The Impact of Urban Sprawl on Carbon Emission in Qingdao-Shandong Province

Zhize Gao[1,*]

[1]Managerial economics, university of California, Davis, Davis , California, 95618, The United States

Abstract. Qingdao is a city located along the eastern province of Shandong, specifically along the east cost of the Republic of China, establishing the reasons why it is considered as one of the largest metropolitan cities within the province. Urbanization of the city is widely considered as one of the inevitable tendencies driven towards accompanying the process of modernization and industrialization of the human society. This research study sought to examine the Impact of urban sprawl on carbon emission in Qingdao-Shandong Province. According to the findings, urban sprawl is considered as an irreversible global aspect, with some of its fundamental characteristics hedged on the increase of populations in major urban centers, the increased densities and expansion of the spatial sizes of cities, and a rampant changes in the manner in which land and buildings are used; all these managed through the inclusion of planning schemes and strategies. Qingdao-Shandong Province is in this case expected to experience a rise in the demand for travel that will see an increase of over 4.7 million people and trips on a daily basis from the 9.4 million thresholds in 2020.

1 Introduction

Urbanization is widely considered as one of the inevitable tendencies driven towards accompanying the process of modernization and industrialization of the human society. As adduced in the views of Denver (2020), urbanisation is equally considered as a phenomenon that has an impetus of stimulating the element of sustainable regional growth, factors that are critical in realising and optimising the allocation of resources. Treated as a core facet in the global economic growth, several of the developing cities are complexes that are formed through interactions with different natural factors and human activities. Evidence suggests that close to 65% of the entire global populations are likely to live in or rather near cities by 2050, thus establishing that the urban population in Qingdao-Shandong Province is expected to exceed the 75% mark. Further, urbanisation is viewed as a dynamic evolutionary process often known to include several dimensions of land, populations, and economies in which different populations agglomerate as an external manifestation of the existing flows in resources. Urbanisation has therefore been a rapid phenomenon for Qingdao-Shandong Province, establishing the purpose of this research study that seeks to examine the Impact of urban sprawl on carbon emission in Qingdao-Shandong Province. To achieve the findings of the study, the calculation of carbon emission was achieved through the consideration of the consumption of the liquidified petroleum gas, annual electricity rates, and natural gas within the city through the use of a scientific and unified scientific model proposed by the IPCC, an aspect that was attributed to the scarcity and limitations of official sources of carbon emissions data specifically in Qingdao-Shandong Province.

1.1 City Overview

Qingdao is one of the largest cities in Shandong Province. The city is low on carbon emissions, with this evidenced in its efforts to achieve a low carbon emission rate. Qingdao remains one of the fastest growing cities with several manufucturers currnelty seeking to engage in the pursuit of economic grwowth. The city is known for its recent low-carbon plan intended at ensuring that itt is not plagued by air pollution. Qingdao is a city located along the eastern province of Shandong, specifically along the east cost of the Republic of China, establishing the reasons why it is considered as one of the largest metropolitan cities within the province [7]. Administered primarily at a sub-provincial level, the city of Qingdao is revealed to have jurisdictions in over 6 other districts as well as four recent county-level cities. Evidence as provided in literature establishes that Qingdao equally remains one of the major naval bases, seaports, as well as industrial centers in China [7]. Earlier in 2009, the city of Qingdao was considered and names one of the best livable cities in China as provided in reports from the Chinese Institute of City Competitiveness

Qingdao-Shandong Province remains one of the renowned fastest growing cities in China with the highest proportion and rates of manufacturing operations ongoing. Further, the city as established in reports has over the recent years been seeking further opportunities for growth, an aspect that has resulted into urban sprawl. The city's new low-carbon plan ensures that Qingdao will not be

* Corresponding author: zzgao@ucdavis.edu

plagued by air pollution like many neighboring cities [7]. Qingdao is equally considered as one of the fastest growing economies and cities, with several manufacturing companies seeking to expand in the pursuit of economic growth within the region. Reports reveal that the cities recent low-carbon plans were designed with the objective of ensuring that the region is not primarily plagued with cases of air pollution like the other neighboring cities.

To this effect, urbanisation is revealed to have taken a rapid growth of the city from the coastal region. The Qingdao Municipal Government as provided in this case is revealed to have focused attention on setting ambitious goals driven towards the reduction of carbon emission intensity specifically by close to 45% from 2005 to 2020. This urban master plan therefore portrays a drastic change and transformation that the city is expected to undergo besides the rise in its population to over 12 million as compared to a population of 8.7 million later in 2012 [14]. The rapid economic transformation and growth of the city due to motorization and urbanisation is expected to significantly fuel the growth of this region, an aspect that is expected to have adverse effects on the environment. By 2030, it is expected that the average speed and rate of travel will rise from 29.7 to over 31.7 km/h, a factor that is attributed to the rise in population within the region. Evidence therefore provides that by 2020, Qingdao-Shandong Province is expected to experience a rise in the demand for travel that will see an increase of over 4.7 million people and trips on a daily basis from the 9.4 million thresholds in 2020 [2]. On the other hand, the total daily vehicle traveled kilometers is expected to significantly increase from a merger 29.4 million km to over 90 million km, thus establishing the possibility of a rise in carbon emission. Further, Agbola (2004) reveals that the mode share of the privately owned vehicles within the region is expected to significantly rise by 40% in the event that no measures and interventions are undertaken [1]. This therefore reveals that by 2020, Qingdao-Shandong Province's transport-related CO2 emissions may therefore make up close to 29% of the total emissions within the region, thus establishing that the region will become one of the fastest growing areas and sources of emissions. This is expected to make it challenging for Qingdao to ensure that it meets its low-carbon and sustainable goals.

1.2 Conditions of Urban Formations

Urban sprawl is considered as an irreversible global aspect, with some of its fundamental characteristics hedged on the increase of populations in major urban centers, the increased densities and expansion of the spatial sizes of cities, and a rampant changes in the manner in which land and buildings are used; all these managed through the inclusion of planning schemes and strategies. As adduced in the views of Agbola (2004), the G21 Regional Growth Plan therefore provides a highlight on the essence of maintaining the regions livability, albeit protecting its finite and unique natural resources, farming, and tourism aspects as a response to the growth pressures mounted in the region [14]. The city of Qingdao as postulated in different literatures to reveal the demonstrated commitment to integrate strategic and systemic planning procedures in enhancing the existing rural, urban, economic, social, and environmental systems within the municipality [11]. A holistic planning process and approach ensures that the States, Communities views, Commonwealth, and regional policies are accentuated into a desired outcome. Greater Geelong planning is currently facing a series of hurdles as posited.

Firstly, the planning process of the city failed to contribute to the well-being of the communities as a whole by failing to foster and support the economic growth of the city that relied on the provision of land, the facilitation of decisions, and the resolution of land use conflicts to enable the district harness its strengths and achieve its economic potential 10. Besides this, a number of commercial and industrial areas in the City of Qingdao have been decentralized, thus creating and resulting into transport issues by businesses generating freight movements. The lack of adequate transport links to cater for the needs of the public therefore continue to pose a challenge in this region, with all these owed to poor planning methods. Since urbanization is considered as an irreversible and positive approach to development, the fundamental issue lies in how effective an urban planning strategy is in the management of the processes of urban development (Groves, 2000). Urban planning in the Qingdao City is in this case characterized by instances of unguided spatial expansions, the proliferation of informal settlements, settlement densification, and the deterioration of public utilities and social amenities. Qingdao City therefore provides a classical example of a region that lacks a proper urban planning strategy as established.

Urban planning schemes and strategies have the potential facilitate equitable and efficient adaptation of development and climate change. However, it efficiency remains dependent on the users. Poor urban planning schemes and strategies may increase vulnerabilities and costs, albeit unfairly affect the interests of different groups within the society. In an effort to illustrate the nature of such risks, this research paper seeks to present a proverbial case study on how urban planning schemes and strategies may impact coastal regions and wetlands and the manner in which these elements may need to be addressed in Qingdao City [12]. It is essential to note that in 2008; new planning frameworks were established within this jurisdiction to guide in the process of development, an aspect that was mainly based on the precautionary measures that sort to minimize the region to exposures of development and communities to future coastal impacts. However, this framework had a significant amount of deficiencies given that the framework mainly encouraged a deterministic approach of decision-making that failed to take emphasis on the opportunity costs of an urban sprawl system of development [12]. The findings of the study revealed that the planning schemes and strategies that were incorporated by Qingdao City failed to generate equitable and efficient results.

The Rural Land Use Strategy (RLUS) was primarily designed and configured by the City of Qingdao, hence underpinning a section of policies that manage the planning schemes of the city. According to reports, the RLUS establishes that there is close to 55,000 hectares of land that is used at the commercial level for farming across Qingdao [7]. Qingdao's rural areas are therefore covered by a wide range of agricultural practices. In order to put these reoccurs into proper use, RLUS developed the Qingdao Regional Growth Plan in 2013 that tasked the municipality with the role of managing the growth as well as land pressures that are mounting. Costal and wetlands are considered as a unique element of landscape that supports distinctive communities of animals and plants. Costal and wetlands are therefore diverse in form, and vary in water chemistry, hydrology, topography, soils, vegetation and the extent to which they are affected by human disturbance. Buxton, Goodman & Moloney (2016) alleges that coastal and wetlands commonly share distinctive characteristics such as the presence of water and the containment of vegetation's that have adapted to the wet conditions [6]. The city of Qingdao remains committed to the management of its environment as well as coastal and wetlands. In its urbanization process, the city made commitments in the management of its environment, with specific focus directed towards the conversation of the coastal and the wetlands. In an effort to achieve this, a Wetland Strategy was established as evident in a study conducted by Buxton et al., (2016). The strategy as established in the findings of this study was meant to provide strategic guidance and direction in the management and conservation of the Greater Geelong city's wetlands.

However reports from the findings of the study reveals that the integrity of the coastal and the wetlands were impacted by a series of process during the urbanization of the Qingdao city, an aspect that poised threats to the regions catchments [8]. Particularly significant to the city of Geelong include the drainage of the wetlands with the intent of modifying the catchments for the purposes of commercial development such as roads, residential developments, landfill salinization of the wetlands, and marinas, thus affecting the ecosystem of the region. On the other hand, the clearance of the catchment regions through the discharge of industrial effluents possess a threat to the wetlands and costal, efforts that are attributed to the urban development of the Greater Geelong city. The coastal areas of the City of Qingdao remains highly valued, with this aspect attributed to the contributions it makes to the economy of the region, amenity and livability of the municipality due to tourism. However, the use of these features has been compromised, thus affecting the existing tourism and farming activities that are part of the attraction of this region. As postulated in this study, for the need for an appropriate development strategy in the rural areas in an effort to support farming and tourism in the region [5]. This establishes the need for a properly and carefully designed strategy that will not compromise the vision of the rural regions.

2 Impact of Urban Sprawl on Carbon Emission in Qingdao-Shandong Province

2.1 Theoretical Model

As established, Qingdao-Shandong Province is expected to experience a rise in the demand for travel that will see an increase of over 4.7 million people and trips on a daily basis from the 9.4 million thresholds in 2020. On the other hand, the total daily vehicle traveled kilometers is expected to significantly increase from a merger 29.4 million km to over 90 million km, thus establishing the possibility of a rise in carbon emission. Further, evidence reveals that the mode share of the privately owned vehicles within the region is expected to significantly rise by 40% in the event that no measures and interventions are undertaken [4]. This therefore reveals that by 2020, Qingdao-Shandong Province's transport-related CO2 emissions may therefore make up close to 29% of the total emissions within the region, thus establishing that the region will become one of the fastest growing areas and sources of emissions. This is expected to make it challenging for Qingdao to ensure that it meets its low-carbon and sustainable goals. As provided, the time series roster of data had a resolution of close to 1km×1km between 2010 and 2020, an aspect that resulted in the following. Firstly, evidence reveals that the carbon emission data on the fossil fuels were specifically obtained from the ODIAC fossil fuel and emission datasets. An annual average level of temperature recorded was further collected from the National Earth System Science Data Center while data on land use as well as the regions GDP density were collected from Resource and Environmental Science and Data Center. As provided in this case, a digital evolution model provides a resolution of close to 30m × 30m that was collected from the Geospatial data cloud. Building coverage floor area and ratio as then calculated through a 3D system that was extracted from a higher resolution satellite imaging system as provided below:

Table 1. Classification of environmental and socioeconomic factors

Types	Environmental Factors		Socioeconomic Factors			
T (Oc)	S (e)	LST	PD (People/Km in Thousands	GDP (Million Yuan/km2)	BCR (%)	FAR
1	9.0-10.6	0-2.33	CL	0-0.2	2.52-22.02	0.2-0.75
2	10.6-11.9	28-64	F	0.1-0.4	22-06-30-08	3.98-8.98
3	11.9-12.5	58-65	W	0.4-0.8	30.08-47.98	8.98-12.68
4	12.4-13.1	65-72	RL	0.8-1.2	47.98-60.76	12.67-16.98

5	13.1-14.0	72-86	UL	1.2-2.0	60.76-86.98	16.98-26.98
6	14.0-15.4	86-142	GL	2.0-3.1	86.98-96.09	26.98-38.78
7	15.4-16.82	142-168	UC	3.1-4.2	96.09-98.08	38.78-46.08
8	16.82-18.12	168-187	R	4.2-6.5	98.78-108.4	46.08-52.98
9	18.12-21.98	187-190		6.5-7.6	108.4-112.87	56.98-64.99

Note: Forest land (F); Cultivated land (CL); Water body (W); Urban construction land (UC); Rural construction land (RL); Roads (R): Unused land (UL); Grassland (GL)

2.2 Figure

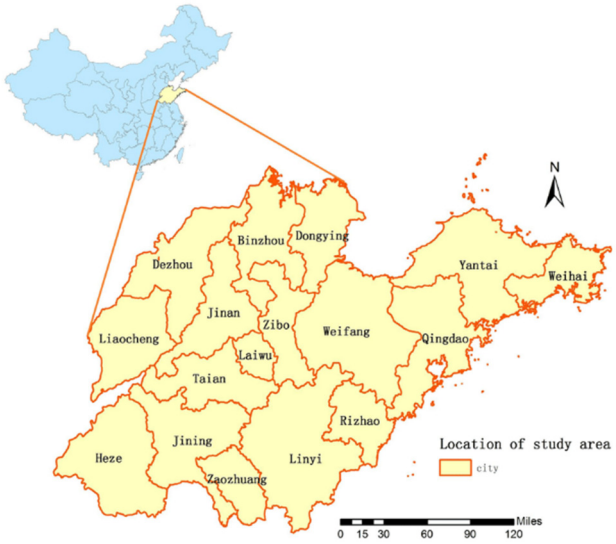

Fig. 1. Geo-location of Qingdao-Shandong Province

2.3 Model

Data on Carbon Emissions

Given the scarcity and limitations of official sources of carbon emissions data specifically in Qingdao-Shandong Province, the calculation of carbon emission may be achieved through the consideration of the consumption of the liquidified petroleum gas, annual electricity rates, and natural gas within the city through the use of a scientific and unified scientific model proposed by the IPCC. The formula used in the calculation of the carbon emission levels is as provided below:

$$CO_2 = C_1 + C_2 + C_3 = kE_1 + vE_2 + \alpha(\mu \times E_3)$$

In this case, CO_2 provides representation of the carbon emission levels in the city while C_1, C_2, C_3 serves as the levels of carbon emissions resulting from liquidified petroleum, annual electricity consumption, and from natural gas. On the other hand, E_1, E_2, and E_3 represent the levels of consumption of natural gas, liquidified petroleum gas, and electricity. On the other hand, k(v) may serve as a converted coefficient of the levels of liquidified petroleum gas, α representing a portion of the generated coal while μ serving as a representation of a converted coefficient of the levels of coal power within the fuel chain. As established in the coefficient of variations, Mann Kendal and Sen Trend analysis may be based on the use of Python, an aspect that may help and play a critical role in the analysis of the change variations and stability trends of the levels of carbon emissions in the city of Qingdao [13]. In this regard, a coefficient of the variations (CV) as given in this case was primarily utilized in estimating the variations in the levels of carbon emissions and calculated as provided in Equation 1 below:

$$Cv = \sigma/\mu \quad (1)$$

In this case, σ serves as a standard deviation of the levels of carbon emission while (t) is treated as a unit. On the other hand μ is primarily treated as an average value of the levels of carbon emission while $Cv \leqslant 0.1$ may be considered as a weak variation. To this effect, it is therefore essential and notable to establish that the Sen's slope model played a critical role in the estimation of the levels and the changes in the emission of carbon in Qingdao within the specified period [13]. A non-parametric model therefore found a higher change of estimation on changes in carbon emission over time [3]. The Sen's slope model (β) may be calculated through the consideration of the median in all the estimated slopes and between the successive provided data points of the carbon emission as specified in the time series. The media played a sentinental role in underpining the functional relationship between the variables, a phenomenon that resulted in the yielding a linear trend. The variables focused on primarily included an examination of E1, E2, and E3 that represented the levels of consumption of natural gas, liquidified petroleum gas, and electricity. On the other hand, k(v) may serve as a converted coefficient of the levels of liquidified petroleum gas, α representing a portion of the generated coal while μ serving as a representation of a converted coefficient of the levels of coal power within the fuel chain.

This may be calculated as provided below:

$$\beta = \text{median}\,\frac{CE_j - CE_i}{j - i} \quad (2)$$

In this case, CE_i as well as CE_j may in this case serve as the levels of carbon emission while i and j act as the number of years, thus resulting in the specified equation below:

$$Z = (S\text{-}1) \div \sqrt{VAR(S), S > 0}$$
$$Z_0, S = 0 \quad (3)$$
$$Z = (S\text{+}1) \div \sqrt{VAR(S), S > 0}$$

S a provided in the equation is the test statistic that represents the levels of carbon emission and that is calculated through the use of the provided equation. To this effect, the sign of Z may be used as an indicator that shows the direction of the provided trend. The negative value in Z further serves as an indicator of a decrease in the trend [3]. This therefore means that in the event that the absolute value of the trend is Z, then it may be considered as higher than a threshold of 1.64, thus meaning that it may have significantly passed the level and significance test with a 90% confidence level besides a 10% interval level.

2.4 Findings

Given the rise in population and the rapid development of Qingdao city leading to urban sprawl, evidence reveals that secondary and economic factors within the industries serve as the driving forces that stimulate the increase in carbon emissions. Further, the comprehensive energy consumption within the city per unit on its GDP is expected to significantly decrease by close to 22% while the average and maximum value of the emissions tends to be slow [3]. This therefore reveals that between 2015 and 2020, the average and the maximum value of the levels of carbon emission are bound to increase with time, establishing the need for the implementation of dial control policies driven towards regulating the intensity and consumption of energy by industries within the region. As established in the findings of this study, the reduction of carbon emission intensity in this city is specifically probably by close to 45% from 2005 to 2020. This urban master plan therefore portrays a drastic change and transformation that the city is expected to undergo besides the rise in its population to over 12 million as compared to a population of 8.7 million later in 2012 [3]. The rapid economic transformation and growth of the city due to motorization and urbanisation is expected to significantly fuel the growth of this region, an aspect that is expected to have adverse effects on the environment. By 2030, it is expected that the average speed and rate of travel will rise from 29.7 to over 31.7 km/h, a factor that is attributed to the rise in population within the region [15]. Evidence therefore provides that by 2020, Qingdao-Shandong Province is expected to experience a rise in the demand for travel that will see an increase of over 4.7 million people and trips on a daily basis from the 9.4 million thresholds in 2020.

2.5 Conclusion

As revealed in the findings of this research study, urbanization is widely considered as one of the inevitable tendencies driven towards accompanying the process of modernization and industrialization of the human society. Qingdao is a city located along the eastern province of Shandong, specifically along the east cost of the Republic of China, establishing the reasons why it is considered as one of the largest metropolitan cities within the province. Urbanization of the city is widely considered as one of the inevitable tendencies driven towards accompanying the process of modernization and industrialization of the human society. This research study sought to examine the Impact of urban sprawl on carbon emission in Qingdao-Shandong Province. Urban sprawl is considered as an irreversible global aspect characterized by increased congestion in cities, spatial sizes, densities and changes in building and land use. All the above list managed through the inclusion of planning schemes and strategies. Qingdao-Shandong Province is in this case expected to experience a rise in the demand for travel that will see an increase of over 4.7 million people and trips on a daily basis from the 9.4 million thresholds in 2020. To this effect, it is evident that urbanisation is equally considered as a phenomenon that has an impetus of stimulating the element of sustainable regional growth, factors that are critical in realising and optimising the allocation of resources. Given the rise in population and the rapid development of Qingdao city leading to urban sprawl, evidence reveals that secondary and economic factors within the industries serve as the driving forces that stimulate the increase in carbon emissions. Further, the comprehensive energy consumption within the city per unit on its GDP is expected to significantly decrease by close to 22% while the average and maximum value of the emissions tends to be slow.

References

1. Agbola, T. (2004) “Readings in Urban and Regional Planning” Published by Macmillan Nigeria Limited, Ibadan, Oyo State, Nigeria.
2. Beigl, P., Lebersorger, S., and Salhofer, S. (2008)."Modelling municipal solid waste management: A review. “Waste Management, 28, 200-214.
3. Bekele, G. W., and Jackson, R. W. (2006).Theoretical Perspectives on Industry Clusters. Regional Research Institute, West Virginia University, Morgantown, WV.
4. Blakely, E. J., and Leigh, N. G. (2010).Planning Local Economic Development: Theory and Practice, Thousand Oaks, CA: Sage Publications.
5. Bogner, J., and Matthews, E. (2003). "Global methane emissions from landfills: new methodology and annual estimates 1980–1996." Global Biogeochemical Cycles, 17(2), 1-34.
6. Buxton, M., Goodman, R., & Moloney, S. (2016). Planning Melbourne: Lessons for a Sustainable City. Clayton, Vic: CSIRO PUBLISHING.
7. Christian, H., Knuiman, M., Bull, F., Timperio, A., Foster, S., Divitini, M., & ... Giles-Corti, B. (2013). A New Urban Planning Code's Impact on Walking: The Residential Environments Project. American Journal of Public Health, 103(7), 1219-1228.
8. Christian, H., Knuiman, M., Bull, F., Timperio, A., Foster, S., Divitini, M., & ... Giles-Corti, B. (2013). A New Urban Planning Code's Impact on Walking: The Residential Environments Project. American Journal of Public Health, 103(7), 1219-1228.
9. Englewood Cliffs. Groves Daniel (2000). “Development Control in Introduction to Planning Practice.” “West Sussex, John Wily and Sons Limited, London.
10. Jacobs, S. J., Gallant, A. E., & Tapper, N. J. (2017). The Sensitivity of Urban Meteorology to Soil Moisture Boundary Conditions: A Case Study in Melbourne, Australia. Journal Of Applied Meteorology & Climatology, 56(8), 2155-2172. doi:10.1175/JAMC-D-17-0007.1
11. Mintzberg, H. (2009). The structuring of organizations a synthesis of the research.

12. Nachmias, C. F and Nachmias, D. (2016). Research Methods in the Social Science.
13. Newton, P. W. (2011). Urban Consumption. Collingwood, Vic: CSIRO PUBLISHING. 5th ed. London: Arnold Publishing
14. Omer, A. M. (2014). Promotion of Greener Technologies for Sustainable Development. Hauppauge, N.Y.: Nova Science Publishers, Inc.