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SPATIAL EVALUATION OF LANDLINE SUBSCRIPTION GROWTH IN KARACHI

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ABSTRACT

Recent technological advancements have increased information access and effective communication among society. In major cities, the varying land use patterns at different geographical scales due to migration and urban sprawl have also resulted in varying landline service demand and usage trends. This study evaluates spatial trends of landline service penetration and subscriber growth among different land use classes at the neighborhood level in Karachi's urbanized area. Findings indicate that the socio-economic segregation of neighborhoods was prominent in spatial trends of landline penetration in residential and shop tenancies, while business tenancies possess the highest service penetration. The subscriber churn effect was still dominant despite substantial demand in residential tenancies during the last couple of years. Through GIS techniques, this study has attempted to understand the spatial aspects of landline consumers' behavior from diverse socio-economic backgrounds against the impacts of ICT evolution in rapidly growing cities of developing countries.

KEYWORDS: Spatial, Geographical Information System, GPS survey, Urban, Land use, Telecommunication, Subscriber Churn.

1. INTRODUCTION

International Telecommunication Union (ITU) defines telecommunication as the transmission, emission, or reception of signs, signals, writings, images, and sounds or intelligence of any nature by wire, radio, optical, or other electromagnetic systems (ITU, 2012). In the local loop system of telecommunication networks, the subscribers are connected with the service provider's telephone exchange. In Fixed local loop (FLL) networks,

the subscribers are linked via cables while in Wireless Local Loop (WLL), these links are wireless.

In recent times the speedy advancements in Information and Communication Technologies (ICT) have shifted communication use from voice to data, and it has amplified communication among society. Simultaneously, increased access to information has also expanded the knowledge base around the globe (Biggs, 2014). Nowadays, ICT plays a pivotal role in basic service provision in different sectors of society like Health, Education, Public Administration, Agriculture, Commerce etc. (ITU, 2015).

Pakistan Telecommunication Company Limited (PTCL) holds 90 % fixed local loop subscriber base of Pakistan (PTA, 2019)**.** One of the key reasons behind such a huge share is its legacy of being a state-owned operator for decades. After the launch of cellular services and change in governmental policies to allow other telecom operators to operate in Pakistan, there is a highly competitive market situation, particularly in metropolitan cities. Despite existing socio-economic inequalities, the ICT adoption in the urban population's lifestyle is relatively higher than the rural areas. Furthermore, in major cities, the changing patterns of land use at different geographical scales due to migration and urban sprawl also changes land use composition and demography of a locality. Overall rapid changes have been observed in landline service demand and usage trends in telecom consumers, which restrict the spatial diffusion of landlines.

This paper attempts to assess the land use composition of the study area at the tenancy level and evaluate the spatial trends of landline service penetration (percentage of tenancies with a landline in an area) among different land use classes in an urbanized area of Karachi. Further, the landline subscriber base growth at neighborhood level has been assessed from 2012 to 2017, along with the overall change in service usage and its impacts on revenue collection.

1.1. Global Telecommunication Trends

During the last ten years, due to cellular services' massive growth globally, the fixed telephone subscription has been significantly declined (Sanou, 2014)**.** Global trends show that mobile technology is preferred for voice communication while in the case of broadband services, local loop (FLL and WLL) is favored (PTA, 2014). Despite rapid penetration of cellular services among users, fiber optic cable networks continue to grow along with hybrid Fiber- copper networks due to xDSL technologies that enable old copper cable-based last-mile networks to provide higher bandwidth serving new services (Biggs, 2014).

A house connected with internet services provides shared access to the inhabitants irrespective of age, gender, employment status, and profession.

1.2. Pakistan Telecom Sector

According to PTA, the teledensity of Pakistan in June 2019 was 78.9 %, its breakup shows FLL-WLL segment was 1.2%, and the cellular subscriber share was 77.7% (PTA, 2019). The cellular subscription numbers do not reflect the number of individual users; however, a user may register and use multiple SIMs. In June 2017, Pakistan's Fixed local loop subscriber base was 2.64 million, while in June-2019, it was 2.54 million (PTA, 2019).

With the arrival of smart devices (*i.e.*, smartphones, mobile tablets etc.) and particularly after the launch of Next Generations Mobile Services (NGMS) (3G-4G) in 2014, the data services usage has increased at a very rapid rate. Collectively mobile technologies (NGMS & EvDO) dominate the broadband sector in Pakistan, whereas FLL technologies (DSL, FTTH & HFC) comprised 3% of national broadband subscriber share till June 2019 (PTA, 2019). Overall due to technological substitution impacts, FLL initially faced a decline, whereas the FLL broadband has been on gradual growth in recent years (Figure-1).

Pakistan Telecommunication Company Limited (PTCL) has its network spread across Pakistan. It serves more than 2.3 million local loop subscribers, making 90% of Pakistan's total FLL subscriber base of 2.46 million in 2017 and 2.3 million in June 2019 (PTA, 2019).

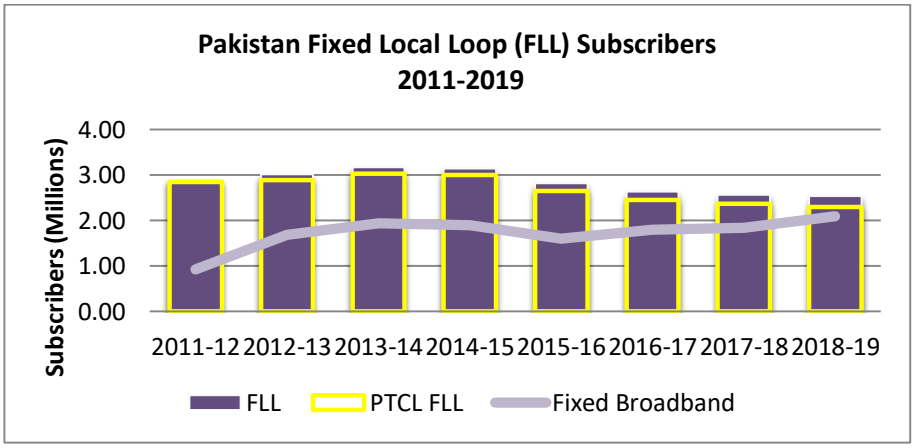

Figure 1: Local Loop Subscriber Base Growth Trend of Pakistan (2011-2019)
Source: PTA (2019)

1.3. Urban Sprawl and Land Use Change

The population in LDCs is progressing at a very high pace. The urbanization is often the outcome of economic, social, demographic, cultural, political, technological, and environmental forces continuously interacting at different spatial scales (Oriye, 2016; Knox & Pinch, 2010). The reorganization process of urban internal functions and activities has evolved overall urban land use structure (Guanghui.et al, 2017). Knox and Pinch (2010) briefly discussed the urban morphology changes over time, and along with the development of new structures, the existing ones may also get modified as buildings, houses, and plots are hybridized. The migration (within the city and from other parts of the country) is mainly caused due to good economic opportunities. At the city level, there is a general trend of migration from inner-city neighborhoods to outer suburbs. There is a common trend that most migrants move to the neighborhoods of the same socio-economic status. These relocation processes generally tend to maintain or reinforce the level of residential segregation, and it may impact the social and demographic structure of city neighborhoods. Particularly in urban areas of LDCs, the degree of spatial disparity in terms of socio-economic and demographic status is relatively higher.

The place-specific concentration of settlements and population densities determines the compactness of urbanization (Salvati .et al, 2018). This urban compactness of different parts of cities changes over time. Oriye (2016) mentioned that due to the rapid increase in population, the city infrastructure comes under immense pressure for housing, health, environment, Telecommunications networks, and other utility service and road infrastructure overall, it yields problems in the functioning of the town.

1.4. Socio-Demographic & Economic Aspects of ICT Adoption

In recent literature, people have worked on the adoption, access, and use of different ICT technologies and its location-based association with socio-economic and demographic aspects at different geographical scales. Anselin and Williams (2015) highlighted the role of digital neighborhoods using geo-located social media users at city level. Driskell and Wang (2009) discussed the adoption of communication technologies that follows the patterns that align with existing spatial inequalities among society from regional/country to neighborhood/house).

There exists a socio-spatial polarization in access to wired digital networks growing the digital divide, and the same cleavage persists for other ICT technologies as well (Torrens, 2008). The inequality of ICT adoption and its subsequent usage is mainly found in consumers segmented in household income, education, employment, economic class (Lengsfeld, 2011;

Sujarwoto & Tampubolon, 2016; Warf, 2012; Perkins & Neumayer, 2011), human capital (technological and social capacity) (Gilbert, 2010), age, gender and place of residence. However, disparities in telecom infrastructure, human capital, and education services are associated with the internet divide (Sujarwoto & Tampubolon, 2016).

At the individual level, income and affordability are the critical factors for technological adoption. In addition to the affordability of high-tech ICT services and equipment could also be associated with a household's lifestyle, which draws a significant variation of ICT demand and use. While in low income, less educated class of consumers, there is low penetration ICT service adoption (Driskell & Wang, 2009) .

Perkins and Neumayer (2011) thoroughly discussed the regions with business actors interacting with international trade have more potential demand and adopters to learn and gain benefits from new communication technologies in their businesses, While Mack (2015) found evidence of a positive correlation of broadband penetration with the presence of knowledge-intensive firms in counties that were near knowledge hubs.

Torrens (2008) discovered the highest concentration of Wi-Fi access points in commercial core areas with a high density of residential and commercial buildings.

Gilbert (2010) has explored the residential segregation in urban neighborhoods also creates education disparities resulting in a fault line for access and use of ICTs. The highest inequalities in internet adoption were recorded in people with basic education, while in the higher educated class, the usage was found equally (Lengsfeld, 2011). The basic infrastructure availability, distance to the facilities, and services (e.g., health, education, job facilities, and commercial area) also caused socio-economic disparities among slums or remote settlements (Knox & Pinch, 2010).

1.5. Factors of Subscriber Base Growth

Telecom service demand and user choices vary between the different users' classes based on age group, economic class (income groups), literacy, profession, etc. Many telecom applications and services are age and occupation oriented. These factors have direct and indirect impacts on the usage of telecom services (Fry, 1999; Madsen & Riaz, 2008). Generally, different land use classes show varying trends in telecom services demand. However, every land use class and its subclasses have its peculiar subscription growth potential in specific terms. Any change in the number of tenancies, land use, demography, and population density could change telecom service use and demand in the area. Furthermore, the economic growth, social changes, increase of disposable income levels can also influence the telecom service consumption (Gupta, 2003).

The Subscriber base growth is influenced by users' demand (need and choice), their affordability, and service access. While the launch of new value-added services has created new business horizons where a user can avail multiple services on a single connection.

In a rapidly changing technological sophistication in telecom goods and services, the trend of changing or switching to updated services and advanced products is taking place (Knox & Pinch, 2010). This is commonly evident in the urban population and particularly in youth (Lengsfeld, 2011). Ding, Haynes and Li (2010) mentioned the regions with higher fixed-line penetration would pose a negative impact on mobile phone diffusion speed. The long-standing subscribers who never switched appeared to be very resistant to switch despite the market competition (Peter & Lyons, 2017), while in the absence of any alternative, the demand for mobile telephony is high (Ramachander, 2016). As the telecom markets evolve in different growth stages and within mature mobile telecom markets, there is growing evidence in developed countries that mobile services can substitute the fixed services (Vogelsang, 2010). However, the magnitude of substitution can vary from minor to moderate in different markets at different scales in developing parts of the world.

In market growth and saturated stages, the factors of consumer intentions to switch may differ. In saturated markets, service providers offer differentiated services to retain existing customers rather than give subsidies to acquire new consumers (Lee, Kwak, & Lee, 2015). With market saturation, attracting a wholly new customer is less important from a service provider's point of view (Peter & Lyons, 2017).

Factors related to customer intention to switch are associated with the consistent experience of low services (Peter & Lyons, 2017). The overall performance of service providers like its network efficiency, fault management, customer service management, service quality, and marketing affects overall subscription growth. Higher rate of repeated faults and complaints cause dissatisfaction amongst subscribers. In landline services, the most common complaints are no dial tone, noise/distortion, low signals, frequent internet disconnection, and internet speed below the subscribed service package.

Large organizations have a large workforce of repair and maintenance staff. Differing behaviors of staff with customers also swings subscriber’s opinion about the impression of the service provider and impacts on overall customer services (Srinivasa & Gangadhara, 2012).

2. METHODOLOGY

2.1. Study Area

The study area is located in Karachi City, the largest metropolitan city of Pakistan, and it is among the world's fastest-growing cities. Being a port city, it is the economic hub of the country with exponential population growth. Karachi has been facing intense urbanization accompanied by changing land use patterns. The area chosen for this study is a 3.2 sq.km strip along the Arabian Sea coast in the south of the city comprising blocks 1 to 4 of Clifton and Shireen Jinnah colony areas (Figure-2). This part of the city is a typical mixture of the highly posh area along with the slum areas. There are around 2430 plots consisting of more than 11717 tenancies. Generally, it represents high, middle, and low-income groups, and it has diversified land use and mixed commercial activities. Whereas, western and north-western parts of the study area are socio-economically deprived neighborhoods having adjacency with slums and the *Kimari* oil terminal, where it's residential and commercial characteristics are heavily influenced by its neighborhood. There are contrasting patterns of land use changes from residential to mix and commercial business corporate areas from west to eastward. There are also corporate towers, shopping malls and commercial neighborhood markets, and luxurious apartments and bungalows.

Traditionally in Pakistan and many other countries, the cadastral maps are available in paper format. The use of such a manual record of plot-level spatial information in planning and development activities limits the efficiency of the application. In this case, GIS is a very effective technology to manage plot level details and its associated records in digital maps (Ali & Shakir, 2012). Its analytical toolset processes the data and reveals the patterns, relationships, and anomalies hidden in the form of geographical content (Longley, Goodchild, Maguire, & Rhind, 2005).

Following is the methodological framework adopted for the spatial evaluation of telecom subscriber growth in the study area using GIS.

2.2. Base Map Development

GIS data development and management were performed by using ESRI's ArcGIS 10.5. The geo database files were used to manage GIS feature classes containing geometric features and associated attribute tables of plot parcels, road, streets, landmarks, and subscriber locations. Quick Bird satellite images of 2017 and 2012 acquired from Google Earth were used as backdrop reference for the digitization of land parcel (plot) boundaries. For the Plot address, the Karachi Development Authority (KDA) cadastral maps have been used. The hard copy maps were scanned, and after image enhancement, these maps were geo-referenced to UTM zone 42 North

projection system so that maps and other vector feature classes can be overlaid on the satellite images. For the parcel base map, landmarks and street networks were digitized, and plot addresses were entered in associated polygon features.

Detailed field surveys were conducted using GPS and map prints to collect land use, tenancy count, and landmarks. Besides, land use categories were documented as residential units, residential apartments, corporate/business offices, banks, shops, shopping centers, mosques, educational institutes, health services, vacant plots, and under-construction buildings.

Furthermore, vacant plots of 2012 were marked using 2012 Google Earth images to determine the plot occupancy difference between 2017 & 2012.

2.3. Study Area Fragmentation

The study area was geographically divided into Blocks, Sub-blocks, and Neighborhoods Units (Figure-2). So that spatial patterns and trends may be revealed and analyzed at smaller geographical units where at such a detailed spatial scale, NUs may have the same socio-economic conditions and are served with the same quality of network and staff. The Blocks are Government defined units while Sub block and NUs were demarcated as per the following criteria:

Sub-block should be a geographically continuous patch, and there should not be any major road crossing that divides the area. If so, the segments may have a significant number of buildings/plots and density because any change in land use of few plots may influence its neighborhoods. Further, it should be a homogeneous area with respect to the building structure and its functions (i.e., Residential Apartments/ multi-storied buildings, Bungalows or smaller housing units).

Neighborhood Unit area may be spread over a couple of streets. The idea was to include the adjacent streets being fed by common street-level telecom Distribution points (DPs), which generally have 100-200m coverage. The NU boundaries were demarcated along the common rear wall between plots facing two adjoining streets to include all plots facing a street. In other cases, boundaries were marked along roads or parks. Neighboring apartments were grouped into single NU to separate from bungalows/units. The number of houses and tenancies was not uniform in NUs.

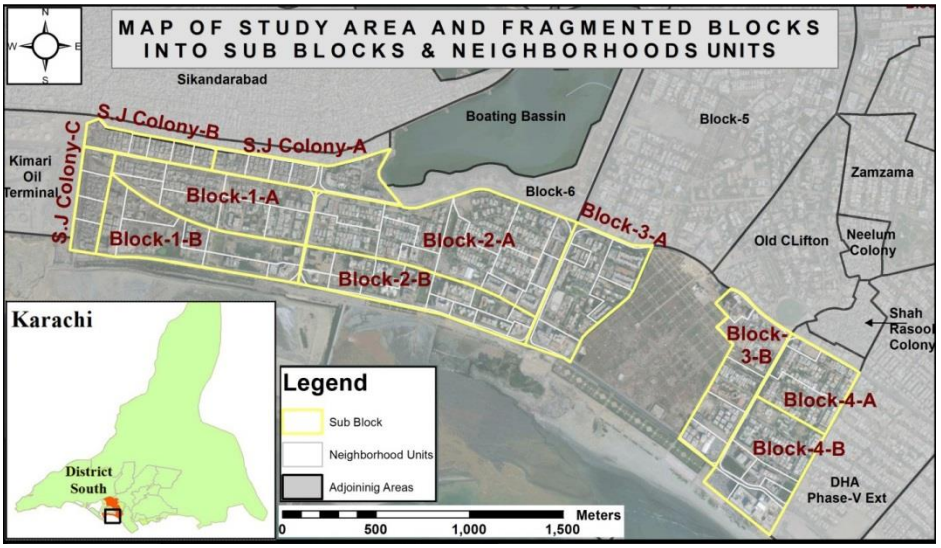

Figure 2: Study Area map and its Fragmentation Backdrop Image Source: Google Earth (2015)

2.4. Subscribers Base

Subscriber records from PTCL for June 2017 have been used, including the new connection demand information, newly installed and service closed connection records, and date of installation.

Available address data tables were unsorted and unformatted. There were severe typographical errors, and the plot/house number, street, sector, block, and area were in a single text string without proper sequence. Therefore, Microsoft Excel was used to rectify these records and categorize them into different fields of plot/house number, street, sector, block, or area. The other attributes included Subscriber Name, Phone Number, Service subscribed, Date of Installation, Subscribed Service, New, and Closed Connections.

Subscribers of 2012 and 2017, new connection application records, and closed connection subscribers were geocoded according to corresponding addresses through GIS mapping techniques. The plotted subscribers were categorized into three broad land use categories (Residential, shops, and Corporate/Business office) using subscriber names, addresses, and surveyed land use of plots and landmarks.

The spatial join was applied to subscriber locations and plots parcels. It is a geo processing operation used in joining attributes of features from the joined layer (*i.e.,* subscriber locations) to features of the target layer (*i.e.,* plot parcels) based on spatial relationship (ESRI, 2016). The attributes of subscriber count, new service connections, and demand were summarized per neighborhood unit and sub-block.

2.5. Subscriber Base Growth (2012-2017)

Service Penetration for June-2017 was computed by dividing the number of service subscribers by the total number of tenancies in a defined area (*i-e,* neighborhood unit, or sub-block or block).

Subscriber churn rate is the number of service subscribers who cease service usage or finally withdraw service subscriptions during a specific period divided by total subscribers count in a defined area. Subscriber churn was calculated where net subscriber change for the 2012-2017 period was negative.

Newly installed and closed connections from June-2014 to December-2016 were summarized on NUs and sub-blocks level. Further average new subscriptions and closed connections per year were also calculated.

3. RESULTS

3.1. Land Use Summary of Study Area

Table-1 shows the block level statistics of tenancies and subscriber density with respect to land use classes and PSTN & DSL service penetration of 2017.

Corporate tenancies, including health and education units, made 6.7% of the study area's total tenancies. The detailed land Use map in Figure-3 shows that spatially the proportion of corporate tenancies increases as we move from east to west (S.J. Colony & block-1 to block-4) where the highest proportion was found in block 4 followed by block-3.

The shops comprised 13.55% of tenancies. The highest ratio of shops was found in sub-block-4B, while a low proportion was recorded in sub-bocks 3A followed by 2A, 4A, and 1B. In Shireen Jinnah colony, the proportion of shops was above average (i.e., 15%) with reference to the overall proportion in the study area (Table-1).

79.9% of tenancies in the study area were residential, where sub-Block-4b has the lowest ratio of residential tenancies, i.e., 44.9%. Whereas Shireen Jinnah Colony, block-1, 2, and 3 had 82% to 85% of residential tenancies (Table-1).

The overall spatial distribution of commercial tenancies of study area reveals in Figure-3 the transformation of existing residential tenancies into hybridized or fully commercial units within the vicinity of residential neighborhoods. The plot occupancy difference identified from 2012 satellite data and survey field details collected from 2017 revealed 50 vacant plots across the study area developed and converted into high-rise buildings, single and double storied units while three plots were still under construction. Overall, 392 new tenancies (229 Residential, 96 corporate/Business offices, and 67 shops) have been added to the study area. Apart from these land use changes in vacant plots of the area, there are routine developments taking place in the study area comprising more

than 2200 already developed plots, which may be due to new and partial construction, bifurcation of existing units, hybridization of land use of existing tenancies and migration of tenants. Although finding these changes at plot and tenancy level over a 5 years period is not part of the scope of this study.

Table 1: *Study Area Land use Share and Service Penetration (2017)*

Zone	Tenancies				Subscribers					
					Land Use Share			Service Share		Total Subscribers
	Residential	Shop	Corporate Offices	Total	Residential	Shops	Corporate	DSL Subscribers	PSTN Subscribers	
S.J Colony	2469	448	69	2986	246	40	110	166	230	396
Block-1	1570	210	82	1862	509	23	115	297	350	647
Block-2	3131	454	228	3813	1614	160	836	809	1802	2611
Block-3	1348	131	143	1622	714	35	617	480	886	1366
Block-4	825	345	264	1434	527	177	1763	588	1879	2467
Total	**9343**	**1588**	**786**	**11717**	**3609**	**436**	**3441**	**2340**	**5147**	**7487**

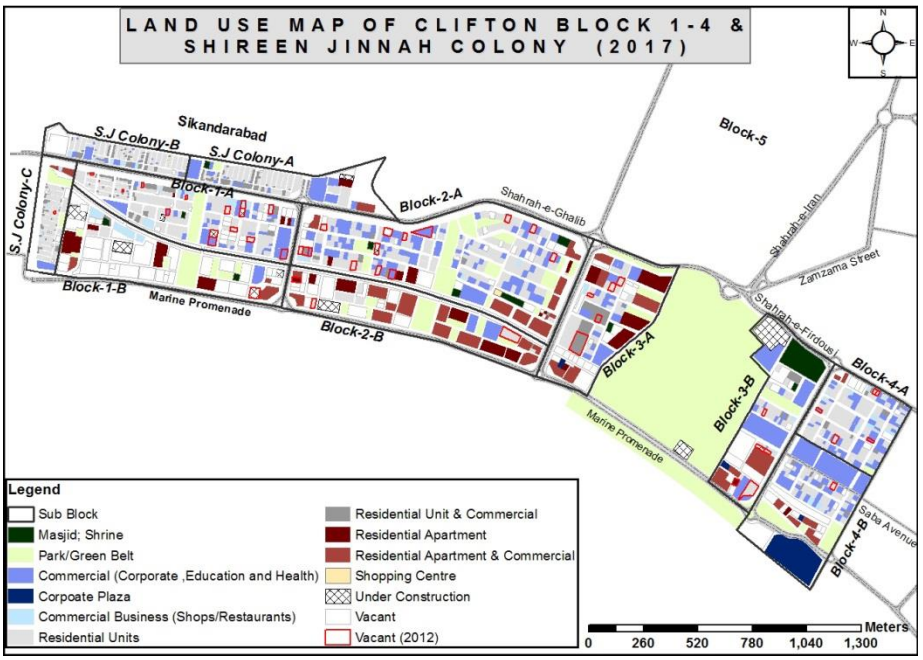

Figure 3: Land Use Map of Study Area

3.2. Landline Services Penetration Trends (June-2017)

Overall the landline service penetration of the study area was 64%, particularly in corporate tenancies, it was more than four connections per tenancy, while in residential and shops categories, it was 36 and 27 connections per 100 tenancies, respectively. Figure-4 depicts the landline subscriber penetration at the neighborhood unit level of the study area.

Where western part appears as the lowest service penetration areas, but there are also low subscriber penetration chunks in eastern posh areas as well.

In PSTN & DSL services, the proportion of service penetration per tenancy varied in different land use classes (Table-1). The PSTN subscription penetration in all study area tenancies was 43.9% with 22 connections per 100 residential tenancies, 19.5% in shops, and 356% service penetration in business offices. In DSL, the overall service penetration was 20% having its breakup in three land use classes as 16.8% in residential, 8% in shops, and 81 connections in 100 business offices.

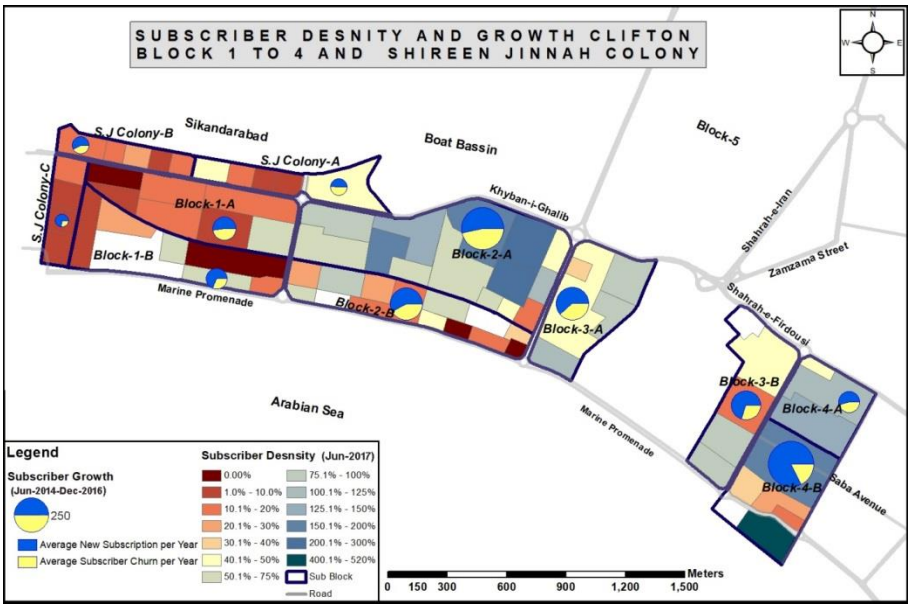

Figure 4: Subscriber Density and Growth

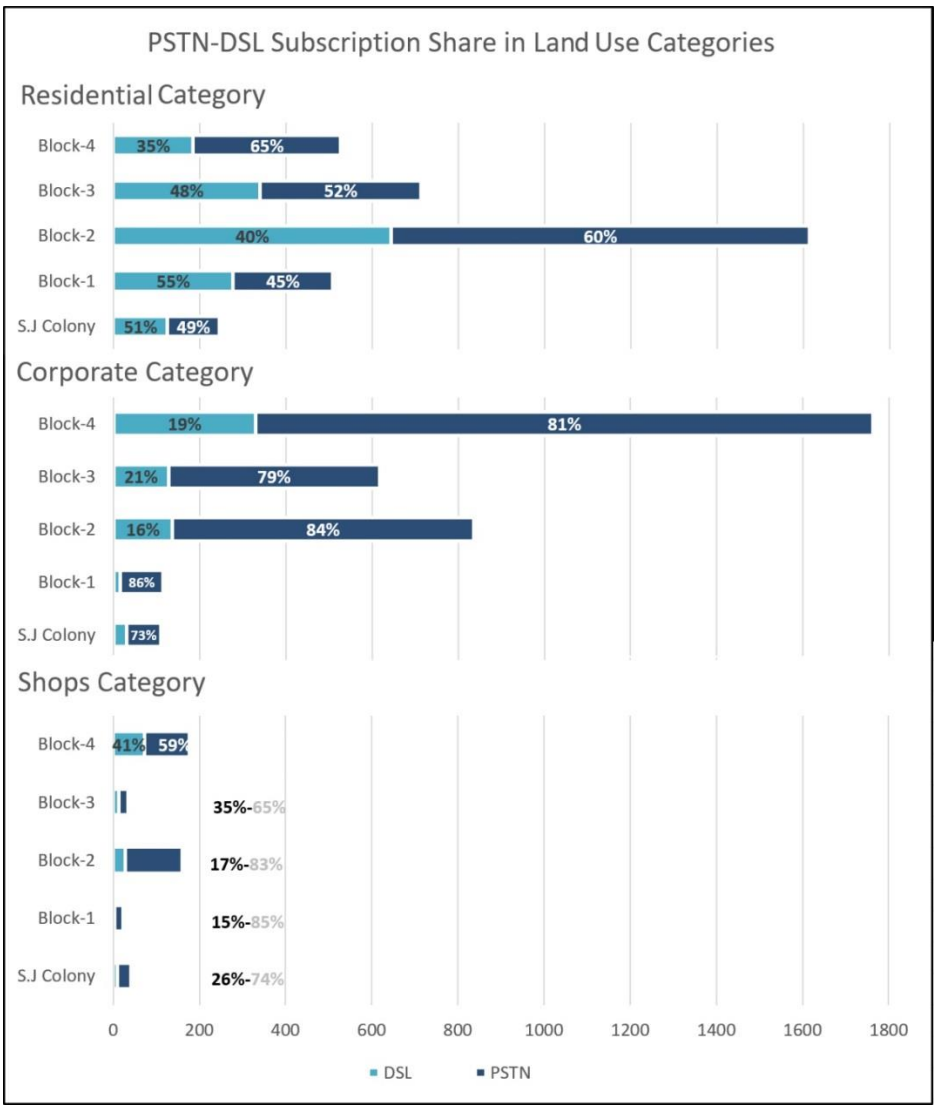

Figure 5: Land Use wise PSTN –DSL Subscription Share (2012-2017)
Source: PTCL

A major part of the study area was residential tenancies (Table-1). Due to the presence of luxurious residential apartments, block-2, 3, and 4 appeared as higher service penetration areas, as depicted in Figure-5. These blocks possessed PSTN and DSL service penetrations of 66% and 27%, respectively. On the other hand, a significant portion of residential tenancies (39%) was in Shireen Jinnah colony and block1, a low socio-economic area where PSTN and DSL service penetration were 12% and

9.5%, respectively (Table-1). Overall higher rates of DSL service penetration were also found in the residential class of subscribers.

In the case of corporate-business tenancies, the PSTN service penetration was higher. The lower rates of DSL service penetration DSL reflect only the count of subscription where a connection may serve many employees in any office but here required broadband service, and its bandwidth is commonly much higher than residential needs.

In the case of shops where the service penetration rates are lowest among other land use classes. Most of the shops in block-4 were owned by brands, or these were in the shopping mall where PSTN and DSL service penetration rate was observed 30% and 21%, respectively. Shireen Jinnah colony and block-1, where the majority (39%) of shops of the study area were situated related to auto workshops and other related accessories, PSTN service penetration was 6.7%, and the DSL service penetration was 2.3% (Table-1).

3.3. Net Subscriber Base Growth (2012-2017)

There has been a significant variation of subscriber churn and new connection trends at sub blocks and NUs level of the study area during the five years. The subscriber base in June-2017 was 7487 compared to 8048 subscribers in Jun-2012, so the net subscriber loss from 2012 to 2017 was 7% concerning the total subscriber base of 2012.

Figure-6 depicts the land use wise subscriber base comparison of 2012 and 2017. The subscriber base growth varied spatially in different land use classes, where residential and shop land use classes witnessed 33% and 7.8% net subscriber loss respectively as compared to the corresponding subscriber base of June 2012, while in contrast, subscription in business/corporate offices grew 51%.

The residential subscriber base has been severely hit due to the churn effect, and in every sub-block of the study area, residential subscriber growth was negative, where it ranged from 20% to 63% of local area subscribers. Likewise, in the case of shops, subscriber growth has been negative, although here, subscriber penetration has also been shallow in most of the study area. Only one sub-block (i.e., 4B) has grown its subscriber base more than three times its 2012 shop subscribers. The rest of the sub-blocks witnessed negative growth in 5 years (Figure-6).

In the business offices category, significant gains have been observed in Block-3, 4, and sub-block-2B. While in Shireen Jinnah Colony, block-1 and sub block2A, where the number of business office subscribers was already low, net growth remained negative or almost unchanged (Figure-6).

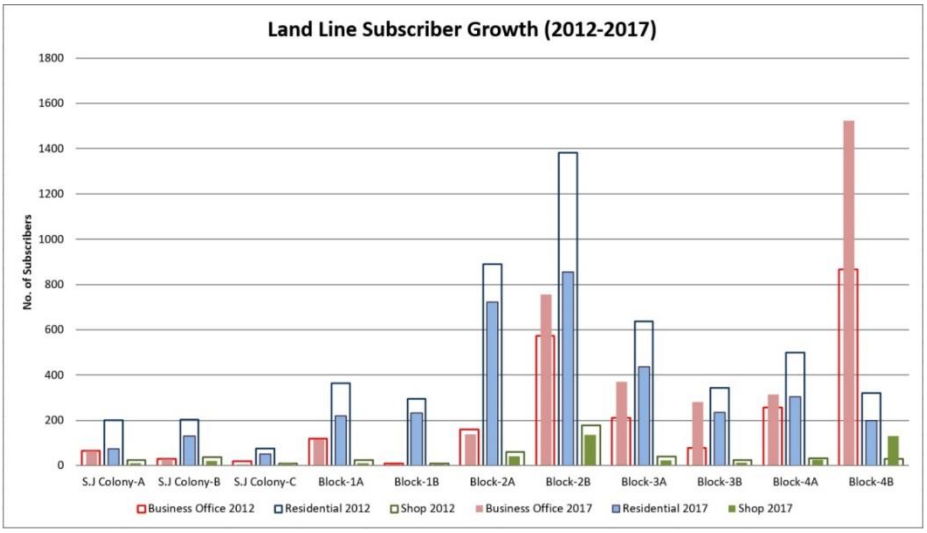

Figure 6 Landline subscriber Base Comparison (2012-2017)

3.4. Average Subscriber Growth per Year (Jun 2014 to Dec-2016)

The average new subscription per year from Jun-2014 to Dec-2016 has been 1158, making 15.7% of the Jun-2012 subscriber base, while the average churn per year was observed 515 (7%).

Figure-7 shows that high rates of average churn per year continue during the last two and half years, and in most sub blocks, its impact was high enough to hamper the average subscription growth per year of the study area. Sub blocks 4B, 3B, and 1B, registered significant positive average growth per year, and these areas retained 70% to 82% of new subscription in a year (Figure-4 and Figure-7).

The churn effect has predominantly affected the average new subscription growth in residential class (Figure-7), where it reduced the positive development of 82% of the average new subscription, and the growing number of subscribers was just 18% of an average new subscription in a year. There was a considerable average new subscription in many areas, but except sub-block-1B and 2A rest of the sub-blocks registered negative or negligible average growth per year. Overall, landline subscription in shop tenancies is low, and also average annual subscriber growth is around 80 connections (66%), whereas new subscription per year is 121. Except for sub-block 4B where shops are brand outlets or situated in the shopping mall, this area added more than 50% of the new subscription and average annual growth in shop subscribers of the study area. There was negligible or no increase in remaining sub-blocks (Figure-7).

In contrast to residential and shop categories, the land line subscription in business subscribers for the last 2 and half years has been significant, where the number of closed subscription was just 13% of new connections installed in a year. Further, 95% of average subscriber growth was observed in block-4, 3, and sub-block-2B, particularly sub-block-4B registered significant new subscription share of the study area. No substantial new subscription and growth were observed in block-1 and Shireen Jinnah colony.

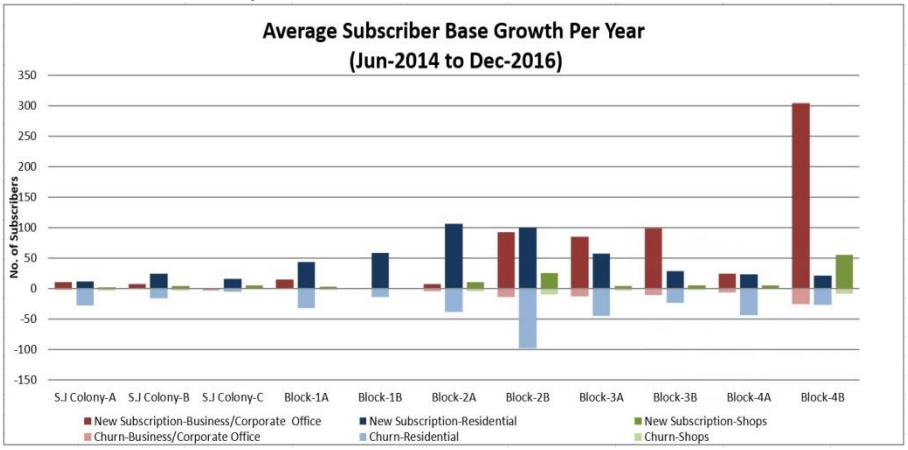

Figure 7: Average Subscriber Base Growth per Year (2014-2016)

4. DISCUSSION

Overall urban land use pattern of the study area reveals a gradual change, where the ratio of business, commercial and mixed land use building increases from western parts to the east (from Shireen Jinnah Colony to Block-4). These land use changes reflect the spatiotemporal impacts of reorganizing the city's urban internal functions and activities (Guanghui.et al, 2017) due to intense urbanization and growth. There exists spatial polarization in the adoption of the wired telecommunication services. The service consumption and adoption in the same land use classes (Residential, shops, and business) spatially varied due to existing socio-economic segregation and inequalities among sub-blocks of the study area. Subscriber growth (new subscription and subscriber churn) is influenced by the service demand, user's affordability, comparable tariff, service availability in the area, and it's quality. Furthermore, the service provider's customer management, marketing, network efficiency, and overall market competition may also influence subscriber satisfaction leading to service consumption and revenue growth.

Spatially there is a general trend of the east to gradual west increase in the proportion of corporate tenancies (S.J. Colony & block-1 to block-4). This trend accompanies existing gradual socio-economic shifts, where the socio-economic characteristics of the area can be evident in each land use class (i-e Residential, shops, and business offices) across the study area. Results show that PSTN and DSL service penetration in specific land use categories (Residential, Shops, and business Offices) also followed these spatial trends in different sub blocks of the study area. The areas with low socio-economic status (*i.e.,* Shireen Jinnah Colony), where commonly due to low income and less education, there is low penetration of ICT services (Driskell & Wang, 2009). Like S.J colony and block-1 had the lowest PSTN and DSL service penetration almost in all land use categories, even business offices situated in these areas had the lowest service penetration rates of respective category. On the other hand, despite low subscriber growth in recent years, there is new connections demand for landline telecommunication services in such deprived areas.

Newly developed residential and commercial projects can change local demography and land use, which directly impacts an area's subscriber growth. Neighborhoods with the significant presence of corporate tenancies registered positive growth with greater margins, where particularly the corporate towers were hotspots for highest service penetration.

Residential tenancies, which comprise a major portion of the study area, the ICT service adoption and consumption of this class directly correlate with the socio-economic status. There exists a very competitive but saturated market situation. This consumer class has been the target of any wired and wireless service operators, particularly cellular companies in voice services and other internet service operators, including local cable internet service providers in the area, which also impacted and the despite churn effect has been dominant across the study area. However, there is also significant new demand in residential class.
In shops, despite the need for communication services in every customer dealing business, the landline service perpetration has been very low, and except shops situated in shopping malls of posh areas, there isn’t such significant growth in this class of tenancies. Possible reasons behind this may be the switching of voice service consumers to mobile services.

As higher mobile phone penetration among society has brought individuals into communication, reach, this also led to an increase in the country's overall teledensity. The increase in service usage and subscriber base leads to earning more revenues. So in a highly competitive market, multiple value-added services were launched, bringing new service packages and

lower tariff offers concerning service usage and budgets to attract different segments of subscriber classes. This increase in national tele density also led to an increase in average PSTN call units per subscriber.

5. CONCLUSION

To explore the untapped geographical content in landline subscriber data and its relation with other business territory's geographical characteristics, the GIS has been a very effective technology, where the location plays a very significant role in the telecom business cycle.

Despite the higher tele-density, especially in urban areas, the landline subscription growth has declined in both the areas of low as well as high socio-economic conditions due to the availability of other cellular and wired telecom services. The business/corporate class has always been at the forefront to adopt the new communication technologies and has still potential for subscription growth. However, particularly in the residential category, there is a switching trend from landline to other services due to market competition and customer service issues. Also, in shops, the reflection of higher tele-density is not evident as far as the landline subscription growth is concerned.

Exploring spatial trends of landline service usage and subscriber growth in different land use classes provided the key insights to evaluate the changing telecom service usage and choice of different classes of subscribers in the study area. This helps to understand the spatial aspects of landline consumers' behavior from diverse socio-economic backgrounds against the impacts of ICT evolution in developing countries' rapidly growing cities. This may also help telecom service providers in highly competitive markets set priorities and focus on localized network management and service improvement in targeted areas to raise consumer satisfaction. Besides, it will lead to redefine business and marketing strategies keeping the geographical aspects for better management, and to achieve business growth.

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