Climate Change in Pakistan: Causes and Consequences

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ABSTRACT

Climate change is inevitable, and developing countries such as Pakistan are more affected by it than any other state in the region. Floods, droughts, and harsh weather will put pressure on depleting resources. In a poverty-stricken country where health, education, and housing are the main issues, climate-responsive policies are of least concern. Mass migration for better living standards has triggered urbanization, causing Greenhouse Gas (GHG) emissions on an unparalleled scale in cities, which is the major contributor to climate change. The five carbon-emitting sectors in Pakistan are Building Industry, transportation, land use and land cover change, energy, and municipal solid waste. The data is collected from primary and secondary sources. The theoretical lens of this study is based on rational comprehensive theory. Data analysis uses qualitative research methodology, focusing more on document analysis. The research concludes that a crippled economy coupled with grave social issues has made the government non-functional against the eradication of GHG emissions and weakened its stance against climate change. Limited data, lack of crisis management, poor or no legislative actions, bureaucratic loopholes, and resource insufficiency have made matters even worse. The study further suggests that cross-disciplinary research and development on carbon reduction technologies to suit indigenous climates is indispensable. Carbon pricing should be ensured at industrial and commercial levels to curb GHG emissions, making cities more resilient against climate change.

KEYWORDS

Climate change, Carbon footprint, Urban infrastructure, Renewable energy, Land use, Municipal solid waste, Transport

INTRODUCTION

Climate change has grown into an indisputable fact around the globe in recent decades (Mashi, Inkani, Obaro, & Asanarimam, 2020). Air pollution, severe weather, rising ocean levels, and deteriorating human health are the issues at hand (Zuccaro & Leone, 2021) (Hossain & Rahman, 2021) (de Perez, et al., 2022) (Pazhuhan, 2023). This rapid climate variation is triggered by carbon-based compounds called carbon dioxide and chlorofluorocarbons (CFCs). The Intergovernmental Panel on Climate Change (IPCC) cautioned about its devastating effects and held urban areas responsible for rapid climatic change (Jiang, Hou, Shi, & Gui, 2017). Many states are reforming their urban design and regional planning to meet the United Nations initiative of Sustainable Development Goals (SDGs) 2030. The SDG-9 encourages eco-friendly infrastructure, and SDG-11 concentrates on making sustainable, safe, and resilient cities (Nop & Thornton, 2019). In 2016, the UN conference on housing and sustainable urban development in Ecuador gave an urban agenda called Habitat-III, which encourages standard guidelines for developing sustainable Urban Areas (United Nations, 2017).

After 2014, a recent wave of urbanization caused Pakistan to experience high migration rates toward megacities, as governmental statistics show that 36.4% of the country's population settled in cities (Malik & Wahid, 2014). The haphazard expansion of metropolitan cities in Pakistan is caused by random development with poor planning and zero topographic considerations. This urban sprawl raised the mean temperature from +0.32°C to +0.50°C per decade of populated cities, such as Karachi, Lahore, Faisalabad, Islamabad-Rawalpindi, Gujranwala, Peshawar, Multan, Hyderabad, and Quetta (Asian Development Bank., 2017). Residential buildings are home to over 207 million people, consuming 49% of the electricity produced. In 2017, the carbon dioxide produced using natural gas was 15.7 MtCO2 (Ghafoor, et al., 2020). Rapid urbanization caused deforestation and massive loss of Agricultural land. Industrialization is the root source of GHG emissions due to Pakistan's dependency on natural gas (Khan, Khan, & Rehan, 2020). During the last decade, the transportation sector has expanded, and the number of public and private vehicles on the road has increased bifold (Ahmed & Long, 2013). It has been estimated that Pakistan's overall GHG emissions will rise from 858 to 1650 kg per year by 2030. The energy and transport sectors contribute at least half of the nation's GHG emissions (Abas, Kalair, Khan, & Kalair, 2017).

It's essential to understand the link between urban infrastructure and its role in operational services. Buildings are connected through roads to move around in cities. Residents of buildings required electricity to sustain thermal comfort around the year. A waste management system is also necessary to dispose of solid waste generated by occupants. Interconnected Urban infrastructure is the response of citizens' activities that serve as a baseline for measuring total GHG emissions and approaches to minimize them (Ali & Askari,2023). The analysis will focus on five main sectors: land use, building industry, transportation, electricity, and municipal solid waste management. Pakistan ranked 142 out of 180 countries in the Environmental Performance Index 2020 (EPI). This study aims to enhance the present condition by discovering optimal solutions within given resources to reduce the carbon footprint of cities in Pakistan.

Materials And Methods:

This study is conducted through qualitative research within the post-positivist paradigm. To find out the answers to research questions, two qualitative approaches, i.e., descriptive and exploratory, have been used. The review study's data is mainly from primary and secondary sources. Primary data is extracted from governmental reports, whereas secondary data is derived from journal articles, periodicals, and reports. The data evaluation is done through documentary analysis, which supports data handling on a scientific basis and sets definite parameters for examining documentary sources rationally.

To eliminate the distortion and prejudices of the sources, documentary analysis is based on four significant authenticity tools: credibility, representativeness, and meaning, which are the primary means of quality control. The first tool of quality control in documentary analysis is authenticity. Since the primary documents are taken from official sources, there is no doubt about the authenticity of the documents used in the study. This approach has helped the researcher to find facts-based documents. The second tool has assisted in eradicating distortions and errors in documents. The third tool of representativeness suggests the consultation of more documents to verify the themes under study. The fourth tool of meaning has helped to confirm the evidence comprehensively while adopting the compare and contrast technique to generate the themes. The last stage of data analysis is based on breaking the data into bits and then merging all of them to develop the major themes. Hence, the conclusion becomes more authentic when it corresponds to every data analysis tool.

Land Use

The surface area of the land influences the radiation balance, water cycle, and Prevailing winds and can affect the delicate balance between the net reduction or increment in CO_2 emission (Committee on Climate Change, 2018) (Chuai, et al., 2016). The modification of land/earth surface by human activities i.e., housing, transportation, agriculture, etc. known as land use (Hassan, et al., 2016) while the biophysical characteristics (Yadav, Chhetri, Raymajhi, RajTiwari, & Sitaula, 2019) with physical land features (J, S, B, & KKG, 2020) covering the surface are called land cover. Grasslands, forests, and wetlands are examples of land cover (Twisa & Buchroithner, 2019) railways, roads, and buildings are the land use respectively (Nath, Niu, & Singh , 2018). According to an estimate, CO_2 emission from LULCC within the past 100 years is equivalent to emissions from fossil fuels burnt in the industrial era (Chang, Hou, Li, Zhang, & Chen, 2017). LULCC from Shifting cultivation agriculture systems in the tropics, deforestation, forest degradation, reforestation, and peat fires are also causes of emissions. Unmanaged ecosystems, fertilizers, and longer growing seasons can also sometimes affect the calculation of total emissions (Houghton, et al., 2012).

The LULCC contributes 25% of the share in total global CO_2 emissions, marking its importance in climate change (Romijn, et al., 2018). Rapid urbanization and industrialization are vital anthropogenic activities that triggered LULCC (Patra, Sahoo, Mishra, & Mahapatra, 2018). Worldwide transformation of forests into farmlands and urban development poses a massive threat to climate change. In developing countries like Pakistan, where urban expansion plays the role of a catalyst in economic growth, LULCC is undeniable (Samal & Gedam, 2015). Pakistan is an agrarian society that directly or indirectly channels 70% of the country's labor force towards agriculture. However, the problem of mass migration to urban areas is still on the way. From 2014 to 2016, the rural population declined from 61.4 to 60.1 percent, while the urban area increased from 38.5 to 40 percent. This migration from rural to urban regions starts a vicious cycle of urban expansion (Erasu, 2017) and a decrease in Cropland, triggering LULCC.

The ever-increasing population in urban areas will demand more infrastructure like education and health care facilities, parks, and roads, which require more land. As urbanization followed by urban sprawl, this rising need for land forced local governments to gain nearby agricultural land from adjacent villages (Bhat, Mifta ul Shafiq, Mir, & Ahmed, 2017) (Addae & Oppelt , 2019). In the long run, increasing unemployment and decreasing fertile land used for cultivation earlier compel the population to migrate to cities for better economic opportunities (Peerzado, Magsi, & Sheikh, 2018).

Building and Energy sector

The rapid urbanization and mass migration toward cities put pressure on existing buildings and raise a desire for building up more, which directly causes environmental deterioration and GHG emissions. The building sector has the highest emissions and energy consumption percentage, followed by industry and transportation. According to the United Nations Environment Program (UNEP), CO2 emissions in 2017, in just the building sector, there were over 11 gigatons of equivalent carbon dioxide (GtCO2), consuming 36% of global energy. UNEP estimated that world-building construction will have a covered area of 230 billion square meters in the next 40 years, equivalent to adding the city of Paris every week (Taffese & Abegaz, 2019). The most extensively used building material in construction is Portland cement, so much so that its production only illustrates 5% of global CO2 emissions. Manufacturing construction products themselves emit 40% of global GHG (Burciaga, Sáez, & Ayón, 2019). From construction to operation, buildings are accountable for high emissions in cities. An urban area with a population density of 5,000 people per square kilometer or higher building produce 54% in winter and reaches 65% in summer because of air conditioning of total CO2 emissions of that region (Lin, et al., 2017). A detailed analysis of residential buildings shows that they emit 156-to-4049.9-kilogram carbon dioxide equivalent per square meter (kgCO2e/m2) in the operation operating phase to get thermal comfort indoors (Chastas, Theodosiou, Kontoleon, & Bikas, 2018) (Besir & Cuce, 2018).

In Pakistan, there is not a single separate agency or institution that controls or promotes sustainable/green development (Bhandari & Bhattarai, 2017). Pakistan has a tropical climate, and indoor comfort is maintained with electricity, so to avert a massive surge in energy demand, green buildings (GB) are need of the hour. There are five main key factors halting the adoption of the green approach in the country, foremost is the absence of public awareness about the advantages of GB practices, unavailability of government-backed economic incentives, deficiency in codes and regulations, poor legislation, and failure to enforce laws, fifth; Insufficient technical knowledge and training in design and construction of GB to withdraw maximum performance (Azeem, Naeem, Waheed, & Thaheem, 2017). The high upfront cost of technology, lack of green products, and wrong perception of having the risk of investment in the green industry also hinder GB from flourishing in Pakistan's market (Azad & Akbar, 2015).

Electricity is vital to human settlements worldwide, and its provision is becoming a demanding task in the wave of urbanization, which is depleting fossil fuels and increasing global warming. Electricity production, consumption, and indirect, associated carbon emissions cause about 40% of the total energy-related GHG emissions in the world (Song, et al., 2018). The primary source of electricity production in these years is non-renewable fossil fuels, as its share elevated from 63% to 67%, with coal as a common choice, accounting for 60% to 64% of the total electricity produced (Ang & Su, 2016). Developed and underdeveloped countries are now taking the initiative to decarbonize their electricity sector through many strategies comprising public policing and technological innovations in renewable energy for long-term solutions (De Leon Barido, Avila, & Kammen, 2020).

Pakistan's sole dependency on fossil fuels and the recent increase in fuel prices with an already massive deficit caused a tremendous gap in demand and supply, resulting in power outages in urban areas. In 2019 the country had 33,836 MW installed capacity to produce electricity (Azam, Rafiq, Shafique, Ateeq, & Yuan, 2020) and an 8% increase in demand is expected yearly (Shabbir, et al., 2020). Moreover, outdated grid stations, poor distribution networks, and the inability to integrate renewable energy (intelligent autonomic systems) are further dragging the efficiency in the electricity sector. Pakistan has the highest transmission losses of any South Asian country (Irfan, Zhao, Ahmad, & Mukeshimana, 2019). Government initiatives and policies also failed to benefit the renewable sector because of the absence of energy development institutes and effective communication that can stimulate local energy markets (Zafar, Rashid, Khosa, Khalil, & Rahid, 2018).

Transportation

According to the International Energy Agency (IEA), the transport sector is 2nd largest CO_2 emitting source after electricity and heat generation in the world, emitting 8 Gigatons (Gt) of CO_2 in 2016, 74% of which was only caused by road transport. The road released CO_2 throughout its life cycle from construction to operation and maintenance (Alzard, et al., 2019). Transportation is also a cause of other Greenhouse gases (GHG), which play an integral part in climate change (Lewis , Zako, Biddle, & Isbell, 2018). There are two modes of urban transportation i.e., Motorized and Non-motorized. Informal, Formal, Public, and Private are sub-divisions of motorized transport (MT) powered by engines, such as cars, trucks, minivans, buses, and suburban rails.

Informal public transport (IPT), also known as para-transit or intermediate public transport, is a low-performance and capacity vehicle without proper credentials (Jauregui-Fung, et al., 2019). They are considered a lifeline for cities in developing countries (Pojani & Stead, 2015). In many Asian, African, and Latin American cities, it is the most frequent and extensively used form of urban public transport (Aworemi, Salami, Adewoye, & Ilori, 2008). In Pakistan, minibuses, rickshaws, Qing-li (chin-chis), retrofitted loaders, etc., are examples of IPT. Although they are accessible, faster, and cheaper, they are also unregulated, unsupervised, and hazardous to the environment (high levels of CO_2 emissions). The presence of IPT in large quality suggests a lack of transportation facilities in cities because the gap between demand and supply will met by IPT providers (Kumar, Singh, Ghate, Pal, & Wilson, 2016) (Alexopoulos & Wyrowski, 2015). Formal public transport (FPT), also known as public transport (PT), has gained substantial attention in recent years. PT, such as taxis, trams, light rail transit (LRT) systems, and metros or bus rapid transit (BRT), apart from being cost-effective, also help in reducing traffic congestion and CO_2 emissions in urban Regions (Cervero, 2013). It offers maximum operating flexibility and Service reliability (Huo, Zhao, Li, & Hu, 2014).

Public Transport (PT) provides more mobility and accessible services than cars or IPT in terms of LULCC [55] and is financially cost-effective for low-income commuters. It can also help overcome the physical gap between residential zones and work locations in already developed and expanded cities (Saif, Zefreh, & Torok, 2019) (Toledo & Rovere, 2018). Private motorized transport (PMT)/(MT) or Personal transport like Motorcycles, Cars, SUVs, etc., are responsible for high CO_2 in Urban settlements for three main reasons. First, PMT requires more space for operation and parking, leading to the ever-rising need for roads and parking areas. Second, running at half occupancy compared to BRT, PMT consumes more space per person on roads (Dalkmann & Brannigan, 2007). A third and most important factor is traffic congestion, which is also a direct cause of CO_2 emissions (Grote , Williams, Preston, & Kemp, 2016) (Bharadwaj, Ballare, & Chandel, 2017). Non-Motorized Transportation (NMT), as the name suggests, does not rely on an engine or motor for movement and is a human or animal-powered mode of transportation. NMT is the most environmentally friendly mode of transportation, i.e., walking, bicycle, pedicabs, push scooters, animal-drawn carts, etc., but this is difficult to implement in most cities of undeveloped countries. The key factors obstructing its worldwide application are the economic crisis caused by a sudden loss of revenue to motorized vehicle manufacturers and the lack of NMT infrastructure in urban regions (Yazid, Ismail, & Atiq, 2011).

The Internal Displacement Monitoring Center (IMDC) reported that transportation is one of the leading causes of rising temperatures and emissions in Pakistan (Mohsin, Abbas, Zhang, Ikram, & Iqbal, 2019). The transport sector consumes 35% of total energy and produces 29% of all CO_2 emissions in Pakistan (Rehman, Ikram, Feng, & Rehman, 2020). The provincial government spends most of the budget allocated for transportation to upgrade existing roads and build signal flyovers and underpasses to ease private transport like cars and motorcycles as they mark 87% of the total vehicles in the country (13% cars and 74% motorcycles). These attempts by the government to build better and larger roads to avoid congestion and improve the environment have done more harm than good. PT is the most ignored/neglected and outdated means of transportation in Pakistan. Since its independence, public transport development has not been synchronized with mixed-use, high-density urban areas. Although BRT works in some cities like Lahore, Karachi, Islamabad-Rawalpindi, and Multan, it still doesn't connect the entire city as BRT should by international standards. There is not a single city in the country that has citywide inclusive bus service. Because of urban sprawl, the area of urban regions has increased remarkably in the last decade, which makes NMT almost impossible. Poor infrastructure combined with weak urban mass transit traffic management creates a gap to be filled by IPT or para-transit, making complex situations chaotic (Haque & Rizwan, 2020) (Haseeb, Iftikhar, & Hasan, 2019).

Municipal Solid Waste Management

The landfill is the most familiar method for MSW management in the world that goes through biological, chemical, and physical changes; once deposited in the landfill, it produces two harmful products, leachates and GHG (Methane and CO_2). Methane contributes 40-60%, while CO_2 marks 45-60% of the total GHG emissions from landfills (Babel & Vilaysouk, 2016). Landfills are one of the largest human-generated sources of Methane and Carbon dioxide emissions (Kormi , Ali , Abichou, & Green, 2016). Methane produces a global warming potential of 21 units of carbon dioxide equivalent per unit of methane, while leachate chemicals escape from landfills and contaminate groundwater reservoirs (MELÉNDEz & GONzÁLEz, 2015). CO_2 discharge from direct and indirect sources like transportation and energy consumption (Sun, Li, Fujii, Hijioka, & Fujita, 2018).

Developing countries like Pakistan have serious MSWM issues as urban centers are experiencing rapid urbanization and urban sprawl. Excessive and irresponsible SW dumping gives rise to colossal scale challenges in waste handling (Korai , Mahar, & Uqaili, Optimization of waste to energy routes through biochemical and thermochemical treatment options of municipal solid waste in Hyderabad, Pakistan, 2016). From collection to disposal of waste, the MSW management system in Pakistan is affected by inadequate and limited resources (Ilmas, Mir, & Khalid, 2018). The deficiency of waste containers and designated land makes MSW collection a repulsive and tiring process, which, as a result, causes poor sanitary conditions and becomes a breeding ground for an outbreak in local suburbs (Ali, Marvuglia, Geng, Chaudhry, & Khokhar, 2017). The general population around these areas is forced to live an unhealthy life all because of the non-existent or poor MSW management. Moreover, it's customary in Pakistan to dump (Ali, Aslam, Dar, & Mumtaz, 2018) and burn waste in the open, which affects vegetation and causes air pollution (Yasin, Usman, Rashid, Nasir , & Randhawa, 2017). Incineration is a new technology in the developing world used to reduce the volume of MSW and minimize land use for landfills. The heat generated by burning waste is converted into electricity (Xin, Zhang, Tsai , Zhai , & Wang, 2020). It produces GHG and heavy metals such as mercury, lead, cadmium, chromium, copper, zinc, and dioxin in an atmosphere that pollutes water, soil, and air, which leads to acid rain. These factors raised questions about environmental degradation and threatened public health (Nabavi-Pelesaraei, Bayat, Hosseinzadeh-Bandbafha, Afrasyabi, & Chau, 2017).

According to the Ministry of Environment, 54,850 tons of MSW are generated in urban regions daily, while less than 60% is ever collected. Then, transportation of this collected MSW to centralized waste processing facilities (WPF) within or on the outskirts of cities adds another factor in GHG emissions caused by MSW (Syeda, Jadoon , & Chaudhry, 2017). District municipalities can't accommodate the entire city even with its total capacity, thus making room for different MSW management systems, simultaneously operating with no coordination among each other. Physical composition, waste density, temperature, and precipitation make matters worse for developing countries (Ejaz, , Akhtar, Nisar , & Naeem, 2010). Turkey-based international waste management corporations like Al-Bayrak and OZPak work in cities like Lahore, Islamabad/Rawalpindi. Still, they, too, couldn't improve Waste handling and management in the country (Masood, Barlow, & Wilson, 2014). The detailed composition of MSW Pakistan is as follows: 1% Metals, 2% Glass, 4% Paper products, 14% Plastic, 53% Kitchen (Food and Green Waste), and 26% Miscellaneous (Korai, Ali, Lei, Mahar, & Yue, 2019).

From landfill to incarnation, not a single method can survive in Pakistan, and that's why a series of processes are required, beginning from the source, to improve existing MSW management practices economically. As the above chart depicts, over 53% of the MSW produced is related to the kitchen and organic. Waste separation in the initial stages of MSW Management can bring far-reaching results regarding control over GHG emissions. Organic waste is the largest source of methane production in MSW, and it can be harvested in the form of biogenic substances (De Medina-Salas, Castillo-González, Giraldi-Díaz, Fernández-Rosales, & Welsh Rodríguez, 2020).

CONCLUSION

The principal reason behind Pakistan's failure to reduce its carbon footprint is the unavailability of accurate socio-economic data and its collection on the national level, which obstructs efficient urban planning in the country. If the government has to build public services like public transport, MSW Management systems, or even parks, there just is no accurate and complete data on that area. Non-serious public behaviour toward the issue, absence of a long-term developmental plan from the government, lack of environmental protection legislation, and failure to implement laws are significant factors in minimizing GHG emissions in Pakistan. That said, economic conditions are also one reason for impeding the country's research and development of green and sustainable practices.

The risk factor of investing in environment-friendly materials manufacturing and construction techniques is halting the local market from flourishing. Without a local market, it's difficult to reduce emissions as the application of any technology highly depends on availability; from photovoltaic solar panels to electric cars, accessibility to the general masses is as crucial as the technology itself. Region-specific technologies and policies are still developing, so they are of little help in achieving something practical. Most of the urban infrastructure is outdated, and to match state-of-the-art modern technology, urban infrastructure must be integrated to improve efficiency. They can decrease GHG emissions production at source and improve existing ones. Besides enhancing the above measures, carbon pricing should be implemented in Pakistan.

Carbon pricing is becoming popular in developed countries as it ensures that emission targets are met. It has the following advantages: taxes on carbon emissions discourage large cooperates from minimizing CO2 on the industrial level and improving the country's economic conditions. These incentives regulate cost-effectiveness in the short run and cost-reducing innovations in the long run. Carbon pricing will cause mass awareness among the public, and the revenue collected will be used in research and development and the formation of GHG emission reduction technologies, strategies, and policies.

References

Abas, N., Kalair, A., Khan, N., & Kalair, A. (2017). Review of GHG emissions in Pakistan compared to SAARC countries. *Renewable and Sustainable Energy Reviews 80 (2017) 990–1016*, 990–1016. doi:http://dx.doi.org/10.1016/j.rser.2017.04.022

Addae, B., & Oppelt , N. (2019). Land-Use/Land-Cover Change Analysis and UrbanGrowth Modelling in the Greater Accra MetropolitanArea (GAMA), Ghana. *Urban Science 3, 26*, 1-20. doi:10.3390/urbansci3010026

Ahmed , K., & Long, W. (2013). An empirical analysis of CO2 emission in Pakistan using EKC hypothesis. *Journal of International Trade Law and Policy*, 188 - 200. doi:http://dx.doi.org/10.1108/JITLP-10-2012-0015

Alexopoulos, K., & Wyrowski, L. (2015). *Sustainable Urban Mobility And Public Transport In UNECE Capitals.* New York: United Nations.

Ali, M., Marvuglia, A., Geng, Y., Chaudhry, N., & Khokhar, S. (2017). Emergy based carbon footprinting of household solid waste management scenarios in Pakistan. *Resources, Conservation and Recycling,*, 1-14. doi:http://dx.doi.org/10.1016/j.resconrec.2017.10.011

Ali, T. Z., & Askari, M. U. (2023). Impacts of the China-Pakistan Economic Corridor on the Natural Environment of Pakistan. *Pakistan Social Sciences Review*, *7*(4), 653-663.

Ali, Y., Aslam, Z., Dar, H., & Mumtaz, U. (2018). A multi-criteria decision analysis of solid waste treatment options in Pakistan: Lahore City—a case in point. *Environment Systems and Decisions*, 1-16. doi:https://doi.org/10.1007/s10669-018-9672-y

Alzard, M., Maraqa , M., Chowdhury, R., Khan, Q., Albuquerque, F., Mauga, T. I., & Aljunadi, K. N. (2019). Estimation of Greenhouse Gas Emissions Produced by Road Projects in Abu Dhabi, United Arab Emirates. *Sustainability 11, 2367*, 1-16. doi:10.3390/su11082367

Ang, B., & Su, B. (2016). Carbon emission intensity in electricity production: A global analysis. *Energy Policy 94*, 56–63. doi:http://dx.doi.org/10.1016/j.enpol.2016.03.038

Asian Development Bank. (2017). *Climate change profile of Pakistan.* ADB publications . doi:http://dx.doi.org/10.22617/TCS178761

Aworemi, J., Salami, A., Adewoye, J., & Ilori, M. (2008). Impact of socio-economic characteristics on formal and informal public transport demands in Kwara state, Nigeria. *African Journal of Business Management 2 (4)*, 72-76.

Azad, S., & Akbar, Z. (2015). The impediments in construction of sustainable buildings in Pakistan. *European Scientific Journal, 11(29),* 369-379.

Azam, A., Rafiq, M., Shafique, M., Ateeq, M., & Yuan, J. (2020). Causality Relationship Between Electricity Supply and Economic Growth: Evidence from Pakistan. *Energies 13, 837*. doi:10.3390/en13040837

Azeem, S., Naeem, M., Waheed, A., & Thaheem, M. (2017). Examining barriers and measures to promote the adoption of green building practices in Pakistan. *Smart and Sustainable Built Environment.* doi:https://doi.org/10.1108/SASBE-06-2017-0023

Babel, S., & Vilaysouk, X. (2016). Greenhouse gas emissions from municipal solid waste management in Vientiane, Lao PDR. *Waste Management & Research*, 30–37. doi:10.1177/0734242X15615425

Besir, A., & Cuce, E. (2018). Green roofs and facades: A comprehensive review. *Renewable and Sustainable Energy Reviews 82*, 915–939. doi:http://dx.doi.org/10.1016/j.rser.2017.09.106

Bhandari, M. P., & Bhattarai, K. (2017). Institutional Architecture for Sustainable Development

(SD): A Case Study from Bangladesh, India, Nepal, and Pakistan. *SocioEconomic Challenges, 1(3)*, 6-21.

Bharadwaj, S., Ballare, S., & Chandel, M. (2017). Impact of congestion on greenhouse gas emissions for road transport in Mumbai metropolitan region. *Transportation Research Procedia 25*, 3538–3551. doi:10.1016/j.trpro.2017.05.282

Bhat, P., Mifta ul Shafiq, Mir, A., & Ahmed, P. (2017). Urban sprawl and its impact on landuse/land cover dynamics of Dehradun City, India. *International Journal of Sustainable Built Environment 6*, 513–521. doi:https://doi.org/10.1016/j.ijsbe.2017.10.003

Burciaga, U., Sáez, P., & Ayón, F. (2019). Strategies to reduce CO2 emissions in housing building by means of CDW. *Emerging Science Journal, 3(5)*, 274-284. doi:http://dx.doi.org/10.28991/esj-2019-01190

Cervero, R. (2013). *Bus Rapid Transit (BRT): An Efficient and Competitive Mode of Public Transport.* Berkeley: IURD - University of California, Berkeley.

Chang, Y., Hou, K., Li, X., Zhang, Y., & Chen, P. (2017). Review of Land Use and Land Cover Change research progress. *IOP Conference Series: Earth and Environmental Science 113, 012087*, 1-7. doi:10.1088/1755-1315/113/1/012087

Chastas, P., Theodosiou, T., Kontoleon, K., & Bikas, D. (2018). Normalising and assessing carbon emissions in the building sector: A review on the embodied CO2 emissions of residential buildings. *Building and Environment 130*, 212–226. doi:https://doi.org/10.1016/j.buildenv.2017.12.032

Chuai, X., Huang, X., Qi, X., Li, J., Zuo, T., Lu, Q., . . . Zhao, R. (2016). A Preliminary Study of the CarbonEmissions Reduction Effects ofLand Use Control. *Scientific Reports*, 1-8. doi:10.1038/srep36901

Committee on Climate Change. (2018). *Land use: Reducing emissions and preparing for climate change* . London: Committee on Climate Change.

Dalkmann, H., & Brannigan, C. (2007). *Transport and climate change , Sustainable transport: A sourcebook for policy makers in developing cities.* Eschborn: Deutsche Gesellschaft für Internationale Zusammenarbeit (GTZ).

De Leon Barido, D., Avila, N., & Kammen, D. (2020). Exploring the Enabling Environments, Inherent Characteristics and Intrinsic Motivations Fostering Global Electricity Decarbonization. *Energy Research & Social Science 61, 101343*, 1-15. doi:https://doi.org/10.1016/j.erss.2019.101343

De Medina-Salas, L., Castillo-González, E., Giraldi-Díaz, M., Fernández-Rosales, V., & Welsh Rodríguez, C. (2020). A Successful Case in Waste Management in Developing Countries. *Journal of Pollution Effects & Control 8:242*, 5. doi:10.35248/2375-4397.20.8.242

de Perez, E., Harrison, L., Berse, K., Easton-Calabria, E., Marunye, J., Marake, M., . . . Zauisomue, E. (2022). Adapting to climate change through anticipatory action: The potential use of weather-based early warnings. *Weather and Climate Extremes*, 1-8. doi:https://doi.org/10.1016/j.wace.2022.100508

Ejaz, , N., Akhtar, N., Nisar , H., & Naeem, U. (2010). Environmental impacts of improper solid waste management in developing countries: A case study of Rawalpindi city. *The Sustainable World 142*, 379-387. doi:10.2495/SW100351

Erasu, D. (2017). Remote Sensing-Based Urban Land Use/Land Cover Change Detectionand Monitoring. *Journal of Remote Sensing & GIS 6:196*, 1-5. doi:10.4172/2469-4134.1000196

Ghafoor, G., Sharif, F., Khan, A., Hayyat, M., Farhan, M., & Shahzad, L. (2020). Energy Consumption and Carbon Dioxide Emissions of Residential Buildings in Lahore Pakistan. *Journal of Environmental Studies, 29(2),* 1613-1623. doi:10.15244/pjoes/109305

Grote , M., Williams, I., Preston, J., & Kemp, S. (2016). Including congestion effects in urban road traffic CO2 emissions modelling: Do Local Government Authorities have the right options? *Transportation Research Part D: Transport and Environment D 43*, 95–106. doi:http://dx.doi.org/10.1016/j.trd.2015.12.010

Haque, N., & Rizwan, M. (2020). *PIDE Urban Monograph Series No. 2: Rethinking Mobility (Urban Transport Policy) in Pakistan.* Islamabad: Pakistan Institute of Development Economics.

Haseeb, S., Iftikhar, M. N., & Hasan, S. M. (2019). Reimagining Pakistan’s Cities: Making Cities More Competitive. *ISSRA Papers*, 21.

Hassan, Z., Shabbir, R., Ahmad, S. S., Malik, A. H., Aziz, N., Butt, A., & Erum, S. (2016). Dynamics of land use and land cover change (LULCC) using geospatial techniques: a case study of Islamabad Pakistan. *Springer Plus*, 1-11. doi:10.1186/s40064-016-2414-z

Higgins, C., Ferguson, M., & Kanaroglou, P. (2014). Light Rail and Land Use Change: Rail Transit’s Role in Reshaping and Revitalizing Cities. *Journal of Public Transportation (2) 17*, 93-112.

Hossain, M., & Rahman, M. (2021). Climate change vulnerability and resilience of urban poor in Khulna, Bangladesh: the role of asset-based community development approach. *INTERNATIONAL JOURNAL OF URBAN SUSTAINABLE DEVELOPMENT*, 131–147. doi:https://doi.org/10.1080/19463138.2020.1828891

Houghton, R., House, J., Pongratz, J., van der Werf, G., DeFries, R., Hansen, M., . . . Ramankutty, N. (2012). Carbon emissions from land use and land-cover change. *Biogeosciences, 9*, 5125–5142. doi:10.5194/bg-9-5125-2012

Huo, Y., Zhao, J., Li, W., & Hu, X. (2014). Measuring Bus Service Reliability: An Example of Bus Rapid Transit in Changzhou. *Journal of Public Transportation*, 113-133.

Ilmas, B., Mir, K., & Khalid, S. (2018). Greenhouse gas emissions from the waste sector:a case study of Rawalpindi in Pakistan. *Carbon Management*, 645–654. doi: https://doi.org/10.1080/17583004.2018.1530025

Irfan, M., Zhao, Z.-Y., Ahmad, M., & Mukeshimana, M. (2019). Solar Energy Development in Pakistan: Barriers and Policy Recommendations. *Sustainability, 11, 1206*. doi:10.3390/su11041206

J, M., S, W., B, G., & KKG, C. (2020). Assessment of Land Use and Land Cover Change Using GIS and RemoteSensing: A Case Study of Kieni, Central Kenya. *Journal of Remote Sensing & GIS 9:270,* 1-5. doi:10.35248/2469-4134.20.9.270

Jauregui-Fung, F., Kenworthy, J., Almaaroufi, S., Pulido-Castro , N., Pereira, S., & Golda-Pongratz, K. (2019). Anatomy of an Informal Transit City: Mobility Analysis of the Metropolitan Area of Lima. *Urban Science 3, 67*, 1-39. doi:10.3390/urbansci3030067

Jiang, Y., Hou, L., Shi, T., & Gui, Q. (2017). A Review of Urban Planning Research for Climate Change. *Sustainability 9, 2224*, 1-21. doi:10.3390/su9122224

Khan, M., Khan, M., & Rehan, M. (2020). The relationship between energy consumption, economic growth and carbon dioxide emissions in Pakistan. *Financial Innovation, 6(1)*, 1-13. doi:https://doi.org/10.1186/s40854-019-0162-0

Korai , M., Mahar, R., & Uqaili, M. (2016). Optimization of waste to energy routes through biochemical and thermochemical treatment options of municipal solid waste in

Hyderabad, Pakistan. *Energy Conversion and Management 124*, 333–343. doi:http://dx.doi.org/10.1016/j.enconman.2016.07.032

Korai, M., Ali, M., Lei, C., Mahar, R., & Yue, D. (2019). Comparison of MSW management practices in Pakistan and China. *Journal of Material Cycles and Waste Management*, 1-11. doi:https://doi.org/10.1007/s10163-019-00951-0

Kormi , T., Ali , N. B., Abichou, T., & Green, R. (2016). Estimation of landfill methane emissions using stochastic search methods. *Atmospheric Pollution Research*, 1-9. doi:http://dx.doi.org/10.1016/j.apr.2016.12.020

Kumar, M., Singh, S., Ghate, A., Pal, S., & Wilson, S. A. (2016). Informal public transport modes in India: A case study of five city regions. *IATSS Research 39*, 102–109. doi:http://dx.doi.org/10.1016/j.iatssr.2016.01.001

Lewis , R., Zako, R., Biddle, A., & Isbell, R. (2018). Reducing greenhouse gas emissions from transportation and land use: Lessons from West Coast states. *Journal of Transport and Land Use*, 343-366. doi:http://dx.doi.org/10.5198/jtlu.2018.1173

Lin, T.-P., Lin, F.-Y., Wu, P.-R., Hammerle, M., Höfle, B., Bechtold, S., . . . Chen, Y.-C. (2017). Multiscale analysis and reduction measures of urbancarbon dioxide budget based on building energy consumption. *Energy and Buildings, 153*, 356-367. doi:http://dx.doi.org/10.1016/j.enbuild.2017.07.084

Malik, S., & Wahid, J. (2014). Rapid Urbanization: Problems and Challenges for Adequate Housing in Pakistan. *Journal of Sociology and Social Work 2(2)*, 87–110. doi:http://dx.doi.org/10.15640/jssw.v2n2a6

Mashi, S. A., Inkani, A. I., Obaro, O., & Asanarimam, A. S. (2020). Community perception, response and adaptation strategies towards flood risk in a traditional African city. *Natural Hazards*, 1-33. doi:https://doi.org/10.1007/s11069-020-04052-2

Masood, M., Barlow, C., & Wilson, D. (2014). An assessment of the current municipal solid waste management system in Lahore, Pakistan. *Waste Management & Research Vol. 32(9)*, 834–847. doi:10.1177/0734242X14545373

MELÉNDEz, G. M., & GONzÁLEz, L. V. (2015). Characterization of Greenhouse Gases Emissions from Urban Solid Waste in Baja California: A Proposal to Incorporate Technical Input into Decision-Making. *FRONTERA NORTE*, 5-28.

Mohsin, M., Abbas, Q., Zhang, J., Ikram, M., & Iqbal, N. (2019). Integrated effect of energy consumption, economic development, and population growth on CO2 based environmental degradation: a case of transport sector. *Environmental Science and Pollution Research*, 1-12. doi:https://doi.org/10.1007/s11356-019-06372-8

Nabavi-Pelesaraei, A., Bayat, R., Hosseinzadeh-Bandbafha, H., Afrasyabi, H., & Chau, K. (2017). Modeling of energy consumption and environmental life cycle assessment for incineration and landfill systems of municipal solid waste management - A case study in Tehran Metropolis of Iran. *Journal of Cleaner Production*, 1-48. doi:10.1016/j.jclepro.2017.01.172

Nath, B., Niu, Z., & Singh , R. (2018). Land Use and Land Cover Changes, and Environmentand Risk Evaluation of Dujiangyan City (SW China)Using Remote Sensing and GIS Techniques. *Sustainability 10, 4631*, 1-32. doi:10.3390/su10124631

Nop , S., & Thornton, A. (2019). Urban resilience building in modern development: a case of Phnom Penh City, Cambodia. *Ecology and Society 24(2): 23*, 1-12. doi:https://doi.org/10.5751/ES-10860-240223

Patra, S., Sahoo, S., Mishra, P., & Mahapatra, S. C. (2018). Impacts of urbanization on land use

/cover changes and itsprobable implications on local climate and groundwater level. *Journal of Urban Management 7*, 70–84. doi:https://doi.org/10.1016/j.jum.2018.04.006

Pazhuhan, M. (2023). Institutionalizing urban climate governance in the global South? Evidence from Tehran urban management, Iran. *Climate and Development*, 1-16. doi:https://doi.org/10.1080/17565529.2022.2161298

Peerzado, M. B., Magsi, H., & Sheikh, J. J. (2018). Land use conflicts and urban sprawl: Conversion of agriculture lands intourbanization in Hyderabad, Pakistan. *Journal of the Saudi Society of Agricultural Sciences 18*, 423–428. doi:https://doi.org/10.1016/j.jssas.2018.02.002

Pojani, D., & Stead, D. (2015). Sustainable Urban Transport in the Developing World: Beyond Megacities. *Sustainability 7*, 7784-7805. doi:10.3390/su7067784

Rehman, E., Ikram, M., Feng, M., & Rehman, S. (2020). Sectoral-based CO2 emissions of Pakistan: a novel Grey Relation Analysis (GRA) approach. *Environmental Science and Pollution Research*, 1-12. doi:https://doi.org/10.1007/s11356-020-09237-7

Romijn, E., De Sy, V., Herold, M., Böttcher, H., Roman-Cuesta, R. M., Fritz, S., . . . Martius, C. (2018). Independent data for transparent monitoring of greenhouse gas emissionsfrom the land use sector – What do stakeholders think and need? *Environmental Science and Policy 85*, 101–112. doi:https://doi.org/10.1016/j.envsci.2018.03.016

Saif, M. A., Zefreh, M. M., & Torok, A. (2019). Public Transport Accessibility: A Literature Review. *Periodica Polytechnica Transportation Engineering 47(1)*, 36-43. doi:https://doi.org/10.3311/PPtr.12072

Samal, D., & Gedam, S. (2015). Monitoring land use changes associated with urbanization:An object based image analysis approach. *European Journal of Remote Sensing*, 85-99. doi:10.5721/EuJRS20154806

Shabbir, N., Usman, M., Jawad, M., Zafar, M., Iqbal, M., & Kütt, L. (2020). Economic Analysis and Impact on National Grid by Domestic Photovoltaic System Installations in Pakistan. *Renewable Energy 153*, 509-521. doi:https://doi.org/10.1016/j.renene.2020.01.114

Song, Q., Wang, Z., Li, J., Duan, H., Yu, D., & Liu, G. (2018). Comparative life cycle GHG emissions from local electricity generation using heavy oil, natural gas, and MSW incineration in Macau. *Renewable and Sustainable Energy Reviews, 81*, 2450-2459. doi:http://dx.doi.org/10.1016/j.rser.2017.06.051

Sun, L., Li, Z., Fujii, M., Hijioka, Y., & Fujita, T. (2018). Carbon footprint assessment for the waste management sector: A comparative analysis of China and Japan. *Frontiers in Energy*, 1-11. doi:https://doi.org/10.1007/s11708-018-0565-z

Syeda, A. B., Jadoon , A., & Chaudhry, M. N. (2017). Life Cycle Assessment Modelling of Greenhouse GasEmissions from Existing and Proposed MunicipalSolid Waste Management System of Lahore, Pakistan. *Sustainability 9, 2242*, 1-8. doi:10.3390/su9122242

Taffese, W., & Abegaz, K. (2019). Embodied Energy and CO2 Emissions of Widely Used Building Materials: The Ethiopian Context. *Buildings 2019, 9, 136*, 1-15. doi:10.3390/buildings9060136

Toledo, A. L., & Rovere, E. L. (2018). Urban Mobility and Greenhouse Gas Emissions: Status, Public Policies, and Scenarios in a Developing Economy City, Natal, Brazil. *Sustainability 10, 3995*, 1-24. doi:10.3390/su10113995

Twisa, S., & Buchroithner, M. (2019). Land-Use and Land-Cover (LULC) Change Detection in Wami River Basin, Tanzania. *Land 8, 136*, 1-15. doi:10.3390/land8090136

United Nations. (2017). *New Urban Agenda (Habitat III).* Quito, Ecuador: UN by Habitat III Secretariat.

Xin, C., Zhang, T., Tsai , S.-B., Zhai , Y.-M., & Wang, J. (2020). An Empirical Study on Greenhouse Gas Emission Calculations Under Different Municipal Solid Waste Management Strategies. *Applied sciences 10, 1673*, 1-23. doi:10.3390/app10051673

Yadav, Y., Chhetri, B. K., Raymajhi, S., RajTiwari, K., & Sitaula, B. K. (2019). Dynamics of Land use Land Cover Change and Mapping of Tree Outside Forest (TOF) in Terai, Nepal. *Environment journal of environmental and natural resources*, 9. doi:10.19080/IJESNR.2019.19.556002

Yasin, H., Usman, M., Rashid, H., Nasir , D., & Randhawa, D. A. (2017). ALTERNATIVE APPROACHES FOR SOLID WASTE MANAGEMENT: A CASE STUDY IN FAISALABAD PAKISTAN. *Earth Sciences Pakistan*, 7-9. doi:https://doi.org/10.26480/esp.02.2017.07.09

Yazid, M. M., Ismail, R., & Atiq, R. (2011). The Use of Non-Motorized For Sustainable Transportation in Malaysia. *Procedia Engineering 20*, 125 – 134. doi:doi:10.1016/j.proeng.2011.11.147

Zafar, U., Rashid, T., Khosa, A., Khalil, M., & Rahid, M. (2018). An overview of implemented renewable energy policy of Pakistan. *Renewable and Sustainable Energy Reviews 82*, 654–665. doi:http://dx.doi.org/10.1016/j.rser.2017.09.034

Zuccaro, G., & Leone, M. (2021). Climate Services to Support Disaster Risk Reduction and Climate Change Adaptation in Urban Areas: The CLARITY Project and the Napoli Case Study. *Frontiers in Environmental Science*, 1-28. doi:10.3389/fenvs.2021.693319