ISSN(E):2522-2260
ISSN(P):2522-2252

Indexing/Abstracting

Published by

Department of Quantitative Methods

School of Business and Economics

University of Management and Technology, Lahore, Pakistan

JQM Journal of Quantitative Methods

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Author(s)
Iqra Paras[1]
Ghulam Mohey-ud-din[2]
Faisal Fareed[3]

Affiliations
[1]Research Associate (Economics), Urban Sector Planning & Management Services Unit, Lahore, Pakistan.
[2]Senior Specialist / Urban Economist, Urban Sector Planning & Management Services Unit, Lahore, Pakistan.
Email: dr.moheyuddin@gmail.com
[3]Provincial Civil Services Officer, Government of Punjab, Pakistan.

Manuscript Information

Citation in APA Style

Paras, I., Mohey-ud-din, G. & Fareed, F. (2018). Infrastructure Development in Punjab, Pakistan: From Assessment to Spatiotemporal Analysis at District Level. *Journal of Quantitative Methods 2*(2), 75-103.

This manuscript contains references to 28 other manuscripts.

The online version of this manuscript can be found at https://journals.umt.edu.pk/sbe/jqm/volume2issue2.aspx#

DOI: https://doi.org/10.29145/2018/jqm/020206

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Infrastructure Development in Punjab, Pakistan: From Assessment to Spatiotemporal Analysis at District Level

Iqra Paras[1]
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Abstract

Access to inclusive and sustainable infrastructure to the masses of each spatial unit of any country and region is of the paramount importance. This paper aims at examining the level of infrastructure development, analysis of spatial disparities in infrastructure and temporal comparison of infrastructure development across the districts in Punjab, Pakistan. For this purpose, the current study uses a wide range of indicators to depict the real picture of infrastructure development in Punjab and to analyze the spatiotemporal dynamics. The overall infrastructure development has been divided into three sub-dimensions; public-utilities infrastructure, communication infrastructure and social infrastructure. All the data has been taken from Multiple Indicators Cluster Survey (MICS) Punjab, Census of Healthcare Establishments in Punjab, and Punjab Development Statistics

[1] Research Associate (Economics), Urban Sector Planning & Management Services Unit, Lahore, Pakistan.
[2] Senior Specialist / Urban Economist, Urban Sector Planning & Management Services Unit, Lahore, Pakistan.
Email: dr.moheyuddin@gmail.com
[3] Provincial Civil Services Officer, Government of Punjab, Pakistan.

Authors' Acknowledgement: Authors are thankful to anonymous referees and editor(s) of JQM for their valuable comments and feedback on the submitted draft of the paper. An earlier version of the paper was submitted as the Urban Unit Working Paper. Authors are also thankful to Dr. Kaiser Bengali, Senior Economist (Consultant to Urban Unit), for his worthwhile comments and suggestions on the working draft. Last but not least, authors are highly grateful to Dr. Nasir Javed (CEO, Urban Unit), for his valuable feedback on working draft and for overall support and patronage of this research work.

Authors' Disclaimer: The opinions and conclusions expressed in this working paper are solely the views of the author(s) and do not necessarily reflect those of the Urban Unit and/or Government of the Punjab.

(PDS). For the temporal assessment, the two different time periods of 2011 and 2014 have also been compared. The Analytical Hierarchical Process (AHP) technique has been used to assign the weights to indicators in sub-dimensions and to each sub-dimension in composite index. Geographic Information System (GIS) tools have also been applied for spatial mapping and representation of analysis results. The study finds that the Southern and South-Western districts of Punjab are the most deprived districts in all dimensions of infrastructure studied in this study. Whereas, the districts of North and North-Eastern Punjab are the best districts in almost all dimensions of infrastructure development. The temporal analysis reveals that the level of infrastructure development depreciated in most of the districts as it could not be developed as per the increase in population. These findings emphasize the need for prioritizing the public investment on infrastructure in the deprived districts on Southern and South-Western border of Punjab to remove the disparities.

Keywords: Infrastructure Development, Infrastructure Development Index, Spatial Mapping, Spatial Ranking, Temporal Analysis, Punjab – Pakistan

JEL Classification: C21, C23, H54, O18, P25

1. Introduction

Infrastructure can be defined as the basic facilities and services which facilitate different economic activities and thereby help in economic development of a country. For instance, provision of education, health, transport, communication, power, science and technology facilities etc. are the examples of infrastructure. Infrastructure is considered as the foundation for economic growth and productivity. Business and commerce depend on roadways, waterways, pipelines, electricity lines, and broadband connections to transport goods, provide accessibility, provide services, communicate, and efficient functioning of the economy (U.S. Chamber of Commerce, 2010).

Mostly, the developed countries of the world are having best infrastructure facilities exhibiting some positive correlation between infrastructure and development. Pakistan's rank in terms of economic development and infrastructure development is very low. According

to the 'Global Competitiveness Report 2017-18', Pakistan is at 110th position in global ranking and slightly improved from last year's report when it was 116th. However, it is still far below than most of the developing countries, even in South Asia (Schwab 2018). O'Neill, Wilson, Purushothaman and Stupnytska (2007) has listed Pakistan in 'The Next Eleven' and has pointed out that Pakistan is a developing country having a high potential of economic growth as it is the second largest economy of South Asia. Punjab, the largest province in terms of population, contributes a lion share in national GDP. Punjab encompasses 110 million population (Population Census 2017). As per 2014-15 estimates, Punjab contributes almost 54% of total GDP (IPP, 2012). The growing economy of Punjab needs to enhance the capacity of all these sectors for present and future generation. The divergent expansion of province requires the public infrastructure expansion along with the equitable provision of public utilities, in all districts of Punjab. The growth of major cities and urban centers, on one side, is putting pressure on infrastructure as all big cities of Punjab are facing a huge burden on infrastructure due to massive urban sprawl. On the other side, many districts of Punjab already are facing regional disparities because of inequalities in development budget allocation. In addition, the limited resources, and growing population of Punjab along with the high migration trend towards major urban centers are also creating emerging issue of scarcity of infrastructure availability and public service accessibility to the citizens. Resultantly, many districts of Punjab are being deprived from basic infrastructure necessities.

This study intends to examine the spatial pattern of infrastructure development across the districts of Punjab. The study also aims at exploring the spatial ranking of districts on basis of infrastructure development along with a temporal comparison over a period (2011 vs 2014). Government of Punjab allocates huge amount of resources for infrastructure development every year. The pattern of allocation for infrastructure development shows a huge upsurge in the annual allocation of infrastructure development in Punjab as it has been increased from Rs. 68,313 million in 2014 to Rs. 112,960 million in 2015 (Government of Punjab, 2013). Similarly, the noticeable resources of Rs. 126,106 million in 2016 and Rs. 117,200 million in 2017 have been allocated for infrastructure development (Government of Punjab, 2016). Although in 2017, the allocation has been reduced

than the previous year 2016 but still 29% of the total budget of Punjab has been allocated to Infrastructure development in 2017 (Government of Punjab, 2016). Another major objective of this paper is to analyze the efficacy of the budget expenditure on infrastructure development in Punjab whether these expenditures are resulting in infrastructure development over time (2011 -2014) or not and whether these are helping in reducing inter-district disparities in infrastructure development or not. The study is significant not only because of exploring the spatial ranking and mapping of existing infrastructure development but also help in identifying the gaps where the government must intervene to eliminate these disparities among districts.

The organization of the paper is as follows. The next section reviews the literature. Section three discusses the data and methodology. Key findings and results are presented in the section 4, whereas, the last section (five) concludes the study and proposes the policy recommendations.

2. Literature Review and Conceptual Framework

2.1. A Review of Selected Literature

There is no such a unanimous index for measuring the level of infrastructure development in the literature. Different studies have used different type of indicators to examine the infrastructure development among the regions. For instance, Naidu (2008) conducted a study on Infrastructure Development in Malaysia and constructed a six-dimensional index comprising of roads, telecommunication, electricity and water sector to compare the growth performance of infrastructure sector over a period of 1965 and 2005. The findings depicted that the performance of water resources and electricity remained highly uneconomical due to the wastage and theft of water and electricity. The study also concluded that the users must pay the full social cost to cover all negative externalities and to reduce the inefficacy of road transport. Oswald, McNeil and Trimbath (2011) constructed a national infrastructure development index for USA over a period of 1990-2008 to examine the transport sector. Using Analytical Hierarchy Process (AHP) method, the performance of infrastructure across nation has been assessed. The results of transportation index revealed a worse situation during last decade despite some huge allocations in this area.

African Development Bank (2016) constructed an infrastructure development index (IDI) for Africa comprising of three dimensions; ICT, transportation and power. Their results revealed that the ICT has a progressive impact to improve the ranking of countries, while power sector and water & sanitation have not showed any noteworthy impact on the ranking. Power sector improvement should be needed to upgrade the ranking of IDI in African countries. Dadashpoor Roshtami and Alizadeh (2016) undertook an analysis of the spatial inequalities in urban facilities for 15 urban facilities using spatial mapping. The study found that the public utilities deprivation among the population of different region resulted in increase of disparities, especially, among the poor cities.

Donaubauer,Meyer and Nunnenkamp (2014) have worked on the global index of infrastructure and ranked 165 countries for years 1990, 2000 and 2010. The study utilized four sub-indices for constructing IDI including transport (road, road network, registered car and vehicles etc.), ICT (Personal computer, telephone line, mobile etc.) and energy. The overall ranking showed a persistent result over time. UN-HABITAT (1998) constructed a City Development Index (CDI) which comprised of the five dimensions; infrastructure, solid waste, health, education and city product. The study was conducted for Africa, Arab state, Asia, HIV, LAC and transition countries. Result revealed that Africa is less developed in terms of physical infrastructure whereas waste disposal problem was found as a major issue in most of the developing countries. Dutta, Geiger and Lanvin (2015) constructed a network readiness index using infrastructure of electricity, mobile & internet for 143 countries across the world. The results revealed that the infrastructure in Pakistan remained even below the average of low middle-income group.

As far as Pakistan is concerned, few studies have been done which performed a spatial ranking and temporal comparison by constructing an Infrastructure Development Index. For instance, Rana, Bhatti and Saqib (2017) performed a spatial and temporal analysis of the five major cities of Punjab with three consecutive time periods (2002, 2007 & 2012). Using five indicators (access to secondary school, electricity, water, sanitation & gas), a temporal comparison of infrastructure development among the cities have also been done. The results suggested that Lahore is at a better position

than other cities, whereas, the temporal analysis reveals slight improvement in these cities over time. Ghaus, Pasha and Ghous (1996) analyzed the social infrastructure development of Pakistan. The study used education, health and water supply indicators to examine the social development disparity among districts. The study found that Punjab has better infrastructure development level than Sindh, Balochistan and NWFP. Rana (2014) analyzed rural-urban disparities in Lahore. The findings suggested that the national economic plan has been more infrastructure-development-oriented than socio-economic growth. Nawaz-ul-Huda and Burke (2011) examined the socio- economic disparities in Balochistan. The study found that the cities are ill-equipped with lack of planning resulting in poor services of; sanitation, access to safe drinking water and other social economic problems. Jamal (2015) worked on studying the spatial disparities on the socio-economic development of Pakistan. The outcomes of the composite index found relative ranking of the districts on socio-economic development. Punjab remained in the highest quintile whereas more than half of the Balochistan's population remained in the lowest quintile. Almost 80% of population of Punjab had been placed in the upper two quintiles, whereas the remaining were placed in the lowest two quintiles.

Since various studies have been undertaken internationally and nationally that represent the pictures of infrastructure development at country, region or city level using numerous indices. Whereas, in case of Pakistan, a very few studies have been undertaken, the studies already done are mostly in the area of socio- economics dimensions. However, a comprehensive study has not been undertaken to examine the infrastructure development at district level in Punjab that envisage the spatial and temporal pattern of development as well as the regional disparities. Therefore, this study is aimed at identifying the gap where the government should align and direct public investment on infrastructure development. Whereas, temporal comparison of Infrastructure Development Index (IDI) has also been analyzed.

2.2. Conceptual Framework

As discussed earlier that infrastructure can be defined as one of the basic facilities and services which facilitate different economic activities and thereby help in economic development of a country. For instance, provision of education, health, transport, communication,

power, science and technology facilities etc. are the examples of basic infrastructure. Infrastructure is considered as the foundation for economic growth and productivity. However, there is no unanimous standard or index to gauge the level of infrastructure development. As reviewed above in the literature review section, different studies have followed different type of indices to examine the state of infrastructure at the country, region or city level. Based on the review of the literature, the present study decomposed the infrastructure development into three sub-dimensions; public-utility infrastructure, communication infrastructure and social infrastructure. The same is depicted in Figure 1.

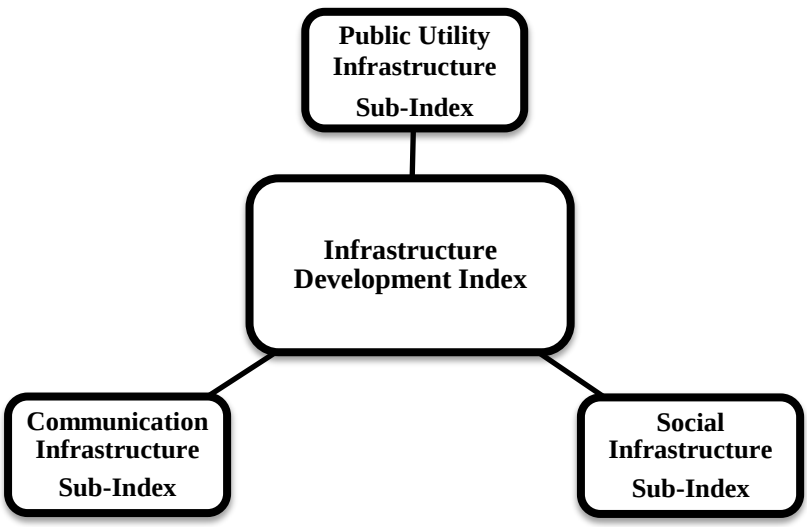

Figure 1: Sub-dimensions of the Infrastructure Development Index (IDI)

Each sub-dimension further comprises of a set of relevant indicators which are shown in the Figure 2 (with the proxy through which these indicators are being measured).

Public Utilities and Services Infrastructure
Electricity Infrastructure (Access to Electricity, as % of population)
Gas Infrastructure (Access to natural gas as a cooking fuel, as % of population)
Drinking Water Infrastructure (Access to improved drinking water source, as % of population)
Sanitation Infrastructure (Access to improved sanitation, as % of population)

Communication Infrastructure
Road Infrastructure (Road Density in km/100sqkm)
Telecom Infrastructure, landline (Access to Telephone, as % of population with access)
Telecom Infrastructure, cellular (Access to Mobile Phone, as % of population with access)
ICT Infrastructure (Access to Computer, as % of population with access)
Public Transport Infrastructure (Access to Public Service Vehicles / 1000 population)
Social Infrastructure
Education Infrastructure Access to Education facilities (number of facilities per 1000 population)
Health Infrastructure Number of Health facilities (per 1000 population)

Figure 2: Indicators in each Sub-dimensions of the Infrastructure Development Index

3. Data and Methodology

3.1. Data Sources

The data of access to electricity, access to gas, access to improved water sources, access to improved sanitation facilities, telephone availability, computer availability, cell phone availability have been taken from the MICS[4] (2011, 2014) reports[5] and microdata[6]. Whereas, the public transport, government health facilities, number of public school & colleges, and private colleges have been taken from PDS (2012, 2015). Whereas, the data on private health care centers have been taken from the Census of Healthcare Establishment (Punjab) conducted by Urban Unit (2011 & 2014). Furthermore, the indicators like number of health facilities, number of education facilities, and number of public service vehicles have been divided by population (in thousand) to measure the access to per thousand population. However, data on road density is taken in kilometers per 100 Square Kilometers which has been taken from the Planning & Design Directorate of Punjab Highway Department, Government of the Punjab[7].

[4] Multiple Indicators Cluster Survey
[5] Reports published by Bureau of Statistics (BOS) Punjab
[6] Microdata has been taken form UNICEF (2017)
[7] As reported in Punjab Development Statistics 2012 and 2015 (Bureau of Statistics, 2012 and 2015)

3.2. Study Area and Unit of Analysis

Punjab province of the Pakistan is the study area, whereas, the unit of analysis for the estimation of Infrastructure Development Index (IDI) is the district. The province of the Punjab is divided into 36 districts. The study aims at analyzing the level of overall infrastructure development (and at sub-dimensions level) among the districts of Punjab, Pakistan.

3.3. Methodology: Analytical Hierarchical Process (AHP) and Weighted Aggregation

To compute a composite Infrastructure Development Index (IDI), following three steps methodology has been used:

Step 1: Normalization of the Indicators / Variables. Firstly, normalized the values of all indicators by equation (1) formula;

$$NV_i = \frac{X_{ij} - X_{i(Min)}}{X_{i(Max)} - X_{i(Min)}} \quad (1)$$

Where, NV_i = Normalized value of Variable i

X_{ij} = Value of Indicator i for district j

$X_{i(Min)}$ = Minimum value of variable i

$X_{i(Max)}$ = Maximum value of variable i

Step 2: Assigning weights to sub-dimensions: Using Analytical Hierarchical Process (AHP) method. Analytical Hierarchical Process (AHP) method has been employed to find the weights of all respective indicators in each sub-dimensional Index (sub-index)[8]. Subsequently, the weights of each sub-dimension in the final composite index (IDI) have also been assigned using AHP.

Analytical Hierarchical Process (AHP) is a linear additive model firstly introduced by Saaty (1980). It is used for measuring the weights and score, the pair-wise comparisons are made amongst criteria and alternative options. It has characteristics to evaluate both qualitative and quantitative framework. Whereas, AHP incorporates both objective and subjective features. AHP is not undertaken by

[8] Same approach has been used by Rana, Bhatti and Saqib (2017)

consensus but rather a synthesis of representative outcomes from verity of judgments (McNeil et al., 2010). It offers the degree of consistent judgment. AHP method also supports hierarchy of attributes and alternatives for judgment. It assigns highest weight to the criteria that has consigned a highest priority amongst pair wise comparison of poor performing alternative (Darji and Rao, 2013).

The AHP works in the sequence of vector of criteria weights, matrix of option score and then ranking the options. AHP is an unbiased process which evaluates the consistency of decision maker about their judgments, both direct and online survey conducted for this purpose. To check the consistency of the survey following formula, as given by Saaty (2008) has been used;

$$CR = CI/RI \quad (2)$$

Where, CI= Consistency Index,

RI= Random Index

The random index value depends upon the number of parameters that are considered to be compared, the formula for Consistency Index (CI) is given as:

$$CI= \frac{\lambda - n}{n-1} \quad (3)$$

Where, λ = is the matrix Eigen value while n = is the matrix size.

Where $\lambda \geq$ n and difference is used to measure the judgment consistency. So, when λ is closer to n the judgment is more consistent. The value consistency ratio (CR) must be CR $\leq$0.1, which shows judgment or evaluation consistency (Zoran, Sasa & Dragi, 2011).

Step 3: Aggregation of Dimension Indices (DI) into Composition Index (IDI). Firstly, the weighted aggregated values for each of these sub-indices have been calculated, separately, using formula given by the equation (4);

$$\text{Dimension Index / Sub-Index } (DI_j) = \sum W_i.NV_{ij} \quad (4)$$

Where, W_i = weight of the indicator "i" computed using AHP

NV_{ij} = Normalized value of indicator "i" for district "j"

The "*Infrastructure Development Index*" represents an integrated and composite measure of the total performance of

infrastructure (McNeil et al., 2010). Therefore, after computing the Dimension Indices, the next step is to compute the Composite Index (i.e. the Infrastructure Development Index) by the weighted summation of all respective sub-indices as per their respective weights[9].

$$\text{Composite Index (IDI)} = \sum W_d . DI_{dj} \quad (5)$$

Where, W_d = weight of the dimesion "d" computed using AHP

DI_{dj} = Normalized value of dimension "d" for district "j"

Finally, values of IDI as computed by equation (4) have been normalized again using the formula given above in Equation (1) such that the Infrastructure Development Index (IDI) ranges from 0 to 1.

3.4. Composition of Experts Panel for AHP

For public expert's opinion, thirteen local experts (most of having international experiences) and one foreign international expert have been selected for their expert opinion regarding prioritization of indicators and sub-dimensions of infrastructure development. The experts selected are of diverse range of expertise and background including the Urban Unit, Planning and Development Department of the Government of Punjab, real estate expert from Toronto McGill University, Academicians from the University of Engineering & Technology Lahore, professionals from Transport Department Government of Punjab and Lahore Waste Management Company (LWMC).

4. Results and Findings

4.1. Analytical Hierarchical Process (AHP) Results

Consistency Ratio. The calculated value of Consistency Ratio (CR) is 0.04 which shows consistency in judgment/evaluation, as it is below the cut-off value of 0.1.

Calculated Weights of Indicators Sub-indices. The weights of indicators in each sub-dimension and the sub-index's weight in the overall composite index (IDI) is given as under;

[9]"The Infrastructure Index recognizes the interconnections among the different infrastructure networks as a weighted index" (McNeil et al., 2010).

Public Utilities and Services Infrastructure	**45.5**
Access to Electricity (% of population)	8.78
Access to Gas (% of population)	3.78
Access to improved water source (% of population)	22.48
Access to improved sanitation (% of population)	10.51
Communication Infrastructure	**29.47**
Access to Road Infrastructure (Road Density in km/100sqkm)	8.05
Access to Telephone (% of population with access)	3.22
Access to Computer (% of population with access)	2.92
Access to Mobile Phone (% of population with access)	6.73
Access to Public Transport (Public Service Vehicles / 1000 population)	8.56
Social Infrastructure	**25.1**
Access to Education facilities (number of facilities per 1000 population)	8.84
Number of Health facilities (per 1000 population)	16.3

Figure 3: Calculated Weights of Sub-dimensions and Indicators of the Infrastructure Development Index (IDI): Based on AHP Results

4.2. Results of Public-Utility Infrastructure Index (PUI): Spatiotemporal Analysis

Spatial Representation of Public-Utility Infrastructure Index. The spatial analysis of Public Utility Sub-index 2011, as shown by Figure 4 (left-panel), depicts that the Lahore, Gujranwala, Gujarat, Sheikhupura, Sialkot, Khanewal are in the best districts in terms of Public Utility Sub-Index of IDI. Whereas, Faisalabad, D.G Khan and Rajanpur are placed at bottom in ranking. The PUI (2011) map represents that all districts at South of the Punjab are amongst the most deprived districts in terms of public utility infrastructure. The Faisalabad with rank 34^{th} seems an outlier amongst the worst districts in terms of public utility provisions.

Figure 4 (right-panel) shows that Lahore, Gujrat, Sheikhupura, Rawalpindi, Gujranwala and Hafizabad are the best ranked districts in terms of Public Utility Sub-Index (for 2014). While Rajanpur, DG Khan & Faisalabad remained at the bottom ranking in terms of public utility dimension of IDI. The spatial analysis depicts that the Eastern and Northern districts of Punjab have a better access to public utility infrastructure as compared to Southern and Western Punjab. Furthermore, it also depicts that Faisalabad worsens more as

compared to 2011 and falls from 34th rank to 36th at bottom most level within 3 years.

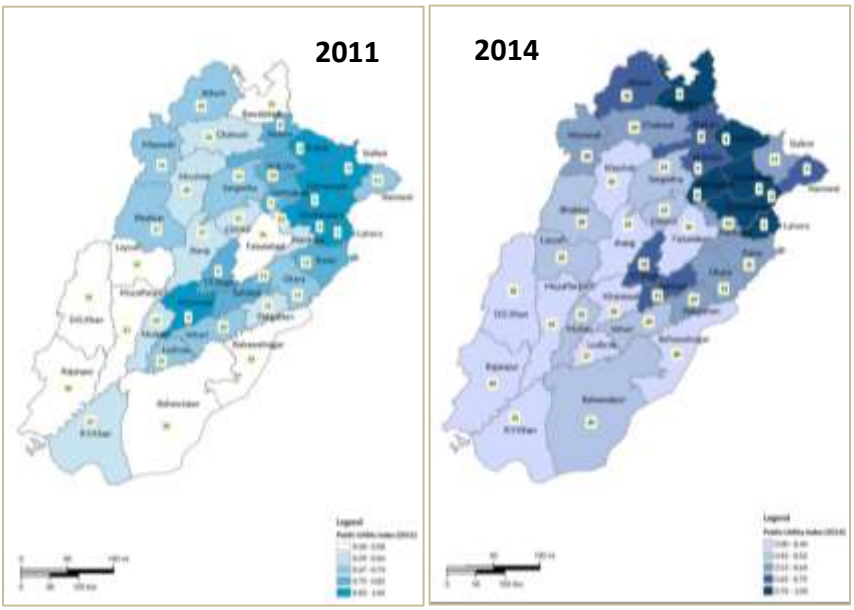

Figure 4: Spatial Representation of Public-Utility Infrastructure Sub-Index (PUI) for 2011 and 2014

Temporal Comparison of Public-Utility Infrastructure. Coming towards temporal analysis of districts ranking from 2011 to 2014, the above figure shows that infrastructure development in 2014 becomes worse in most of the districts. Whereas, improvement can be seen only in the districts of Rawalpindi & Rajanpur from 2011 to 2014. While utility access level in all other districts of Punjab becomes worse in 2014 than 2011, however, Lahore & Gujrat remained at the same ranking in terms of public utility sub-index for the both years.

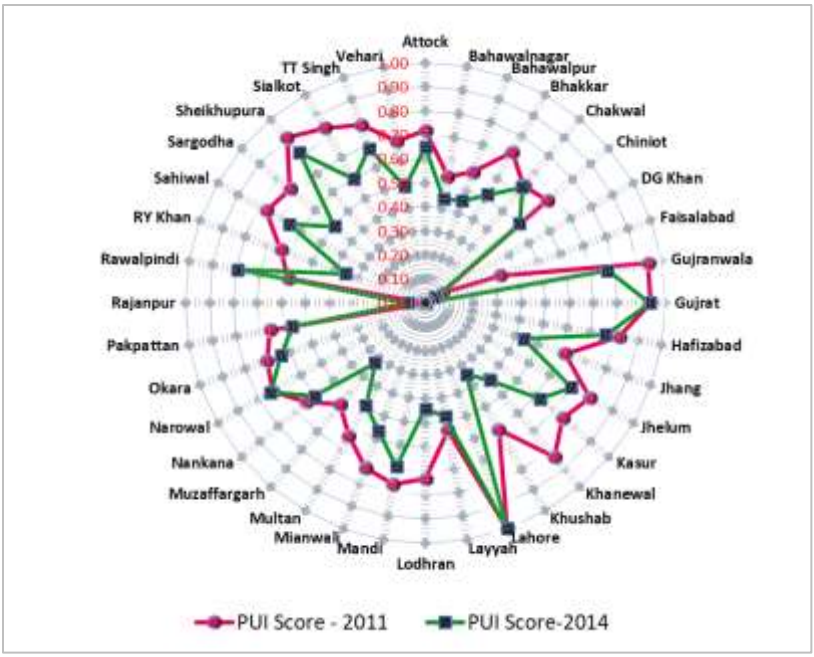

Figure 5: Temporal Comparison of Public-Utility Infrastructure Sub-Index (PUI) for 2011 vs 2014

4.3. Communication Development Index: Spatiotemporal Analysis

Spatial Representation of Communication Infrastructure. For communication infrastructure sub-Index of IDI, the Figure 6 (left-panel) depicts that the Rawalpindi, Lahore, Sialkot, Gujranwala, Gujrat are the best districts in terms of communication infrastructure. Whereas, Muzaffargarh, D.G. Khan and Rajanpur districts remained at bottom with respect to communication development in 2011.

For the year 2014, spatial representation, as depicted by Figure 6 (right-panel), shows that the top three (Northern) districts remained on the top 3 positions while Jhelum district improved in communication infrastructure development as compared to 2011. While the districts of Multan, Gujranwala and Rajanpur are the most deprived in terms of communication infrastructure development sub-index ranking in Punjab for 2014.

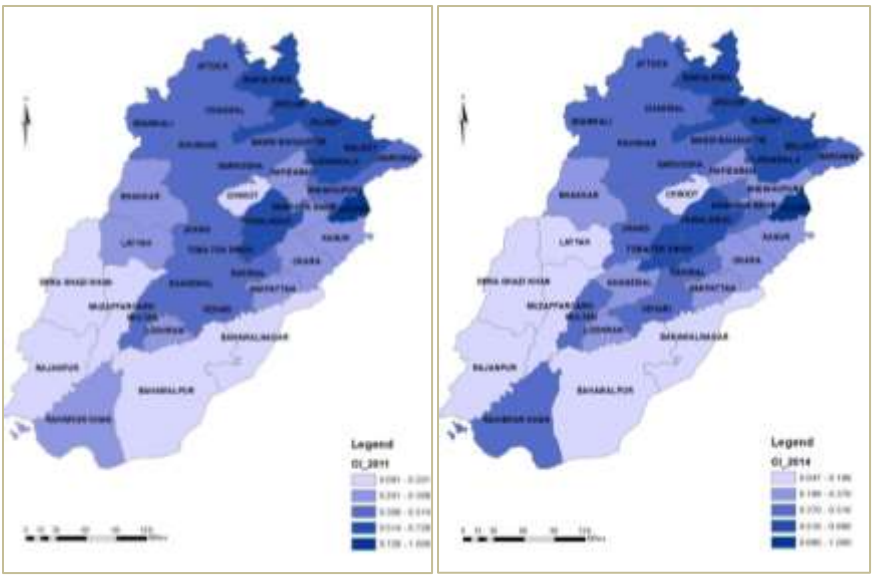

Figure 6: Spatial Representation of Communication Infrastructure Sub-Index (CII) for 2011 and 2014

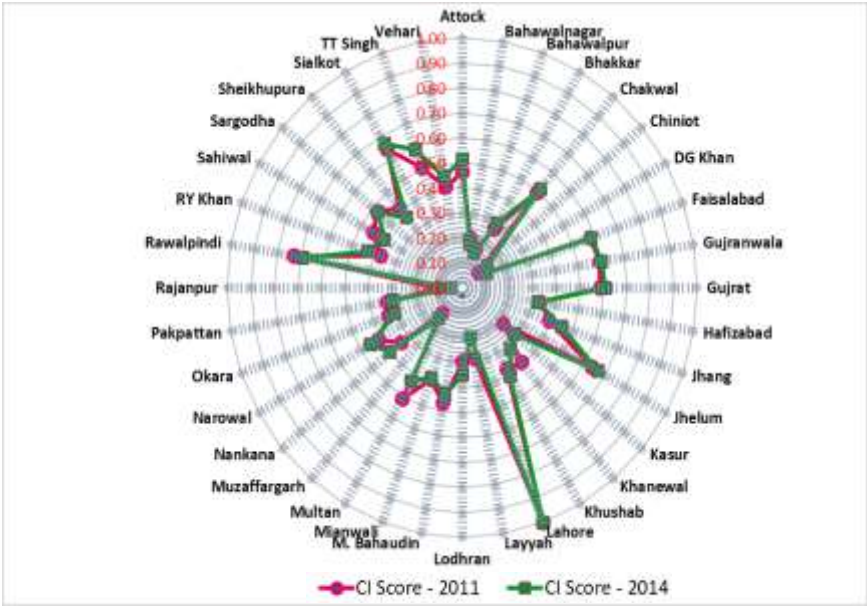

Figure 7: Temporal Comparison of Communication Infrastructure Sub-Index (CII) for 2011 vs 2014

Temporal Comparison of Communication Infrastructure. The temporal comparison between 2011 and 2014 shows a prominent improvement in case of Lahore, Nankana, Khushab, Toba Tek Singh, Muzaffargharh, Rahim Yar Khan, Jhang and Lodhran (See Figure 7). But Rawalpindi and Pakpattan remains persistent on the same position in terms of communication infrastructure development in 2011 and 2014. However, Kasur & Khanewal are the two districts that have declined in 2014 for communication infrastructure development than in 2011.

4.4. Results of Social Infrastructure Index: Spatiotemporal Analysis

Spatial Representation of Social Infrastructure. As shown by Figure 8 (left-panel), the socially developed best districts are Rawalpindi, Pakpattan, Nankana, Toba Tek Singh, Khushab and Attock. However, Lahore, Gujranwala and Sargodha, despite being the large districts and urban centers, have been placed at bottom in terms of basic education and health. The data shows that social infrastructure has grown in absolute terms, however, grown less as compared to population growth because indicators used for measuring index have been converted into per thousand population ratios.

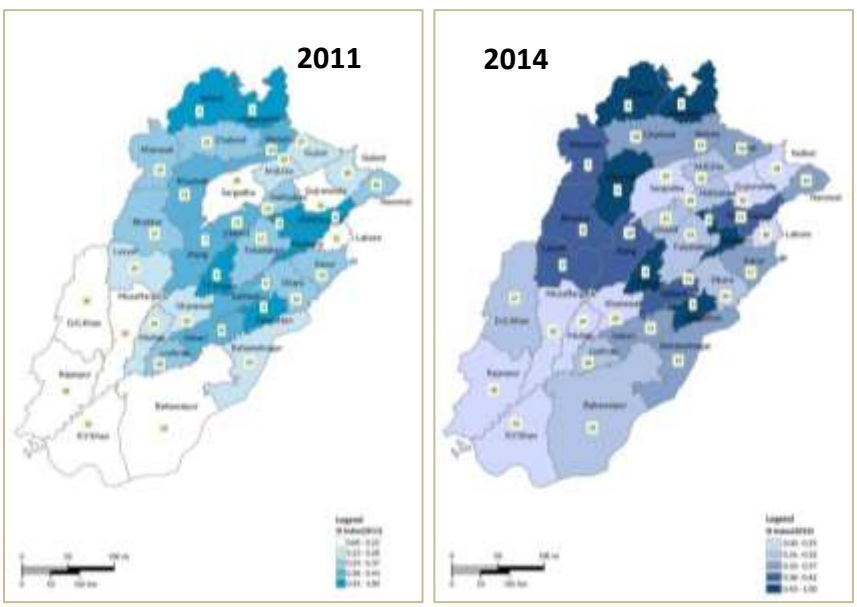

Figure 8: Spatial Representation of Social Infrastructure Sub-Index (SII) for 2011and 2014

Whereas in 2014, same ranking of top five districts has been found of Social Infrastructure Sub- index. Whereas, top mega industrial districts of Punjab i.e. Lahore, Gujranwala and Sialkot remained at bottom in terms of SII, as social infrastructure is not improved in a proportion as that of population growth.

Temporal Comparison of Social Infrastructure. Comparative analysis of social infrastructure Sub- Index of IDI depicted some improvements in Layyah, Gujrat and Mianwali districts from 2011 to 2014 (see Figure 9). Whereas, Rawalpindi remains at the same position of development in both years. However, SI sub-index of Pakpattan, TT sigh and Nankana worsens in 2014 as compared to 2011.

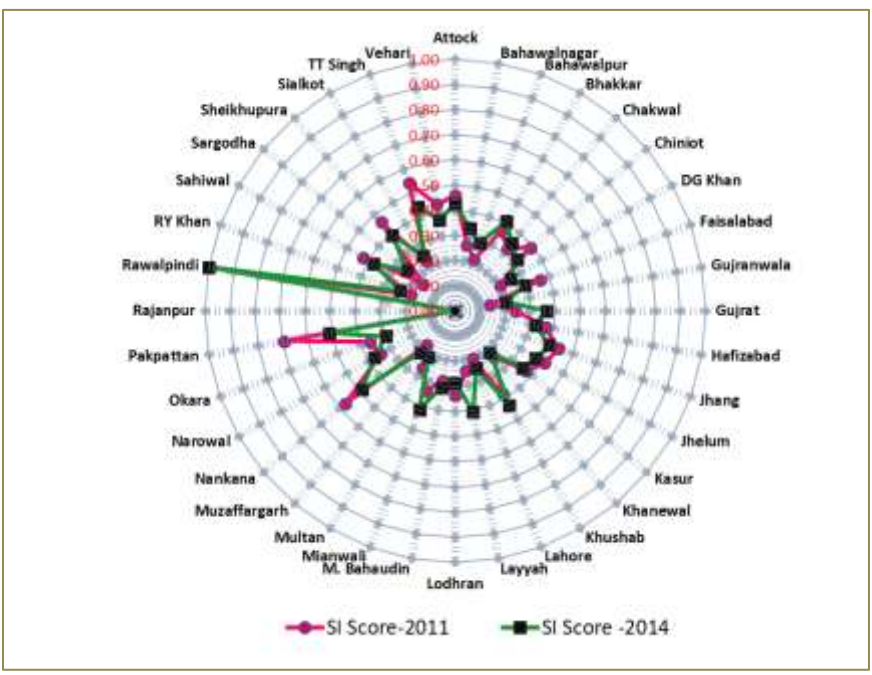

Figure 9: Temporal Comparison of Social Infrastructure Sub-Index (SII) for 2011 vs 2014

4.5. Results of Composite Index: Infrastructure Development Index

Spatial Representation of Composite Infrastructure Development Index (IDI). Figure 10 (left-panel) shows that overall infrastructure development situation in Punjab seems good for North-Eastern

Punjab for the year 2011. As, top ranked districts, in terms of overall composite infrastructure development, are Rawalpindi, Lahore, Gujrat, TT Singh, Gujranwala and Sheikhupura. It is evident that the districts which are industrialized or situated alongside the mega urban centers are most developed in terms of overall infrastructure. However, Western and Southern districts of the Punjab are poorer in terms of infrastructure development in 2011.

Figure 10 (right -panel) depicts that the top ranked districts for 2014 are mostly on the North-Eastern border of Punjab. However, Southern and lower Western side of Punjab is mostly deprived of the basic facilities of infrastructure. Despite being the textile hub, Faisalabad remains among the worse districts in the ranking of Infrastructure Development Index (IDI) for 2014.

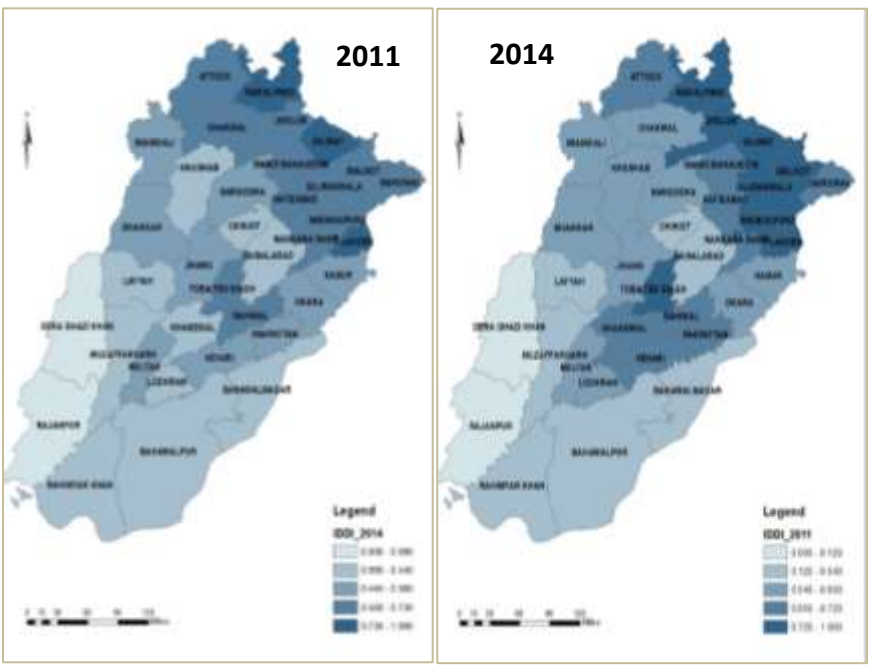

Figure 10: Spatial Representation of Infrastructure Development Index (IDI) for 2011 and 2014

Temporal Comparison of Composite Infrastructure Development Index (IDI). Temporal comparison among the districts of Punjab is shown below in Figure 11.

It is shown above that the improvement can been seen only in district Rawalpindi whereas the district Lahore, Gujrat, Narowal and Chakwal have remained on the same position of infrastructure development level in both years (2011 and 2014). However, rest of the districts worsened in 2014 as compared to 2011. It is evident that provisions infrastructure facilities have not grown at rate at which the population and urbanization rates increased. Figure 11 also shows disparities within the districts in terms of Infrastructure Development as D.G. Khan and Rajanpur are placed among the least developed and most deprived districts throughout the IDI indexes, in both years, whereas, the Rawalpindi, Lahore and Gujrat have remained at top in both years.

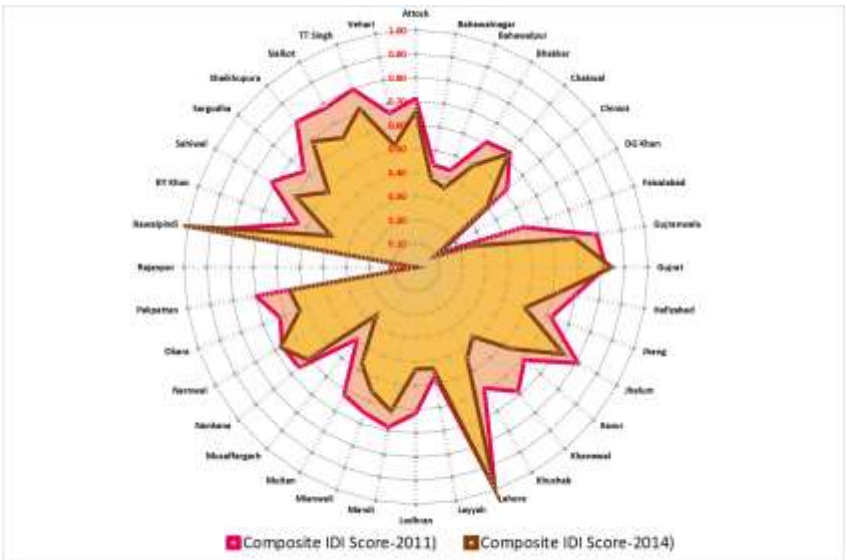

Figure 11: Temporal Comparison of Infrastructure Development Index (IDI) for 2014

4.6. Relative Bench-marking Analysis of Indices against Provincial Average

In addition to spatiotemporal analysis, the present study has also performed a relative bench-marking analysis. Because, the analysis reveals that not only districts' conditions worsen over time but also the conditions of overall province worsen in terms of infrastructure development in 2014 as compared to 2011. To that end, each sub-index and composite index have been computed for entire Punjab as

an average aggregate measure. Subsequently, each individual district has been compared with provincial aggregate index and sub-index to establish their relative position in the province that whether it becomes better than overall provincial level of infrastructure development or further worsens.

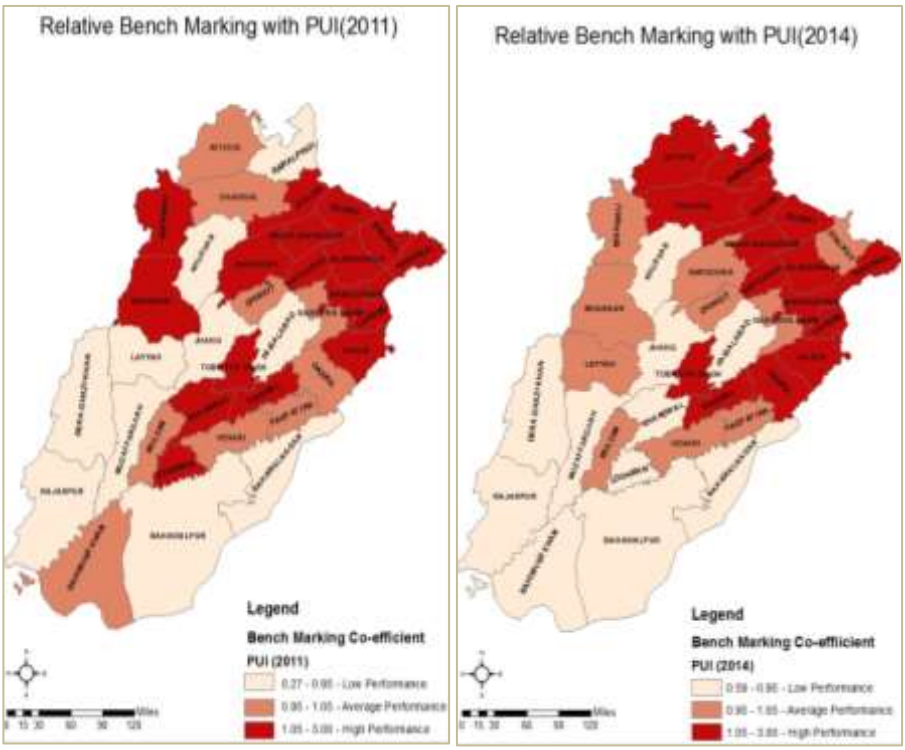

Figure 12: The Bench Marking Analysis of Public Utility Sub-Index (2011 & 2014)

The above figure shows that in 2011, mostly Eastern districts like Lahore, Kasur, Narowal, Sialkot, Gujrat etc. are comparatively high performing districts in terms of Public Utility accessibility as compared to the provincial average bench-mark. However, excluding Lodhran, Rahim Yar Khan, Multan, the rest of the Southern districts of Punjab are the poor performing in terms of Public Utility Infrastructure. The relative bench-marking of public utility sub-index for 2014 shows some improvement in the Northern districts of Punjab, however, Eastern side performance remains more or less the same in both years. Except Vehari & Multan, worse situation has been seen in Southern districts as most of the districts remained

underprivileged in public utility infrastructure development. Whereas, comparing 2011 to 2014, Rawalpindi Chakwal and Attock from the Northern side of Punjab show some improvement by moving from low and average performing districts to high performing districts, respectively. While Mianwali, Bhakkar and Layyah shows a declining trend in their infrastructure development as against 2011. Although from Eastern side, Sialkot & Sargodha have shown demotion from high performance to average performance districts of Punjab in 2014 than in 2011.

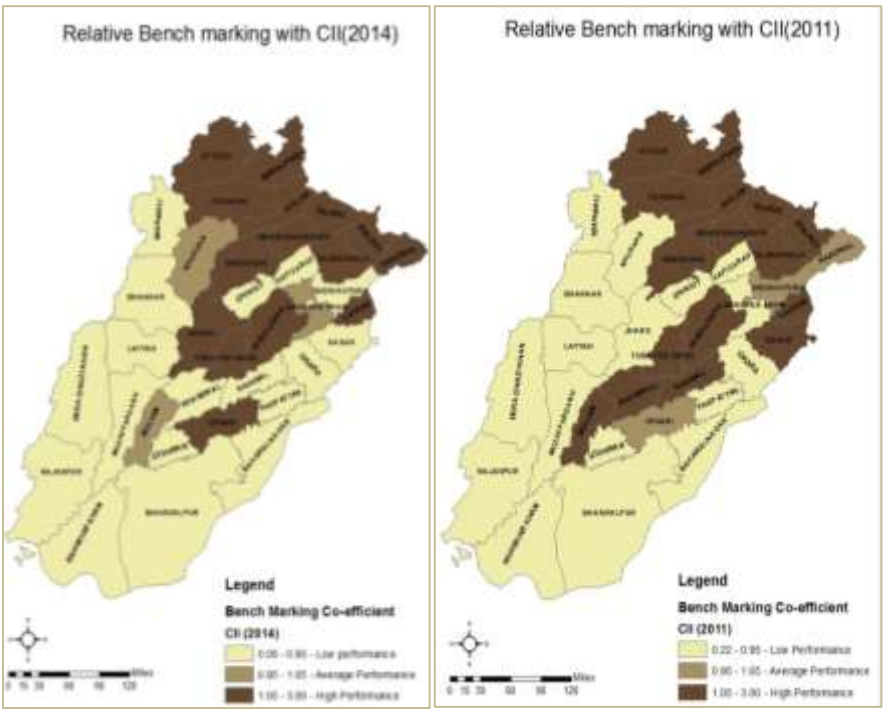

Figure 13: The bench marking analysis of Communication Infrastructure Sub-Index (2011 & 2014)

The above figure shows that high performing districts for communication infrastructure development are mostly from North-Eastern region of Punjab. Excluding Multan, Khanewal and Vehari districts, the South-Western districts of Punjab are mostly comprised of poor performing districts in terms of communication infrastructure development. Similarly, the Western districts are categorized as poor performing districts of Punjab, as well.

Khushab, Nankana sahib and Multan have been placed among the average bench-marked districts as compared to the high performing North-Eastern upper districts of Punjab in 2014. Multan and Vehari are the merely two districts that achieved high and average performance from the Southern and Western side of Punjab in 2014, respectively. Some districts have shown some improvement while rest of the districts move down in 2014 than 2011.

The two-year (2014 and 2011) bench-marking comparative analysis for communication Infrastructure development reveals that the Khushab, Nankana Sahib, Narowal, Jhang, Vehari are the districts which have been upgraded from poor to average and high performing districts, respectively. However, Khanewal, Sahiwal, Kasur, Sheikhupura and Multan have been declined from high to low and average to low performing districts in CII, comparatively.

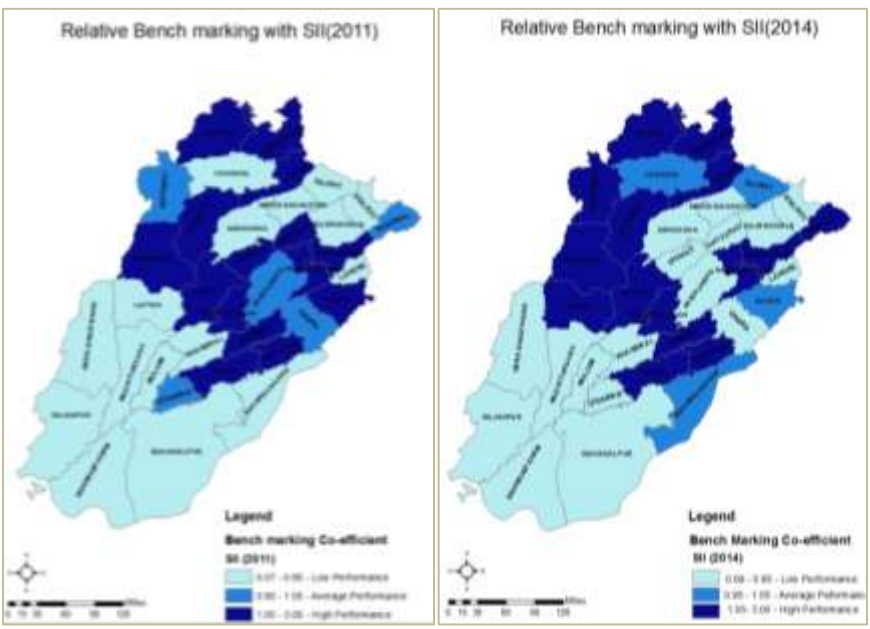

Figure 14: The bench marking analysis of Social Infrastructure Sub-Index (2011 & 2014)

Figure 14 depicts very surprising results for social infrastructure development in Punjab. Through these results, the impact of rising population and rapid urbanization can easily be seen in the social infrastructure development sub-indices. High tendency of

migration towards developed cities and mega districts is exerting pressure on the provision of social facilities for rising population of mega cities like Lahore. It is evident that level of social infrastructure could not keep pace with the rising population and high rural-urban migration trends. For 2011, as against the results of communication and utilities infrastructure, many districts of the North-Eastern Punjab are also amongst the poor performing districts in terms social infrastructure. Similarly, the Southern districts of Punjab are also among the poor districts in terms of social infrastructure. Some North-Western and Eastern districts of Punjab have positioned themselves on the top districts in terms of social infrastructure. The districts Faisalabad, Lodhran, Mianwali, Narowal and Okara are relatively better districts. Whereas, Lahore, Gujranwala, Sialkot, Gujrat, Sargodha, Chakwal and Mandi Bahauddin are the districts from North-East which are ranked as poor in terms of social infrastructure. Development in social infrastructure has been upgraded in South-Western districts of Punjab, in 2014. The districts with average performance are Kasur, Gujrat, Chakwal and Bahawalnagar. Whereas, the Eastern and Southern side districts are the most deprived with low performance

The figure shows that Mianwali, Layyah and Chakwal have improved to best and average performing districts, respectively. However, the Gujrat and Narowal have been able to attain progress from low to average and average to high developed districts during 2011 & 2014. While Chiniot, Hafizabad, Faisalabad, Okara and Kasur declines in their social progress from high to low and average to low performing districts of Punjab in 2014 as compared to 2011, respectively. From Southern side, Lodhran becomes worse and Bahawalnagar improves in 2014.

Figure 15 shows that upper North-Eastern districts are amongst high performing districts in terms of infrastructure development as they are above the overall provincial average. Similarly, Mianwali, Chakwal, Sargodha, Nankana Sahib, Jhang and Okara have been ranked as average performance districts as they are equal to provincial average. Whereas, Khushab, Chiniot and Faisalabad have been found poor in terms of infrastructure development.

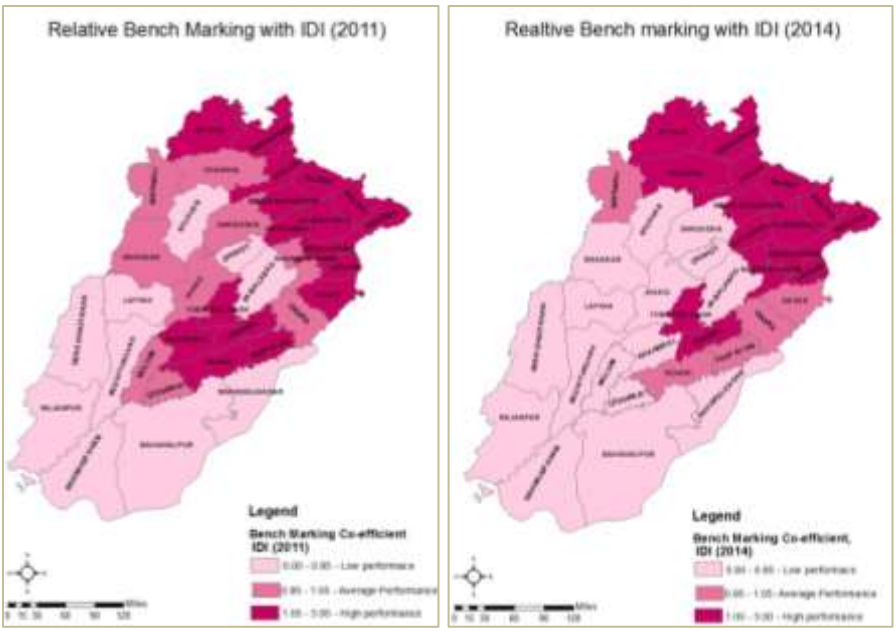

Figure 15: The bench marking analysis of Composite Infrastructure Development Index (2011 & 2014)

The composite index (IDI) bench-marking analysis reveals that the most of Southern districts have poor level of infrastructure development. However, IDI for 2014 shows that only North-Eastern districts are enjoying the fruits of infrastructure development. Whereas, Southern districts are generally less developed in terms of Infrastructure development. Average performing districts with respect to infrastructure development are Okara, Pakpattan, Vehari and Mianwali. Chakwal and Nankana districts show some improvements in their position from average performing districts to best developed districts in terms of infrastructure development.

A comparison of 2011 and 2014 shows that Bhakkar, Jhang, Sargodha, Multan and Lodhran have been further deteriorated in terms of infrastructure progress while Khanewal, Vehari, Pakpattan and Kasur have come down from best to poor and best to average, respectively. Overall comparison illustrates that only few districts have got up while majority of districts become worse in 2014 as compared to 2011.

5. Conclusion and Recommendations

This paper found that the Southern districts and some of Western districts of Punjab are the most deprived districts in all dimensions of infrastructure, considered in this study. Whereas the upper side districts of North, East and North-Eastern Punjab are the relatively better districts in all dimensions of infrastructure development. It looks that some Western districts of Punjab have grown in social infrastructure development, especially. However, the IDI for both years (2011 & 2014) shows that mostly the progress of North, East and some districts of Northern West is either comparatively better or on average in terms of infrastructure facilities as compared to other districts of Punjab. However, temporal analysis shows that all dimensions become worse in 2014 than 2011 as the infrastructure development could not keep pace with the population growth, rapid urbanization and augmented rural to urban migration. Amongst the developed districts, Faisalabad seems an outlier as it remains lagged behind in facilitating the improved water provision to its citizen.

The results of this paper can be used to assess patterns of infrastructure development and to identify the relevant corrective measures which can be taken to set priorities for improvement of infrastructure in the province. This paper also highlights relative benchmarking analysis of districts under different dimensions of infrastructure. Thus, areas of prioritization and public investment can also be identified. Accordingly, a balanced and equitable infrastructure development agenda can be set and future resources allocations for infrastructure up-gradation of the region.

This paper's results suggest important implications for policy makers. It highlights the disparities among the districts in terms of provision and access to infrastructure. An inclusive strategy must focus on reducing the disparities in the budget allocation for infrastructure. Districts which are mostly lagging-behind in all dimensions and in composite index include the Southern districts and some of the Western districts. These districts need to be given priority in ADP (annual development plan) allocation for infrastructure sector development and future infrastructure investments also need to be focused on these districts, lagging behind in the infrastructure development. Furthermore, the result suggests that, with the increasing population in

coming years, the government needs to work for developing the infrastructure according to the growing proportion of population in each district of Punjab.

References

African Development Bank (2016). The Africa Infrastructure Development Index 2016. Retrieved from https://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/Africa_Infrastructure_Development_May_2016.pdf.

Bureau of Statistics (2012). *Punjab Development Statistics 2012*. Lahore, Pakistan: Bureau of Statistics, Government of Punjab.

Bureau of Statistics (2015). *Punjab Development Statistics 2015*. Lahore, Pakistan: Bureau of Statistics, Government of Punjab.

Dadashpoor, H., Rostami, F., & Alizadeh, B. (2016). Is inequality in the distribution of urban facilities inequitable? Exploring a method for identifying spatial inequity in an Iranian city. *Cities. 52*, 159-172. https://doi.org/10.1016/j.cities.2015.12.007

Darji, V. P., & Rao, R. V. (2013). Application of AHP/EVAMIX Method for Decision Making in the Industrial Environment. *American Journal of Operations Research*, *3*, 542-569. http://dx.doi.org/10.4236/ajor.2013.36053.

Donaubauer, J., Meyer, B., & Nunnenkamp, P. (2014). A New Global Index of Infrastructure: Construction, rankings and applications. *The World Economy*. *39*(2), 236-259. https://dx.doi.org/10.1111/twec.12290.

Dutta, S., Geiger, T., & Lanvin, B. (2015). *The Global Information Technology Report 2015*. World Economic Forum. Retrieved from www3.weforum.org/docs/WEF_Global_IT_Report_2015.pdf.

Ghaus, A. F., Pasha, H. A., & Ghaus, R. (1996). Social Development Ranking of Districts of Pakistan. *The Pakistan Development Review*. *35*(4), 593-614.

Government of Punjab (2013). *Medium term development framework: Development Programmes 2013-16*. Lahore, Pakistan: Department of Finance, Government of Punjab.

Government of Punjab (2016). *Medium term development framework: Development Programmes 2016-19*. Lahore, Pakistan: Department of Finance, Government of Punjab.

IPP (2012). *The State of The Economy: The Punjab Story*. Lahore, Pakistan: Institute of Public Policy (IPP), Beaconhouse National University. Retrieved from www.sjbipp.org/publications/AR/reports/AR-05-12.pdf.

Jamal, H. (2015). *Spatial Disparities in Socioeconomic Development: The Case of Pakistan*. (*Working Paper No. 15-3)*. Karachi, Pakistan: Centre for Business and Economics Research (CBER), Institute of Business Administration (IBA).

McNeil, S., Li, Q., Oswald, M., Gallis, M., Kreh, E., Peterson, Z., ... & Skancke, T. (2010). Developing and Infrastructure Index Phase I. University of Delaware-University Transportation Center. Retrieved from http://www.ce.udel.edu/UTC/current%20Research/McNeil_Li_Oswald_FinalReport.pdf

Naidu, G. (2008), International Infrastructure Development in East Asia – Towards Balanced Regional Development and Integration, In Kumar, N. (ed.), *Infrastructure Development in Malaysia (*pp.204-227), ERIA Research Project Report 2007-2, Chiba: IDE-JETRO.

Nawaz-ul-Huda, S., & Burke, F. (2011). Socio-economic Disparities in Balochistan, Pakistan –A Multivariate Analysis. *Malaysian Journal of Society and Space, 7*(4), 38-50.

O'Neill, J., Wilson, D., Purushothaman, R. and Stupnytska, A. (2007). The N-11: more than an acronym. Global economics paper no. 153. *GS Global Economic Website-Economic Research from the GS Institutional Portal http://www2. goldmansachs.com/ideas/global-economic-outlook/n-11-acronym-doc. pdf.*

Oswald, M., Li, Q., McNeil, S., & Trimbath, S. (2011). Measuring infrastructure performance: development of a national infrastructure index. *Public Works Management & Policy*. *16*(4), 373-394. https://doi.org/10.1177/1087724X11410071.

Pakistan Bureau of Statistics (2018). *Population Census of Pakistan 2017*. Islamabad, Pakistan: Pakistan Bureau of Statistics.

Rana I.A., Bhatti S.S., Saqib S. 2017. The Spatial and Temporal Dynamics of Infrastructure Development Disparity – From Assessment to Analyses, *Cities*, *63*, 20–32. https://doi.org/10.1016/j.cities.2016.12.020.

Rana, I. A. (2014). *Rural Urban Development Disparity in Lahore City Region: Policy Implications.* Thailand: Asian Institute of Technology.

Saaty, T. L. (2008). Decision making with the analytic hierarchy process. *International journal Services Sciences*. *1*(1): 83-98. https://doi.org/10.1504/IJSSci.2008.01759.

Schwab, K. (Ed.) (2018). *The Global Competitiveness Report 2017-18*. World Economic Forum LLC. Retrieved from http://www3.weforum.org/docs/GCR20172018/05FullReport/TheGlobalCompetitivenessReport2017%E2%80%932018.pdf.

U.S. Chamber of Commerce. (2010). Infrastructure Performance Index: Initiation Phase Report. Retrieved from http://library.uschamber.com/sites/default/files/lra/docs/lraindexinitphasereport100406.pdf

UN-HABITAT (2001). Epilogue - The City Development Index (CDI). In The State of the World's Cities, 2001. New York, USA: United Nations Centre for Human Settlements.

UNICEF (2017). Multiple Indicators Clusters Surveys of Punjab Pakistan (2011 and 2014) [microdata]. UNICEF, United Nations Organization. Retrieved from http://mics.unicef.org/surveys

Urban Unit (2011). *Census of Healthcare Establishments in Punjab*. Interim Results of Census conducted for Punjab Healthcare Commission.

Urban Unit (2015). *Census of Healthcare Establishments in Punjab*. Interim Results of Census conducted for Punjab Healthcare Commission.

Zoran, D., Sasa, M., & Dragi, P. (2011). Application of the AHP Method for Selection of a Transportation System in Mine Planning. *Underground Mining Engineering*, *19*, 93-99.

Appendix

Table A-1: Indicators with Data Sources

Indicator / Dimension	Source
Access to Electricity (% of population)	MICS* (2011 & 2014)
Access to Gas (% of population)	MICS (2011 & 2014)
Access to improved water source (% of population)	MICS (2011 & 2014)
Access to improved sanitation (% of population)	MICS (2011 & 2014)
Access to Road infrastructure (Road Density in km/100sqkm)	PDS** (2012 & 2015)
Access to Telephone (% of population with access)	MICS (2011 & 2014)
Access to Computer (% of population with access)	MICS (2011 & 2014)
Access to Mobile Phone (% of population with access)	MICS (2011 & 2014)
Access to Public transport (Public Service Vehicles/1000 population)	PDS (2012 & 2015)
Access to Education facilities (number of facilities per 1000 population)	PDS (2012 & 2015)
Access to Health facilities (number of facilities per 1000 population)	PDS (2012 & 2015), and CHE*** (2016)

Notes: * Multiple Indicators Clusters Survey, ** Punjab Development Statistics, *** Census of Healthcare Establishments in Punjab.