Digital Divide in Riyadh Neighborhoods: A Spatial Analysis

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Abstract

The objective of this paper is to use Geographical Information Systems for identifying Digital Divide in Riyadh Neighborhoods, Saudi Arabia. Geo-database was created that includes Streets, Neighborhoods, ICT Access Data and Coverage Map for Riyadh. We used QGIS and overlay for analysis, intersection selected as tool for this paper. The results indicate that after analyzing the use of information communication technology in all regions of the Kingdom it turns that Riyadh, Ash Sharqiyyah and Makkah in average with percentage 50%, While Al Jawf, Al Madinah, and Najran are the least with percentage 42%. Then we focused on Riyadh to analyze the digital divide because it is the capital of Saudi Arabia and occupations the highest percent of communications towers in the KSA due to population density. Regarding coverage of the 4G, the neighborhoods at the center have recorded very high coverage score. While neighborhoods at the edges of the city have low values of coverage score. Same for 3G, it is more intense in the center and the coverage percentage is higher than 4G. For 2G we found it had the highest coverage compared to 3G or 4G

Keywords:

Geographical Information System, QGIS, Digital divide, GIS, Spatial analysis.

1. Introduction

Continuous development of technology led to the increase of using smart devices. For keeping up with this development Users need to obtain high telecommunication services from Telecom companies. One of the most important Telecom companies in Saudi Arabia is telecommunication provider xyz. Provider xyz can cover user's demands and provide services through telecom towers, which contains send and receive stations to build user communication channels [1].

Telecom Company interested in choosing the right area to establish a vast number of telecom towers and distributed them in different areas. The telecom towers and dependent on some criteria like city area, urban areas, and Population density and number companies, universities [2]. To continuous keeping, customer loyalty must offer high coverage and stable signal strength. The rapid development of technology maybe occurs the digital divide. It means a gap between who have use or access to digital technologies and who not have use or access its. addition, the global divide is the variation of access to the Internet between societies. The digital gap negatively affects people [3][4].

According to statistics published by the Saudi general authority for statistics in 2018, The percentage of households who can access to the internet is 86.8% [5]. These statistics led to research on the availability and distribution of telecom towers in Saudi Arabia, especially focusing on the Riyadh area to study the digital divide on the level of Riyadh neighborhoods. In this paper, we propose a Geographical Information Systems based approach(GIS) for identifying digital divide using xyz mobile network in Riyadh city and its' neighborhoods.

The spatial variation of the distribution of telecom towers in the city of Riyadh effect of the efficiency of the services provided by xyz and may cause the occurrence digital divide between its neighborhoods.

2. Related Work

The emergence of wireless communication has caused major change in our lives as the world is growing and evolving in the use of technology. When the use of the information technologies escalated, researchers started to focus on the meaning of "digital divide", which is unequal access to and use of the information technologies. Hence, the goal of all previous studies was to try to find out the distribution patterns of towers and serve them appropriately in populated areas to decrease the digital divide. Some of the literature outside Saudi Arabia includes:

1- A study in Istanbul, Turkey [7] looked at the spatial distribution of digital divide. Their goal was to analyze 10

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areas of Istanbul with a focus on socio-economic to comprehend diversity between the digital divide categories. Also using Geographic Information Systems to map the spatial distribution to know the gap between the families and their children to learn technology. The data was formed by applying a detailed questionnaire (with 48 items) to 1140 individuals with different geographic locations and various socio-economic levels. The methodology consisted of using the K–means clustering algorithm to analyze the questionnaire. The result from this research generated three different clusters that determined the state of digital literacy which are digital literates, digital immigrants and digital illiterates. Also ArcGIS was used for spatial distribution of digital divide clusters. They generated three maps for each category to indicate the number of individuals attached to each class. According to these maps, it is observed that the majority of the "digital literate" groups are spatially located along waterfront regions of the city where higher education and income levels are observed. Also, the "illiterates", in general, spatially located in outer regions of the city where lower education and income [7].

2- In Mosul City Iraq [9], the research examined spatial distribution of the towers of Internet networks for nine companies. At first they studied distribution location of towers in the city and referred to the conditions and standards that require the construction of Internet towers, the most important of which is the distance between each tower. In addition, they indicated the proportion of the population with the number of towers in the districts, which the larger the population will increase the number of towers. They [9] evaluated the construction of the towers of the internet networks to detect the efficiency of the spatial distribution of the towers of the Internet networks and determine the amount of space served according to the spheres of spatial coverage of the towers. For the purpose of identifying the strengths and weaknesses of the Internet communications service system. A 2 kilometers buffer for each tower was used. The Internet company (Words) has emerged as the most efficient for its ability to provide 65% services to the city [9]. To asses the overlap between towers, [9] used union overlay analysis. It has emerged that towers 6 and 7 have high communication coverage areas but have a problem with the interference of wireless transmission frequencies of each company which affects the quality of Internet service [9] in the area.

3- In Riyadh city, research of [8] studied the effect of Radio Frequencies emitted from communications towers, which can be absorbed by human tissues and might cause serious diseases. They [8] propose a GIS based approach that utilizes users and mobile towers locations to detect the exposure area of (RF). Different buffers were created to calculate radiation at different distances. Buffer data used to establish a mapping of the density of radiation around each mobile tower.

3. Methodology

The objective of our project is to use Geographical Information Systems (GIS) for identifying digital divide using xyz mobile network in Riyadh city and its' neighborhoods, Saudi Arabia. An Excel file was created that includes the location of xyz towers, xyz communication distribution and road networks. Also include many attributes that help to analyze study in best way like communication network and internet users percentage, devices type that used and difficulties faced of individuals when deals with the service provided by service provider xyz.

3.1 Study Area

This research focused only on Riyadh Neighborhoods for a couple of reasons. Statistical results issued by the General authority for Statistics in the Kingdom of Saudi Arabia for the year 2018, indicated a high utilization rate of use communications networks in Riyadh. In addition, Riyadh is the capital of Saudi Arabia and occupies the highest percent of communications towers in KSA due to population density and urban sprawl. The Communication and Information Technology Commission (CITC) data used in this research was limited to Riyadh city.

3.2 Tool used

QGIS is an open source geographic information system (GIS). It contains many functions and allow users to analyze and add spatial information. QGIS supports raster and vector data [6]. Plugins created in Python language extends QGIS's capabilities [6]. QGIS is maintained by volunteer developers and different companies offer support and development features. QGIS is used in this research.

3.3 Dataset

We have obtained 3 datasets in shapefile format showing the areas that covered by 4G, 3G, and 2G Networks Where the signal is best. It should be noted that the collected data was converted from raster to polygon by data provider. This is clear from the mini-polygons taking the shape of pixels as shown in the figure below. So, data contains large number of isolated square polygons (original pixels) with very small areas. These polygons make the dataset very heavy and storing unnecessary features. So, deleting such polygons will assist in cleaning the data, making the datasets lighter, and not affecting the analysis

results. This is a necessary preprocessing step before going ahead to the analysis. The data used is explained in table 1.

Field	Description
TV	Percentage distribution of households who have *TV access*
RADIO	Percentage distribution of households who have *Radio access*
FIXED_PHONE	Percentage distribution of households who have *Fixed Phone access*
SMART_PHONE	Percentage distribution of households who have *Smart Phone access*
NON_SMART_PHONE	Percentage distribution of households who have *No smartphone access*
DESKTOP_COMPUTER	Percentage distribution of households who have *Desktop computer access*
LAPTOP	Percentage distribution of households who have *Laptop access*
TABLET	Percentage distribution of households who have *Tablet access*
INTERNET_ACCESS	Percentage distribution of households who have *Internet access*
SUBSCRIPTION DWELLING	Percentage distribution of households who have *Internet subscription* in dwelling
LACK_SKILLS	Lack of knowledge or skills to use internet
PRIVACY	Privacy or security concerns
COSTY_EQUPMENT	High cost of equipment
INTERNET_NOT_NEEDED	No need for internet in the dwelling (unhelpful, uninteresting or it lacks local content)
COSTY_SERVICES	High cost of services
SOCIAL_CULTURE	social or cultural reasons
LACK_INTERNET	Lack of Internet in the region
DSL	Percentage distribution of households using DSL in accessing Internet
ROUTER	Percentage distribution of households using Router in accessing Internet
MOBILE_PHONE_PACKAGES	Percentage distribution of households using Mobile Phone Packages in accessing Internet
OPTICAL_FIBER	Percentage distribution of households using Optical Fiber in accessing Internet
THRESHOLD	The threshold value which marks the best signal for 2G,3G and 4G
SIGNAL	Type of the signal (Indoor, or Outdoor)
POPULATION	Population in each Neighborhood
NEIGHBORH	Neighborhood name

Table 1: Dataset Collected

In addition to Datasets of Coverage Areas (figure 7), we have obtained Shapefile of neighborhoods of Riyadh City. We will use overlay analysis to identify the gap in coverage for each neighborhood.

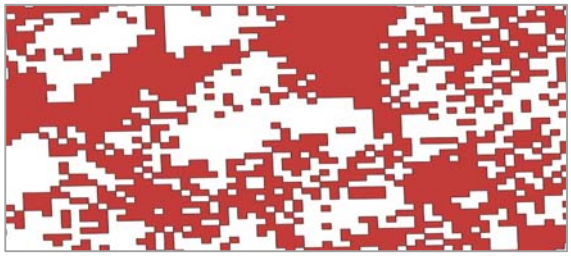

Figure 7: Coverage polygons provided by data provider for 4G Network

3.4 Functions Performed

1. Some datasets were provided in ***WGS84*** Coordinate System, to unify the coordinate system, we projected the datasets into ***Ain El Abd/ UTM Zone 38 N*** coordinate system.
2. Delete all isolated mini-polygons as explained earlier.
3. After the previous two steps, to ensure that the dataset has valid geometries**, *Fix Geometry Tool*** has been utilized to validate geometries.
4. Performing the overlay analysis using ***Intersection tool*** to find the parts of each neighborhood which intersect with coverage maps for 4G, 3G, and 2G networks.

Below is a screen shot of the intersection tool and the parameters used for 4G Coverage

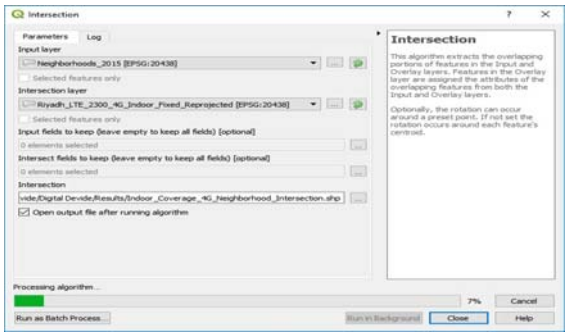

Figure 8: Intersection Tool

5. Calculate the area covered in each neighborhood and its percentage from the overall area of the neighborhood. We added a new field to the Neighborhood dataset to store the calculated values. We will refer to this percentage as ***Coverage Percent.*** It should be noted that the intersection tool will result in many coverage polygons in each neighborhood. So, we need to sum the areas of those polygons for each neighborhood. to accomplish this, we installed ***GroupStats Plugin***. This plugin helps in grouping and summarizing data.
6. Create a map showing which neighborhoods are most covered and which are the least. Use the values of ***Coverage Percent*** to color each neighborhood. This map will give indication where the digital divide may be concentrated. This map will be useful for decision makers.
7. Compare the coverage maps to population maps.

Table 2 list the tools used for each analysis step.

Steps	**Tools used**
Project the datasets	Reproject Layer Tool
Split the datasets	Select by Expression Tool
	Export Tool
Delete all isolated min-polygons	Select by Expression
	Delete Command

Overlay Analysis	Intersection Tool
Calculate Coverage Percentage	GroupStats Plugin
Colored Coverage Map	Layer Symbology

Table 2: Analysis performed

4. Data Analysis

4.1 Mapping the ICT ACCESS Data on the level of regions

This part of the analysis aims at mapping the ICT ACCESS data for each region. The ultimate purpose of such mapping is inspecting if there are any patterns in the data. For example, Does the regions with a high percentage of households who have an access to smart phones tend to be clustered or dispersed? Are there any hot spots or cold spots on the level of the regions?

The following figures show the maps for each technology. We have statistics for Percentage of households who have access to 10 technologies for each Region in Saudi Arabia as follows: TV ,Radio ,Fixed Phone ,Smart Phone ,Non-Smart Phone ,Desktop Computer ,Laptop Computer ,Tablet ,Internet and Internet Subscription in Dwelling. Finally, a map averaging the values from all ICT Technologies is presented in the end of this section.

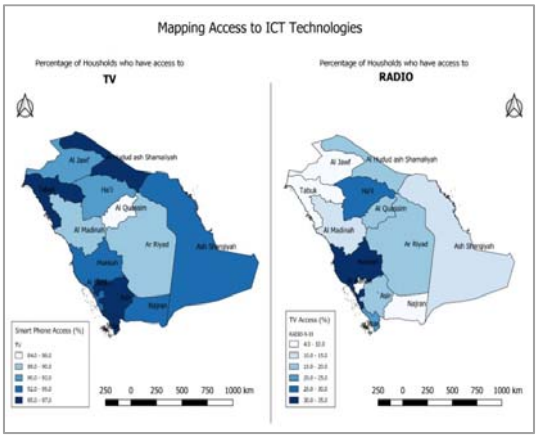

Figure 1: Percentage of Households Who have access to TV and

Figure 1 shows that Asir, Al Bahah, Tabuk, and Al Hudud Ash Shamaliyah are at the top in using and access TV with percentage more than 95%, While Al Qassim is the least one. With respect to Radio, Makkah comes at the top with percentage more than 30%, while regions of Al Jawf, Tabuk, Najran, and Al-Bahah are the least in using Radio with percentage less than 10%. In total, TV is still most used if compared with Radio.

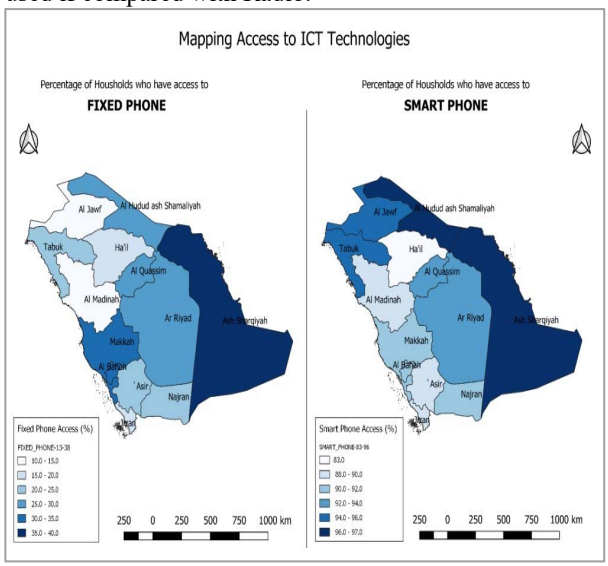

Figure 2:Percentage of Households Who have access to Fixed Line Phone and Smart Phones

Figure 2 shows that Ash Sharqiyah, is at the top in using and access Fixed Line Phone with percentage approximately 40%, While Al Jawf, Al MAdinah are the least with percentages less than 15%. With respect to Smart Phone, Ash Sharqiyyah and Al Hudud Ash Shamaliyah come at the top with percentage more than 96%, while Ha'il region is the least in using Smart Phone with percentage around 83%. In total, Smart Phone dominates the Fixed Line Phones.

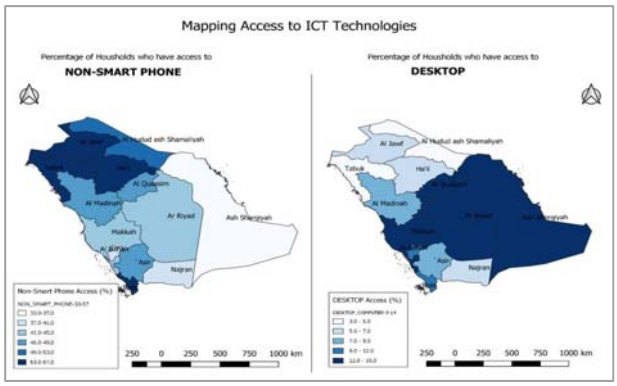

Figure 3:Percentage of Households Who have access to Non-Smart Phone and Desktop

Figure 3 shows that Al Jawf, Ha'il, and Tabuk, are at the top in using and access NonSmart Phone with percentage

approximately 55%, While Al Ash Sharqiyyah is the least with percentage around 35%. With respect to Desktop Computer, Ash Sharqiyyah and Al Riyadh, Makkah come at the top with percentage around 15%, while Tabuk and Al Hudud Ash Shamaliyah regions are the least in using Desktop Computer less than 5%. In total, Desktop Computer has very low access percentage. As you will see in the next page, Laptops and tablets dominate the desktops.

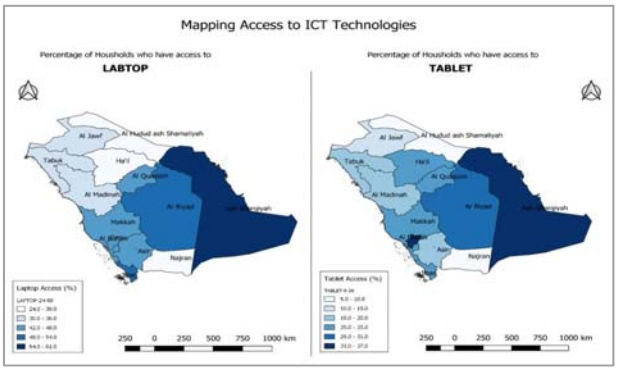

Figure 4:Percentage of Households Who have access to Laptop and Tablet

Figure 4 shows that Ash Sharqiyyah, is at the top in using and access laptops with percentage approximately 60%, While Al Hudud Ash Shamaliyah, Ha'il, and Najran are the least with percentage around 30%. With respect to Tablets, Ash Sharqiyyah is till at the top with percentage around 35%, while Al Hudud Ash Shamaliyah and Najran regions are the least in using Tablets with percentage less than 10%. The maps show the similarity in the relative variation for both tablets and laptops. Both technologies are similar.

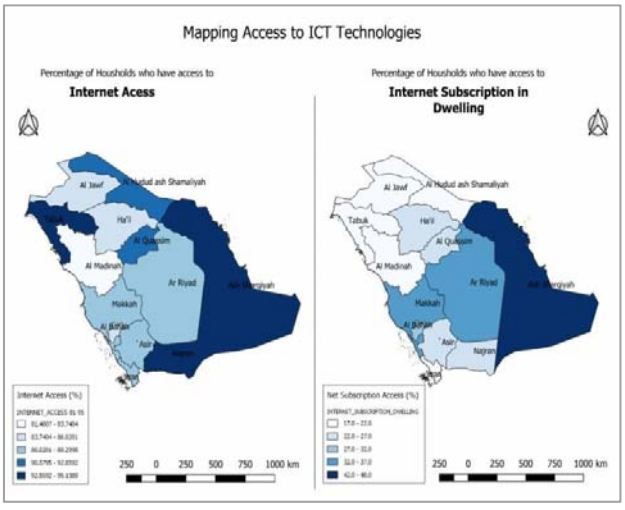

Figure 5: Percentage of Households Who have access to Internet and Internet Subscription in a dwelling

Figure 5 shows that Ash Sharqiyyah and Tabuk, are at the top in using and access Internet with percentage approximately 95%, While Al Madinah is the least with percentage around 81%. With respect to Internet Subscription in a dwelling, Ash Sharqiyyah is still at the top with percentage around 45%, while Al Hudud Ash Shamaliyah, Tabuk, Al Jawf, and Al Madinah are the least with percentage around 20%.

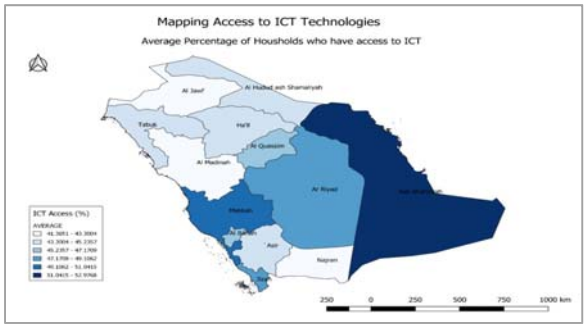

Figure 6: Average Percentage of Households Who Have Access to ICT Technologies

Figure 6 shows that Ash Sharqiyyah, Makkah, and Riyadh are at the top in using and access ICT technologies in average with percentage around 50%, While Al Jawf, Al Madinah, and Najran are the least with percentage around 42%.

4.2 Mapping the gaps in coverage for Riyadh City

From the result of a previous analysis (section 4.1), the regions of Riyadh, Makkah, and Sharqiyyah are among the top regions in accessing the ICT technologies. Riyadh is the capital of Saudi Arabia, Makkah is the holiest place for Muslims where it attracts millions of Muslims each year, and Sharqiyyah is the most important areas in which economic activities applied. So, these regions have a special attention from decision makers. So, ICT Access is expected to be high in such regions. We agreed to develop a deep analysis in Riyadh City, due the Riyadh is the capital of Saudi Arabia and occupations the highest percent of communications towers in the KSA due to population density and urban sprawl.

The main analysis outputs are maps showing the percentage of each neighborhood area covered by strong signals of mobile networks. The maps with darker colors are more covered than those with light colors.

Gap Analysis in 4G Coverage

The following maps shows how much each neighborhood is covered by strong signals of 4G network in Riyadh City.

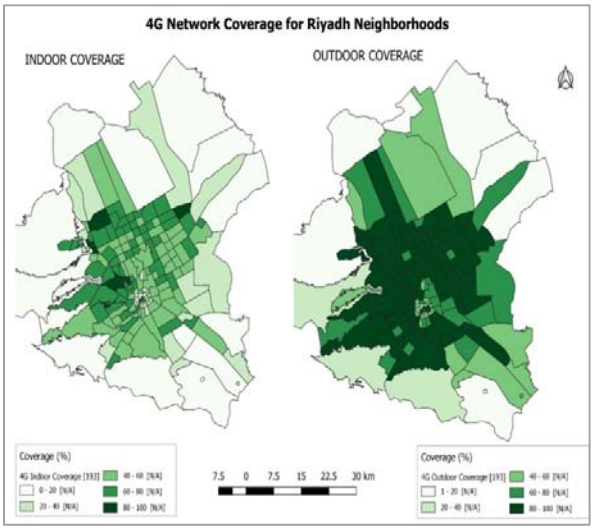

Figure 9: Coverage Percentage for Riyadh

Inspecting indoor and outdoor coverage maps in Figure 9, It is clear that the neighborhoods at the center has recorded very high coverage score. While neighborhood at the edges of the city has low values of coverage score. This may be attributed into the high population concentration at the center and vital institutions as well as the following map shows as shown in Figure 10.

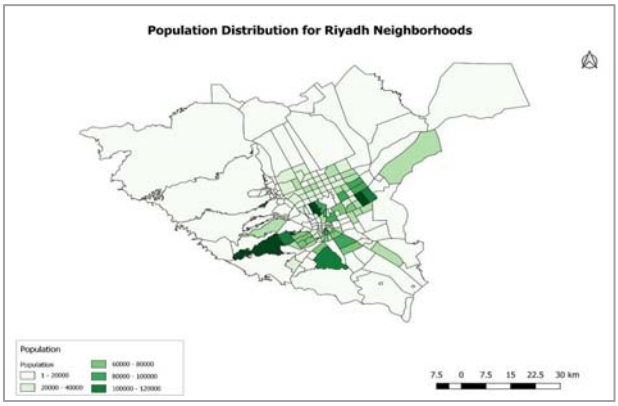

Figure 10: Population Concentration

Gap Analysis in 3G Coverage

The following maps show the coverage percentage of 3G Network for each neighborhood. If they are compared with 4G Network coverage, we will find that coverage percentage is higher than 4G. This may be because the 4G Network is newer and require more resources.

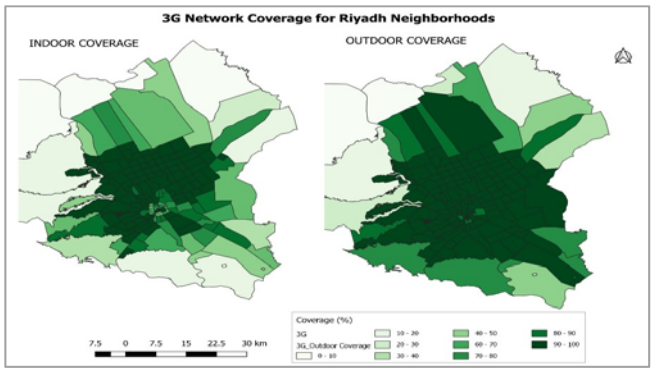

Figure 11: 3G Coverage

Gap Analysis in 2G Coverage

The following maps show the coverage percentage of 2G Network for each neighborhood. If they are compared with 4G Network coverage, we will find that coverage percentage is higher than 4G and 3G. This may be because the 2G Network is older.

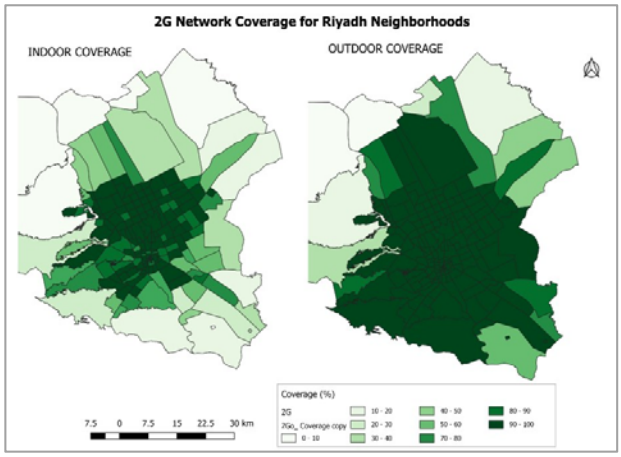

Figure 12: 2G Coverage

All Networks (2G, 3G, 4G)

The following maps average the coverage percentages from the three types of the networks (2G, 3G, 4G).

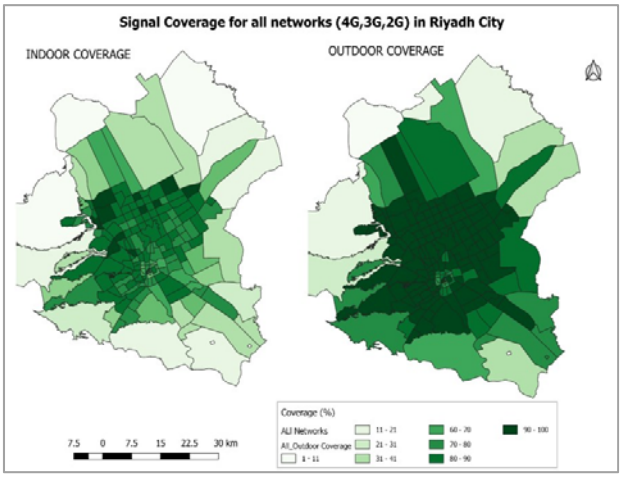

Figure 13:Coverage Map for all networks

5. Conclusion

Unfortunately, we couldn't obtain all the necessary the data to compute the digital divide index. So, our analysis plan aimed to map the available data to get indication where the digital divide may concentrate. According to the data collected, we performed two types of analysis:

1. Mapping ICT Access data on the level regions. The main results of such analysis revealed that the regions of Sharqiyyah, Riyadh, and Makkah are among the top regions in accessing the ICT technologies, Sharqiyyah is the most important areas in which economic activities applied, Riyadh is the capital of Saudi Arabia, and Makkah is the holiest place for Muslims where it attracts millions of Muslims each year. So, these regions have a special attention from decision makers. So, ICT Access is expected to be high in such regions.
2. Riyadh is the capital of Saudi Arabia and occupations the highest percent of communications towers in the KSA due to population density and urban sprawl. The second analysis was to identify which neighborhoods of Riyadh City are most covered and which are least covered by Mobile Networks (2G, 3G, and 4G). It was shown that the central neighborhoods are most covered and the edge ones are least covered. It is also shown that the 2G and 3G have higher coverage than 4G network.

The obstacles and limitations that we faced which are:

- Data privacy: It was difficult to access the telecommunication data. Consequently, researchers cannot easily access and collect telecommunication data because many organizations are not comfortable to share their data due to the privacy of data. Even if can get data, it is required to apply data security protocols to ensure the privacy is not violated. Ultimately, the telecommunication organizations must support researches in order to get new helpful solutions.
- Data quality: Indeed the success of study analysis relies on the data itself which must be correct, valid, reliable, recent and understandable for use by researchers. The time and effort were highly consumed in order to understand and clean data to serve our study.

we recommend expanding the tower coverage in Riyadh City in order to get more benefits and cover the digital divide in the city. Moreover, achieving the vision of Saudi Arabia 2030 in order to get up in the economic and educational indexes and compete with other countries.

It was shown that the central neighborhoods are mostly covered and the edge ones are least covered. It is also shown that 2G and 3G have the highest coverage. At the end, we hope that our study is helpful for other researchers in order to develop and achieve the kingdom visions.

Acknowledgments

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