

Full Length Research Paper

The preliminary study of urbanization, fossil fuels consumptions and CO₂ emission in Karachi

S. H. Sajjad^{1, 2*}, N. Blond¹, A. Clappier¹ and Asif Raza³

¹Laboratoire Image Ville et Environnement (LIVE), ERL 7230, Université de Strasbourg, Centre National de la Recherche Scientifique (CNRS), 67000, France.

²Department of Earth Sciences, University of Sargodha, 40100 Sargodha, Pakistan.

³Department of Computer and Information Science, Pakistan Institute of Engineering and Applied Sciences (PIEAS), Islamabad, Pakistan.

Accepted 19 February, 2010

According to population, Karachi ranks as largest city of Pakistan and the ninth largest in the world. It is the most urbanized and largest economic centre of Pakistan. During the last three decades, it has faced mass urbanization, huge population growth, many fold increase in vehicles and industrial development. As a result, the demand of more energy in form of fossil fuels has increased for domestic, industrial and transportation purposes. In this research, the maximum available data of Karachi urbanization, population and vehicles growth, industrialization, energy consumption and CO₂ emissions are computed using statistical regression method. Time periods considered for this work are according to the availability of data. The results showed that during 1947 to 2008, both urban population and urban area increased to 1500%. During 1990 to 2008, the percentage growth in vehicles versus population is almost twice than before. During 1980 to 2007 the consumption of oil and petrol, natural gas and coal increased to 219, 365 and 287%, respectively. The emission of CO₂ jumped from 39 million metric tons in 1980 to 151 million metric tons in 2007. The share of vehicles in emission of CO₂ in atmosphere on Karachi through combustion of fossil fuels is more than the industries.

Key words: Urbanization, fossil fuels, CO₂ emission, energy consumption, population growth.

INTRODUCTION

The 20th century witnessed rapid urbanization throughout the world. The global proportion of urban population increased from 13% in 1900 to 29% in 1950 and, according to the 2005 Revision of World Urbanization Prospects, it has reached 49% in 2005. Since the world is projected to continue to urbanize, 60% of the global population is expected to live in cities by 2030. According to the latest United Nations population projections, 4.9 billion people are expected to be urban dwellers in 2030 (Figure 1) which was 3.2 billion in 2005 (Population Division of United Nation, 2005).

Primarily, the movement towards the cities is because of the application of new methods of cultivation that enabled a large production of food from small land,

making a portion of the rural population to go to towns to find opportunities for employment. Secondly, the growth of commerce and industry in the towns and cities offered better opportunities of employment (Ahmed, 1965). Today urbanization is a worldwide phenomenon.

Every nation, city and probably individual in the world is directly or indirectly involved in the continuing process of urbanization which is fast growing. The level of urbanization in Pakistan has gone up from 17.8, 32.5 and about 40%, in 1951, 1998 and 2008, respectively.

Karachi is the provincial capital of Sindh province of Pakistan. It had an area of 3,640 km² in 2008 and is located on the Arabian Sea coast in the extreme south of Pakistan (Figure 2). Its geographical co-ordinates are 24°45' north and 66°37' east. Topographically, it can be divided into two major parts; the hilly areas in the north and west and an undulating plain and coastal area in the south-east. The hills in Karachi are the off-shoots of the Kirthar Range (mountain range located in Balochistan

*Corresponding author. E-mail: shsajjad@hotmail.com. Tel: +33 (0) 6 28 47 78 28.

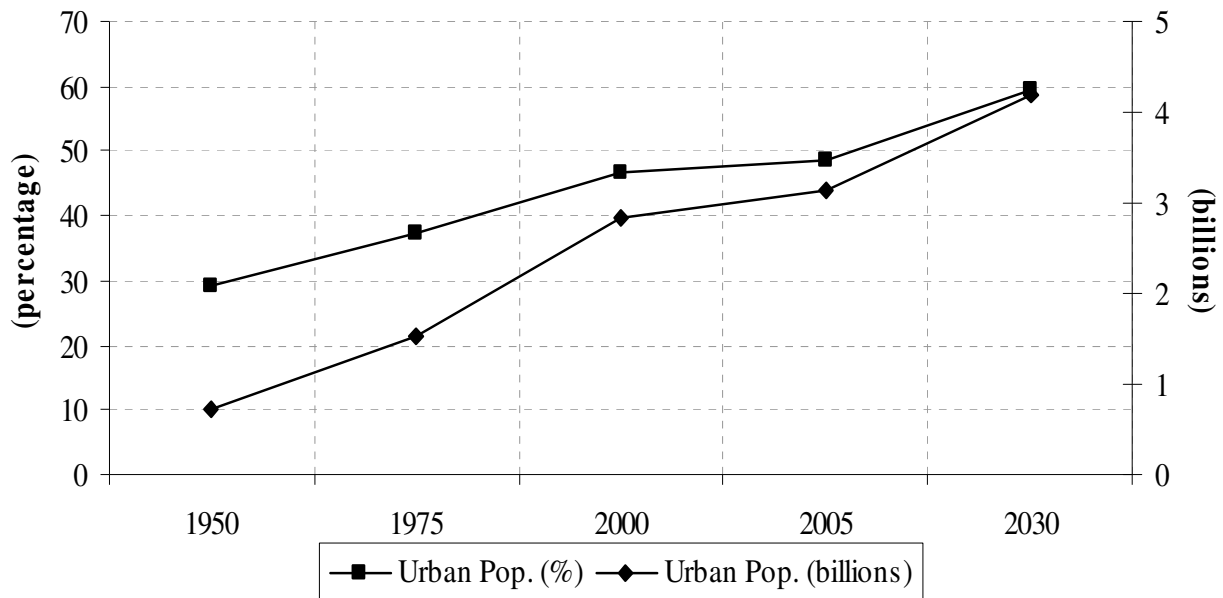


Figure 1. World urban population in percentage as well as in total since 1950 to 2030.



Figure 2. The location of Karachi on the political map of Pakistan. (Source of map: <http://maps.google.fr/map>)

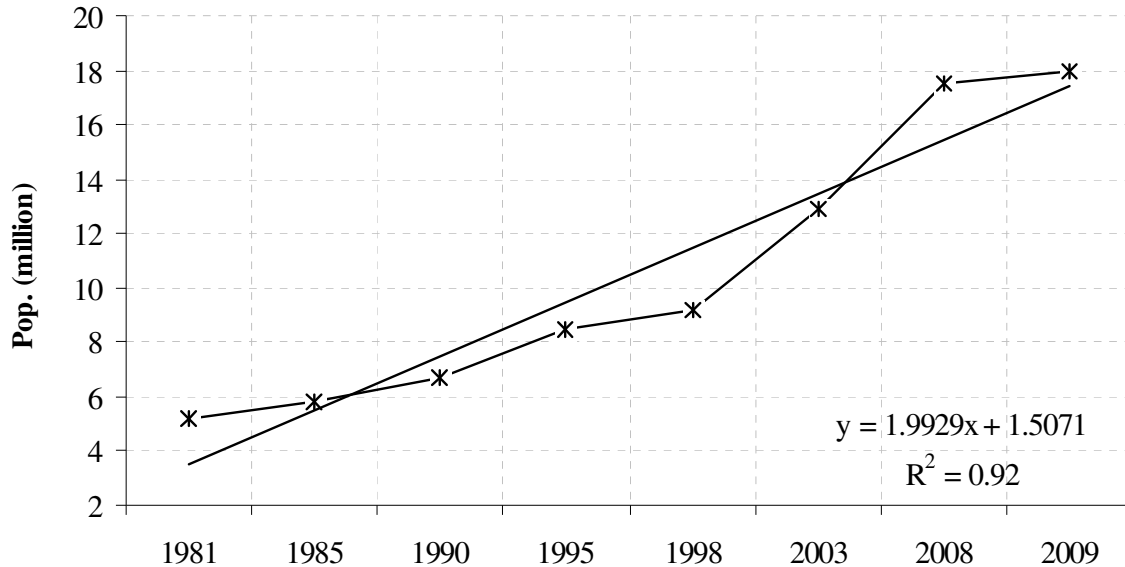


Figure 3. The growth and trend of population of Karachi since 1981 to 2009.

and Sindh provinces of Pakistan which extends from north to southward for about 300 km). The highest point of these hills in Karachi is about 528 m in the extreme north of the city. All these hills are devoid of vegetation and have wide intervening plains, dry river beds and water channels. Karachi has a long coastline in the south. Away from the shoreline are small islands including Shamsh Pir, Baba Bhit, Salehabad and Monora (the local names). Karachi has moderately temperate climate with a general high relative humidity that varies from 58% in December (the driest month) to 85% in August (the wettest month). In winter, the average temperature of the city is about 21 °C while in summer it reaches up to 35 °C. Karachi receives about 256 mm of average annual rainfall (Hassan and Mohib, 2009).

Karachi is the financial and commercial capital of Pakistan. The major sea port of Pakistan is in Karachi. So it plays an important role in the economy of Pakistan and is considered as the economic and financial gateway of Pakistan. Karachi has several large industrial zones such as Karachi Export Processing Zone, SITE, Korangi, Northern Bypass Industrial Zone, Bin Qasim and North Karachi, located on the fringes of the main city (FPCCI, 2009). Its primary areas of industry are textiles, pharmaceuticals, steel, and automobiles. In addition, Karachi has a vibrant cottage industry (Wikipedia encyclopedia, 2009).

MATERIALS AND METHODS

To study urbanization, energy consumption and carbon (iv) oxide (CO₂) emission in Karachi, simple regression method of all data used were worked out. For comprehensive study, we have used different kinds of data that made us to understand the urbanization scenarios and its effects on the demand of energy consumption and

CO₂ emission. For this purpose the following data were analyzed: (i) World urban population as total and in percentage from 1950 to 2030 (Population Division of United Nation 2005); (ii) Urban population of Karachi from 1981 to 2009 (CDG Karachi, 2009); (iii) Industrial units and industrial area from 1947 - 2009 (FPCCI, 2009 except data from 1986 to 2009); population and vehicles growth from 1990 to 2002 (Qureshi and Huapu, 2007; Linden, 1993) and from 2003 to 2008 by using the equation $y = 0.1621x + 3.2269$ for population growth and by using the equation $y = 0.4659x + 2.7154$ for vehicles growth; and (iv) Oil and petrol, natural gas, coal consumption and CO₂ emission from 1980 to 2006 (Energy information administration). Being the largest city of Pakistan, Karachi is the major consumer of energy and is emitting the greater part of CO₂ in atmosphere than other cities of the country. In this work, the analyzed data of fossil fuels and CO₂ emission for Karachi is taken into account as 15% of the total consumption of fossil fuels and emission of CO₂ of Pakistan while for the coal consumption, it was taken as 12% for Karachi

RESULTS AND DISCUSSION

Urban population and areal extension

Karachi is the largest city of Pakistan with about 18 million population. On the basis of population, it is the ninth largest city of the world (City District Government Karachi, 2009). Due to industrialization, business activities, infrastructure development and excessive job facilities, Karachi has been facing mass scale rural-urban migration from all over Pakistan. The city expanded very rapidly due to this mass rural-urban migration as well as natural urban population growth. The mass urbanization period in Karachi is seen after the 1980s. Figure 3 describes the population growth with trend line since 1981 to 2009. According to the Pakistan census reports, in 1951, the population of Karachi was just 1.1 millions, in 1981, it grew up to 5.2 millions and reached 18 million in

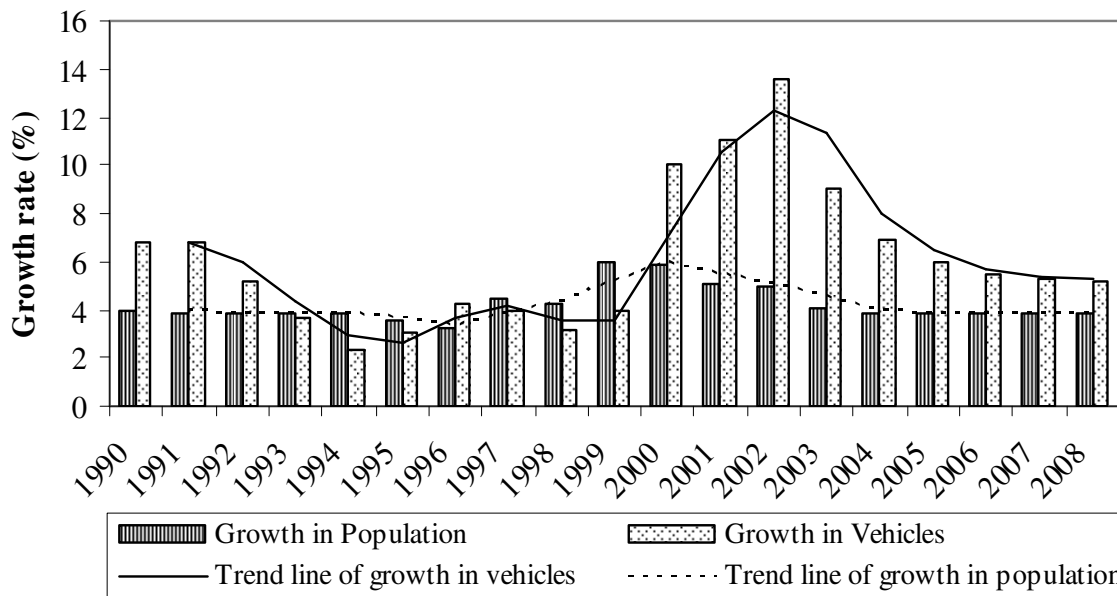


Figure 4. Growth rate of vehicles versus population in percentage (The data until 2002, is derived from Qureshi and Huapu, 2007 and afterward from urban resource centre).

2008. Since independence of Pakistan (1947 to 2008), the increase in population is about 1,500%. The rapid growth in urban population is observed after 1998. To fulfill the residential requirements for the increasing number of people in the city, new towns, housing societies and industrial zones were established at open spaces within the city and in suburbs. The urban area of Karachi in 1947 was 233 km² and in 2008, urban area of Karachi is measured as 3,640 km².

Transportation

The transport sector in Karachi had been developing with population growth and rapid urbanization. Unfortunately, Karachi has still poor transportation system as compared to the transport system of other mega cities of the world. In the modern era of technology and development, the city of 18 million population still has no tram or subway system to fulfill the transport facilities of the residents of Karachi. Total length of road network in Karachi is over 8,000 km with a density of 219 km per 100 km².

Figure 4 shows the growth rate of vehicles versus urban population. During 1990 to 2008, the observed growth in vehicles is comparatively greater than the population growth. The average mobility of trend line shows that the growth in vehicles is more than the growth in population. The maximum difference between population and vehicles growth is measured from 2000 to 2008. During this time period, the trends were contrary to each other in which population growth declined while vehicles growth boosted up to 14% annually. It shows that the difference in growth of population and vehicles is due to

increasing demand of transportation in the city. Among the increasing vehicles, the percentage share of personal cars is maximum than the other vehicles. According to one study, in 2003, there were 50% cars, 42% motorcycles, 3% taxis, 3% auto rickshaws and 2% buses and minibuses. About 98% of the local transport is run by the private sector while the remaining part is in the hands of the public sector. Among all transport sources, buses/mini buses provide about 50% of the travel demand (Qureshi and Huapu, 2007; Khan, 2007).

This information clearly highlights that about 92% vehicles are for personal use by the individuals and only 8% vehicles are used as public and private source of transport in the city. The 92% personal vehicles are the major source of energy consumption and CO₂ emission in the city.

Table 1 shows that there were 1,113,000 registered vehicles in Karachi in 2002 and this figure reached up to 8,420,000 registered vehicles in 2008. During this short time period, we saw a regular growth in vehicles. The observed growth during this time period is about 656% and it is many times more than the growth in urban population, infrastructure and industrial development.

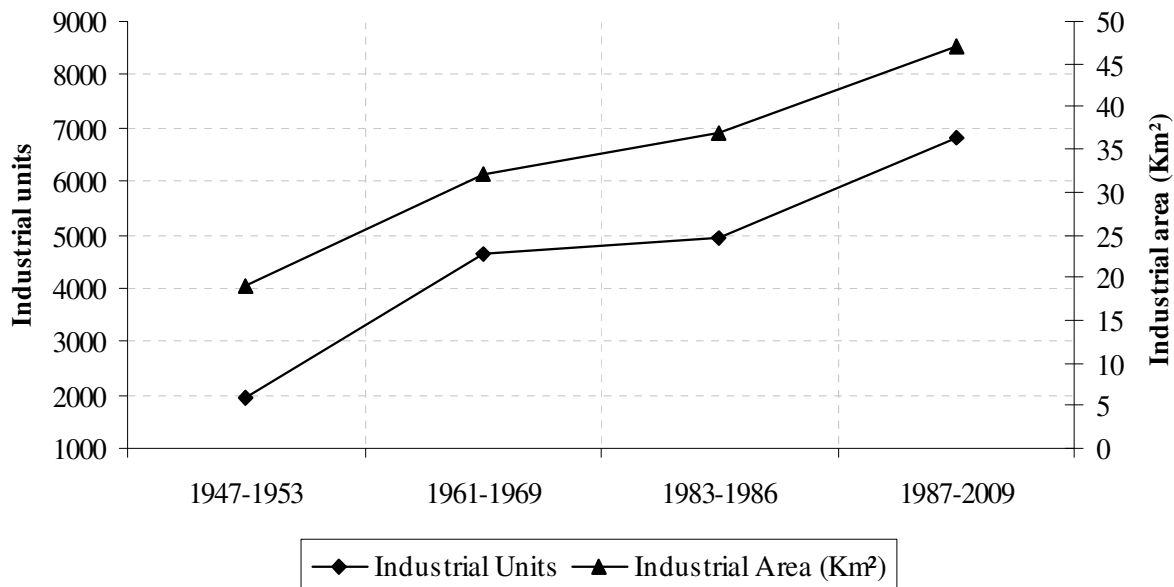
Fossil fuels consumption

The demand of fossil fuels in Karachi increased many folds than before. It is mainly due to the above stated reasons of increasing population, vehicles growth and industrial development. The demand of petroleum products, natural gas, electricity and coal in Karachi has been increasing with time. Total per-capita energy

Table 1. Total numbers and per year growth of vehicles in Karachi from 2002 to 2007.

Year	Total no of registered vehicles (in thousand)	Total number of vehicles (in thousand)
2002	1113	1113
2003	1177	2290
2004	1280	3570
2005	1431	5001
2006	1610	6611
2007	1809	8420

Source: Urban resource centre.

**Figure 5.** The growth in industrial units and Industrial area in Karachi since 1947 to 2009.

consumption in Pakistan is 12.4 million BTUs (Energy Information Administration, 2008) and it is estimated that Karachi alone consume about 15% of the total energy in Pakistan.

Figure 5 presents the growth in industrial area and industrial units. In this figure, it is seen that the major industrial development in Karachi was during 1947 to 1969 and during 1986 to 2009. During this time period, we can also see the high rate in population growth and urbanization. The computed growths in industrial units and industrial area in the above figure are 249 and 147%, respectively. It clearly shows that the proportion of increasing trends between industrial units and area is not uniform and the industrial zones became denser with time.

Figure 6 highlights the consumption of oil and petrol in Karachi. The per day consumption of oil and petrol jumped from 16000 barrels in 1980 to 51000 barrels in 2007 with an increase of 219%. Figure 7 elaborates the consumption of natural gas that increased from 40 billion cubic feet in 1980 to 186 billion cubic feet with an

increase of 365%.

Figure 8 shows that the coal consumption in 1980 was 262,000 short tons that reached up to 1,009,000 short tons in 2007; with an increase of 285%. Coal is mainly used in thermal electric power stations near Karachi to generate electricity while natural gas, oil and petrol are mainly consumed for domestic use and to run the transport and industries.

CO₂ emission

According to report of University College London workshop on climate change (2005), eleven of the world's global cities are responsible for some 70% of CO₂ emissions. Although Karachi is not included among these eleven cities but the rising trends of increasing emission of CO₂ are significantly showing that it will be one of the major cities which have maximum emission of CO₂. Total per-capita energy consumption in Pakistan is 12.4 million BTUs (1 BTUs = 1,055.055 joules) that contribute 0.7

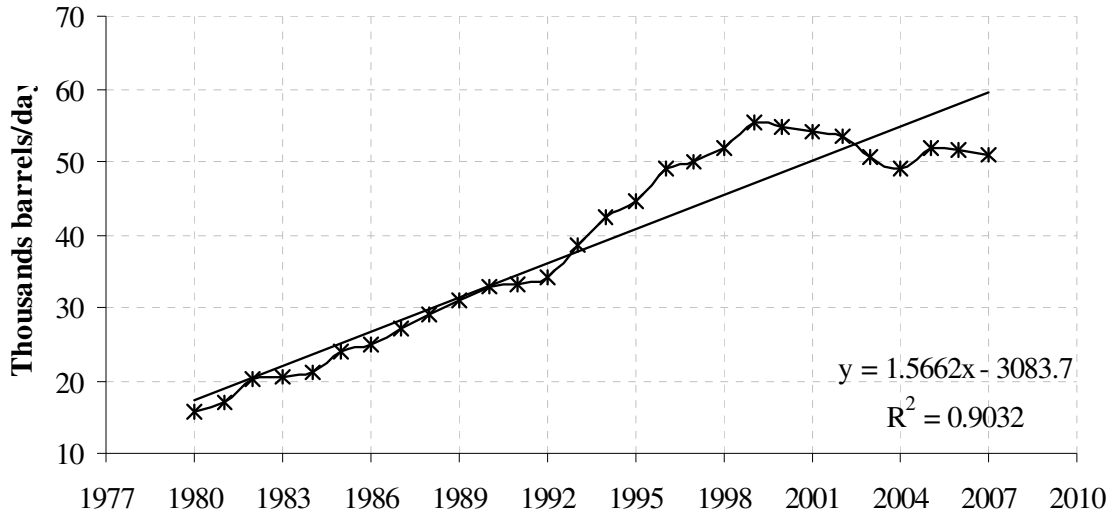


Figure 6. The consumption of oil and petrol in Karachi (000 barrels per day) since 1980 to 2007.

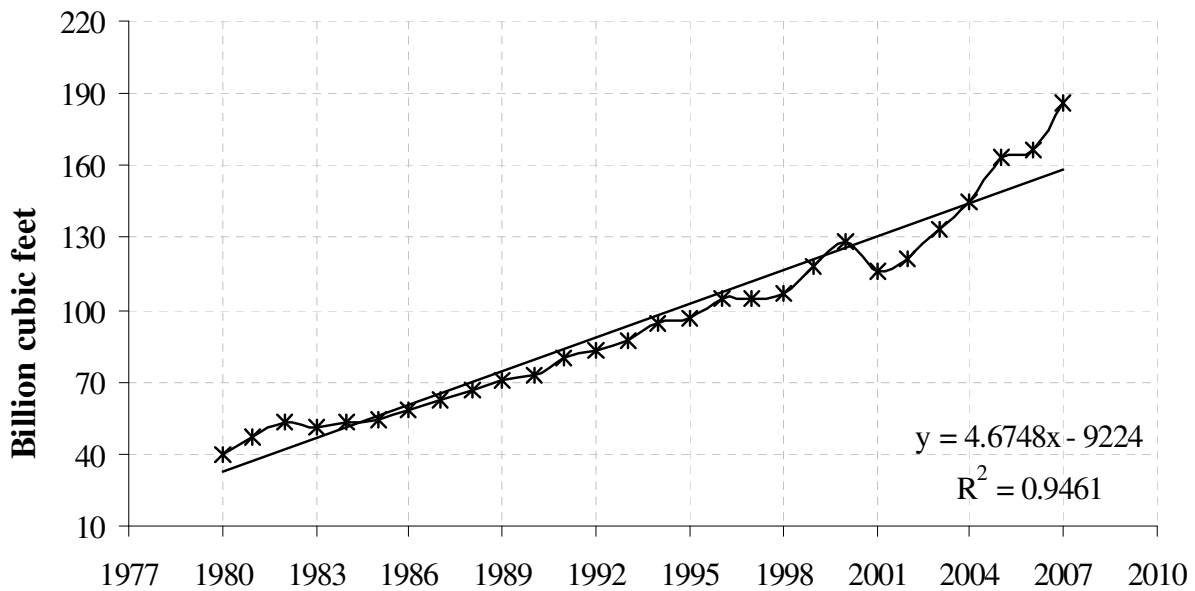


Figure 7. The consumption of natural gas in Karachi (billion cubic feet) since 1980 to 2007.

metric tons per-capita energy related CO₂ emission in environment. Being the largest city of Pakistan, Karachi is the major consumer of energy and the contributor of CO₂ emission in atmosphere than any other city of Pakistan.

Figure 9 presents the regular increase of CO₂ emission in atmosphere over Karachi. The rate of emission of CO₂ is not only rapid but it shows a regular exponential trend without any significant down fall throughout the computed time. It is observed that the CO₂ emission in atmosphere has reached up to 151 million metric tons in 2006 that was just 39 million metric tons in 1980. This 287% increase in CO₂ during 1980 to 2007 is the result of mass urbanization and energy consumption in Karachi.

Conclusion

The mega city of Karachi in Pakistan has been facing many social and environmental problems. The majority of the created problems are due to unplanned extension of the city since the creation of Pakistan to date. The meagre planning and expansion of the city with time, greatly affected the city and its residents due to shrinking open and green space, higher emission rate of pollution and CO₂ in atmosphere as well as rising urban temperature at alarming levels.

In this research, it was found that the rapid urbanization, industrialization, population and vehicles growth

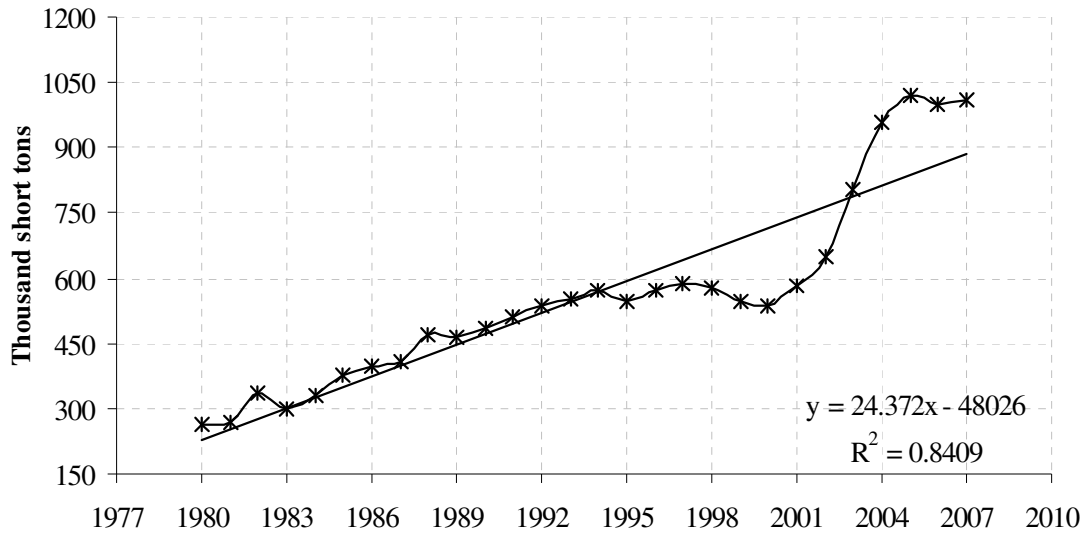


Figure 8. The consumption of coal in Karachi since 1980 to 2007 (000 short tons) since 1980 to 2007.

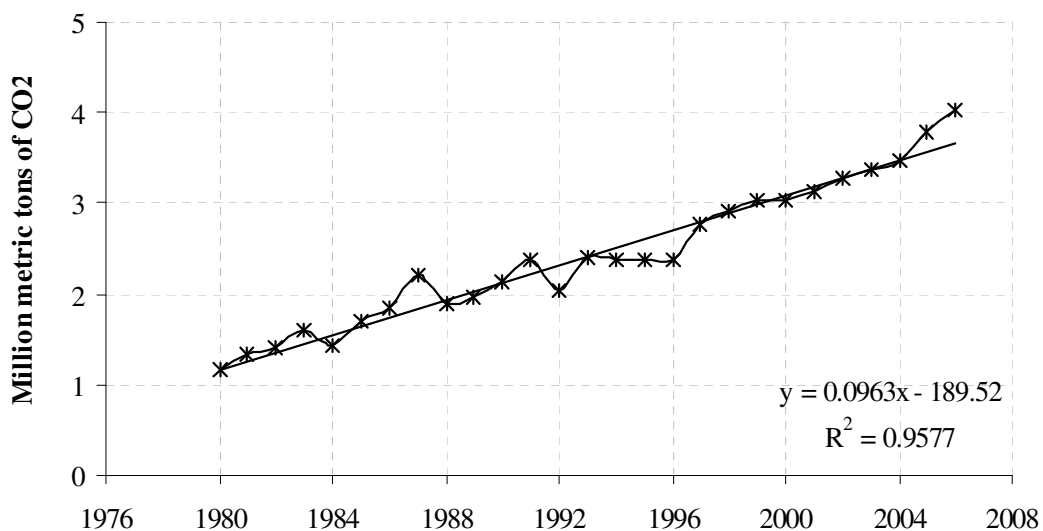


Figure 9. The emission of CO₂ from consumption of fossil fuels in Karachi (million metric tons of CO₂) since 1980 to 2007.

played a critical role in the consumption of fossil fuels in Karachi. The hypothesis of this work was to find out if the rapid urbanization in Karachi is boosting up the use of energy resources and how are they affect the emission of CO₂ in atmosphere. In the results, the computed data of Karachi's population, growth in population, vehicles, industrial area and industrial units showed a greater correlation. Conclusively, we have seen that there had been regular growth in urban population. The demand of transport has increased with time as the population has also increased. Before the 1990s, the growth in population was more than the vehicles growth. As we have seen previously, after the 1990s, the growth of vehicles in the city increased than the growth in

population which was mainly being due to the public and private banks in Pakistan which offered loan policies with low interest rate for vehicles and houses. This growth in vehicles caused greater part of fossil fuels in the transport sector. Among the analyzed data of vehicles, it was seen that about 92% of vehicles are self owned which move in the city for personal use (cars and motorcycles) and only 8% are used for passengers transport (buses, taxis and rickshaws). It shows that individual source of transport has more share in fossil fuels consumption and emission of CO₂ for the consumption of fossil fuels.

Many strategies can be adopted and measures can be taken by the local, provincial and federal government to

save the huge amount consumed in terms of utilization of oil, petrol and imports of vehicles and their parts. To make Karachi an environmentally friendly city by reducing the energy consumption and CO₂ emission, the most important action should be to develop the urban transport system on scientific basis. The efficient subway train or tram system like many of the world mega cities must be started in the cities. It will be the greater source of transport for the commuters of Karachi which will help to provide transport to all those millions of commuters who use their self transport to go from one place to another of the city for their daily jobs and work places. The project of Karachi Circular Rail should be restarted as it had been working in past. In this way, the government can reduce up to 50% traffic from the roads. It will help to reduce at least 40% of the consumption of fossil fuels and CO₂ emission. It can also help out the government to decrease the number of traffic wardens from the road who control the huge traffic. More over, to minimize the pressure of rural-urban migration to Karachi, the government should develop other economical zones in other parts of the country to provide better job facilities. Failing to adopt these strategies will not only increase the environmental problems in Karachi but will cause economic, social and security disasters in the coming future.

ACKNOWLEDGEMENTS

We are grateful to the Higher Education Commission, Government of Pakistan and University of Sargodha - Pakistan. Société française d'exportation des ressources éducatives (SFERE), Laboratoire Image Ville et Environnement, Université de Strasbourg, Centre National de la Recherche Scientifique (CNRS) and Réseau Alsace de Laboratoires en Ingénierie et Sciences pour l'Environnement (REALISE), France.

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