilities to resist, absorb and adapt to transformation. Each of these seven dimensions is further divided into various sub-dimensions that can be assessed. These sub-dimensions are illustrated in Figure 2.

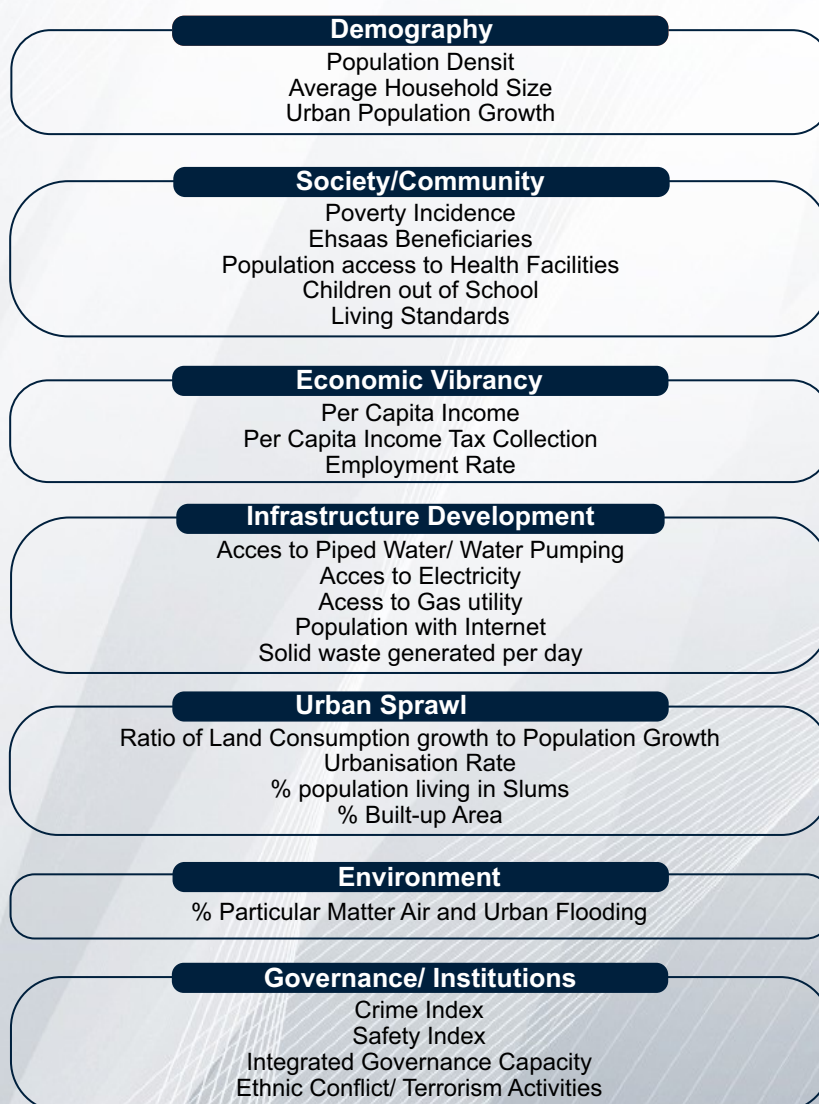


Figure 2 Urban Resilience Dimensions/ Sub-Dimensions

We have estimated the urban resilience index for the three Pakistani cities _ Karachi, Islamabad and Peshawar using the following formula:

$$URI = \sum_{i=1}^7 w_i D_i \quad \dots\dots\dots (1)$$

$$D_i = \sum_{j=1}^n u_{ij} Y_{ij} \quad \dots\dots\dots (2)$$

Where URI is urban resilience index; D_i is resilience component index; Y_{ij} is the standardised value of each indicator; w_i is the weight of each dimension and u_{ij} is the weight of each sub-dimension.

The value of urban resilience closer to one will indicate higher resilience.

Urban Resilience Index is estimated to compare the present developmental progress of three cities in this study. Indices are set with 23 sub-dimensions (indicators) based on seven dimensions as listed in Figure 2. Additionally, positive and negative signs are assigned to every indicator to indicate the impact of urban resilience. Besides, the value of these indicators is normalised. The normalised values are adjusted between 0 and 1.

Weights assigned to each dimension and sub-dimensions are derived from the significance of that variable to urban resilience as perceived in the literature and from the electricity utility perspective.

Besides estimating urban resilience for each city, each of its dimensions and sub-dimensions are linked to the electricity utility performance and issues faced by these utilities using a problem tree analysis as depicted in Figure 3.

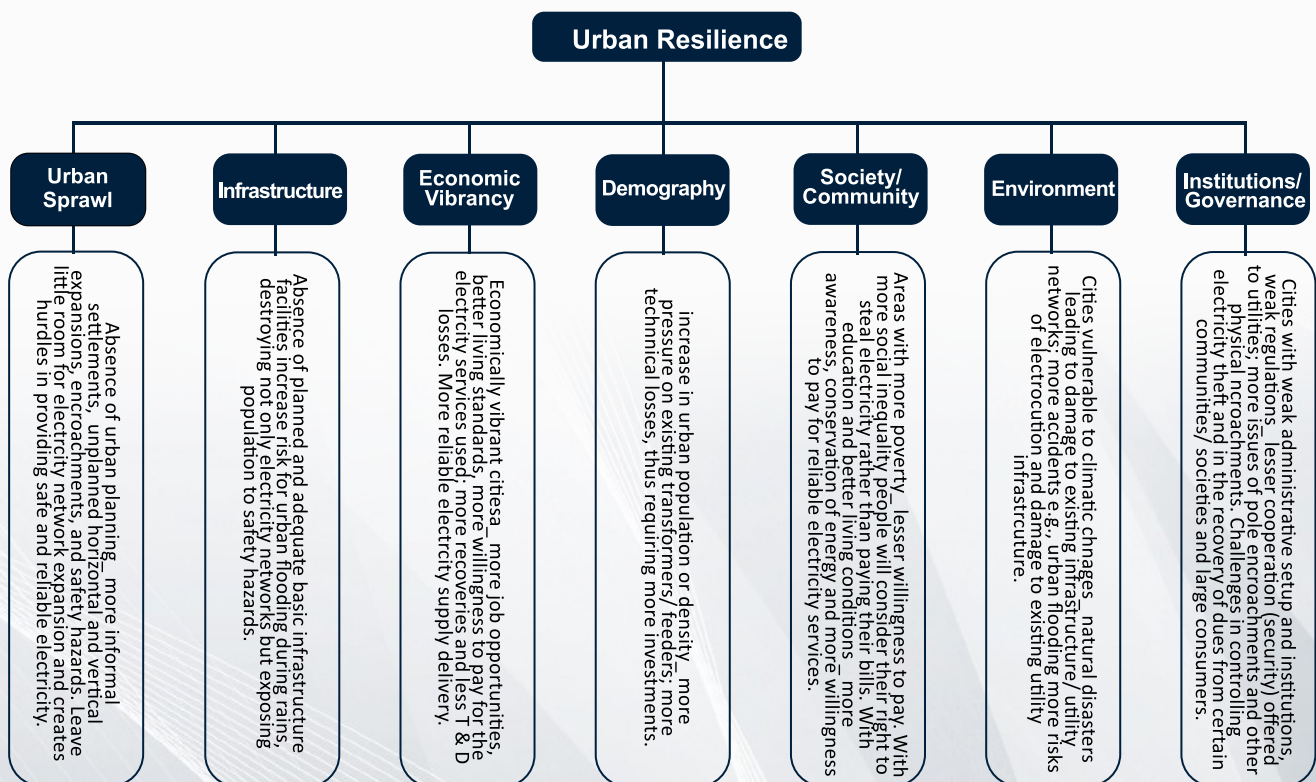


Figure 3: Urban Resilience and Electricity Utility Performance/ Challenges

Data Sources:

- GIS mapping data, census data, PSLM 2019-20, published reports/ articles and information collected from utility officials in informal interviews.
- Utility data from NEPRA State of Industry Reports, Performance Evaluation Reports and primary information shared by three Distribution Companies.

Data Limitation: Comparative analysis regarding urban resilience for several years is not possible because of the lack of time-series data of city characteristics. Besides, the collection of city-level data has not been institutionalised in Pakistan. Therefore, we have relied on proxy variables. For some variables, for instance, integrated governance capacity, ethnic conflict/ terrorism activities, we have assessed the value of variables based on available information. Likewise, information on city income and employment status is not collected regularly. We have cited these figures from the State of Pakistani Cities Report, 2018. However, utility performance is compared for the last five years.



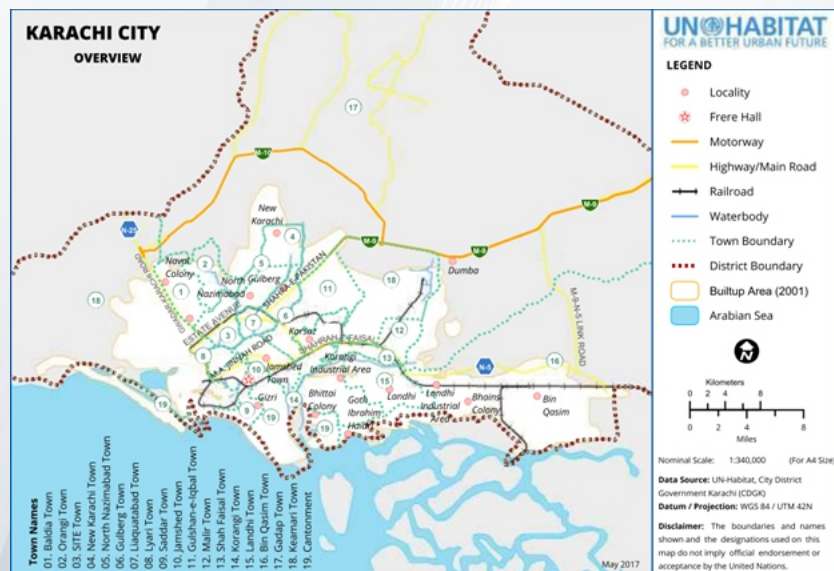
3.1. City Profiles

As mentioned earlier, the research targets three Pakistani cities_ Karachi, Islamabad and Peshawar.

3.1.1. Karachi

Karachi is the largest city in the country. It is the sixth most populated city in the world. The city is home to more than 16 million (unofficially 21.2 million or above). In the 1960s and 1970s, it was called the city of lights because of its economic vibrancy. The population influx in Karachi began right after independence when 0.6 million migrants arrived from India; inducted into a city of 0.4 million. The trend continues till today, economic opportunities are attracting migrants from all across the country. With an area of 3648 square kilometres, divided into 178 Union Councils (UCs) and a population of 16.1 million (urban & rural) is growing at the rate of 2.6 percent.

More than 2.5 million of its inhabitants are political, economic or illegal migrants; half of these migrants are living in informal settlements. The extraordinary urbanisation growth in Karachi has deeply impacted the city's politics and social fabric. Despite being the economic hub, there are grave urban governance issues; creating difficulties in the provision of utility services across the city.



Source: Cited from State of Pakistani Cities, UN- Habitat, 2018

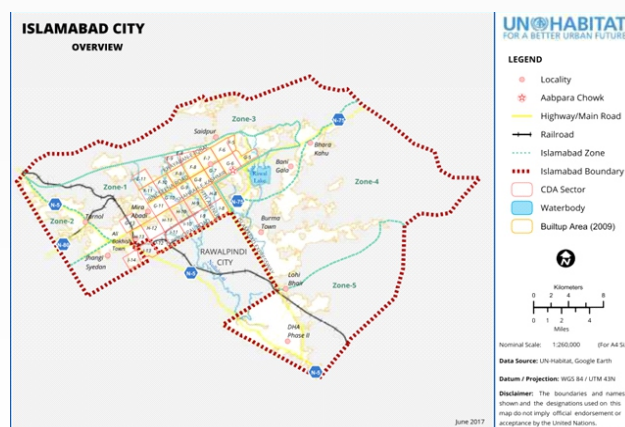
³According to Hasan (2015), Karachi is the fastest-growing large city in the world. He reports that between 1998 and 2011, the city grew by 115 %.

⁴Most of the trade flows into the country through this city and it is home to the largest number of industries.

3.1.2. Islamabad

Islamabad is located in the Potwar Plateau, which is one of the most thickly populated regions in Pakistan. The city was built in 1961 as the national capital. The administrative region of Islamabad is divided into five zones. Zone I and II are divided into sectors with a size of about 2 km by 2 km. Some sectors are well-developed, while others are under-developed. Zone-III mainly refers to the Margalla Hills national park. Zone-IV and the north Zone-V are distinguished as agricultural landscapes, whereas, the south Zone-V is close to Rawalpindi City featuring private houses, social and industrial facilities.

The territorial limits of Islamabad have expanded. The urban area has increased from 58.854 sq.km in 1990 to 309.697 sq.km in 2018.

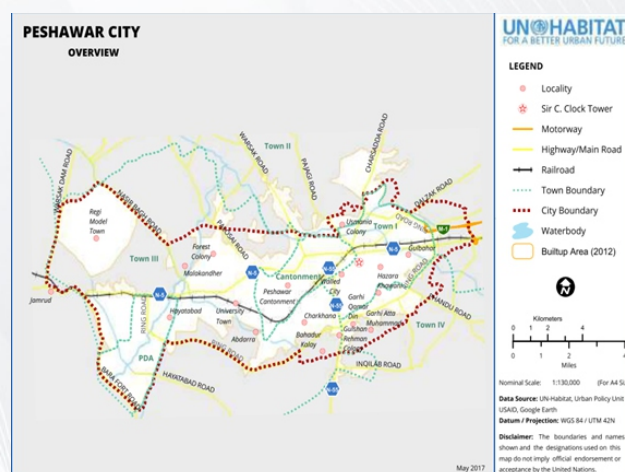


Source: Cited from State of Pakistani Cities, UN- Habitat, 2018

Whereas, the population of the city has increased more than three folds from 0.559 million in 1979 to 2 million in 2017. Out of these two million, about 50.5 percent live in the rural areas and the remaining 49.5 percent in the urban areas of Islamabad. From 1979 to 2019, there is an increase of 377 sq. km in a built-up area and 47 sq. km of agricultural land in Islamabad. The main reasons cited for urban sprawl in Islamabad are population growth, migration from other cities due to increase in economic activities, road and railway transportation system, security issues in KPK and Afghan war, neighbouring urban effect and above all increased investment in real estate and development of new housing schemes. With an area of 906 square kilometres, divided into 50 UCs and a population of 2 million (urban & rural), is growing rapidly at the rate of 4.9 percent.

3.1.3. Peshawar

Peshawar _ the capital of Khyber Pakhtunkhwa (KPK) is connected to Khyber Agency in the West, Mohmand Agency in the North, Kohat in the South, Charsadda and Nowshera in the North and North East respectively. With an area of 1518 square kilometres, divided into 97 UCs and a population of 4.3 million (urban & rural), is growing rapidly at the rate of 3.99 percent. Apart from rural-urban migration, Afghan Refugees and Internally Displaced People (IDPs) are mainly responsible for rapid urbanisation and rising population in the city. These migrants with limited financial resources end up settling in informal settlements (slums) (Urban unit, 2013). The urban population of Peshawar is growing at a fast pace; it is expected to reach 2.8 million by 2030 (Safdar, 2018). With alarmingly high growth, the city is facing acute shortages of housing leading to an increase in the number of slums. Peshawar is the second poorest provincial capital in the country after Quetta, Baluchistan (State of Pakistani Cities, 2018).



Source: State of Pakistani Cities, UN-Habitat, 2018

3.2. Urban Resilience in Pakistani Cities

Urbanisation is a socio-economic process that leads to the shifting of the population from rural to urban settlements. Generally, more job opportunities and improved services are associated with cities. This perception attracts more and more people to urban centres in search of better living. It is central to economic development but at the same time poses serious challenges when cities lack the capacity to absorb, adapt and transform in accordance with changing dynamics. A city with poor capacity to absorb, adapt and transform to changing city dynamics due to population growth, environmental changes or deteriorating city law and order etc., put the lives of the most vulnerable to natural and safety hazards; and create difficulties for the utilities to perform efficiently.

In Pakistani cities, lack of urban planning, limited and unplanned infrastructure, weak administration and governance, social variation, poverty, conflict, and environmental issues are common. Informal settlements with limited access to basic utilities are prevalent. Unplanned urban growth often led to congestion, poor housing, pressure on limited public services, air and water pollution and associated health issues (cited from Avis, 2016).

*According to the Housing Census 2015 and data available with the Peshawar development authority (PDA), the total number of houses in Peshawar was 0.167 million in 1981. It went to 0.236 million in 1998 and the number of houses in Peshawar remained 0.897 million in 2015.

3.2.1. Urban Sprawl

Urban sprawl is the geographical expansion of cities/ towns accompanied by a significant loss of density (Morollón and Yserte, 2020). It is often linked to increased energy use, pollution, congestion and a decline in community distinctiveness (Rafferty, Britannica). The most common indicator used to compare urban sprawl is the ratio of the growth in the physical extent of urban areas to the population growth.

Literature suggests haphazard urbanisation in Pakistani cities, where lopsided and outdated zoning laws further aggravates the rational use of urban land for residential, commercial, and industrial needs. In terms of urban sprawl measured as a ratio of the growth in the physical extent of urban areas to growth in population, Islamabad is at the top with a ratio of 1.9 followed by Peshawar and then Karachi. The proportion of the built-up area is also maximum for Islamabad (Table 1). Even in the supposedly planned city of Islamabad, 55% of the land is earmarked for residences, while only 5 percent for commercial activities, thus increasing the built-up area.

Whereas, both Karachi and Peshawar are even worse in terms of urban planning. Both cities have experienced exponential growth in informal settlements (slums/ Katchi Abadi's) without basic facilities. Both Karachi and Peshawar have large informal settlements and have grown beyond the boundaries of the planned urban areas (Fazal and Hotez, 2020). The percentage population living in slums in both cities is exceptionally very high (Table 1).

Karachi is among the world's most dense megacities; 62 percent of its population resides in 8 percent of the residential area, increasing densification. Whereas, 38 percent of the population (mainly middle-income, elite class, bureaucrats and politicians) is settled in the remaining 92 percent of the area (Hussain, 2016). There are more than 600 slums in Karachi. Karachi is also home to the largest slum in Asia, that is, Orangi Town, with an estimated population of 2.4 million (UNICEF, 2020). The huge number and size of slums in Karachi is partially explained by urbanisation without structural transformation. However, because of the lack of urban planning in the city, everything is on an ad hoc basis. The policymakers have never responded effectively to the needs of people migrating to the city (Hussain, 2016).

In the city, the service delivery of electricity is affected by these informal settlements and physical encroachments which not only result in frequent power breakdowns but also pose serious safety concerns and are a major reason for significant electricity theft. As reported in Hasan (2016) most of the development in Karachi is taking place on the periphery of the city, particularly in the Malir and West district. Large formal housing has gained momentum, whereas poor and vulnerable communities have become denser in the existing informal settlements and spread to new settlements in the periphery. More than 60 percent of Karachiites live in informal settlements on 23 percent of the city's residential lands. Densities in these settlements are between 1,500 to 4,500 persons per hectare and continue to increase. Meanwhile, rest of Karachiites live in "planned" settlements on 77% of the city's residential lands. Densities can be as low as 80 persons per hectare and continue to decrease in new settlements (Hasan, 2016). About 35 % of slums are in Karachi West, 20 % in Karachi East, 22 % in Karachi Central, 12 % in Malir and 11 % in Karachi South (Hussain, 2016). There is little to zero coordination on planning and development between the various land-owning organisations in the city. This creates problem for electricity utility.

The case of Peshawar is no different from Karachi as more than 70 percent of the city population lives in slums/underserved areas, which is an indication of unplanned city growth, poor urban management and lack of resources. The only difference is, planning and development of the city is the sole responsibility of Peshawar Development Authority (PDA), other than Defence Housing Authority (DHA) and cantonment areas. Reportedly, almost 156 illegal housing societies have been set up in Peshawar District without any approval or No-objection Certificate (NOC) from Peshawar Development Authority. All the buying selling and transferring of plots is going on with the support of government departments and the police.

That's why these societies are provided with electricity. PESCO officials are of the view that there is a flaw in administrative law, which needs to be rectified. However, the fact is more than 70 percent of illegal housing are not approved not because of size but because they are built on agricultural land. By characteristics, they are defined as informal settlements/ slums.

Table 1. Urban Growth and Sprawl

	Area Square km	Ratio Land cons. To Pop. Growth	Built-up Area Km ²	% Population Living in Slums)	Urban population Growth %
Karachi	3648	0.772	666.18	62	2.43
Islamabad	906	1.866	474.8	38	3.48
Peshawar	1518	1.075	84.39	78	3.72

Source: World Cities Report, 2020, Raza, et al (2020), Shah et al (2020) and UNICEF (2020)

⁷According to Sindh Katchi Abadi Authority, the number of the city's 'Katchi Abadi' is ⁵⁷⁵.

⁸Some sources quote 181 illegal housing societies

⁹<https://www.thenews.com.pk/print/753457-156-illegal-housing-societies-set-up-in-peshawar>

Islamabad has also expanded extensively in the last two decades, thus creating serious challenges for the city administration and utilities in providing basic amenities to these new settlements. Although initially, the city was planned, the rising urbanisation has led to unplanned expansion at the periphery. This unplanned urban sprawl is continuing unchecked due to lack of monitoring of the land use, poor adherence to the land-use policies and lack of real-time data (Mannan et al., 2018).

The people migrating to the capital city often got settled in more formal, planned townships and housing schemes (mainly for the middle- and upper-income groups) such as Bahria Towns, DHAs, and many such approved societies at the periphery. These societies have extended the de-facto urban limits making it difficult for the authorities (mainly the Capital Development Authority (CDA)) to guide the urban growth as planned. For instance, housing growth has created a demand for infrastructure and services in directions other than the planned growth of Islamabad's sectors (State of Pakistani cities, 2018).

Islamabad has a relatively low share of informal settlements as compared to the other two cities (officially). The reason cited is its closeness to an old cantt city of Rawalpindi (Shah, et al, 2021). However, some experts are of the opinion, Islamabad's rural areas (officially) in fact reflect the development of slums around the urban region. Huge population growth has been in areas at the Islamabad periphery. About 65 percent of the population shown in the National Census as rural is slum development (Butt, 2017). As per CDA official website, there are about 140 illegal housing societies_ some of which are complete and densely populated. By definition, some of these are considered informal settlements or slums.

In short, the urban development in Islamabad is haphazard. The urban growth in Zone I and II was due to the master plan; the growth in Zone 4 is cited as due to urban-neighbour effect; in Zone-V related to industrial and real estate development. Insufficient urban capacity in Islamabad leads to the development of informal settlements. The area encompassing slums has increased from 5.534 sq.km in 1990 to 28.979 sq.km in 2018 (Liu, et al, 2020). The Afghan War is also one of the reasons behind the increase in number and size of slums in the city.

Such huge expansion and illegal build-up have increased challenges for city administration_ increased demand for electricity and gas, shortage of ground water resources, basic infrastructure deficiency including sewerage and waste management, urban flooding, traffic congestion on roads increasing travel time, deforestation, loss of barren lands, and increase in street crimes (Shah, et al, 2021). Urban development in Islamabad is considered unsustainable, as it is not linked with creating resilience to natural and man-induced disasters, a green and clean transportation system, a planned expansion of industrial and economic extension (Abdul & Yu, 2020). The urban sprawl of Islamabad is putting pressure on the regulator (CDA) to regularise the unauthorised construction and unapproved developmental schemes in the peripheries of the city. In some cases, the regulator has done so (Shah, et al, 2021).

Even if they are unapproved, these housing societies exist. Urban flooding in E-11, this month (July 2021) is an example, where the size of rainwater nullah was reduced a few years back to accommodate more housing units in an illegal housing society (constructed without CDANOC and people are living there).

It is a tough call to compare urban sprawl in three cities. For estimation purposes, we are relying on official data in published reports and articles in international journals.

¹⁰Slums are a connecting settlement where the inhabitants are characterised as having inadequate housing and basic services. A slum household is defined as a group of individuals who live under the same roof that lacks one or more of the following conditions: limited access to improved water and sanitation; weak housing structures; insufficient living area; and uncertain about legal ownership of the residential area. It is often not recognized and addressed by the public authorities as an integral or equal part of the city (UNICEF, 2020). That's why PESCO management was of the view that there are no 'Katchi Abadi's in Peshawar.

¹¹The barren land is depleting fast from 489.1sq.km in 1979 to 155.4 sq. km in 2019.

¹²Tarnol, Sihala, Rawal Dam, Bani Gala, Barakahu, Bari Imam, Golra, Shah Allah Ditta, Nilore Road and Jhangi Sayedan.

3.2.2. Demography

Table 2 & Table 3 compare demographic variables across three cities. As discussed in Section 3.1 *Karachi is the most densely populated city with a population growth of 2.6 percent. In terms of population growth, Islamabad is at the top, while in urban population growth, Peshawar has grown at the fastest speed.*

Rapid urbanisation has increased housing demand in the Pakistani cities in general, and in these three cities in particular. Lack of housing for low-income urban populations and or for the people migrating from rural areas with limited financial resources has led to the creation of large informal settlements, both within cities and more towards city boundaries. These unauthorised neighbourhoods have limited to no access to public utilities including electricity, infrastructure, and places for social activities. They often opt for illegal means to fulfil their needs.

Table 2: Demographic Profile

District	Area (Square Km)	Population		Density	Pop. Gr. (1998 -2017) %	Urban Pop. Gr. (1998 -2017) %	Average HH Size (members)
		Total	Urban %				
Islamabad	906	2001579	50.5	2209	4.9	3.48	5.9
Peshawar	1518	4269079	46.1	2812	3.99	3.72	8.4
Karachi Central	69	2972639	100	43082	1.41	---	---
Karachi East	165	2909921	100	17636	3.64	---	---
Karachi West	929	3914757	92.8	4214	3.35	3.14	---
Karachi South	122	1791751	100	14686	1.02	---	---
Malir	2268	2457019	100	1083	3.86	3.11	---
Korangi	95	2008901	100	21146	2.41	---	---
Karachi (Total)	3648	16054988		4401	2.6	2.43	5.7

Source: Population Census, 2017.

Note: Urban population includes slum population.

Table 3. Population

	1951	1961	1972	1981	1998	2017
Islamabad			77000	208000	529180	2001579
Peshawar	391000	529000	807000	1113000	2019000	4269079
Karachi	1137667	2044044	3606746	5437984	9802134	16054988

Source: Census Reports

3.2.3. Infrastructure Development

The provision of urban services_ clean drinking water, sewerage system, waste collection etc is the responsibility of government institutions. Despite the provision of better basic services like access to clean water, power, and sanitation etc. in the urban areas as compared to the rural areas, these basic amenities are scarce in the three urban regions under study. Especially, people living in informal housing have limited access to such services.

Karachi has severe water supply problems. The supply of clean water to Karachi's residents has remained around 550 million gallons per day against a daily demand of 1100 million gallons. Karachi's population is increasing but the areas with access to piped water are still the same (State of Pakistani Cities, 2018). In the absence of formal facilities, residents often use illegal connections; they have installed water motors inside their small houses in congested localities, creating safety hazards. Some people in relatively better locality (who can afford) also rely on informal water sources such as expensive water tankers, reflecting the poor state of urban governance in these two cities

The situation for Islamabad is not different either, the total production of water supply does not go beyond 84 million gallons per day against an average demand of 176 million gallons per day. The city receives its water supply from Simly Dam (about 107 million gallons per day) and groundwater sources. Despite the claims about the improvement of water supply made by the Capital Development Authority (CDA), the situation remains challenging especially during summers. People residing in many neighbourhoods, including the peri-urban locations, often rely on water tankers (as in Karachi), supplied by private operators at high prices. .

¹³ It is reported at CDA website, as on May 5, 2021 there are 140 illegal housing societies in Zone I to Zone V.

¹⁴In a survey of 100 Katchi Abadis in Karachi, it has been estimated that people have invested Rs 84.4 million in water and sanitation while the government has invested Rs 180.6 million. However, water is often not available and sewage systems do not function due to the absence of disposal points. All such settlements dispose of their sewage in natural drainage channels (Hasan and Mohib, 2003).

Table 4. Infrastructure Services

	Main source of Drinking Water (% share)			Waste Generated Tonnes/Day
	Piped water	Motorized Pumping	Tankers	
Karachi	85.4	1.0	9.8	9000
Islamabad	20.8	37.1	3.5	500
Peshawar	78.5	16.9	--	564

Source: State of Pakistani cities, 2018.

Note: Main source of drinking water explains safe drinking water infrastructure as provided by municipalities and other sources

An increase in urban population coupled with inefficiencies in water use leads to groundwater depletion and the declining quality of surface water in Pakistani cities. Droughts, unexpected water supply interruptions, or dilapidated networks may further jeopardise the water resilience of urban areas (Abdul and Yu, 2020). Similarly, sewerage system and waste disposal management are serious concerns in the three cities, but the magnitude varies. Although an exact figure is not available, the problem is very severe in Karachi, as evident from media reports_ showing footage of heaps of garbage in various parts of the city.

Waste management, sewerage and provision of clean drinking water all are under the domain of local government. But the changing status of local governments, frequent amendments in their duties/ domain and nature of relationships with federal and provincial governments, have deeply impacted their performance, especially in Karachi (State of Pakistani Cities, 2018). In Karachi, the authorities lack the capacity to lift all garbage (more than 9000 tonnes per day). Peshawar faces similar issues; out of 564 tonnes of waste collected, only 40 percent reaches dumping sites. Perhaps, the problem is not as acute as in Karachi due to the relatively smaller population in the city. The exact figure is not available for Islamabad.

A large amount of the sewage (including hospital waste) is disposed into rivers without treatment which pollutes the rivers. Besides, solid waste is disposed of at open dumping sites located near water streams which often block the flow of water in these natural drains. The presence of dumping spots near residential areas, water reservoirs or water drains is the result of ill-planning in all three cities. There is no monitoring mechanism in place to avoid serious health and environmental risks.

It is the lack of basic infrastructure facilities and deforestation that urban flooding and other natural disasters have now become a common feature in all three cities, destroying not only electricity networks but exposing population to safety hazards. For instance, in the floods of 2010, thousands of households were affected in Peshawar; similarly in 2016. Additionally, Peshawar is about 200 kilometres from the Hindu Kush seismic region which makes it exposed to earthquakes.

Likewise, Karachi is vulnerable to natural disasters like earthquakes, floods, cyclones, and urban heat island phenomena due to the expansion of built-up areas and increase densification. Due to high population density as well as encroachments along the drainage, the city often faces water accumulation affecting existing infrastructure. In recent years, urban floods have damaged communication, transportation and public infrastructure networks significantly. As mentioned earlier, the authorities in Islamabad should seriously take the recent incident of urban flooding in E-11 Islamabad that causes damage to life, property, and infrastructure.

Though households in these cities have in general access to electricity and natural gas for cooking purposes. But reliable power supply remains an issue, in particular, in some areas of Karachi and Peshawar. It is interesting to note that household electricity access is 100 percent in Islamabad. Where the evidence shows the existence of about 140 housing societies without NOC or LOP.

Table 5. Household characteristics

District	HH with Internet %	HH with Access to Electricity %	HH with Gas as Cooking Fuel	HH with toilet facility	Pre-natal consultations
Islamabad	70	100	93	99	97
Peshawar	51	96	73	95	86
Karachi	51	97	97	99	91

Source: PSLM 2019-20

Note: PSLM is a representative sample, it may not include illegal connections.

3.2.4. Economic Vibrancy

Pakistani cities vary not only in terms of their physical size but the size of the economy, employment opportunities and tax revenue collection. In the three cities, services and industry are the primary employment generating sectors.

Karachi has a comparative advantage as most of the international trade passes through Karachi port, it is home to the Pakistan Stock Exchange, about 30 percent of the manufacturing sector is in its vicinity, and account for 20 percent of the country's GDP_ making it the largest business and financial centre (Fazal and Hotez, 2020). Of the city's total labour force, 37 percent are employed (64 percent in the services sector and 36 percent in industry). The per capita income of the city is Rs 56,000, the lowest among the three cities (Table 6). It is worth mentioning here that the city has a large informal economy, not reflected in the country's GDP estimates or in income and expenditure surveys.

Table 6. Economic Profile

City	Income Tax Revenue Rs Billion 2017 -18	Per Capita Income Tax (Rs)	Per Capita Income 2014-15(Rs)	City Employment rate %
Karachi	424.8	28476	56000	36.8
Islamabad	204.2	202161	70000	35
Peshawar	13.6	6926	67000	29.6

Source: State of Pakistani cities, 2018, FBR Tax Directory, 2018

Note: Per capita income is based on PSLM 2014-15 survey which is only a representative sample, not the exact national account figure. Additionally ,tax figure includes taxes from corporate sector, while income is for individuals only. For estimating per capita income tax, only urban population is used.

Peshawar is not only at the top in poverty estimates, but has the second-highest per capita income among the three, reflecting income inequality. Out of the total 30 percent employed (lowest among the three), 86 percent are employed in the services sector. The low share in the industry reflects the city's low production base. Islamabad, with an employment rate of 35 percent, again is a service economy, as 87 percent of its employed population are in the services sector. Per capita income in Islamabad is the highest among the three.

Income tax collected indicates economic vibrancy as well as culture of compliance to the law. In absolute terms, Karachi is at the top. The city collects Rs 425 billion of income tax in 2018 (41 percent of the country's total tax revenue), twice the amount Islamabad collected (Rs 204 billion) in the same year. In comparison to these two, income tax collection in Peshawar is minimal (2 percent of total tax revenue) showing a lack of tax culture and informal economy. However, after controlling for population size, Islamabad is more tax compliant than Karachi. It collects Rs 202,161 tax per capita compared with Rs 28,476 by Karachi (cited from Hasan and Chaudhry, 2020)¹⁶.

Karachi is an economically vibrant city therefore the rate of migration into Karachi is high. However, a large segment of the labour force that migrates into Karachi is poor, employed in the informal economy and cannot afford to live in formal housing. In comparison, the economic activities in Islamabad have increased substantially in the last decade. In particular, business activities in the real estate and housing sector. It is a Capital city, home to diplomatic and Federal Government activities. Besides, there is an increase in the commercial activities with the construction of new malls and high-rise buildings in the peri-urban areas, due to the availability of relatively cheap land.

3.2.5. Social/ Community Profiles

Selected social indicators of the three cities under study are reported in Table 7. There is a considerable difference among the three cities in terms of social indicators. Peshawar is at the lowest end in all indicators, except for out of school children. The maximum out of school children are in Karachi. Peshawar is the poorest city among the three, it is the second poorest provincial capital in the country after Quetta with a poverty rate of 31 percent (State of Pakistani Cities, 2018). About 2.5 percent of Peshawar's population availed Ehsaas Kafalat Programme last year. The Average Intensity of Deprivation for Khyber Pakhtunkhwa, in general, is at 57 percent (UNICEF, 2020).

Rapid urbanisation has led to the emergence and expansion of slums in both Karachi and Peshawar. However, in terms of overall living conditions, Karachi is much better off than Peshawar. Lack of sewage treatment and health facilities; low literacy and education attainment rate; contaminated water and poor sanitation facilities in houses is common in Peshawar.

¹⁶The data on employment is extracted from PSLM 2014-15, cited in the State of Pakistani, 2018. It covers mainly salaried employment in the formal sector. Self-employed not included and informal employment not included.

¹⁷The income tax collected from the city includes personal income tax as well as corporate income tax. Thus, a city that has more businesses is likely to generate more income tax. Having a business firm depends upon several factors including business prospects, infrastructure, income levels etc. Secondly, as under the income tax law, the corporate

Table 7. Social Profile

City	Poverty Incidence %	Out of School Children	Overall Health Indicator	Ehsaas Beneficiaries % of Total Population	Living Standards %
Karachi	4.5	25.9	24.4	0.77	26
Islamabad	3.1	10	26.5	0.36	25.2*
Peshawar	31.5	25	23.2	2.45	22.2

Source: PSLM 2019-20; Living standard is extracted from PSLM (based on education, health, information and communication technology and household living standards).

*This data is based on PSLM survey_ it is a representative survey, may not reflect actual data. Per capita income as reported in Table 6 is based on PSLM Survey 2014-15, whereas, living standard data here is based on PSLM Survey 2019-20. Some discrepancy is possible.

3.2.6. Environment

Islamabad is the most planned city among the three. Yet, with the passage of time and mushroom growth in the built-in area, and decline in forest cover has led to severe environmental degradation. Not only air quality has deteriorated, but the city is also experiencing relatively warmer temperatures. The absence of waste-water treatment and dumping of solid waste in open land-fill sites has destroyed the overall environment of the city. Now the quality of air is much below WHO standard. Road traffic is increasing rapidly to cater for the demands of rapid urbanisation; where, emissions from vehicle is another key contributor to high particulate matter in the city. The average level of Particulate Matter (PM) in the air was 39 ug/m³ in 2020.

Peshawar also faces growing environmental issues due to rapid urbanisation, population explosion and exploitation of natural resources. Besides, unplanned urban expansion and rapid growth in Peshawar's population has resulted in a significant rise in temperature and urban flooding. Likewise, visible smoke and dust all around the city are creating serious health risks.

Karachi just like other cities in the country is witnessing relatively warmer temperatures and unexpected monsoon rains over the past few years as a result of climate change. Unpredictable rains are also causing damage to the existing infrastructure. Besides, increased densification is further adding to environmental challenges. The city witnesses exceptionally high levels of traffic congestion and environmental pollution with an increasing number of motor vehicles, especially, fuel-inefficient vehicles. Besides, the absence of waste-water treatment and inefficient as well as insufficient solid-waste management are a further contribution to climatic woes in the city. The level of air quality is decreasing rapidly, an average level of Particulate Matter (PM) in the air was 43.8 ug/m³ in 2020.

In the last two decades, Karachi has experienced cycles of drought and intense rainfall in certain districts. Hub, Lyari and Malir rivers were used to be the main drainage sources in Karachi; with a capacity to discharge extra water safely to the Arabian Sea. However, unplanned informal or illegal settlements in surrounding and especially encroachments on natural nullahs have seriously affected riverbeds, making Karachi more vulnerable to the harmful effects of monsoon season flooding (State of Pakistani Cities, 2018). Regardless of serious challenges, there is no serious disaster monitoring system in the city.

3.2.7. Governance/ Institutions

Urban governance is not just about the formal structures of city government involving planning, finance and management but includes economic and social forces, institutions and relationships_ formal and informal (Avis, 2016). In cities with weak administrative setup and institutions, lesser cooperation is offered to utilities by law enforcement agencies in controlling theft and in the collection of payments.

Table 8. City Governance Indicators

	Karachi	Islamabad	Peshawar
Crime index %	53.65	29.15	46.14
Integrated Institutions*	0.2	0.6	0.3
Safety Index %	46.35	70.85	53.86
Ethnic Conflict/ Terrorism**	0.6	0.1	0.6

Source: https://www.numbeo.com/crime/country_result.jsp?country=Pakistan;

* Assessment based on literature, available information, number of institutions involved in administrative activities, its value ranges between 0 and 1; ** assessment based on number of conflicts and terrorist activities in the city in the last 20 years (documented evidence), its value ranges between 0 and 1 depending upon the frequency of events.

income tax is to be paid by the Head office (regardless of where the branches of a firm operate). One of the reasons for more tax collection from Islamabad could be that Head offices of certain big firms are located in Islamabad. The same is true of Karachi.

^{1a}Average Intensity of deprivations is part of multi-dimensional poverty index. It reflects average number of deprivations a poor person suffers. It is calculated by adding up the proportion of total deprivations each person suffers (for example, access to good health clinic, quality education, housing quality, etc.) and dividing it by the total number of poor persons.

Rapid urbanisation in Pakistani cities has led to several challenges including poverty, inadequate housing, infrastructure deficits, traffic congestion, natural and man-made disasters and diseases. Besides, it has led to security issues related to terrorism, crime, ethnic conflicts and so on. In Karachi, one of the serious challenges is high crime rates and lack of citizen safety. Undoubtedly, in recent years, after Ranger's operations, the crime rate and violence have decreased substantially. Still, it is more than 50 percent and is highest among the three cities (Table 8).

Accentuating the problems of urbanisation, poverty, and climate change have been political instability resulting from wealth disparities and ethnicity issues and conflicts in Karachi (Fazal and Hotez, 2020). Karachi is ethnically diverse with the poor of different communities residing in a particular slum. Specific communities residing in particular neighbourhoods add to the woes of utility agencies as each community may enjoy the support of one or the other political party or interest group, thus creating problems in the collection of dues from the residents. Given these strong and well-knit communities, it is difficult to control electricity theft. Electricity theft via 'Kunda' is a special feature in Karachi. K-Electric efforts to control power theft are discussed in detail in Section 4.3. While the role of the Commissioner's office is coordination and managing the balance between municipal and utility services, unfortunately clear boundaries on a district level are not available. Administrative control is with the Commissioner office but planning is delegated to KDA, MDA and Local Governments

After the Afghan War, Peshawar became an important centre for Afghan refugee settlements. Consequently, abductions for ransom, extortion and illegal activities by organised crime syndicates along with violent attacks by religious militants added to the hazards to the lives and fundamental freedoms of citizens. The dumping of bodies in different parts of Khyber Pakhtunkhwa and the adjoining tribal areas became a recurring phenomenon. The stress, Peshawar has experienced over the last three decades has weakened its economic stability. In Peshawar, the government failure in showing flexibility in development plans strategies has further weakened the overall governance landscape in the city.

The roots of urban crimes in both Karachi and Peshawar are more to do with dysfunctional urban development than any other factor. The criminal outfits in both Karachi and Peshawar are flourishing on the back of the illegal economy. The division of the city between planned and unplanned areas, the rivalry over limited resources as well as public amenities and the adverse relationship between political parties or interest groups have affected the cities social fabric.

Though, unplanned urban growth in Islamabad has compromised the quality of life and environment. Islamabad is a relatively safe city. There is one authority, that is, Capital Development Authority (CDA) mainly responsible for city planning and development. Apart from DHA, all housing societies 'planning, development and maintenance of the Master Plan for Islamabad' is the responsibility of CDA. Though there are many illegal and unauthorised societies (without LOP or NOC) from CDA, because of the proximity of the city to the powerhouse, these are developed unchecked. Metropolitan Corporation Islamabad (MCI) and union councils for the city's governance were established in 2015 through Islamabad Capital Territory Local Government Act; with responsibility for managing and providing municipal services and infrastructure, regulating markets and promoting cultural, social and economic development activities (Haque, 2020); but so far are not very effective.

Municipal Councils have limited say in major planning decisions, not only in Islamabad but in other cities as well. Though on papers, they have the responsibility of urban management, major decisions are taken by various other government departments including district administration. As a result, private and individual actions and public interventions do not come together, but rather, conflicting situations are created that require crisis management more than planned interventions (State of Pakistani cities, 2018).

Peshawar Development Authority (PDA) is the main governing body in the city. Unlike Islamabad and Peshawar, Karachi has multiple governing authorities. In all, the city is managed and governed by 13 different departments simultaneously. Lack of coordination among these leave little room for a comprehensive urban framework as is the norm in metropolitan cities around the globe (Hussain, 2016). Thus, more issues for city utilities, e.g., K-Electric, SSGC and KWSB.]

¹⁹<http://hrp-web.org/hrpweb/data/ar14c/2-1%20Law%20and%20order%20-%202014.pdf>

²⁰<https://tribune.com.pk/story/1145097/fragile-economy-peshawar-policy-failure>

3.3 Urban Resilience in Pakistani Cities

Based on eq. (1) and (2), urban resilience index is estimated for the three cities using seven dimensions and several sub-dimensions. The weights and signs (positive means increase in urban resilience and negative means decreasing effect on urban resilience) assigned to these dimensions are illustrated in Table 9.

Table 9. Urban Resilience_ Weights and Signs

Urban Resilience Dimensions	Weight	Sub Dimensions	Integrated Weight	Sign
Urban Sprawl/ Urban Planning	0.200	Land Consumption Growth to population growth Ratio (2000-2015)	0.055	-
		Built-up Area Km ²	0.052	-
		% Population living in informal housing (Slums)	0.058	-
		Urbanisation Rate	0.035	+
Demography	0.056	Population Density	0.0187	-
		Urban Population Growth	0.0186	-
		Average Household Size	0.0187	-
Social/ Community	0.116	Poverty Incidence	0.021	-
		Ehsaas Beneficiaries	0.022	-
		Children in School	0.021	+
		Health	0.025	+
		Household Living Standard	0.027	+
Economic Vibrancy	0.195	Income per Capita	0.061	+
		Income Tax Collected per Capita	0.081	+
		Employment rate	0.053	+
Infrastructure	0.180	Access to Piped Water/ Water Pumping	0.036	+
		Population with Internet	0.036	+
		Access to Electricity	0.036	+
		Access to Gas for Cooking	0.036	+
		Solid-waste generated	0.036	-
Environment	0.05	% Particular Matter Air and urban flooding	0.05	-
City Governance/ Institutions	0.203	Crime Index	0.051	-
		Safety Index	0.062	+
		Integrated Governance Capacity/ Effective Institutions	0.065	+
		Ethnic Conflict/ Terrorism Activities	0.025	-

Source: Author's Assessments

The main issue in developing an integrated assessment index is how dimensions or inputs are weighted. The three cities are more or less similar in terms of social progress, institutional ability, urbanisation trends/ sprawl, infrastructure planning, city governance and environmental pressures, this makes it difficult to assess. Therefore, we have applied different weights using Analytical Hierarchy Process (AHP) based on information available in the literature. More weightage is given to the sub-dimension, whose significance in the context of urban resilience is more. Secondly, in weight assessment, we also take into account the perspective of electricity utility management, e.g., the problems they face because of urban sprawl, poverty, city governance and so on.

Table 10. Urban Resilience Across Pakistani Cities

	Urban Resilience Index
Islamabad	0.20
Karachi	0.12
Peshawar	0.10

Source: Author's Estimates

As the estimated index shows, **none of the three cities in Pakistan is resilient enough to absorb changes/ shocks to urban systems, none of the estimated index is close to 1.** However, among the three cities, Islamabad is relatively more resilient, which is not a surprise. Being the Federal capital, it is the most privileged city. Both Peshawar and Karachi are close, but Peshawar is at the lowest level.

The rising population in Pakistani cities, in particular, in Karachi and Peshawar, calls for expansion of utility infrastructure at a fast pace and the fact that a significant demand for expansion comes from slums or informal housing units makes the job of the utility agencies even more difficult. Overall, there seems to be a convergence of accelerated urbanisation, climate change, political instability, and poverty. This mix of issues has created a toxic mix to disturb the existing electricity infrastructure facilities.

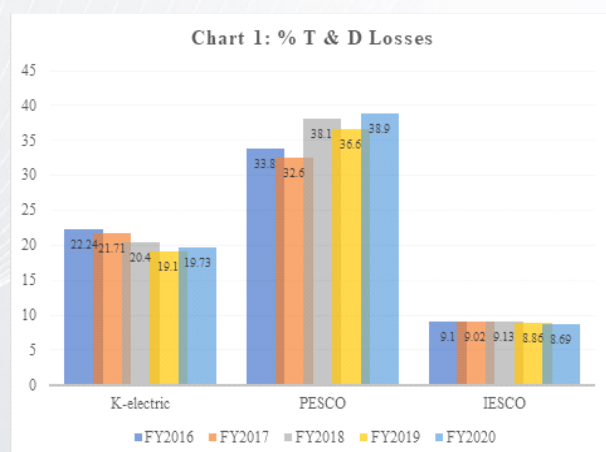
4. Urban Resilience and Electricity Utility

Utility networks, including clean drinking water, waste disposal management, electricity, gas, and telecommunication systems, reinforce the economic, social, and environmental performance of modern life. The availability of these networks provides the medium through which a modern city operates. In the last two decades, rapid urbanisation has created serious issues/ challenges in the management and provision of utility systems in Pakistani cities.

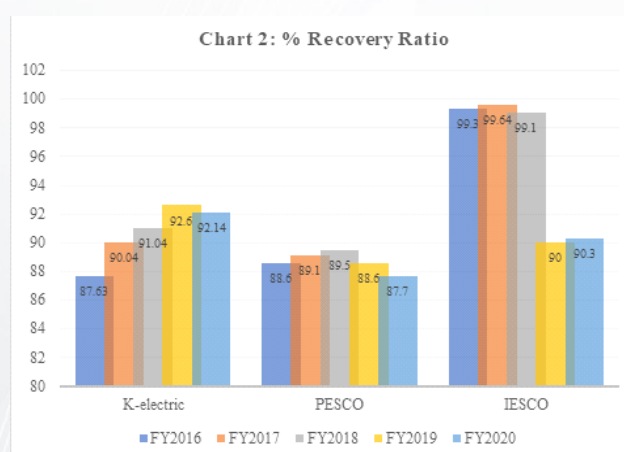
For instance, in the case of electricity utility, increase in demand caused by city expansion or sprawl, the challenge of ageing and badly maintained networks; the need to create more environmentally sustainable networks; the increased costs of investment; constraints on investments because of the lack of investment-friendly tariffs and other regulatory hurdles. All these factors create challenges for utility management.

These transformations have important implications for urban planning. As discussed in the previous section, in the cities which are more resilient, it is easier for the electricity utility to perform there efficiently (as explained in Figure 3). This is pretty obvious from various standard Key Performance Indicators (KPIs) among the three electricity utilities (Chart 1 to Chart 5 and Table 11 and Table 12). The performance of IESCO is relatively better than PESCO and K-Electric. In less resilient cities_ Peshawar and Karachi, it is challenging for the electricity utility to transform their systems to cope with the changing needs and to absorb shocks.

In the absence of these transformations, infrastructure systems are forced to use beyond the available capacity. The result is overload, congestion, and adverse implications on service and reliability for utilities operating in such settings. The overall operation becomes inefficient and costly both to the managing agency and the user. This is exactly what is happening in the case of K-Electric and PESCO.

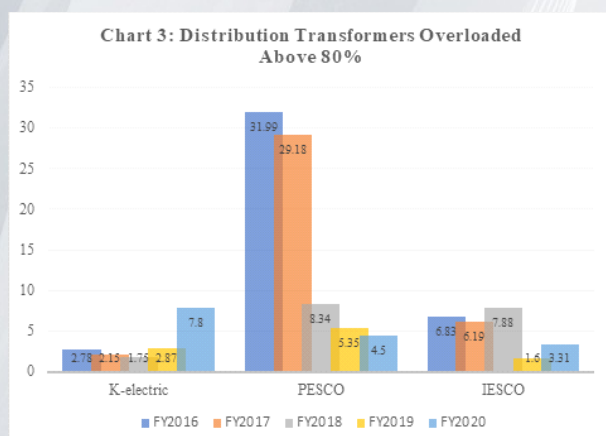


Source: NEPRA Performance Evaluation Report_Distribution Companies, 2019-20.

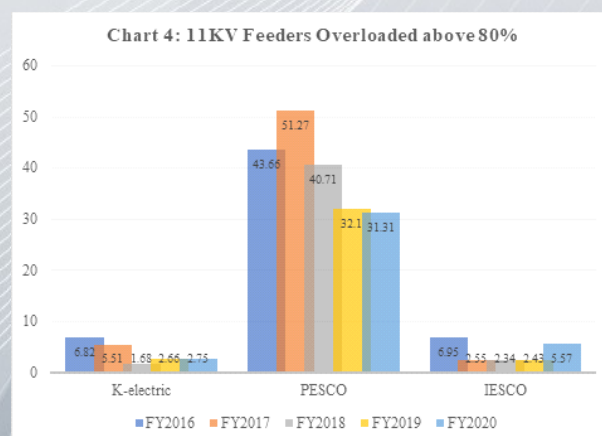


Source: NEPRA Performance Evaluation Report_Distribution Companies, 2019-20.

In high loss areas, both PESCO and K-Electric have adopted a policy of revenue-based load-shedding. IESCO with relatively better records of T&D losses and recoveries has not adopted this strategy (as reported). In areas under IESCO, there is no 'Kunda' culture or electricity theft. There were issues of metre tempering, especially at night; the issue is resolved to a great extent through regular monitoring by the IESCO officials. Besides, a large number of metres have been replaced over the last couple of years to curb electricity theft. Most of the losses in the IESCO are due to technical reasons. But the IESCO officials are working on these as well through the replacement of electricity infrastructure; the utility has surplus supplies of distribution equipment in its stock. Through these measures, the utility is largely meeting the targets set by NEPRA.

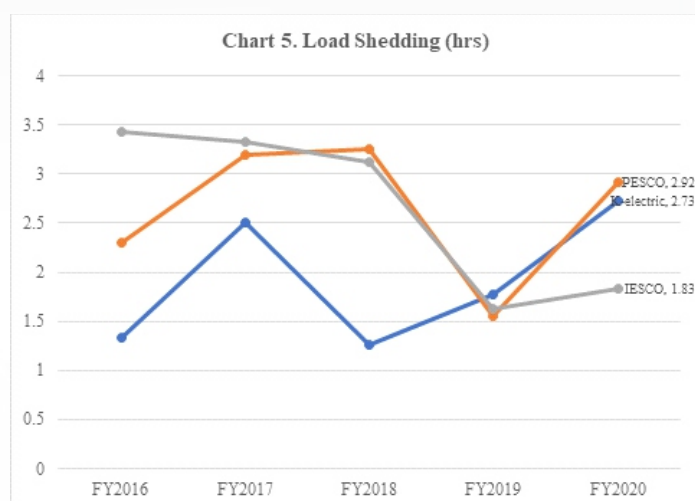


Source: NEPRA State of Industry Report, Various Years.



Source: NEPRA State of Industry Report, Various Years.

There is no commercial or revenue-based load shedding in IESCO. In recoveries, there are delays, but once the company approaches defaulters, they cooperate and pay their bills. Sometimes, IESCO does disconnect supplies, but without creating any law-and-order situation, bills are paid. It is because of the relatively better socio-economic status of the Islamabad populace. City administration and law enforcement agencies are cooperative²².



Source: NEPRA State of Industry Report, Various Years.

In Islamabad, although there are issues of urban sprawl, lack of civic amenities, informal settlements, impact of climate change etc, its impact on electricity infrastructure is not as grave as in other two cities, in particular, Karachi. One reason is relatively new power infrastructure; and secondly, in most of the large (new) housing societies, it is underground. Therefore, relatively safer.

Commercial load-shedding or revenue-based load-shedding is not a good policy as it penalises compliant consumers. The low cost and uninterrupted supply of power (solar) is shifting compliant consumers away from distribution companies, creating another big challenge for the cash-starved distribution companies. However, as informed by utilities, e.g., in the PESCO jurisdictions, the entire blocks of consumers are non-compliant. Therefore, no chance of penalising 'compliant consumers' as all are non-compliant.

Table 11. System Average Interruption Frequency Index (SAIFI)

	FY2016	FY2017	FY2018	FY2019	FY2020
K-Electric	20.52	19.6	17.55	28.95	27.56
PESCO	261.65	160.6	170	189.01	187.93
IESCO	0.03	0.029	0.04	0.05	0.06

Source: NEPRA Performance Evaluation Report_ Distribution Companies, 2019-20

Table 12. System Average Interruption Duration index (SAIDI)

	FY2016	FY2017	FY2018	FY2019	FY2020
K-Electric	1210	1142.5	1451.42	2950.22	2655
PESCO	24927.12	14643	16222.79	16696.51	14924.4
IESCO	0.82	0.79	0.73	1.27	1.36

Source: NEPRA Performance Evaluation Report_ Distribution Companies, 2019-20

Since here it is the comparison between cities, it is important to mention here, as informed by PESCO officials, more non-compliance is in areas in the outskirts of Peshawar. A total of 20 percent to 30 percent of the total area in PESCO's jurisdiction can be considered as the challenging area. In some cases (e.g., Mattani) the non-compliance has been prevailing for over 20 years. All efforts including instalments and engaging elders have not yielded. In some cases, the accumulated arrears are more than the market worth of the house in question.

²¹As shown in Chart 5, NEPRA Performance Evaluation Report 2019-20 reports an average load-shedding of 1.83 hours in IESCO, the reason is not clear whether it is due to demand-supply gap or due to commercial reasons, but the company officials claimed there is no commercial load-shedding in IESCO.

²²As reported by IESCO, the recovery rates in IESCO are expected to be around 98 to 99 percent in FY2021.

²³This policy is adopted by distribution companies after the National Power Policy, 2013 which states 'focus load-shedding in areas where collections are low'.

²⁴In several low-income areas in Karachi, e.g., Liaquatabad, Federal B. Area, Surjani Town, Orangi, Landhi, Korangi and Baldia now have many service delivery outlets (mostly informal) for solar panels (UN Habitat, 2018).

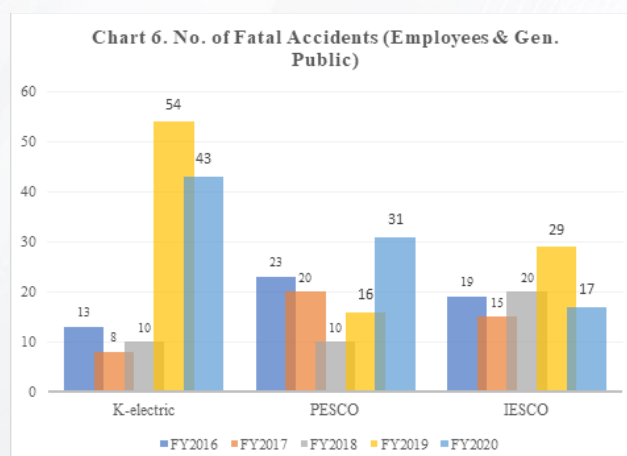
Within Peshawar city, the magnitude of non-compliance is relatively low. A special police task force has also been constituted to help in the recovery of dues but this has not proved fruitful – the police cannot register FIRs against the entire neighbourhood. According to PESCO, it is more of a political issue and needs political settlement. Beyond that, the non-complaint or high loss areas are not supplied electricity round-the-clock, hardly 4 to 5 hours of electricity is supplied to them.

More support from civic authorities and law enforcement agencies to curtail commercial or revenue-based load shedding is required. Now the new power policy is announced, that is, National Power Policy 2021. Its implementation on ground is required to improve recovery rates rather than choosing the option of commercial load-shed policy. Respective Provincial Governments must provide all necessary support to the power companies for recoveries, bill collection, theft detection and other legal processes. For efficient recovery systems, the support of law enforcement agencies is compulsory.

K-Electric is the only privatised utility in the country. Its strategy to deal with commercial and operational issues are discussed in detail, in Section 4.2.1. and Section 4.3. However, it is important to mention here that the utility is working in an environment with deeper and more old urban challenges, which may not be reflected in numbers.

4.1. Safety Hazards

One major issue common in all three cities (though proportion differs) is the encroachment around or in the vicinity of electricity distribution networks. This kind of encroachment happens continuously due to weak governance checks by the civic authorities. Rapid urbanisation in the absence of urban planning has resulted in an illegal (vertical and horizontal) expansion of buildings/ houses beyond the allowed limit. Thus, creating safety hazards. City agencies, in general, in all the three cities under study, are not responsive to curb the encroachment of electricity infrastructure.



Source: NEPRA State of Industry Report, Various Years and NEPRA Performance Evaluation Report_ Distribution Companies, 2019-20.

In Islamabad, encroachment is common in areas located at the periphery, where people have built or expanded houses beyond approved and allowed boundaries or heights. As informed by IESCO officials, the company, however, is vigilant about it. Daily record keeping is done at the utility, not only to identify the safety hazards but to address these as well through operation or shifting of electricity networks to appropriate places, away from the hazard radius. In the majority of these cases (75% in June 2021), IESCO is re-routing lines to avoid accidents. In Islamabad, it is relatively easy as still vacant space around such possible hazards is available. Moreover, IESCO is not facing any 'right of way' issue_ neither in monetary terms nor in terms of approvals_ IESCO is not required to pay 'right of way' charges.

In Peshawar, especially the old city has narrow unplanned streets – it is a challenge to find the right place to install feeders in these unplanned narrow streets. People have constructed houses under high tension cables (like 66 KV) wires or close to these wires. This causes safety hazards. PESCO approaches municipal authorities and the police to prevent such unauthorized construction but to little avail – the authorities have not been of much help in this regard. A total of around 6000 plus hazard points have been identified in the jurisdiction of PESCO. An amount of Rs.60 million had been committed by the Power Division (Ministry of Energy), but the funds were not disbursed.

²⁵Cross-subsidisation policy of the government, that is, high-end consumers subsidising low-end consumers is encouraging the use of alternate sources of energy like solar panels. According to K-Electric sources, most of these consumers are affluent or high-end consumers, which under the existing tariff setting cross-subsidise low-end consumers. By shifting to solar or self-generation these high-end consumers are able to avoid charges above the actual cost of service.

²⁶The problem aggravates after the Afghan War when security concerns emerged in Pakistan, in particular, KPK province. People stopped paying bills.

Moreover, encroachment of electricity poles (unauthorised use of these poles by internet and cable operators without the permission of utility also sometimes becomes the reason for accidents. In Islamabad, concerning pole intrusion by internet or cable operators, there exists a policy 'rent a pole' but it is hardly implemented. Beyond that, the issue is not as grave as in Karachi and Peshawar. In Peshawar, PESCO has tried to implement a pole-rent policy but the cable operators have gone to court against the policy and the matter is under litigation.

Karachi is the largest city among the three, so is the magnitude of safety hazards in the city. There is widespread encroachment of sensitive distribution and transmission infrastructure to the extent that entire homes are built around electricity homes. In addition there is encroachment of the electricity wires by internet and cable wires which are haphazardly placed on electricity poles due to no alternate arrangements.

There is also tremendous resistance on the part of the cable TV operators, many of whom are based in Karachi to invest in building safety into their networks or shifting them underground. According to K-Electric, they undertook a Constitutional Petition in the Sindh High Court against the encroachment of its infrastructure in 2019, however the case is still pending in 2021. The utility is investing regularly to remove these hazards through the replacement of old infrastructure, running earth-wire on LT network, replacement of delapidated HT/LT poles, PMT structures, installation of HT double earth & guard wires, and conversion of LT mains to LT Aerial Bundled Cables (ABC) etc. The revalidation of earthing/ grounding of K-electric network which comprises of over 250,000 poles is completed. K-Electric has earmarked over Rs 30 billion for safety and rain mitigation plans during the period 2017-2023 subject to regulatory approvals. But not only the magnitude of the problem is big in Karachi, challenges the utility (K-electric) is facing are also more in terms of seeking the 'right of way' and its costs. Sometimes, even if 'land right' is secured after payment, the land gets occupied by illegal encroachers.

4.2. Utility Characteristics and Challenges

Certain characteristics of electricity utilities operating in the three cities are shown in Table 13. K-electric is a vertically integrated utility, engaged in generation, transmission and distribution of electricity. It supplies electricity across Karachi, Dhabeji and Gharo in Sindh, and Uthal, Vinder and Bela in Balochistan. Whereas, IESCO and PESCO are only distribution companies. IESCO supply electricity across Islamabad, Rawalpindi, Attock, Jhelum and Chakwal; and PESCO supply across Peshawar, Bannu, Hazara, Khyber, Mardan, Swabi, and Swat. It is pertinent to mention here that net profit margin is for the whole utility, while number of consumers and consumer density is for the particular city under study.

Table 13. Utility Characteristics

	Governance	Share -holders	Net Profit (Loss) Margin 2019 -20	No. of Consumers in City	Consumer Density
K-Electric	Private; Independent Board (With 3 Govt. representatives)	Private 66.4%) Govt. (24.36%)	-1%	2596251	712
IESCO	State -owned (Under the administrative control of Power Division; with Independent Board	88% WAPDA; 12% others**	-7.8%	476068	525
PESCO	State -owned (Under the administrative control of Power Division; with Independent Board	100% WAPDA	-17.6*	606962	400

Source: *Financial Footprint: SOE Annual Report 2018-19, Ministry of Finance, Government of Pakistan; Financial Statements of Companies; and information shared by the company.* * 2018-19, as financial statement for 2019-20 is not publicly available. **12% of shares belong to Employee Trust Fund since FY2014-15 (transferred under Benazir Employees Stock Option Scheme).

4.2.1. K-Electric

In Karachi, electricity theft through 'Kunda' is common in several areas. It is like an organised crime, making it difficult for the utility to deal with it. The utility removes thousands of 'Kundas' daily, but these are re-installed within hours. Besides, it is not easy for the utility company (K-Electric) to register an FIR for theft. FIR registration for power theft is through utility courts, which have been found to be ineffective, as several pre-requisites have to be met before formally registering a complaint and any action by the court to be taken. Given that kundas are temporary installations that are easy to apply and remove at will, building long-term evidence against such power theft is difficult. Among the three utilities being examined in this study, only K-Electric faces this situation, while both IESCO and PESCO did not cite FIR registration as a challenge. Consumers who are not paying their bills are liable for penalties under the Land Revenue Act, which can go as far as seizing the defaulter's property and can also include jail time. This authority exists but is never applied.

²⁸Source: K-Electric officials.

The area-wise data shows, more-loss areas are at the city periphery with relatively more informal settlements or illegal housing, for instance, Orangi, Korangi, Gadap, Layari, Baldia, Landhi, Malir, Surjani, etc. (with distribution losses more than 20%). As mentioned in Section 3.2.1, in general, more deprived are residing in these areas with less civic amenities. These are congested areas where in many cases, it is difficult for the utility staff to operate rather even enter the area. On top of that, most of such areas are sensitive from political, ethnic or income perspective. In the absence of reasonable city infrastructure, these areas are more prone to natural and man-made disasters as well, making it more vulnerable to accidents.

Additionally, as mentioned in Section 3.3.7, security issues related to terrorism, crime are more common in these areas. In the absence of adequate support from law enforcement agencies, it is difficult for the company staff to go there and work efficiently. In such congested and risky areas, not only it is difficult to identify safety hazards, but to move utility network away from such hazardous areas as there is no space left for installation.

For the K-Electric, securing the 'right of way' and installing infrastructure is a lengthy and expensive process. In practice, none of the concerned departments grants the 'right of way' without hefty charges and various approvals, which consume a lot of time. In addition, given the city density and massive horizontal encroachments, not enough space is available to shift electricity infrastructure. Additionally (as discussed earlier), even if the 'land-right' is secured for the pole after the payment and other processes, the land gets occupied by illegal encroachers. Consequently, the utility has to spend more time and money in litigations against those encroachments.

Similarly, illegal use of K-Electric's network and encroachments creates safety hazards, specifically during monsoon rains when water is filled in those areas, which in most cases is not K-Electric fault. There is no proper rainwater drainage system as this is often blocked by unauthorised encroachments, thus creating problems sometimes beyond the control or capacity of electricity utility.

Planning is absent for underground conduits which can carry internet/tv/telephone cables. Public infrastructure is encroached by unauthorised cables that can damage electricity infrastructure and become the source of electrocution. K-Electric is facilitating cable operators in implementing a pilot project whereby tv/internet cables within a defined area are being shifted underground - about 19 kilometres has been completed in South District, and the remaining work is in progress.

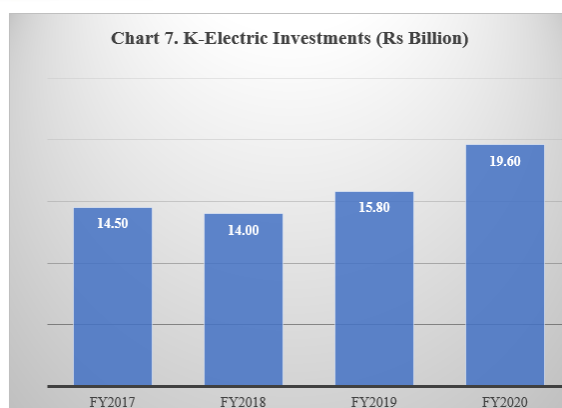
Encroachment of roads is a challenge as houses constructed on them prevent access to underground infrastructure. However, Provincial Coordination Implementation Committee (PCIC) is taking up this matter. The operation against nullah encroachment is proceeding on a fast-track basis. As informed by the K-Electric officials, capital expenditures for K-Electric are going up because it is working on Project ENSURE that includes elevating the infrastructure to avoid rain-related incidents and to enhance the overall safety and resilience of the distribution system. The rain-related issues (as discussed in previous sections) are due to or aggravated due to climatic changes and the lack of proper sewerage systems, and lack of waste management systems etc.

In Karachi, as mentioned earlier, there are several organisations; where each department has different SOPs for dealing with utility agencies like the K-Electric. Politicking between the provincial government and the local authorities is also creating challenges for utility agencies. Likewise, different political parties being at the helm at the federal and provincial levels (with limited coordination) is causing problems for a utility agency. For example, to curb power theft support of the local police is crucial – while electricity is a federal subject, the police, which can help in curbing power theft, is under provincial control. With different political parties ruling at the centre and in the province, the will to deploy police to curb power theft is missing.



Despite all the challenges, K-Electric is trying its best to overcome these challenges. K-Electric is investing across the city to upgrade and strengthen the distribution network (Chart 7). The utility has attempted to move towards the Smart Grid. At present, there are over 56,000 Automated Meter Readers (on the HT and LT network) in its system, giving the utility visibility of its network at the PMT level, which is a first amongst all power distribution companies. Over 11,000 PMTs in the KE network have been converted to ABC. These are insulated, theft-resistant cables that help curb losses and ensure the supply of safe and reliable electricity to Karachi. K-Electric is using ESRI's ArcGIS platform and Schneider's ArcFM suite to strengthen the digitized network, that is, using an electrically intelligent data model specific to power networks. The implementation of the advanced system of Schneider's ArcFM suite is for the first time in Pakistan²⁹.

The utility is also investing in social uplift programs in some of the poor localities (densely populated and predominantly informal settlements) under their flagship project 'Sarbulandi'. Through this consumer-centric project, the company has been successful in reducing line losses and improving recovery rates substantially (details in Section 4.3)



Source: K-Electric³⁰

4.2.2. PESCO

PESCO is among the high loss-making state-owned companies in the country. As mentioned earlier, although in Peshawar city there are less problem of theft or low recoveries. But in the older city areas, because of congested housing units, there is a significant problem of network encroachment (as mentioned in previous section). Just like Karachi, there are several such areas where there is no space left_ making it difficult for the utility to maintain or shift network away from hazardous area. The existing distribution infrastructure is old and in dilapidated form requiring immediate replacement/ improvement.

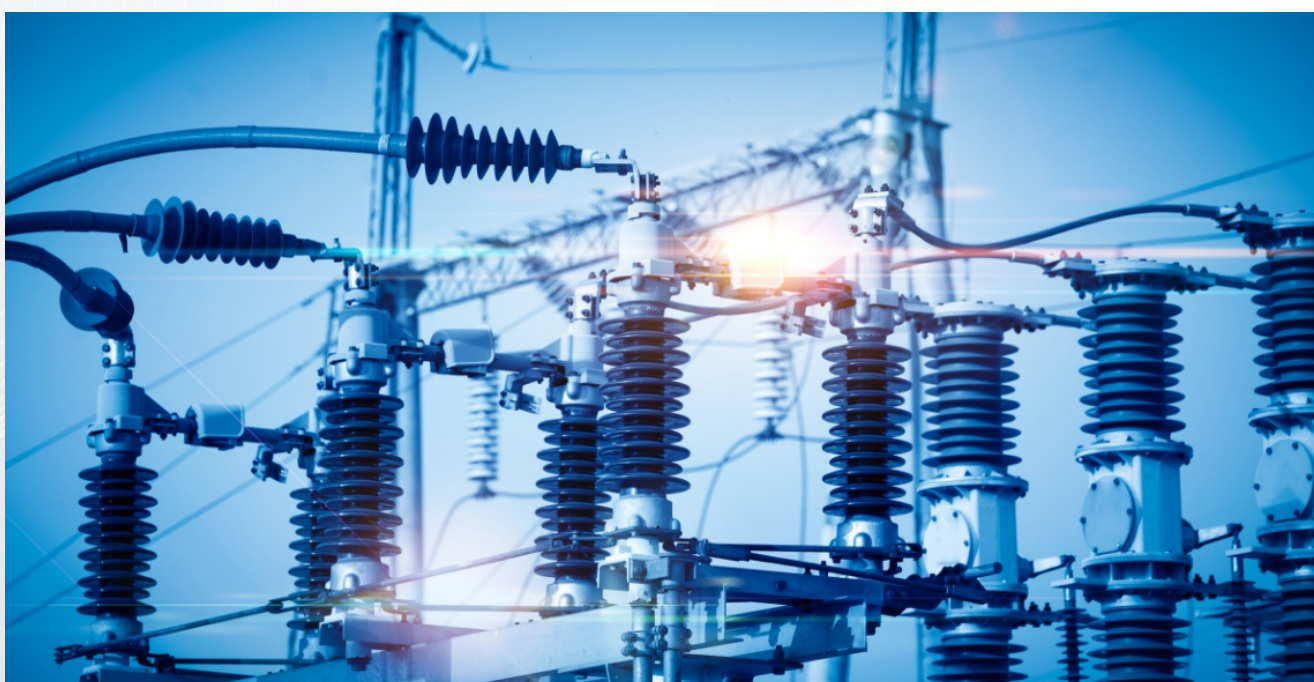
The primary issue faced by PESCO is of human resource capacity – 20 years ago PESCO was serving 1.8 million consumers with a staff strength of 27,000. Today it serves more than double the consumers that it served 20 years ago with less than half the strength (present number of consumers: 3.8 million, Staff strength: 13,000). Beyond that, existing employees are over-burdened and aging, cannot handle distribution network problems, which is already in bad shape. More than 279 employees at PESCO lost their life in the last few years because of accidents resulting from work over-load.

The board of PESCO is empowered now to hire staff. In the past, several factors, including lack of board's capacity to take decisions and confusion as to whether the DISCO would remain with the state or will be privatised has held up fresh recruitment while the existing staff continued to move out due to superannuation or resignations. Human resource constraint has influenced the performance of PESCO.

Another main issue is lack of investments and government approvals. If timely funding is provided to them, they can easily remove safety hazards from densely populated streets/ areas through shifting of network (where possible) and through using latest technologies in more congested areas/ streets. Replacement and strengthening of electricity infrastructure are critical for reliable electricity supplies to its consumers. Currently, PESCO is unable to provide maintenance service because of resource constraints in high-loss areas. As a result, the consumer develops 'why should we pay' kind of attitude. Regarding the 'right of way', the company has to pay to the relevant land-owning department, in some cases.

As mentioned in Section 3.2.1, several housing societies do not fulfil the legal requirements for the land development and the construction undertaken. Accordingly, the concerned housing development authorities do not issue NOC to them. As the societies do not have the NOC, PESCO is not allowed to provide them electricity connection. However, these societies are connected to grid illegally. The bigger housing societies have their infrastructure within their jurisdiction and PESCO provides electric connection at one point to the entire society – the infrastructure within the society is installed and managed by the society itself. However, in the case of smaller housing societies door-to-door electricity connection is provided by PESCO. Almost all societies demand a separate feeder but the PESCO cannot provide a separate feeder to smaller housing societies due to low demand.

The PESCO staff apprehends that with the introduction of Competitive Trading Bilateral Contract Model (CTBCM) the low-cost producers, like PEDO, may capture a portion of their compliant segment thereby increasing their share of challenging segment, however the staff is not too sure about the effects of the CTBCM.



4.2.3. IESCO

In comparison, it is relatively simple and convenient for IESCO, and the company is doing it quite effectively. The area under the jurisdiction of IESCO is the area of people with powers and influence. In comparison to Karachi, there are fewer government authorities to deal with regarding seeking permissions etc. Above all, authorities are relatively more cooperative. Apart from DHA, mainly CDA is responsible for all housing societies. Though there are many illegal and unauthorised societies (without letter of approval (LOP) or No Objection Certificate (NOC) from CDA), but because of weak regulatory laws, weak city governance, corruption, these are supplied electricity. At times, action is taken against unauthorised 'Katchi Abadi' where the poor are residing. Sometimes, their electricity is also cut, at the request of CDA. Besides, IESCO has never faced any law-and-order situation, as they respond quickly to complaints. Priority is given to consumer satisfaction.

There is no issue of 'right of way' in IESCO jurisdiction and no fee is charged from IESCO for the 'right of way' or for pole installation as in Karachi. In most of the new localities or housing societies (approved or un-approved by CDA), like PESCO, the internal network is installed by the society itself. IESCO is only asked to energise at one point from outside.

4.3. Situation Analysis

As observed in previous sections, the lack of urban resilience is creating challenges for electricity utilities. IESCO is working in a relatively better urban environment, is facing lesser challenges. Its operational performance is better than the other two. In FY2020, its T & D losses were recorded at 8.69%, distribution transformers overloaded above 80% were 3.31%, SAIFI was 0.06, SAIDI was 1.36 and average load-shedding hours were 1.83.

Among the other two, although both are working in a less resilient urban environment, the challenges are more for K-Electric as a private company; and as a company working in a city environment with challenges that are larger in magnitude (in absolute terms) and deeper. Yet, the K-Electric performance has shown significant improvement over the years. In terms of recovery in FY2020, K-electric was at the top among the three. During the period FY2016 to FY2020, K-Electric's recovery rate has gone up from 87.6% to 92.1%, that is, an improvement of 4.5%. In FY2020, its 2.75% of 11KV feeders were overloaded above 80%, lowest among the three. In terms of T & D losses, the utility has reduced losses by 2.51% during the period FY2016 to FY2020. In comparison, in PESCO, recovery rates have decreased by 0.95% and T & D losses have increased by 5.1% (Chart 1 and Chart 2).

In the public sector, it is often difficult to make investment decisions to stay ahead of demand until there is a crisis of service and a level of public inconvenience which motivates action. Generally, there is a lesser tendency to spend on improving infrastructure in the public sector until there is significant pressure to improve service. The pressure normally comes from overall city governance, awareness and socio-economic class residing in the area (Bishop, 1997). Besides, overall organisational capacity to make timely decisions is important. This is obvious from the difference in the performance of IESCO and PESCO.

Whereas, K-Electric_ privatised entity, despite facing deep structural and governance issues in Karachi city manages to do better than PESCO. Mainly it has been driven by targeted and accelerated investments that K-Electric has made over the last decade. However, as K-Electric operates under a regulated environment (just like state-owned distribution companies in the country), the power utility depends on timely regulatory approvals to execute its investment plans. Despite all the challenges K-Electric is facing in the form of approvals and exorbitant charges for the 'right of way', delays in tariff determinations, delays in the disbursements of Tariff Differential Claims (TDCs), and delays in receivables from the government departments, is investing in the upgrading and strengthening of distribution infrastructure (Chart 7). However, delays in Tariff determination and regulatory approvals of the investment plans, and delays in the disbursement of TDCs by the government_ all are affecting the working capital of the utility.

In Karachi, as said above, overall city governance is not in favour of private utility. In a city like Karachi, with a large number of informal settlements with less willingness and less ability to pay utility bills, encroachments, investment in the utility infrastructure is critical to ensure uninterrupted supply to all consumers. Investment is also essential to overcome safety hazards, to reduce transmission and distribution losses and to avoid environment-related challenges and accidents. *This requires an investment-friendly tariff, its timely determination, and timely disbursements of TDCs if the government likes to apply the national uniform tariff policy to Karachi as well.* The resolution of all these issues is crucial for sustainable investments in the upgradation and expansion of distribution infrastructures, which in turn, benefits consumers through safe and reliable electricity services. No doubt, the utility (K-Electric) despite all odds is investing across the city to upgrade and strengthen the distribution network

The utility is also investing in social uplift programs in some of the poor localities (densely populated and predominantly informal settlements) under their flagship project 'Sarbulandi'. The company under this project is building a relationship with communities, involving them and creating awareness. Via offering different payment packages, low-cost metres, and investment in upgradation of infrastructure, instalment of Aerial Bundle Cables (ABC). The utility has achieved some success in curbing 'Kunda' connections, reducing losses and increasing recoveries. For instance, in Korangi (Karachi), under this project the utility has successfully reduced distribution losses from 41 % to 16% and improved recovery rate from 63% to 94% in Ghous Pak & G-Market feeder; and reduced distribution losses from 38% to 13% and improved recovery rate from 71 % to 95 % in Madina colony.

Being a private company, they must have an incentive to invest. Without adequate returns on investments, together with the resolution of all pending issues of outstanding payments from government entities, it would be difficult for the company to continue with its investments plans for upgrading, expanding and enhancing overall network safety.

Reduction in utility losses via social uplift programs is a good strategy to be followed in other loss-making utilities, e.g., PESCO. Peshawar is a relatively poor city; it needs such projects not only from a utility perspective but for improving the overall resilience of the city as well. Beyond restructuring, the focus should be on making a long-overdue investment in strengthening and upgrading the crumbling infrastructure and in the enhancement of technical human capacity. In short,

³³Source: K-Electric staff.

improvement in the organisational capacity and public investments in PESCO could help in containing losses, in ensuring reliable electricity supplies to the consumers, and in the expansion activities of PESCO.

Population-dense cities are huge sources of power demand. Not only consuming more energy but emitting a similar proportion of carbon as well. That's why large cities are at the heart of the climate change discussion. So is the case of cosmopolitan city_ Karachi; where electrical infrastructure needs to be developed in a way that supports economic growth and high quality-of-life while also integrating more sources of renewable energy to mitigate climate change impact. A smart city is an answer for sustainable energy management.

Energy efficiency and demand-side management strategies represent an essential component of the smart city's energy matrix. K-Electric is doing well at this front. It has institutionalised energy conservation measures by setting up a separate Energy Conservation department. K-Electric is active in reducing its carbon footprint. That is, reducing energy consumption in its operations, converting its offices to 'Green Buildings' etc. Its Energy Conservation department is actively creating awareness among consumers through various initiatives_ through a door-to-door campaign under 'Sarbulandi' and schools etc. But without support from city authorities, it is impossible to have a meaningful impact on a large scale.

In Pakistani cities, urban development policies and energy policies are required to be integrated_ via improving the energy efficiency of housing, buildings etc., as done in Toronto. Similarly, local urban planning must include land use and regulations of the physical environment considering renewable energy. Any conflicts between distributed energy facilities and urban design can be addressed by the landscape rules, as done in Perpignan (France) (Cited from Sugahara (2016)).

Besides, distributed energy or microgrid projects offer a localised energy infrastructure that can help improve system resilience. For several years now, cities around the globe have been integrating the use of new technologies in their energy systems (Gontar, 2018). The distributed generation (DG) in Pakistan is still in its early stages but rising (Table 14). DG offers one of the most promising solutions to advancing the clean energy transition in Pakistan.

Table 14: Net- metering Licences

Year	PESCO		IESCO		K-electric	
	No. of Licenses	Capacity KW	No. of Licenses	Capacity KW	No. of Licenses	Capacity KW
FY2018	2	37.56	114	1732.81	28	288.40
FY2019	10	96.60	377	3849.07	253	4270.21
FY2020	131	3200.84	863	9990.0	730	12240.0

Source: NEPRA State of Industry Report, 2020

Power grids in Pakistan, in general, are underinvested, overburdened and subject to many new challenges, that is, uncertainty related to market development and the infiltration of renewable energy systems. In densely populated cities, the Smart Grid offers long-term solutions to urban energy dilemmas. Despite the threat seemingly presented by the emergence of distributed generation, existing utilities (e.g., K-Electric) still have a critical role to play in preparing current grids for more advanced smart city technologies. But of course, this requires huge investments.

Public-private partnerships are an option to finance the necessary improvements. Similarly, performance contracting and other concession agreements provide ways to enhance investments without exerting an undue burden on consumer bills. Smart cities for the future offer an opportunity for electricity utilities, all that is required is a progressive mindset to make a jump. That, unfortunately, seems lacking in two state-owned companies under study here. But the way K-Electric has proceeded in the last few years, the company can set an example for others to follow.

5. Conclusion

In the study, we have explored urban resilience across three cities in Pakistan_ Karachi, Islamabad and Peshawar. Using available statistical information, we have estimated the urban resilience index for these cities. In the study, the linkage between various operational (transmission and distribution losses, safety systems, outages etc.) and commercial (recovery rates) performance of a utility and urban resilience of the city is also examined. We find that none of the cities is resilient enough to absorb the impact of rapid urbanisation. However, the Federal Capital Islamabad with a score of 0.20 is relatively more resilient as compared to Karachi (0.12) and Peshawar (0.10).

Modern cities require innovative procedures and processes to address the urban sprawl, which we find missing in all the three cities under study, urban resilience index for none of the three cities is closer to 1. Therefore, ***we reject the hypothesis that Pakistani cities are resilient enough to absorb the impact of rapid urbanisation.*** We conclude that rapid urbanisation leads to the expansion of slums/ informal settlements, illegal housing in Pakistani cities creating issues of service delivery. Illegal extensions /encroachments create safety hazards and hinder reducing losses and in the recovery of charges against electricity consumed.

Regarding our second hypothesis, that urban dynamics of Karachi are similar to Islamabad and Peshawar, although Peshawar is the least resilient city among the three; ***we reject the null hypothesis and conclude that the urban dynamics of Karachi are different from the other two cities because of its size, density, population, vulnerability to calamities because of rising sea levels, weak governance_ partly owed to the political relationship between the federal and provincial governments and fragmented institutional structure.*** Though all three cities are suffering from the impact of urban sprawl, its impact on Karachi began relatively earlier and is much greater in magnitude and so is its impact on electricity utility, i.e., the K-Electric.

The magnitude of encroached electricity infrastructure, which resultantly becomes a foremost reason for safety hazards, is more in Karachi as compared to Peshawar and Islamabad. The population living in just one of the Karachi slums_ Orangi Town (2.4 million) is more than the total slum population in Peshawar (1.5 million). Besides, the challenges faced by K-Electric, as a privatised company are different from PESCO and IESCO_ state-owned companies. For instance, regarding seeking permission for the 'right of way' or for installing electricity poles, K-Electric has to deal with several parallel agencies, whereas, it is relatively better and simple for both IESCO and PESCO. Although PESCO pays for the 'right of way' in certain cases, charges are more for K-Electric³⁴.

The impact of urban resilience is also reflected in the performance of the three utilities. IESCO is better than K-Electric and PESCO in terms of transmission and distribution losses, existing distribution infrastructure, load-shedding hours and supply reliability. However, K-Electric despite being working in less resilient environment is not only at the top in terms of recovery rates, line losses over the last couple of years have improved substantially. Such radical improvement is not obvious in PESCO. In K-Electric, the consumer centric 'Sarbulandi' project is paying off significantly. Additionally, K-Electric is investing in the upgradation of infrastructure across the city³⁵.

No doubt it is the job of the utility to ensure reliable and safe electricity to city dwellers. But it needs support from the administrative management of the city. While comparing three utilities IESCO, PESCO and K-Electric we find, IESCO is working in a city with a relatively better governance system. It also gets due support from various administrative units, when required. But this is not the case with PESCO or K-Electric which must deal with safety hazards created due to tampering and encroachment of its infrastructure. Both PESCO and K-Electric are not getting support from law enforcement agencies. Among these two, the situation is more challenging for K-Electric on account of external challenges.

In the last two decades, natural calamities are occurring more frequently as a result of global warming. Cities play an increasingly important role in tackling climate change, because their exposure to climate and disaster risk increases as they grow. In less resilient cities, infrastructure, particularly, electricity distribution networks/ equipment is more vulnerable to such calamities. Similarly, rapid urbanisation in the absence of required urban development is resulting in large informal settlements, often creating hurdles for electricity utilities (sometimes encroaching existing electricity infrastructure too).

In Pakistani cities, urban expansion is near hazard-prone areas and built through informal and unplanned settlements. For building sustainable and resilient cities requires intensive policy coordination and investment choices. The government at every level (Federal, Provincial and Local or Municipal) have an important role to play to take timely decisions to shape the future of city development and to create opportunities for all.

³⁴Though the exact amount is not shared by utilities, the inference is drawn from the informal discussion with the management.

³⁵Investments are allowed by NEPRA in a Multi-Year Tariff Determination. For investments over and above NEPRA allowed levels, NEPRA approval is required (K-Electric officials).

A city economy depends on reliable electricity services. Thus, building the resilience of electricity systems is crucial for human welfare and economic growth. A utility company must have the capacity (sufficient investments) to remain prepared for absorbing the effects of dangerous events_ in a timely and efficient manner (ESMAP, 2016). Similarly, it must have the human and financial capacity to replace/ upgrade/ expand its infrastructure for ensuring reliable supplies to the rising urban population.

Building a resilient power sector is challenging because of the dilapidated infrastructure and lack of timely periodic maintenance of infrastructure in Pakistani cities, because of lack of resources. Although, investment decisions seem relatively easier for the privatised utility (K-Electric), it needs regulatory support in terms of timely determination of investment-friendly tariffs and their approvals. Whereas, organisational/ human resource capacity apart from lack of financial resources is a serious constraint in PESCO, a state-owned company.

Above all, the compilation of city level data on a regular basis is essential to build the resilience of energy companies. The readily available data can help forecast future trends/ risks/ changes in city dynamics. Thus, helping utilities in making investment decisions in time.

Pakistani cities demand planning, innovative solutions for water and sanitation, affordable housing, standard education and health facilities, improved law and order, and a sustainable environment. Urban population growth demands an efficient electricity infrastructure to cope with rising demand and changing circumstances. For densely populated cities like Karachi, a smart city with smart energy systems could be an option for future.

On November 12, 2020, NEPRA has approved the detailed design and implementation plan of the Competitive Trading Bilateral Contract Market (CTBCM). NEPRA has given a timeline of 18 months for the preparation and its implementation. The model envisages that all the future contracts for the sale/purchase of electricity will be bilateral between the parties. The wholesale market model is envisaged to be implemented by 2022. Under the NEPRA amended Act 2018, the two distribution functions, that is 'wire or distribution network' and 'sale' are required to be separate licensed activities by 2023 to allow for retail competition in future. A level playing field for all utilities, whether in the private sector or the public sector, is essential to create a competitive market environment.

A financially viable sector and a reliable payment chain are crucial for a market to function. In CTBCM, the distribution companies would be required to provide a credit cover for future procurement of power. This will not be possible, given the current poor balance sheets of several state-owned distribution companies (DISCOs). If buyers, that is, DISCOs, are financially unsound how the envisaged wholesale or retail power market will function? Moreover, the benefits of market competition are unlikely to pass to end-users if market power is concentrated either in the generation or in the distribution sector.

A stable macroeconomic, political and social environment is necessary for the market to develop and function. Institutions play a crucial role in the success of any market, not just electricity. The dismal state of our institutions and governance failures as discussed in the report warrant that the current conditions are not feasible for the development of a full-fledged electricity market. A resilient urban environment is critical for the smooth transition and for its sustainable operation of energy market.

Thus, a sustainable framework must be developed to address challenges currently faced by the sector. That is, restructuring in the power sector must focus on tariff reforms to ensure the financial viability of power sector companies. No doubt, 'wheeling of power' is a precursor to market development. It is the job of the regulator to ensure that wheeling charges are enough for the sustainable performance of distribution companies, as well as, these are not hurting the interests of those involved in 'wheeling of power'. A fair mechanism is required for the recovery of stranded costs that arise as a result of the open-access regime. Besides, the development of a pragmatic strategy for the recovery of bad debts/ arrears, and replacement of cross-subsidy with direct and targeted subsidy, are pre-requisites for the sustainable open market regime.

It is equally important to adopt an integrated power sector planning approach to achieve an adequate balance in the energy system. This approach must include accurately forecasting demand, adding generation capacity, improving transmission and distribution systems, increasing efficiency and bringing costs down, and ensuring environment and economic sustainability. Finally, before the formal implementation of open market competition, a detailed assessment study must be conducted, to identify the fears of all distribution companies and to suggest optimal solutions for a sustainable transition to an open market framework.

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