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# Measuring Sustainable Development through Eco-efficiency: A Case Study of Mega Cities of Pakistan

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## Abstract

*Imbalanced and unplanned social and economic development along with urbanization is the main reasons for environmental degradation in Pakistan. Eco-efficiency approach is used to make development tangible so that sustainable urban development can be promoted. Eco-efficiency of Karachi is found lowest among all other cities. Lahore has the high prosperity score as compared with Karachi but its eco-efficiency is greater than Karachi. Differences in eco-efficiency among cities are fare more than the differences in prosperity scores. Eco-efficiency is not found in accordance with the pattern of spatial development in Pakistan. It has been suggested that distinguished polices should be developed by the Government as per the need of the cities. Current study calls forth the recognition of eco-efficiency by Government and the masses in order to put it into implementation for sustainable urban development.*

**Key Words:** Urbanization, Eco-efficiency, Cities, Development, Environment
**JEL Codes:** D61, O44, Q01, Q56.

## 1 Introduction

Urbanization is a continual process throughout the world. Urban population growth of the world is found more than the overall population growth (UNFPA, 2007). Cities contain 74% of the population of developed countries (United Nations, 2007). However, most of the population growth is projected to occur in developing countries by 2035(Cohen, 2006). Moreover, developing countries are facing unprecedented increase in urban population growth. Analogous to the other developing countries,

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urbanization in Pakistan has increased from 17% to 36% during the last 6 decades. Urban development in Pakistan is going through a dynamic change as it has the highest 3% level of urbanization as compared with 2.7% urbanization growth rate of South Asian countries (TFR, 2009).

This pace of urbanization process poses serious challenges related with urban governance, poverty and provision of public services. Moreover, higher growth in urbanization cause serious issues that restrict sustainable urban development (Grimm et al., 2008). Similarly, rapid growth in urbanization has degenerated quality of life in Pakistani cities. Annual Development Plan 2011-12 reported that all major cities of Pakistan face haphazard, unplanned expansion leading to increase in pollution and has created slums. Socioeconomic inequality and environmental degradation are the two most common outcomes of urbanization. Specifically, traffic congestion, social and economic disordered, reduction in biodiversity, water and air quality deterioration are a cause of dense conditions.

Socio-economic conditions of plenty of urban population are very poor. 1/5th of urban population in Pakistan is considered as poor (Human Development Report) (Economics & Information, 2009) and 1/3rd of urban population is residing in slums or kacchi abaadi. Only 15% of urban population has access to safe drinking water. Moreover, Pakistan is ranked at number 80 among 122 nations regarding drinking water quality. Drinking water sources, both surface and groundwater are contaminated with coliforms, toxic metals and pesticides throughout the country (Azizullah, Khattak, Richter, & Häder, 2011). According to Pakistan council for research in water resources; less than 1% of waste water is treated in the country. The pressure on resources is mounted due to rising share of urban population (Pakistan Bureau of Statistics, 2017). The socio-economic an environmental problems of metropolitan cities as informal settlements, improper basic facilities, lack of clean water, inadequate sanitation and solid waste management facilities, environmental pollutions, inconvenient public transport, stagnation of economic activities, poor governance are the great hindrances in making cities sustainable (Mangi. et al., 2020).

Perusal economic activities through traditional approaches is making Pakistani cities more vulnerable and results in worsening the environmental factors of the country as Besides other environmental factors, Pakistani cities are considered vulnerable under any change in environment as majority of the cities' air quality index is more than the desirable limits . In majority of the cities it is ranked as moderately to hazardous for air quality index (World most polluted cities 2020). As in major cities air quality is exceeding the national guidelines, Lahore and Gujranwala are observed as in the list of top polluted countries worldwide ( Anjum et al., 2021).

The problem of urbanization and urban development is getting recognition in the documents of MTDF and annual development plans but consideration is not given up to the mark as related socio economic problems are continuously swelling in Pakistan putting higher demand on environment and hence affecting the process of sustainable development in the country. It is therefore important to comprehend the process of urbanization in different regions and design appropriate policies for sustainable development. But lack of information on magnitude and direction of the environmental variables in Pakistan make it difficult to calculate and compare sustainability of the cities (Ghalib et al., 2017).

The Vision 2030(PC, 2007) and the Framework of Economic Growth for Pakistan recognized the cities as primary engines of growth, development, and innovations. Cities are facing inevitable problems as social-disorder, deterioration in the quality of air and water traffic congestion etc comprehensive response to such achievements and solution to the above mentioned problems require development of sustainable cities. Least efforts have been put in understanding the link between economic activities and environmental factors for city level analysis. Therefore, extent and nature of this environment-economic link need to be understood.

In order to underrated the environmental-economic link; a composite measure relating different sets of economic and environmental variables is considered as a unique approach (Singh et al., 2012). To make sustainability tangible a proposed measure is using eco- efficiency approach (Mickwitz et al., 2006 , Yin et al., 2014).

The rest of the paper is organized as follows. Section 2 presents the background of sustainability considering Eco-efficiency. Section 3, depicts the methodology adopted by the study. Data collection is presented in Section 4. Results and discussions are described in section 5. Section 6 concludes the findings and provides suggestions for policy implications. References are presented at the end of the paper.

## 2 Literature Review

Substantial amount of literature is available on sustainable development since the launch of the term in 1980. Development is sustainable if it doesn't harm the interests of future generations Social, economic and environmental sustainability are considered as the present dimensions of sustainability (Basiago, 1998; Koglin, 2009). Sustainable cities got official recognition in City Summit in 1996 (Satterthwaite, 1997). Number of approaches, definition and implementation for sustainable urban development are found in literature. "A 'sustainable city' is organized so as to enable all its citizens to meet their own needs and to enhance their well-being without damaging the natural world or endangering the living conditions of other people, now or in the future." (Girardet, 1999). Some studies has advocated the reduction for ecological footprint of the cities (Rees & Wackernagel, 1996). Adverse Effects on living environment can be reduced by reduction emissions from the usage of resource (Blowers & Pain, 1999; Bromley, Tallon, & Roberts, 2007); it has also been argued that changes in urban structure and built environment can endorse sustainable cities (Attoh-Okine, Cooper, & Mensah, 2009; Jabareen, 2006; Jenks, Burton, & Williams, 1996). Some studies has focused on participatory approaches to achieve the same purpose (Agyeman & Evans, 2004; Lafferty, 2004). It has also been observed that there is a limited understanding of principles sustainability low implementation is resulted (Agyeman, 2003).

Sustainable development has been adopted as a fundamental strategy of development by many countries since United Nations Conference on Environment and Development (UNCED) in 1992. It has been accepted widely as goal of development rather than the mean of transforming unsustainable to sustainable development.

Strategies for the utilizing the natural resources optimally plays an important role in sustainable development. It is useful to assess the sustainable development with the concern of developing cities sustainably. Construction of composite indicator is required for the evaluation of sustainable development (Singh, Murty, Gupta, & Dikshit, 2012). Currently, many indicators are available for measuring sustainable development. A set of well-defined and harmonized indicators is considered the only way to make sustainability tangible. It is recognized as most appropriate approach besides having many issue regarding quality of data, comparability (Reed, Fraser, & Dougill, 2006)

Eco-efficiency is proposed as a route for transformation to sustainability; indicates an empirical relationship between economic activity and its environmental impact (Mickwitz, Melanen, Rosenström, & Seppälä, 2006).

The term eco efficiency can be linked with environmental efficiency; which was pursued in 1970 (McIntyre & Thornton, 1978). It has received significant importance on literature in sustainable development. Eco-efficiency was considered a way to promote the link between business and development. (Choucri & Berry, 1995; DeSimone & Popoff, 2000; Reith & Guidry, 2003). It can also be viewed as a link between efficiency in economic activity with natural goods and services used (Zhang, Bi, Fan, Yuan, & Ge, 2008). Moreover, in eco-efficiency ecological resources are compared if they have ability to meet economic needs (Ren et al., 2020).

The concept of eco-efficiency has gained substantial attention at different levels. Application of the concept has been found at corporate level (Hahn, Figge, Pinkse, & Preuss, 2010), products (Cerutti, Beccaro, Bagliani, Donno, & Bounous, 2013) and industrial sectors (Oggioni, Riccardi, & Toninelli, 2011; Wang, Liu, Hansson, Zhang, & Wang, 2011). Currently this concept has been extended to assess eco-efficiency between the regions (Kielenniva, Antikainen, & Sorvari, 2012; Yu, Chen, Zhu, & Hu, 2013) and between cities (Reed et al., 2006; Yin, Wang, An, Yao, & Liang, 2014, Liu et al., 2020). Eco-efficiency is a multi- dimensional concept; it includes inputs and outputs having different units. Prefix eco means economic and environmental efficiency. It is the comparison of the ratios of the change in economic output to the ecological impact (Schaltegger & Burritt, 2000).

To calculate eco efficiency , the indicators of GDP are used as denominator and for numerator the energy and water used, material consumption and indicator for environmental impact as waste water, solid waste generated, greenhouse (GHG) and acidic gaseous emissions are used(Yin et al., 2014). Ratio can be significant, numerator and denominator can be converted into single score. But the indicators have different units so cannot be integrated into single value. Moreover, integration of ecological impact in single unit also requires assigning them the appropriate weights.

Considering the weighting system of eco efficiency, once score can be computed using life cycle analysis (Cerutti et al., 2013) and converting the numerator (ecological) into some substitutable number through energy indicator(Li, Bao, Xiu, Zhang, & Xu, 2010), ecological footprint indicator (Cerutti et al., 2013) and material flow analysis indicators(Seppäläa et al., 2005) And one other way is to employ factor analysis(Singh et al., 2012) and principal components analysis (Jollands, Lermit, & Patterson, 2004). Recently, the data envelopment analysis (DEA) model has got special attention for eco-efficiency analysis as it doesn't require to specify weights for ecological indicators as it is a unit free measure (Wu, Yang, & Liang, 2006).

## 3 Methodology

Data envelopment analysis (Charnes, Cooper, & Rhodes, 1978; Farrell, 1957) has a good potential for aggregating different environmental pressures to construct an encompassing of eco-efficiency indicators as it requires no explicit weight(Allen, 1999). Output of the DMU(decision making units) neither considered good or bad but from ecological point of view emissions that are generated from economic activity are not desirable so known as undesirable output of economic process (Dyckhoff & Allen, 2001; Zhang et al., 2008). Undesirable output is considered as inputs so that DMU reduce the use of inputs and desirable outputs to increase eco-efficiency. Considering the above perspective current paper has employed the model for eco efficiency used by Yin et al. (2014) and Zhang et al. (2008) . Assume there are n homogeneous decision-making units, and consuming m inputs and producing p outputs. The outputs corresponding to indices 1,2,. . .,k are desirable, and the outputs corresponding to indices k + 1,k + 2,. . .,p are undesirable. The goal is to maximize the desirable outputs while excluding undesirable outputs. In the model,  and  are the matrices which consisting of non-negative elements and containing the observed input and output measures for the DMUs. The matrix Y is decomposed into two parts,  where a k × n matrix Yg stands for "good" outputs and a (p − k) × n matrix Yb stands for "bad" outputs. The model further assumes that there are no duplicated units in the data set. Vector of inputs consumed by DMUj is denoted by xj(the jth column of X) and the quantity of input i consumed by DMUj is denoted by xij. A similar notation is used for outputs. Occasionally, the vector yj is decomposed into two components, where the vectors  and  refer to the desirable and undesirable output values of unit j, respectively. Based on the Charnes et al. (1978) model; Yin et al. (2014) and Zhang et al. (2008) Yin et al, 2014 developed and used the following model considering the undesirable output an inputs.

$$\max = \frac{\sum_{r=1}^{k} u_r y_{r j_0}}{\sum_{i}^{m} v_i x_{i j_0} + \sum_{r=k+1}^{s} u_r y_{r j_0}}$$

$$S.t. \frac{\sum_{r=1}^{k} u_r y_{r j}}{\sum_{i}^{m} v_i x_{i j} + \sum_{r=k+1}^{s} u_r y_{r j}}$$

$$j = 1, 2, \ldots, n; u \geq 0, v \geq 0,$$
$$i = 1, 2, \ldots, m; r = 1, 2, \ldots, s$$

The input oriented CCR primal model is as follows

$$\min[\theta - \varepsilon E^T (S^g + S^b + S^-)]$$

$$s.t.: \sum_{j=1}^{n} \lambda_j X_j + S^- = \theta X_{j_o},$$

$$\sum_{j=1}^{n} \lambda_j Y_j - s^g = Y_{j_0}^g,$$

$$\sum_{j=1}^{n} \lambda_j y_j^g + s^b = \theta y_{j_0}^b,$$

$$\lambda \geq 0, s^g \geq 0, s^b \geq 0, s^- \geq 0,$$

$$\varepsilon \succ 0,\ j = 1, 2, \ldots, n,$$

$s^-$ & $s^b$ are excess in inputs and bad outputs respectively and $s^g$ is the shortage of good output.

DMU $(x_0, y_0^g, y_0^b)$ is efficient in the presence of undesirable output if and only if $\theta^* = 1, i.e., s^{g*} = 0, s^{b*}, s^- = 0$. DMU is inefficient if $\theta^* < 1$ ; by deleting excess inputs , bad outputs and augmenting the shortfalls in good output it can become efficient as

$$x^0 - s^- \Rightarrow x_0$$

$$y_0^g + s^{g*} \Rightarrow y_0^g$$

$$y_0^b + s^{b*} \Rightarrow y_0^b$$

## 4 Data Collection

Data has been taken from various sources for the year 2007-08 as most of selected environment related variables are available for this period only. Data on investment in assets and number of employed person has been taken from the Pakistan Social and Living Standard Measurement (PSLM) Survey. Fuel consumption is taken from HIES (2007-08) and then translated into comprehensive energy consumption and GHG emissions as per national data.

Data on Water usage has been calculated through water footprints taken from (Sadaf & Zaman). Waste water produced has been taken from (Murtaza & Zia, 2012). Data on Particulate matters, total suspended particulates and solid waste is adopted from various report of Pakistan Environmental Protection Agency. There has not been found any data on GDP of the cities. Prosperity scores based on the district poverty profile by Naveed and Ali (2012) has been considered. This measure can be more appropriate as other than GDP measure a comprehensive measure of desirable output is recommended by Zhang et al. (2008) , (Yin et al., 2014) and many other research articles. DEAP Version 2.1(Coelli, 1996) Program is used for calculations of eco-efficiency of cities.

## 5 Results and Discussion

Provincial capital and other major industrial cities are considered as the unit of analysis. They are found as the center of major economic, social and cultural activities. Headquarters of big enterprises and important government offices are located in these mega cities. Implementation of polices are regulated from these urban centers. These cities are the representative of highest level of development in the regions. Descriptive statistics of the selected variables is given in table 1.

**Table 1**
***Descriptive statistics of selected input and output indicators***

| Category | Variable | Units | Obs | Mean | Min | Max |
|---|---|---|---|---|---|---|
| Input | Total water consumption | $10^6$ Tones | 7 | 3557.35 | 705.11 | 9249.82 |
| | Energy consumption | $10^9$ BTU | 7 | 1088451 | 4468651 | 35457215 |
| | Construction land area | Million $Km^2$ | 7 | 334.26 | 90.94 | 934.32 |
| | Investment in fixed assets | Million Rupees | 7 | 88529.28 | 19572.57 | 307423.24 |
| | No. of employed person | Million Persons | 7 | 1.16 | 0.25 | 3.50 |
| Undesirable Output | $CO^2$ emission | Million Tons | 7 | 32.90 | 7.81 | 103.68 |
| | Total Suspended Particulates | $10^6 \mu g/cm^3$ | 7 | 2.78 | 0.57 | 5.05 |
| | Particulate Matter | $10^6 \mu g/cm^3$ | 7 | 1.38 | 0.23 | 2.20 |
| | Solid waste emission | $10^6$ tons | 7 | 1.05 | 0.24 | 3.37 |
| | Waste Water | $10^6$tons | 7 | 238.33 | 53.76 | 811.73 |
| Desirable output | Prosperity Score | - | 7 | 0.92 | 0.81 | 0.97 |

Water consumption, comprehensive energy consumption, constructed land area, investment in assets and no of the people employed are taken as an inputs. Average water consumption is found as 3557 million tones. 1.16 million People on average are found employed in selected cities. Moreover, CO2 emissions, total suspended particulates, waste water and solid waste emissions are selected undesirable output or indicator of environmental degradation and have the average value of 32.90

million tons, 2.78 million micro gram/cubic meter, 238.3 million tons 1.05 million tons respectively. Propensity scores is considered as the desirable output and has the minimum and maximum value of 0.81 and 0.97 respectively.

Results from eco efficiency indicate that all of the cities are eco-efficient except Karachi and Lahore. Eco-efficiency of Karachi is found as 20% which means that it could be able to reduce its input by 80% to have the existing level of prosperity score. In practical terms it means that Karachi can reduce its inputs energy consumption by 5485 million BTU, carbon dioxide emissions by 12.5 tones. It can generate less waste as 0.3 million tones and water wastage can also be reduced by 56 million tones. Similarly, Particulate matters can also be reduced substantially to have the same level of prosperity score.

Faisalabad and Rawalpindi are found as the peers of Karachi as they are relatively efficient than Karachi. Similarly, eco-efficiency of Lahore is found as 30%. It also reduce significant amount of desirable and undesirable inputs to achieve the same level of prosperity score. Gujranwala and Quetta are not appeared as peer for any of the inefficient cities. So there efficiency can also be increased even if they are 100% efficient. Rawalpindi appears twice in the peering as compared with other efficient cities. Faisalabad and Peshawar can only be compared with Karachi and Lahore respectively. So there exist the potential to increase the efficiency of both to make comparable with rest of the inefficient cities.

Assumption of constant returns to scale can be relaxed to check the eco efficiency in variable returns to scale. Results are depicted in the table 3. No substantial difference has been found among the eco efficiency between the cities.

**Table 2**
***Results of Eco-efficiency under Constant Returns to scale for Pakistani Cities***

| Values | | | | | | Input Slacks | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Area | DMU | θ | [3]PG | PW | PC | CLA | EC | A | EP | WC | EM | WWE | SW | TSP | PM10 |
| Sindh | Karachi | 0.2 | (4,3) | (0.25 ,0.64) | 0.0 | 99.4 | 5485.4 | 25139 | 0.2 | 0.0 | 12.5 | 56.8 | 0.3 | 0.0 | 0.2 |
| Punjab | Lahore | 0.3 | (6,4) | (0.21, 0.16) | 0.0 | 49.6 | 6456.1 | 0.0 | 0.3 | 956.6 | 11.7 | 41.7 | 0.4 | 0.0 | 0.0 |
| | Faisalabad | 1.0 | 3.0 | 1.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Rawalpindi | 1.0 | 4.0 | 1.0 | 2.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | Gujranwala | 1.0 | 5.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| KP | Peshawar | 1.0 | 6.0 | 1.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Baluchistan | Quetta | 1.0 | 7.0 | 1.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

[3] Peer Group are written according the numbering the cities column wise from 1 to 7

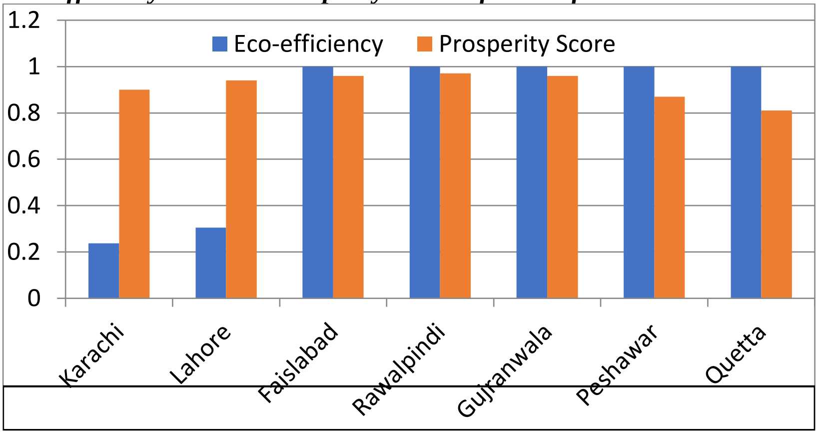
 

**Table 3**
***Eco-efficiency results under VRS to scale for Pakistani Cities***

| Area | DMU | CRS θ | VRS θ | Scale θ | Peer Group | Peer count |
|---|---|---|---|---|---|---|
| Sindh | Karachi | 0.24 | 0.26 | 0.9 | 4,3 | 0 |
| Punjab | Lahore | 0.31 | 0.33 | 0.9 | 6,4 | 0 |
| | Faisalabad | 1.00 | 1.00 | 1.0 | 3 | 1 |
| | Rawalpindi | 1.00 | 1.00 | 1.0 | 4 | 2 |
| | Gujranwala | 1.00 | 1.00 | 1.0 | 5 | 0 |
| KP | Peshawar | 1.00 | 1.00 | 1.0 | 6 | 1 |
| Baluchistan | Quetta | 1.00 | 1.00 | 1.0 | 7 | 0 |

Figure 1 shows the comparison between eco efficiency and prosperity scores. It can be viewed that the cities with high level of prosperity score are more inefficient in eco efficiency as compared with the cities having low prosperity scores.

**Figure 1**
***Eco-efficiency Vis a Vis Prosperity scores of cities of Pakistan***




## 6 Conclusion and Recommendations

Two biggest provincial capitals are found as less inefficient comparing with the other cities. Prosperity score of Lahore is greater than that of Karachi but it is less inefficient than Karachi. Overall phenomenon is found as more developed are the city and more they are inefficient in eco-efficiency. Hence it is not found in accordance with the spatial distribution of development in Pakistan. This is due to the reason that industrial and urban expansion is unplanned and mismanaged in Pakistan. Our results are partially similar to Ghalib et al., (2017) that city prosperity scores are not different rather than there is a great room of improvement in eco-efficiency scores of all cities. The industries with high consumption of energy, contamination and emission are established in developed areas. There has been hardly found any policies for the expansion of such entities. But policies and environmental laws are available for cities to improve sustainability. Present status is the result of lack of implementation of the policies.

There is need to develop a distinguished list of policies as per the need of the development of the cities. Tight control over the regulations regarding pollution shouldn't be ignored. Traditionally, business people are mostly concerned with their economic wellbeing without considering the impact on social and environment performance. So polices are made accordingly. Eco-efficiency approach provides insights to the local government to include environmental protection in comprehensive development strategies. Improved implementation as a result of environmental protection can be reinstated. There exist some technical and data related weaknesses in current study. Eco-efficiency can only help to compare the regions or cities and plays a limited role for governing the direction of progress towards sustainable development. Eco-efficiency over the time can be used to compare the dynamics of the sustainable urban development between the cities. Eco-efficiency along with other approaches related with ecological footprint and input output analysis will present a more accurate picture for sustainable development. There is a need for the recognition of the concept of eco-efficiency so that this term can get public attention and it can be put into practice for sustainable urban development.

**References:**

Agyeman, J. (2003). Just sustainabilities: Development in an unequal world: MIT press.

Agyeman, J., & Evans, B. (2004). 'Just sustainability': the emerging discourse of environmental justice in Britain? The Geographical Journal, 170(2), 155-164.

Allen, K. (1999). Dea in the ecological context—an overview Data envelopment analysis in the service sector (pp. 203-235): Springer.

Anjum, M. S., Ali, S. M., Subhani, M. A., Anwar, M. N., Nizami, A. S., Ashraf, U., & Khokhar, M. F. (2020). An emerged challenge of air pollution and ever-increasing particulate matter in Pakistan; a critical review. Journal of Hazardous Materials, 123943.

Attoh-Okine, N. O., Cooper, A. T., & Mensah, S. A. (2009). Formulation of resilience index of urban infrastructure using belief functions. IEEE Systems Journal, 3(2), 147-153.

Azizullah, A., Khattak, M. N. K., Richter, P., & Häder, D.-P. (2011). Water pollution in Pakistan and its impact on public health—a review. Environment International, 37(2), 479-497.

Basiago, A. D. (1998). Economic, social, and environmental sustainability in development theory and urban planning practice. Environmentalist, 19(2), 145-161.

Blowers, A., & Pain, K. (1999). The unsustainable city? Unruly Cities? Order/Disorder, 265-275.

Bromley, R. D., Tallon, A. R., & Roberts, A. J. (2007). New populations in the British city centre: Evidence of social change from the census and household surveys. Geoforum, 38(1), 138-154.

Cerutti, A. K., Beccaro, G. L., Bagliani, M., Donno, D., & Bounous, G. (2013). Multifunctional ecological footprint analysis for assessing eco-efficiency: A case study of fruit production systems in Northern Italy. Journal of Cleaner Production, 40, 108-117.

Charnes, A., Cooper, W. W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. European Journal of Operational Research, 2(6), 429-444.

Choucri, N., & Berry, R. (1995). Sustainability and diversity of development: Toward a generic model. System Dynamics Proceedings, 1, 30-39.

Coelli, T. (1996). A guide to DEAP version 2.1: a data envelopment analysis (computer) program. Centre for

Efficiency and Productivity Analysis, University of New England, Australia.

Cohen, B. (2006). Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability. Technology in society, 28(1), 63-80.

DeSimone, L. D., & Popoff, F. (2000). Eco-efficiency: the business link to sustainable development: MIT press.

Dyckhoff, H., & Allen, K. (2001). Measuring ecological efficiency with data envelopment analysis (DEA). European Journal of Operational Research, 132(2), 312-325.

Economics, U. N. D. o., & Information, U. N. D. o. P. (2009). The millennium development goals report 2009: United Nations Publications.

Farrell, M. J. (1957). The measurement of productive efficiency. Journal of the Royal Statistical Society. Series A (General), 120(3), 253-290.

Ghalib, A., Qadir, A., & Ahmad, S. R. (2017). Evaluation of developmental progress in some cities of Punjab, Pakistan, using urban sustainability indicators. Sustainability, 9(8), 1473.

Girardet, H. (1999). Creating sustainable cities: Resurgence Books.

Grimm, N. B., Faeth, S. H., Golubiewski, N. E., Redman, C. L., Wu, J., Bai, X., & Briggs, J. M. (2008). Global change and the ecology of cities. Science, 319(5864), 756-760.

Hahn, T., Figge, F., Pinkse, J., & Preuss, L. (2010). Trade-offs in corporate sustainability: you can't have your cake and eat it. Business Strategy and the Environment, 19(4), 217-229.

Jabareen, Y. R. (2006). Sustainable urban forms their typologies, models, and concepts. Journal of planning education and research, 26(1), 38-52.

Jenks, M., Burton, E., & Williams, K. (1996). The compact city. A sustainable urban form.

Jollands, N., Lermit, J., & Patterson, M. (2004). Aggregate eco-efficiency indices for New Zealand—a principal components analysis. Journal of Environmental Management, 73(4), 293-305.

Kielenniva, N., Antikainen, R., & Sorvari, J. (2012). Measuring eco-efficiency of contaminated soil management at the

regional level. Journal of Environmental Management, 109, 179-188.
Koglin, T. (2009). Sustainable development in general and urban context: A literature review. Bulletin 248/3000.
Lafferty, W. M. (2004). Introduction: form and function in governance for sustainable development.
Li, H., Bao, W., Xiu, C., Zhang, Y., & Xu, H. (2010). Energy conservation and circular economy in China's process industries. Energy, 35(11), 4273-4281.
Liu, Q., Wang, S., Li, B., & Zhang, W. (2020). Dynamics, differences, influencing factors of eco-efficiency in China: A spatiotemporal perspective analysis. Journal of Environmental Management, 264, 110442.
Mangi, M. Y., Yue, Z., Kalwar, S., & Ali Lashari, Z. (2020). Comparative Analysis of Urban Development Trends of Beijing and Karachi Metropolitan Areas. Sustainability, 12(2), 451.
McIntyre, R. J., & Thornton, J. R. (1978). On the environmental efficiency of economic systems∗. Europe-Asia Studies, 30(2), 173-192.
Mickwitz, P., Melanen, M., Rosenström, U., & Seppälä, J. (2006). Regional eco-efficiency indicators–a participatory approach. Journal of Cleaner Production, 14(18), 1603-1611.
Murtaza, G., & Zia, M. H. (2012). Wastewater production, treatment and use in Pakistan. Paper presented at the Second Regional Workshop of the Project 'Safe Use of Wastewater in Agriculture.
Naveed, A., & Ali, N. (2012). Clustered deprivation: District profile of poverty in Pakistan: Sustainable Development Policy Institute.
Oggioni, G., Riccardi, R., & Toninelli, R. (2011). Eco-efficiency of the world cement industry: a data envelopment analysis. Energy Policy, 39(5), 2842-2854.
Pakistan Bureau of Statistics (2017), 6th Population and Housing Census. Pak. Bur. Stat.
PC. (2007). Pakistan in the 21st Century: Vision 2030. Planning Comission: Government of Pakistan, Islamabad.

Reed, M. S., Fraser, E. D., & Dougill, A. J. (2006). An adaptive learning process for developing and applying sustainability indicators with local communities. Ecological Economics, 59(4), 406-418.

Rees, W., & Wackernagel, M. (1996). Urban ecological footprints: why cities cannot be sustainable—and why they are a key to sustainability. Environmental impact assessment review, 16(4), 223-248.

Reith, C. C., & Guidry, M. J. (2003). Eco-efficiency analysis of an agricultural research complex. Journal of Environmental Management, 68(3), 219-229.

Ren, W., Zhang, Z., Wang, Y., Xue, B., & Chen, X. (2020). Measuring Regional Eco-Efficiency in China (2003–2016): A "Full World" Perspective and Network Data Envelopment Analysis. International Journal of Environmental Research and Public Health, 17(10), 3456.

Sadaf, M., & Zaman, A. (2013). Potential of water management through Pakistani Provincial Trade of Agriculture Commodities. Int. Water Technol. J, 3(3), 131-137.

Satterthwaite, D. (1997). Sustainable cities or cities that contribute to sustainable development? Urban Studies, 34(10), 1667-1691.

Schaltegger, S., & Burritt, R. (2000). Contemporary environmental accounting: issues, concepts and practice: Greenleaf Publishing.

Seppäläa, J., Melanen, M., Mäenpää, I., Koskela, S., Tenhunen, J., & Hiltunen, M. R. (2005). How Can the Eco-efficiency of a Region be Measured and Monitored? Journal of Industrial Ecology, 9(4), 117-130.

Singh, R. K., Murty, H., Gupta, S., & Dikshit, A. (2012). An overview of sustainability assessment methodologies. Ecological Indicators, 15(1), 281-299.

TFR, T. F. R. (2009). Population, labour force and employment. Economic Survey, 10.

UNFPA. (2007). UNFPA state of world population 2007: unleashing the potential of urban growth: UNFPA New York.

Wang, Y., Liu, J., Hansson, L., Zhang, K., & Wang, R. (2011). Implementing stricter environmental regulation to enhance eco-efficiency and sustainability: a case study of

Shandong Province's pulp and paper industry, China. Journal of Cleaner Production, 19(4), 303-310.

Wu, D. D., Yang, Z., & Liang, L. (2006). Efficiency analysis of cross-region bank branches using fuzzy data envelopment analysis. Applied Mathematics and Computation, 181(1), 271-281.

Yin, K., Wang, R., An, Q., Yao, L., & Liang, J. (2014). Using eco-efficiency as an indicator for sustainable urban development: A case study of Chinese provincial capital cities. Ecological Indicators, 36, 665-671.

Yu, Y., Chen, D., Zhu, B., & Hu, S. (2013). Eco-efficiency trends in China, 1978–2010: Decoupling environmental pressure from economic growth. Ecological Indicators, 24, 177-184.

World most polluted cities, 2019 World most polluted cities 2019 (PM2.5) (IQAIR, 2020) (https://www.iqair.com/world-most-polluted-cities).

Zhang, B., Bi, J., Fan, Z., Yuan, Z., & Ge, J. (2008). Eco-efficiency analysis of industrial system in China: a data envelopment analysis approach. Ecological Economics, 68(1), 306-316.