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Evaluation of Developmental Progress in Some Cities of Punjab, Pakistan, Using Urban Sustainability Indicators

Ambreen Ghalib *, Abdul Qadir and Sajid Rashid Ahmad

College of Earth and Environmental Sciences, University of the Punjab, Lahore 54590, Pakistan; aqadir.cees@pu.edu.pk (A.Q.); sajid.geo@pu.edu.pk (S.R.A.)

* Correspondence: ambreen_ghalib@hotmail.com

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Abstract: Sustainable urbanization is a challenge to human beings in the modern era of technology. Cities all over the world are facing several problems due to urbanization and industrialization. Urban problems could be assessed through development of indices of urban sustainability on the basis of its three dimensions: environment, economics and social. The present study was conducted to identify indicators to develop indices for assessment of sustainability in some populated cities of Punjab. The study focused on the indicators based on environmental, economic and social development to develop a rational indicator system on the basis of secondary data collected from 2004 to 2014. A total of 40 indicators were identified to assess the urban sustainability progress in Lahore, Rawalpindi, Multan, Gujranwala and Faisalabad cities. The result of the sub-indices indicated that poor performance was evident in the environmental sector, rather than in the economic and social sectors. The cities scored between 0.27 and 0.58 in environmental dimensions, showing a decreasing trend from 2004 to 2014. The declining trend of indices was due to population influx, rapid urbanization, reduction in green areas, industrialization, high level of atmospheric and water pollutants. In case of the economic sector, an increasing trend was observed which indicates the gradual improvement in living standards of people. In the social dimensions of the indicator system, less variations were observed among the cities and ranged between 0.49 and 0.58. Overall, the results of the urban sustainability index showed score was ranges between 0.41 to 0.52. None of the Punjab cities attained the position as a sustainable city (0.75) Lahore (0.52) and Faisalabad (0.52) were ranked as moderately sustainable cities, whereas, Rawalpindi (0.48), Gujranwala (0.47) and Multan (0.41) were ranked as weak sustainable cities. The study highlighted that the urban sustainability indicator system could be useful to determine the existing sustainability in cities of the developing countries for better resource management practices.

Keywords: city; indicators; sustainable cities; urban sustainability index; sustainable urban development; Punjab

1. Introduction

After the industrial revolution, people started to move rapidly to urban areas [1]. Only 10% of the world's population lived in urban areas in 1900; now, that percentage exceeds 50%, which will increase to 69% by 2050. Only 3% of the world surface is covered with cities and responsible for 75% consumption of world energy, 60% use of residential water, 80% emissions of greenhouse gases and 76% use of wood for industrial purpose. Urban centers have been recognized for the provision of economic growth and development opportunities, education, health care facilities, and social services, which also give better chances for cultural and political participation [2–4]. Apart from all these opportunities for human development and progress, the environment of cities is deteriorating [5,6].

Due to economic, industrial, social and corporate activities, the environment of cities become unhealthy. In addition, competition among the people for resources also triggers the socio-economic problem like public safety, increasing unemployment, social segregation and crime rate that affect the urban quality of life [7]. These problems are the barriers for sustainable development where proper planning, checks and balances were not properly implemented. From this perspective, sustainability of urban centers must be taken as an important step both in science and policy arenas.

Sustainability is a dynamic and multi-dimensional process that takes into account different components of local, regional and global development like environmental quality, economic growth and well-being of the population [8,9]. It was broadly recognized that sustainability has three dimensions, or three pillars: social, economic and environment, which are also known as the triple bottom line [10,11]. While, environmental sustainability concerns making decisions on the protection of the natural environment, economic sustainability intends to efficiently and wisely use resources and make reliable for long term benefits. Social sustainability refers to the support for present and future generations to generate livable and healthy environments [12–14]. The balance between these three dimensions is the aim of sustainable urban development. The economic and social structure of the cities should be improved without compromising on the environment and in order to attain appropriate balance among natural resources and humans [15,16]. Sustainability indicators could be helpful in developing the mechanism to quantify the sustainability level within cities [10]. Indicators with reference to specific urban areas provide information about the state and performance of sustainability, which can be useful for future management of resources [8,17,18].

The urban sustainability index is a useful tool to determine the sustainable progress of city and guide the urban managers, how to develop the conditions conducive to the sustainability [19]. Several studies have been conducted all over the world to evaluate the sustainability and indicator selection criteria. Lee and Huang developed a city based sustainability index on the basis of different clusters of indicators to examine the sustainable development of Taipei on the basis of the four dimensions of indicators: environmental, social, economic and institutional framework [20]. Balachandra and Sudhakara Reddy assessed the sustainability indicators to identify the pattern of urban development in Mumbai and Bangalore, India and compared these metropolitan cities with London [21]. Choon et al., developed the sustainable city index with reference to Malaysia and incorporated indicators into the index to evaluate urban sustainability [19]. Lu et al., developed 22 indicators that grouped into social, environmental and economic subsystem to assess the sustainability of 15 typical resource-based cities in northeast China [22].

Indicators play an important role in building knowledge and displaying the coherent image of urban development [23]. Sustainability indicators not only reflect the environmental pressure but also point out interactive characters between ecological and socioeconomic factors [7,24]. Indicators are the useful tool in providing information to decision makers to address more important issues in development, which is helpful for involving political decision making at the territorial level to promote and generate equilibrium between environment and socio-economic systems. In this way, the measurement of urban sustainability could be possible when urban sustainability indicators are integrated into the index, which provides an ideal and short summary of sustainability. A composite index can be attained from all dimensions, variables, and indicators used [25]. Index and indicators are useful communication tools for both scientists and authorities [19,26].

Pakistan is a developing countries and it economy based upon the agriculture and now gradually shifting to words industrial development. Alam et al., reported that the rapid growing population, urban expansion, increasing demand for the energy and the environmental problems are the major constraints in the economic development [27]. Limited information is available about the magnitude of environmental, social and economic problem of cities in Pakistan. Therefore, this study was focused on the evaluation of sustainability in five cities of Punjab, Pakistan using urban sustainability indices.

2. Study Area

Lahore, Multan, Rawalpindi, Gujranwala and Faisalabad are major cities of Punjab, Pakistan with respect to population which was selected for comparative assessment of sustainable urban development (Figure 1). Lahore is second largest city of Pakistan in term of population (7,684,000 people) and a hub of trade, transportation, politics, education and entertainment. [28]. Faisalabad (3,142,000 people) famous for its industrial growth, having numerous textile mills, chemical plants and fertilizer manufacturing plants [29]. Gujranwala (2,441,000 people) is a commercial and industrial center, playing an important role in supporting the economy [30]. Multan (1,824,000 people) is situated in the southern part of the Punjab and is located on flat alluvial plains with a good agricultural market [31,32]. Rawalpindi has a population of 2,622,000 people and is located in Potohar region [33]. The estimated city populations were followed from the annual report (2105) published by Bureau of statistics, Govt of the Punjab [34].

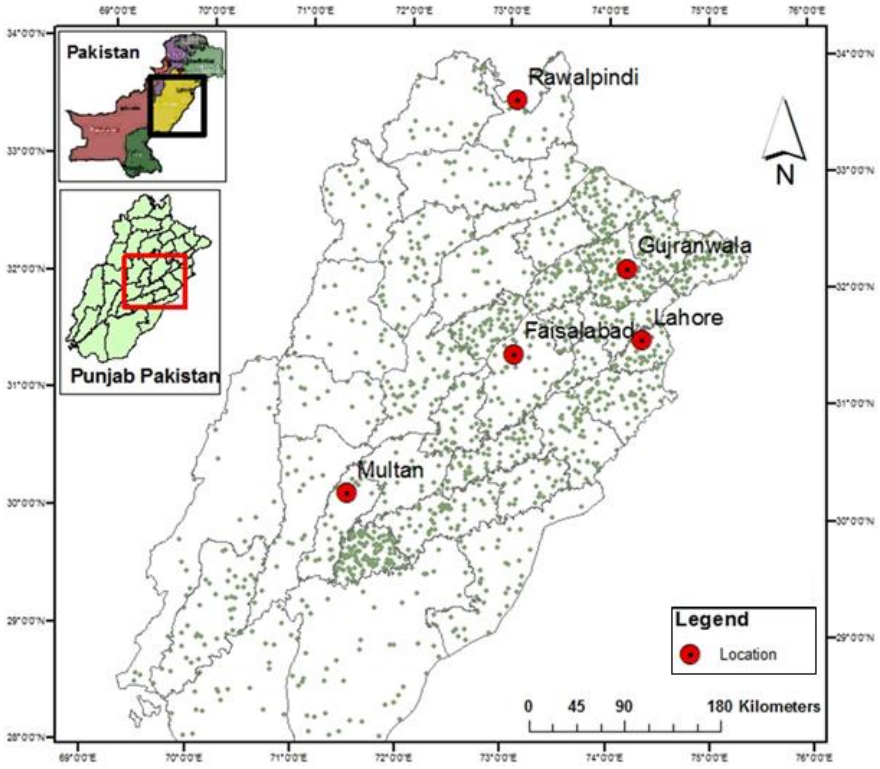

Figure 1. Map of the studied area showing the locations of the five cites of Punjab, Pakistan.

3. Methodology

3.1. Construction of Urban Sustainability Index

To develop the urban sustainability index, a set of indicators (n = 40) based upon environmental, social and economic parameters were selected. The procedure of calculating the index has been carried out by following the various steps which are shown in Figure 2.

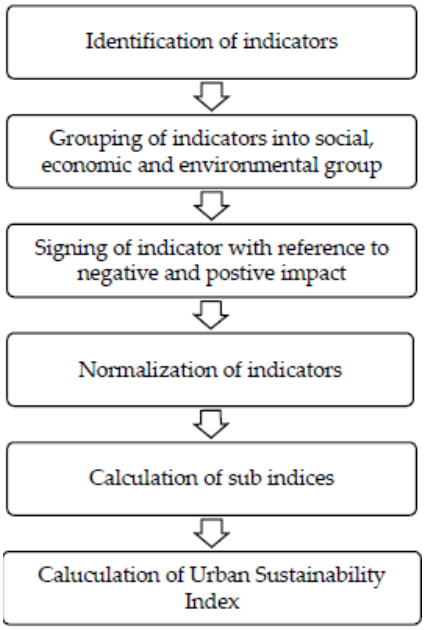

Figure 2. Procedure of calculating urban sustainability index.

3.1.1. Context of Urban Sustainability Indicators

The indicators are the set of urban conditions, processes and management and are considered on the basis of the existing situation of the city's economy, health, environment and social cohesion, which can persist over time. The urban sustainability indicator should be based on the following:

i. Simplicity—an indicator should be simple and reliable, also fully understandable to the citizens [19,20].
ii. Effectivity—an indicator should be flexible enough to accept changes because of minor variations from statistical interference [35].
iii. Independence—the indicator system should be independent, meaning the indicator is used separately to calculate different consequence [36].
iv. Sensitivity—an indicator should be sensitive to space and time changes to show the changes in the dimensions of sustainability [20,37,38].
v. Extensibility—an indicator system should provide entire understanding of the social, economic and environmental health of the city [21].
vi. Quantifiable—an indicator should be based on data for which high quality of information is available [19,39].
vii. Significance to policy—an indicator should be relevant to current and future urban policies [20,38,40].

This study discussed a number of indicators set which were taken on the international agenda, such as The Organization for Economic Co-operation, the European Union EUROSTAT indicator set, The United Nations Commission on Sustainable Development Indicator Set and Development Core indicator set, and United Nations Commission on Sustainable Development [41].

3.1.2. Data

An indicator framework for the cities of Punjab was determined by accessing the data from 2004 to 2014, and were extracted from different sources, i.e., District census reports of Punjab (Punjab Development Statistics 2004–2014); Pakistan social and living standards measurement (PSLM 2004–2014); Multiple indicator cluster survey for Punjab (MICS) and Compendium of Environmental

statistics. Missing data was managed using an ad hoc method [42]. Some data were gathered from departments, i.e., Punjab Health Department, Punjab Environmental Protection Departments, The Urban Unit, Punjab Industries, Commerce and Investment Department and Lahore Waste Management Company.

3.1.3. Grouping and Signing of Indicators

The set of 40 indicators were identified and each indicator was grouped into environmental social and economic dimensions labeled as 'j' shown in Figure 3. The ranking of categories for urban sustainability indicators has been made with the support of logical assessment and literature [21,42–45]. Indicators have both the impact on sustainability, some indicators were responsible in promoting sustainable city and some indicators were the barriers of sustainable development. The indicators were analyzed on the basis of 11 years of data, and the trends of sustainability in every city were accessed. The trend of sustainability indicators was calculated for each city. The principal component was applied to highlight the linear combination of indicators (Appendix A).

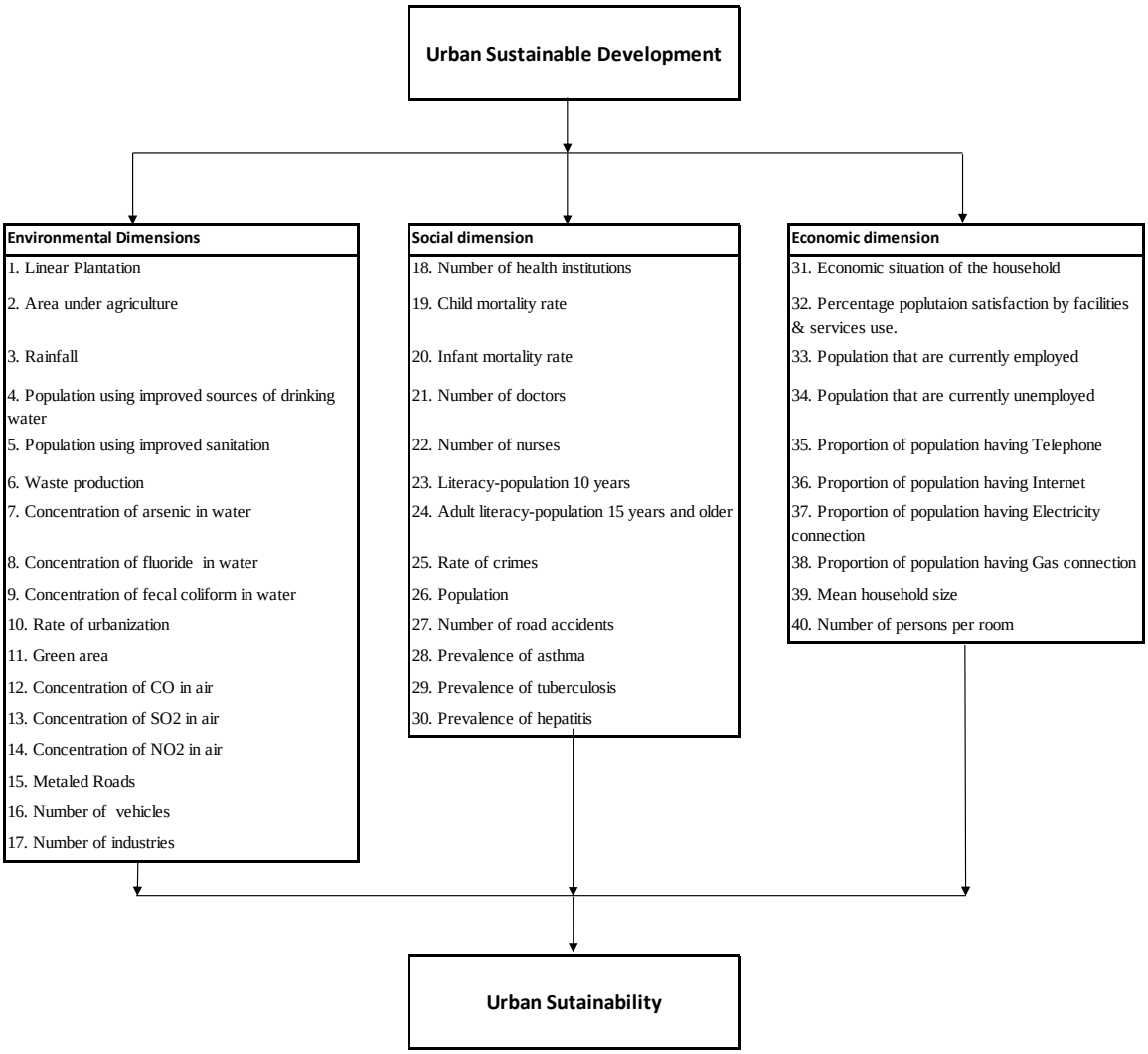

Figure 3. Group of indicators used for urban sustainability index calculation in the five cities of Punjab, Pakistan.

A sign of positive and negative was given to each indicator to indicate the impact of urban sustainability (Table 1). Each dimension has indicators with negative or positive impact on urban

sustainability. In environment, linear plantation has positive impact on the community, as it acts as carbon sinks [45] and continues to improve the quality of air and water, which also effects climate for the reduction of extreme temperature [46]. Agriculture acts as carbon sequestrations [47] and reduces greenhouse emissions by different agriculture practices [48]. Assess of safe water and sanitation decreases water related diseases [49]. Large production of solid waste and mismanagement in collection of wastes causes pollution by matter affecting resources, such as land, natural soil fertility, water purity, and large quantity of aquatic resources [50]. Arsenic, fluoride and fecal coliform have a negative impact on human health, for instance, as seen in the long term intake of arsenic which causes cancer in the lungs, bladder and skin [51]. However excessive intake of fluoride leads to dental and skeletal fluorosis [52]. Fecal coliform caused water pollution due to pathogens which are disease causing organisms [53]. Urbanization and industrialization have negative impact on sustainable development due to reason urbanization change the environment by depletion of natural resources, and in turn pollute the environment by affecting health and quality of life [54]. Carbon monoxide (CO), sulfur dioxide (SO_2), and Nitrogen dioxide (NO_2) are ambient air pollutants. Exposure of NO_2 causing catastrophic injury to humans and SO_2 brings about respiratory diseases [55]. Similarly, indicators of social dimensions have negative and positive impact on sustainable urban development, such as accessibility and availability of doctors and nurse provide patient primary care, as well emergency and urgent services. Literacy rate encourages individuals to get out from poverty, improves the community, empowers girls and women and have positive impacts on economic growth [56]. Expansion of roads has effects on land, water run-off, pollution and sediment load in streams [57]. Economic situation leads to gain material standards necessary for adequate life.

3.1.4. Mathematical Calculation

The previous studies were comprised of some adoptions for calculation of data. The present study was comprised of standard method using maximum and minimum value to each indicator. In this way, all the indicators' values were transformed into normalized values using Equations (1) and (2). This method provided simplification to different indicators that have different units and characteristics. The normalized values were adjusted between 0 and 1 which helps in weighting the indicator that falls within the range of 0 to 1. The value closer to 1 indicates better sustainability while the value closer to zero indicates weak sustainability [19,58].

$$I^{+}_{N,ijt} = \frac{I^{+}{}_{j,it} - I^{+}{}_{min,j,i}}{I^{+}{}_{max,j,i} - I^{+}{}_{min,j,i}} \quad (1)$$

$$I^{-}_{N,ijt} = 1 - \frac{I^{-}_{j,it} - I^{-}_{min,j,i}}{I^{-}_{max,j,i} - I^{-}_{min,j,i}} \quad (2)$$

where $I^{+}_{N,ijt}$ is the normalized indicator i with a positive impact for j group of indicator at time (year) t; and $I^{-}_{N,ijt}$ is the normalized indicator i with negative impact for j group of indicator at time t; $I^{+}{}_{min}$ is the indicator of positive impact with minimum value and $I^{+}{}_{max}$ is the indicator of positive impact with maximum value. I^{-}_{min} is the indicator of negative impact with minimum value and I^{-}_{max} is the indicator of negative impact with maximum value [59]. Sub-indices ($I_{S,jt}$) were calculated for group of indicators for j by using Equation (3).

$$I_{S,jt} = \frac{1}{N}\sum_{j,it}^{N} I^{+}_{N,ijt} + I^{-}_{N,ijt} \quad (3)$$

Table 1. Trends of urban sustainability indicators for five major cities of Punjab, Pakistan.

Indicators	Units	Index Properties	Lahore	Faisalabad	Gujranwala	Multan	Rawalpindi
Environment Dimension							
Env_1-Linear plantation	Hectares						
Env_2-Area under agriculture	Thousand hectares	Positive					
Env_3-Rainfall	Millimeters	Positive					
Env_4-Population using improved sources of drinking water	%	Positive					
Env_5-Population using improved sanitation	%	Positive					
Env_6-Waste production	Tons	Negative					
Env_7-Concentration of arsenic in drinking water	As (ppb)	Negative					
Env_8-Concentration of fluoride in drinking water	F (ppm)	Negative					
Env_9-Concentration of fecal coliform in drinking water	Fecal Coliform (00/100 mL)	Negative					
Env_{10}-Rate of urbanization	Square kilometers	Negative					
Env_{11}-Green area	Square kilometers	Positive					
Env_{12}-Concentration of Carbon monoxide in air	CO (mg/m^3)	Negative					
Env_{13}-Concentration of Sulphur dioxide in air	SO_2 (ug/m^3)	Negative					
Env_{14}-Concentration of Nitrogen dioxide in air	NO_2 (ug/m^3)	Negative					
Env_{15}-Metaled Roads	Kilometers	Negative					
Env_{16}-Number of vehicles	Number	Negative					
Env_{17}-Number of industries	Number	Negative					
Social Dimension							
Soc_1-Number of health institutions	Number	Positive					
Soc_2-Rate of child mortality and infant mortality	%	Negative					
Soc_3-Rate of child mortality and infant mortality							
Soc_4-Number of doctors	Per thousand person	Positive					
Soc_5-Number of nurses	Per thousand person	Positive					
Soc_6-Literacy-population 10 years	%	Positive					
Soc_7-Adult literacy rate	%	Positive					
Soc_8-Rate of crimes	Number	Negative					
Soc_9-Population	Per thousand person	Negative					
Soc_{10}-Population Number of road accidents	Number	Negative					
Soc_{11}-Prevalence of asthma	%	Negative					
Soc_{12}-Prevalence of tuberculosis	%	Negative					
Soc_{13}-Prevalence of hepatitis	%	Negative					
Economic Dimension							
Econ $_1$-Economic situation of the household	%	Positive					
Econ $_2$-Percent distribution of household's satisfaction by facilities & services use	%	Positive					
Econ $_3$-Population that are currently Employed	%	Positive					
Econ $_4$-Population that are currently Unemployed	%	Negative					
Econ $_5$-Proportion of household having Telephone	%	Positive					
Econ $_6$-Proportion of household having Internet	%	Positive					
Econ $_7$-Proportion of household having Electricity	%	Positive					
Econ $_8$-Proportion of household having Gas	%	Positive					
Econ $_9$-Mean household size	%	Negative					
Econ $_{10}$-Mean household size and the number of persons per room	%	Negative					

Note: ↗ toward sustainability; ↘ away from sustainability; → experienced some changes.

Equation (3) provides assessments of environmental, economic and social dimensions/group of sustainability as intermediate outputs. Finally, urban sustainability index (I_{USI}) was calculated by combining sub-indices using Equation (4).

$$I_{USI} = \frac{1}{N}\sum_{j,t}^{N} S_{j,t} \quad (4)$$

Equation (4) for the urban sustainability index enables the assessment and comparison of urban sustainability performances for understanding the impact of cities on the human life and environment, and also provides the tool to evaluate city sustainability.

The urban sustainability index was developed using the above methodology and classification system, which was developed by Li, et al. [36], and was adapted. Four level classification of urban sustainability were determined: sustainable (Level I; >0.75), followed by moderately sustainable (Level II; 0.50–0.75), poorly sustainable (Level III; 0.25–0.50) and then unsustainable (Level IV; <0.25).

The present study adopted an equal weight method for analyzing the sustainability index. For confirmation of results obtained through urban sustainability index, the sensitivity test was applied. The sensitivity test for urban sustainability index was based on weight selection criteria. In this regard, a questionnaire was developed on the basis of existing environmental, social and economic situation of the cities and distributed to 30 experts from environment, energy, ecological, law, economy, management, policy and social development. Over all, experts gave the opinion 75% environment, 46% social and 23% to economic situation of the urban areas.

4. Results

4.1. Sustainability Indicator Trends for Cities of Punjab

The indicators of environmental dimension showed that in all cities rate of urbanization, concentration of arsenic and fluoride in drinking water, concentration of fecal coliform, production of solid waste was rapidly increased, which have strongly negative impacts on the environment (Table 1). The increase of urbanization and industries contributed to a decrease in green resources, due to which CO, SO_2 and NO_2 concentrations were increased in the atmosphere, causing respiratory problems in humans. Among the indicators of social dimensions, the annual rate of crimes, number of road accidents, and percentage of child mortality, number of motor vehicles, metalled roads, prevalence of asthma, tuberculosis and hepatitis was increasing rapidly, which shows a negative impact on urban sustainability wherein the social development moves away from sustainable development. The indicators of the economic dimensions showed that there some issues of unemployment, which has a negative impact on sustainability. In case of unemployment, a decreasing trend was observed in Lahore city, as compared to other cities. Indicators, including percentage population that was currently employed, proportion of population having internet, proportion of population having electricity, proportion of population having gas showed increasing trends in respective cities.

4.2. Sub-Index and Urban Sustainability Index for Cities of Punjab

4.2.1. Environmental Sub-Index of the Cities

The environmental dimension of urban sustainability among the five cities shown in Figure 4, indicated that Lahore ranked as moderately sustainable (0.57; Level II) in 2004, rose to 0.62 in 2005 then gradually declined to its ebb (0.38; Level III) in 2014. Faisalabad was categorized as moderately sustainable (0.61; Level II) in 2004 then declined after 2008 to poorly sustainable (0.37; Level III) in 2014. However, Gujranwala demonstrated 0.62 (Level II) in 2005, and then after ten years in 2014 attained (0.32; Level III). While Multan was moderately sustainable with the value of 0.64 and 0.58 (level II) in 2005 and 2007, this gradually decreased to poorly sustainable (0.27; Level III) in 2014. Moreover, Rawalpindi scored 0.55 (Level II) in 2004 with little variation in eleven years, and decreased to 0.39

in 2014. All cities, namely Lahore, Faisalabad, Gujranwala, Rawalpindi, and Multan showed poorly sustainable in the environmental dimension in 2014, as compared to the 2004.

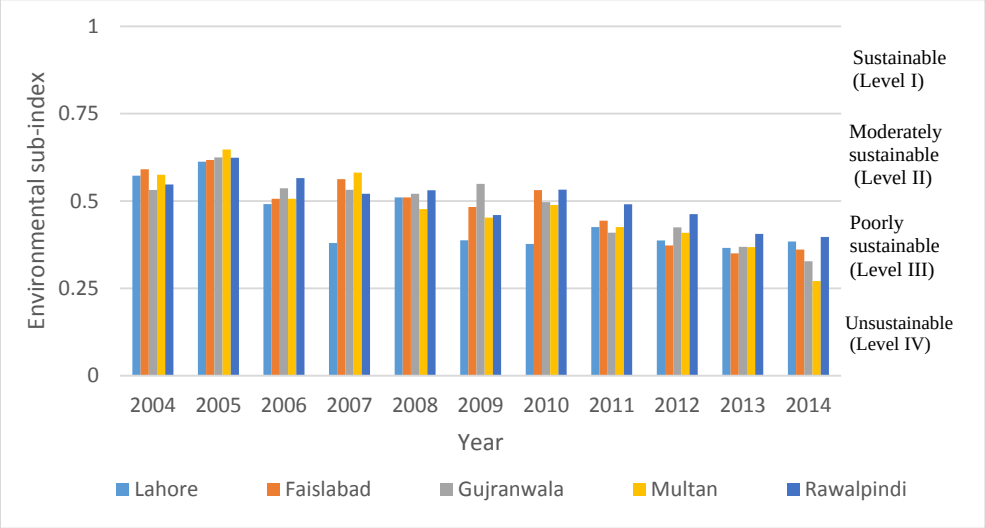

Figure 4. Trend of the environmental dimension (sub-index) for five cities of Punjab, Pakistan.

4.2.2. Social Sub-Index of the Cities

The social dimensions of cities from the year 2004 to 2014 shown in Figure 5. In 2004, the social dimension of sustainability of Lahore recorded as 0.41 (Level III), which decreased to lowest (0.31) in 2008 then gradually improved and reached highest (0.59; level II) in 2014. In the case of Faisalabad, the lowest value of the social dimension sub index was recorded as (0.46; Level III) in 2004 then gradually improved to its highest value (0.54; Level II) in 2014. However, in Gujranwala city, it was ranked as Level II (0.55), in 2004, and then declined to the ebb (0.43; Level III) in 2014. Multan scored (0.47; Level II) in 2004 and attained highest level in 2005 to 2011 then declined to lowest (0.42; Level II) in 2014. Similarly, Rawalpindi attained (0.51; Level III) in 2004, increased to highest (0.57; Level II) in 2011 then declined to 0.43 in 2014 (Level III). Among these cities Faisalabad and Lahore showed little social progress while other cities exhibited a decreasing trend.

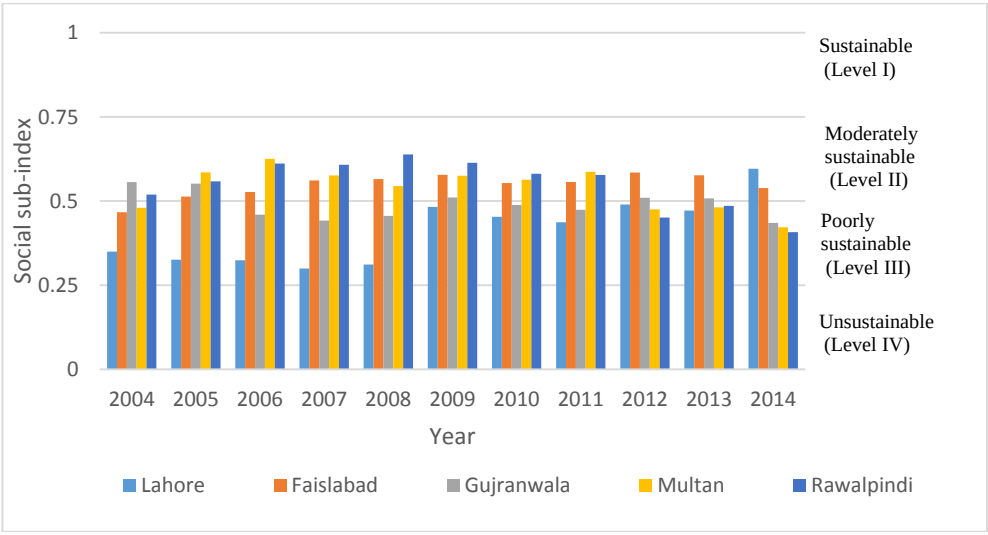

Figure 5. Trend of the social dimension (sub-index) for the five cities of Punjab, Pakistan.

4.2.3. Economic Sub-Index of the Cities

The trend of economic development is shown in Figure 6. An increasing trend in economic dimension of sustainability of Lahore was observed from 2004 (0.30; Level III) to 2014, where it achieved 0.62 (Level II). A similar trend was observed in the case of Faisalabad, with the lowest score (0.37; Level III) in 2004 and highest (0.59; Level II) in 2014. However, Gujranwala was at (0.32 Level III) in 2004, with tremendous progress, showing an increasing trend (0.67; Level II) in 2014. In contrary to other cities, Multan demonstrated negative economic growth from 2004 (0.52; Level II) and decreased to lowest (0.48 Level III) in 2014. Moreover, Rawalpindi showed weak economic dimensions was at (0.32; Level III) in 2004, whereas, 2014 has get rise it achieved moderate (0.63; Level II) in 2014. All cities: Lahore, Faisalabad, Gujranwala and Rawalpindi showed increasing trends followed by Multan.

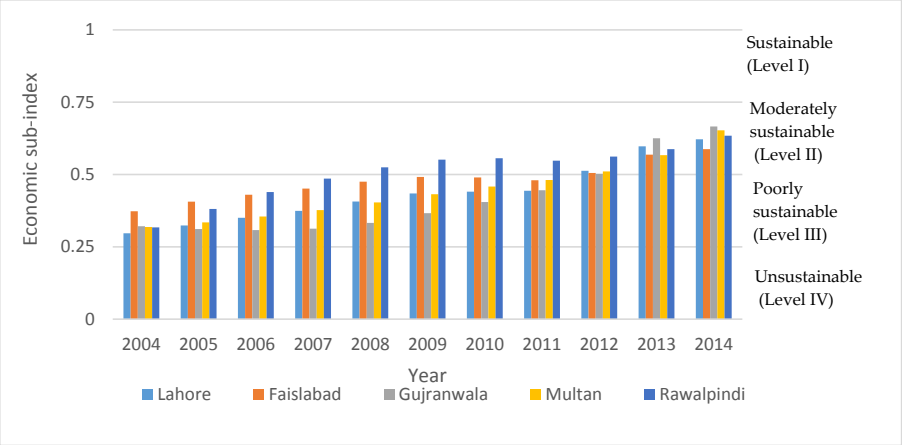

Figure 6. Trend of the economic dimension (sub-index) for the five cities of Punjab, Pakistan.

4.2.4. Urban Sustainability Index

Most of the cities of Punjab are growing and expanding rapidly, thus the sustainable urban development is very important to attain the sustainable urbanization in Punjab. The urban sustainability index was calculated as: Lahore (0.52, moderately sustainable), Faisalabad (0.52, moderately sustainable), Multan (0.41; poorly sustainable) and Gujranwala (0.47; poorly sustainable) and Rawalpindi (0.48; poorly sustainable). None of the cities achieved a sustainable level of 0.75 or above. Lahore and Faisalabad attained moderate levels, while Gujranwala, Rawalpindi and Multan fit into the weak category of sustainability (Figure 7).

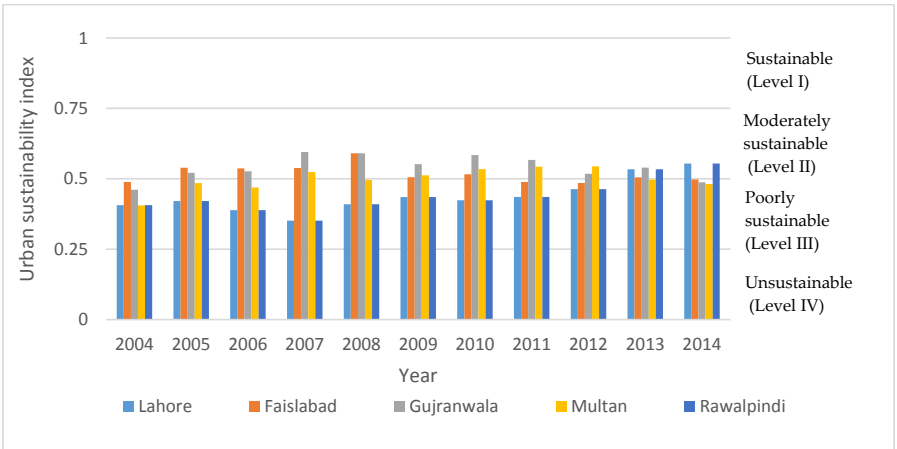

Figure 7. Trend of urban sustainability index for the five cities of Punjab, Pakistan.

Principal Component Analysis identified the first four Principal Components as major contributors and explained the maximum variations within data set. The first principal component was associated with indicators related to urban infrastructure and socio-economic factors. The second principal component was associated with the urbanization and of air and water pollution. The third principal component exhibited correlation with the human population and services. The fourth principal component was inclined with indicators reflecting the urban environmental health (Table A1).

5. Discussion

Cities are the centers of economic, administrative and cultural activities which are governed by some regulatory authorities [60]. These centers are the repositories of major resources, where most of the commodities are consumed by people to maintain their living requirements. Industries, communication, networks and markets are established to fulfill human demands. Rapid expansion and development of cities creates several problems related to the environment and socio-economics. In developed countries, governments are focused on the management of cities and problems related to the environment, whereas, in developing countries, high population, limited resources and poor administration are major constraints [61].

A number of studies have been carried out with a diverse range of work in different parts of the world that refers, in one way or another, to urban sustainability (Table 2). Lee and Huang [20] developed sustainability for Taipei, Taiwan. Reddy and Balachandra conducted study on mega-cities of India Mumbai and Bangalore and compared with London, Singapore and Shanghai [62]. Li et al. evaluated urban sustainable development on Jinning city [36]. Choon et al. assessed sustainable city index on major cities of Malaysia [19]. In the present study, the sustainability index of the studied cites was ranged from 0.41 to 0.52. It was found that the sustainability index values were lower than Bangalore (India), Mumbai (India), London (UK), Singapore, Shanghai (China), Jining (China), Taipei (Taiwan), Kuala Lumpur (Malaysia), Ipoh (Malaysia) and Shah Alam (Malaysia) shown in Table 2.

The urban sustainability index for Lahore, Faisalabad has attained a moderate level, whereas, Gujranwala, Rawalpindi and Multan have a weak level of urban sustainability. Although all five cities were succeeding towards sustainable urban development, economic dimensions make substantial positive contributions to overall urban sustainability; however, the decline of natural resources and environmental degradation negatively influenced overall urban sustainability. Therefore, it is suggested to take some concrete steps for environmental protection and management in Punjab. Sustainable urban development cannot be achieved by only economic development; in fact, it is dependent on how economic and environmental sustainability are managed in these cities.

In comparison, the environmental sustainability index assessed the condition of environment, which was weak in Punjab, and to improve the level of environmental conditions, planners must emphasize control of the growth of industries inside and outside of the urban areas, unplanned urbanization, reduction in vegetation cover, waste management, effluents treatments and air pollution. Social performance in the Punjab cities attained moderate levels of sustainability. In this regard, there is a need to improve the limited health facilities, water borne diseases and epidemics, social injustice, corruption and extremism. The economic dimension in the Punjab cities were moving towards sustainability and the cities have an opportunity to develop its potential sustainability by focusing on wise resource utilization and the need to improve communications gadgets, institutional coordination, energy resources and investment.

There are several reasons for the low scoring of urban sustainability in major cities of the Punjab. In Punjab, Pakistan there are several factors responsible for this growing challenge such as high population growth rate, industrial growth, migrations, and employment and socio-political factors [63]. Social performance in Punjab cities attained moderate levels of sustainability. In this regard, there is a need to improve social securities, health, education facilities. Khyber Pakhtunkhwa, Baluchistan and urban Sindh have been facing the problem of terrorism and insurgency, which trigger the migration of families from disturbed areas to the urban areas of Punjab. In this regards, a regular monitoring

required for the social and political situation because improved socio political situation can lead the cities to words sustainability.

Table 2. Comparison of urban sustainability index of Punjab cities and other international cities.

Cities	Number of Indicators	Sustainabilty Index Score	Sustainability Status	Sources
Lahore, Pakistan	40	0.52	Moderate	Present study
Faisalabad, Pakistan	40	0.52	Moderate	Present study
Gujranwala, Pakistan	40	0.47	Weak	Present study
Multan, Pakistan	40	0.41	Weak	Present study
Rawalpindi, Pakistan	40	0.48	Weak	Present study
Bangalore, India	60	0.59	Moderate	[62]
Mumbai, India	60	0.67	Moderate	[62]
London, England	60	0.79	Excellent	[62]
Singapore	60	0.77	Excellent	[62]
Shanghai, China	60	0.669	Moderate	[62]
Jining, China	52	0.62	Moderate	[36]
Taipei, Taiwan	51	0.71	Moderate	[20]
Kuala Lumpur, Malaysia	38	0.64	Moderate	[19]
Ipoh, Malaysia	38	0.62	Moderate	[19]
Shah Alam, Malaysia	38	0.62	Moderate	[19]

6. Conclusions

The present study evaluated the urban developmental progress of cities using the information collected from different sources related to environmental, social and economic dimension in a balanced way. The overall developmental performance of the studied cities was moderate and poor on the basis of the sustainability index. Even the cities having moderate performance were situated near the border line of poor categories. Overall environmental indicators showed a declining trend, whereas, an increasing trend was observed in the case of economic indicators. No significant change was observed in the case of social development. The major stigma to attain the sustainability is the environmental constraints in different cities of Punjab. There is dire need to address environmental issues of these cities to improve the progress towards sustainability. Environmental laws and acts already exist in the provisional and national constitutions but improper implementation is the major obstruction. The present study is not only helpful for the government officials to identify the status of sustainable development in urban areas, but is also helpful for the authorities to make environmental protection policies and take actions on the basis of assessment results for protection of Environment. The present study could be the extended further to assess the governance system of the cities. Firstly, it can be extended to include the performance of the different departments contributing to the provision of services, management and administration within cities. Secondly, it can be extended to develop strategies to minimize the contribution of those factors, which dwindles the sustainability. Thirdly, in this study we focused on the major cities of Punjab to evaluate the sustainability; it could be extended to the other cities of Pakistan.

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Appendix A

Table A1. Factor loadings of sustainability indicators on first four Principal Components (PCs) of data collected from the five cities of Punjab, Pakistan.

Indicators	Indicator Code	Principal Components			
		PC 1	PC 2	PC 3	PC 4
1. Linear Plantation	Env. 1	0.648	0.143	−0.528	0.530
2. Area under agriculture	Env. 2	−0.816	−0.339	−0.091	−0.459
3. Rainfall	Env. 3	0.557	0.820	0.099	−0.084
4. Population using improved sources of drinking water	Env. 4	−0.484	0.026	0.840	0.242
5. Population using improved sanitation	Env. 5	−0.484	0.026	0.840	0.242
6. Waste production	Env. 6	−0.582	0.312	0.697	0.277
7. Concentration of arsenic in water	Env. 7	−0.494	0.858	−0.138	0.032
8. Concentration of fluoride in water	Env. 8	−0.643	−0.141	0.529	0.536
9. Concentration of fecal coliform in water	Env. 9	0.728	0.266	−0.358	−0.520
10. Rate of urbanization	Env. 10	−0.195	0.400	−0.182	−0.877
11. Green area	Env. 11	0.197	−0.408	0.183	0.872
12. Concentration of CO in air	Env. 12	−0.102	−0.760	−0.590	0.252
13. Concentration of SO_2 in air	Env. 13	0.101	−0.898	−0.417	0.101
14. Concentration of NO_2 in air	Env. 14	0.091	−0.893	−0.427	0.107
15. Metaled Roads	Env. 15	0.780	0.215	0.035	0.586
16. Number of vehicles	Env. 16	−0.702	0.017	−0.502	0.505
17. Number of industries	Env. 17	−0.527	−0.648	0.014	−0.549
18. Number of health institutions	Soc. 1	0.190	−0.694	−0.620	0.313
19. Child mortality rate	Soc. 2	−0.910	−0.345	0.009	0.229
20. Infant mortality rate	Soc. 3	−0.764	−0.622	0.032	0.170
21. Number of doctors	Soc. 4	0.453	0.027	0.777	−0.437
22. Number of nurses	Soc. 5	−0.270	−0.824	−0.256	0.426
23. Literacy-population 10 years	Soc. 6	0.613	−0.543	0.489	−0.301
24. Adult literacy-population 15 years and older	Soc. 7	0.335	−0.773	0.535	−0.058
25. Rate of crimes	Soc. 8	−0.560	−0.347	−0.440	−0.610
26. Population	Soc. 9	−0.256	0.501	−0.808	0.177
27. Number of road accidents	Soc. 10	−0.898	0.100	−0.349	0.251
28. Prevalence of asthma	Soc. 11	−0.102	0.742	−0.509	0.425
29. Prevalence of tuberculosis	Soc. 12	−0.689	0.700	−0.028	−0.187
30. Prevalence of hepatitis	Soc. 13	−0.210	0.212	0.095	0.950

Table A1. *Cont.*

Indicators	Indicator Code	Principal Components			
		PC 1	**PC 2**	**PC 3**	**PC 4**
31. Economic situation of the household	Econ 1	0.268	−0.491	0.816	0.145
32. Percentage population satisfaction by facilities & services use	Econ 2	0.331	0.109	−0.834	0.428
33. Population that are currently Employed	Econ 3	0.747	0.221	0.264	0.569
34. Population that are currently Unemployed	Econ 4	0.598	0.267	0.704	0.276
35. Proportion of population having Telephone	Econ 5	0.604	0.364	−0.620	−0.344
36. Proportion of population having Internet	Econ 6	0.605	−0.733	−0.286	0.122
37. Proportion of population having Electricity connection	Econ 7	−0.822	0.161	0.534	0.114
38. Proportion of population having Gas connection	Econ 8	−0.814	0.286	−0.457	0.217
39. Mean household size	Econ 9	−0.952	0.285	−0.043	−0.104
40. Number of persons per room	Econ 10	−0.263	−0.875	0.039	−0.403
	Expl.Var	12.945	10.733	9.355	6.968
	Prp.Totl	0.324	0.268	0.234	0.174
Sources of Variation		**Infrastructure and socio economic factors**	**Urbanization, pollution factor**	**Population and services**	**Environmental Health**

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