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KEY POINTS

- Urban areas account for more than 70% of global greenhouse gas (GHG) emissions. These come from the cities' energy use, transport, industries, and agriculture.
- Nationally Determined Contributions (NDCs) pave the way for adaptation and mitigation measures to address GHG emissions in urban areas. Policy options include benchmarking and measurement studies, strategic environmental assessment, comprehensive city planning, green infrastructure, investing in cleaner and efficient technologies, and encouraging urban agriculture and lifestyle change, among others.
- Adopting sustainable and climate-responsive policies entails addressing institutional challenges in improving policy implementation at the local level. These challenges include coordinating with stakeholders; strengthening technical capacity, especially regulatory functions of government agencies; and supplementing human and financial resources in delivering urban services.

Urban Sector Inclusion in the Revised Nationally Determined Contributions of Pakistan

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INTRODUCTION

Nationally Determined Contributions (NDCs) are at the core of the Paris Agreement and the achievement of its long-term goals. The revised NDC for Pakistan, now under preparation, is envisioned to be more advanced and granular than the first NDC.[1] According to its updated commitments, a road map for emission control will be developed. All four sectors that are major contributors of greenhouse gas (GHG) emissions—energy, transport, land use and forestry, and agriculture—relate mostly to cities and urbanization.[2] Integrated city-level initiatives building on the role of urban planning and policies in mitigation and adaptation measures are important to be part of the road map. These policy notes provide guidelines to assist the relevant agencies and entities in developing the most appropriate policy framework.

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[1] This policy note was prepared as a discussion material during the consultations for the updating of Pakistan NDC. The Updated NDC of Pakistan was submitted to the United Nations Conference on Climate Change in October 2021.
[2] It is worth noting in this regard that while agriculture primarily takes place in the rural areas, demand is substantially attributed to the urban population.

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CITIES AND GREENHOUSE GAS EMISSIONS

Cities are usually blamed for most GHG emissions. According to the International Energy Agency (IEA), urban areas contribute around 70% of energy-related global GHG emissions and this is expected to increase to 76% by 2030 (IEA 2008). There are also claims that 80% of the world's anthropogenic GHG emissions are attributable to cities (Satterthwaite 2008). In Pakistan, the situation is no different, and could be even more serious: growth in most cities has led to urban sprawl and low-density development, and public transport is underdeveloped. As Glaeser (2009) put it, "to save the planet, build more skyscrapers."

A city-centric approach to delivering on the UN Sustainable Development Goals and Paris Agreement offers a significant premium. The key is cooperation among sectors—energy production and consumption; water resources management; thermal conditioning; transport; and food and agriculture. Taken all together, the impact of urban settlements is extensive, but there are opportunities to improve urban efficiency. However, these are conditioned on a better understanding of the role that each sector can play in reducing emissions.

In summary, building cities that are green, inclusive, and sustainable would need to be the core of every climate change agenda. It requires better planning, development, and management, including mobilization of a range of global actors, financial resources, and stronger partnerships. It also requires policy reforms in key sectors, such as energy efficiency, urban transportation, urban planning, sustainable food practices, and improved urban resilience.

ENERGY-RELATED EMISSIONS AND THE URBAN SECTOR

Energy is the largest contributor of GHG emissions, with an estimated share of almost 46% in 2015. Its net contribution is likely to increase as economies grow and urbanization proceeds.

The ambient temperature is generally higher in cities than in their surroundings. This phenomenon, known as the urban heat island effect, is primarily due to changes in land use and large increases in energy consumption in the urban areas, and to the greater heat absorption and retention capacity of surfaces in urban areas than in the surrounding rural areas.

Urban settlements present a complex challenge in that they demand high supply of energy. Major cities get their energy requirements from big power plants that transmit electricity over the shortest possible distance to reduce transmission losses. Similarly, mobility within and between cities including air transportation requires fuel with high energy content. Switching to electric vehicles will, in all likelihood, only increase the need for concentrated sources of energy and for a complex fuel distribution network. As freshwater becomes less available, some coastal cities like Gwadar and Karachi may also look for more energy sources for desalination. Major changes in energy supply to reduce GHG emissions will mean shifting to new and more sustainable energy use habits—for example, use of mass transport and more energy-efficient buildings.

Proposed Policy Measures

Some of the climate change solutions identified below could contribute to achieving GHG emission reduction targets.

1. Green Infrastructure
There is a need for green infrastructure, rather than all bricks and mortar. More green spaces, and urban design integrated with the natural environment, would reduce overall energy consumption by providing shade, lowering ambient temperatures, and lessening the need for air-conditioning.

Using surface water for municipal purposes will make energy-intensive tube wells less necessary. In addition, other measures like rainwater harvesting can be adopted to decrease demand for freshwater and reduce the volume of wastewater for (usually energy-intensive) treatment and discharge.

2. Energy-Efficient Buildings
Buildings are major consumers of energy, especially for temperature conditioning. Architecture in the region was originally much more climate friendly, with thick walls, high-pitched roofs, and adequate ventilation. Modern buildings with their glassworks and low-pitched roofs are designed only with air-conditioning in mind, leading to much higher energy use. Choosing materials with high thermal mass, using double or triple glazing, shading windows, maximizing cross-ventilation, and insulating the building envelope to improve energy efficiency are some passive cooling principles. A regulatory framework that promotes less energy-intensive urban design and architecture could provide significant support, especially in a country that is fast urbanizing.

3. Green Building Code
The country is in the process of adopting a green building code to support a climate-friendly built environment in new developments. Retrofitting the existing lot or using active or passive techniques for thermal comfort as well as energy conservation may not be possible in all cases, but could be made part of building regulations for major repair or reconstruction works. The National Building Code of 1984, still in use, and the building regulations for all local governments may need to be revisited.

4. Waste Recycling
Not all waste disposal is necessary. Some waste products can be recycled as alternatives to fresh raw materials. Recycling reduces the waste going to landfill sites, and thus also mitigates GHG emissions, while at the same time cutting energy use in the production of fresh raw materials. Construction debris, for instance, could be reused in road construction and for other purposes.

5. Waste-to-Energy Conversion
A disposal option much preferred over traditional open burning, open dumping, or even landfilling is incinerating municipal solid waste to produce electricity or steam for heating, including generating biogas from organic waste as a source of energy.

6. Energy-Efficient Appliances
Improvements in the efficiency of appliances can have a large impact on energy consumption. But while energy-efficient appliances often tend to be cheaper over their lifetime (as their running costs are lower), consumers sometimes struggle to calculate the life-cycle costs of an appliance and make purchase decisions based on the purchase price alone. Appliance labels can help consumers overcome this barrier by providing them with information about the energy use of appliances (NEECA, n.d.).

7. Energy Audit
A regular energy audit of all urban infrastructure, especially public sector systems (e.g., water supply and wastewater pumping units) can save substantial levels of energy use and encourage conversion to more energy-efficient engines, motors and turbines, etc. Such an audit would entail a one-time nationwide exercise, followed by periodic reviews, but would also have to be adequately funded and supported with the necessary technical capacity.

8. Electricity Grid Efficiency Improvement
It is estimated that improving global grid efficiencies could reduce GHG emissions worldwide by about 500 million metric tons of carbon dioxide equivalent ($MtCO_2e$) each year (Jordaan and Surana 2019). More efficient transmission and distribution of electricity could substantially lower the amount of electricity to be produced. Countries with a large share of fossil fuel generation and inefficient grid infrastructure have the most to gain. In Pakistan, for instance, inefficient grid infrastructure has resulted in transmission and distribution losses of 17% or more each year (World Bank, n.d.).

9. Use of Renewable Energy
Current energy production mostly uses fossil fuels, with renewables still accounting for only a small share. However, there is a growing policy shift toward promoting solar energy at the consumer level, with net metering and financing incentives. Emerging renewable source of energy for cities include wind and solar, especially for residential and commercial buildings.

INDUSTRY-RELATED EMISSIONS AND THE URBAN SECTOR

Like the waste and transport sectors, industrialization and industrial production are primarily urban phenomena. Urban settlements and industries have a symbiotic relationship: as the traditional planning concept of locating industries in special zones away from the cities has been modified in the last few decades, some industrial units are being planned closer to residential areas, thus adding to citywide GHG emissions (as well as to air pollution). In Pakistan, though there are dozens of industrial estates, most industries are located either within municipal limits or within two kilometers of the city area (Government of Punjab, Pakistan, P&D Board, 2017). This intermingling of urban residential and commercial areas with industries, especially cottage, small, and medium units, has had a major impact on overall emissions and air quality, magnifying the hazards and vulnerabilities of the urban population. The type and density of industrial units in and around cities vary, from predominantly textile units in Faisalabad and Karachi, and leather and sports goods in Sialkot, to highly polluting steel rerolling mills in Lahore.

GHG emissions from the industrial sector can be categorized into two main types. One type of emissions is due to energy use in industries. The second type, process emissions, are generated during production and not energy-related. Process emissions contributes around 3%–8% of total emissions,[3] although these may be significant in specific industry sectors, i.e., cement and aluminum processing.

Pakistan emitted an estimated 342 million $MtCO_2e$ of GHG emissions in 2012, with the industrial processes contributing 5%. GHG emissions increased by 87% between 1990 and 2012, primarily because of emissions from the energy and agriculture sectors (USAID 2016). While the industrial sector may not be contributing significantly to the country's total GHG inventory, its contribution at the urban sector level is significant. Reducing the GHG emissions of industry will help improve air quality and also lead to other co-benefits. Moreover, GHG emissions from the industrial sector have increased over the last 30 years and are likely to increase further because of the China–Pakistan Economic Corridor (CPEC), a regional connectivity framework that includes planned energy-producing plants and at least nine special economic zones across the country. According to estimates, whereas overall emissions would increase up to four times (from 406 $MtCO_2e$ in 2015 to 1,603 MtCO2e by 2023), the industry contribution would go up by much more (from 22 $MtCO_2e$ to 457 $MtCO_2e$) (Janjua, Khan, and Asif 2018).

Proposed Policy Measures

Industrial growth is propelled by market forces, but governments continually support policies and investments to speed up industrialization. These policies have impact on the natural environment, whether directly or indirectly. Industrial and environmental policies can be harmonized. The challenge is to set-up (and enforce) environmental standards without some negative impact on industrial development options, or formulate industrial policies that do not compromise environmental consideration. A sound knowledge base and an adequate understanding of emissions are needed for more balanced policy choices and targeted interventions.

[3] For manufacturing industries and construction only. The International Energy Agency (IEA) and the United Nations Framework Convention on Climate Change (UNFCCC) have slightly different figures for carbon dioxide emissions from fuel combustion (2002).

1. Benchmarking and Measurement Studies
Availability of relevant and detailed data in industrial processes is limited, and more granular measures are needed. Some production processes especially those in the informal sector are not available and remain undocumented. Data and information on industrial production are published in economic survey reports, but only on selected items. Collaboration between the provincial industry departments and the Ministry of Climate Change (MOCC) is important in the development of a credible database.

2. Urban Planning
In addition to planning for core city areas, industrial development and its impact on the rural and peri-urban environment are important factors to be considered. Urbanization is gradually transforming the rural and peri-urban areas and including them in the urban core. Once these areas are fully developed, the costs of reforming or improving them would be either too high or downright unreachable. Urban planning and urban governance polices that cover the peri-urban areas likely to be urbanized in the next 20–30 years, given the current rate of urbanization, are critical in this respect.

3. City Master Planning
Professional city-level master plans, with well-designed zones for industrial development, especially for polluting units, could be developed. Care is also needed in planning to avoid overly long commutes for workers, which would add to transport-related emissions.

4. Strategic Environmental Assessment
The strategic environmental assessment (SEA) is a useful tool to analyze and integrate environmental considerations into economic and industrial policies and plans. A well-prepared and well-implemented SEA provides options for environmental protection including climate mitigation and adaptation, avoidance of threats, and building partnerships among stakeholders. SEA has advantages over environmental impact assessment, while considering larger programs. An SEA may therefore be planned and carried out as a mandatory requirement for all special economic and industrial zones under the China–Pakistan Economic Corridor (CPEC). This is important, given the interplay between cities and economic zones.

5. Green Infrastructure
Green infrastructure may be considered over conventional options, given its benefits to decreasing overall energy usage. Integrating the natural environment in urban design can contribute to regulating indoor light and temperature, minimizing reliance on electronically-operated appliances for both.

6. Energy-Efficient Buildings
A considerable amount of energy, notably for temperature conditioning, is used up by buildings. Some passive cooling principles are choosing materials with high thermal mass, using double or triple glazing, shading windows, maximizing cross-ventilation, and insulating the building envelope to enhance energy efficiency. A regulatory framework that promotes a less energy-intensive industrial buildings could provide significant support.

7. Recycling of Industrial Waste
Not all waste has to be disposed of. Waste products that can serve as alternatives to fresh raw materials could take a different stream. Waste recycling not only reduces the waste going into landfill sites, thus mitigating GHG emissions, but also leads to less energy use in the production of fresh raw materials. A practice adopted in many sugar mills is the generation of electricity from bagasse, which was largely treated as waste a few years ago (Ahmad 2016). In leather processing, another key industry in the country, the management of solid and liquid waste is a major environmental consideration. Many options are available for the recycling and reuse of these wastes (Tahiri and de la Guardia 2009).

8. Circular Economy
A circular economy is an industrial system that is intended and designed to be restorative or regenerative. As industrial production and energy use depends highly on urban consumer behavior, an overall positive change in consumer attitudes and behavior toward all aspects of the circular economy would have significant impact on industrial GHG emissions.

9. Recycling of Industrial Wastewater
Of the 1,000 billion gallons of wastewater produced each year in the country, almost one-third is industrial wastewater (Murtaza and Zia 2012). There are very few operational wastewater treatment plants, at either the industrial unit or the city level. As a result, all the wastewater is discharged directly into freshwater bodies and to the sea, and hence becomes a source of GHG emissions. It is time for industry to take responsibility for the sustainable use of industrial water, and begin to reduce, reuse, and recover all industrial (waste) water.

10. Waste-to-Energy Conversion
The use of industrial solid waste to produce electricity or steam for heating and biogas generation from organic waste for use as energy source are disposal options much preferred over traditional open burning, open dumping, or even landfilling. In Pakistan, some local power plants already use bagasse and agricultural waste from sugar mills to generate electricity (Ghani et al. 2020), thus reducing the load on the grid and coal- or oil-based power generation. This practice could be promoted, through investment financing and tariff incentives for power purchase agreements.

11. Energy Audit
A regular energy audit of all industrial processes and conversion to more energy-efficient engines, motors and turbines, etc., can substantially reduce energy use.

TRANSPORT-RELATED EMISSIONS AND THE URBAN SECTOR

Carbon dioxide (CO_2) from fossil fuel combustion is responsible for almost all GHG emissions from transportation sources. The transport sector contributes around 23% of global CO_2 emissions from burning of fuels. Even more alarming is the fact that it remains the highest consumer of fossil fuels; thus, one of the significant sources of CO_2 emissions. Rapid urbanization in developing countries has increased energy use and CO_2 emissions in the urban transport sector (World Bank 2012). The emissions come essentially from the fuel combustion of petroleum-based fuel for transportation.

However, for sustainable urban transport, addressing the transport sector alone will not be enough. Sustainable city planning that reduces or optimizes transport and integrates land use and transportation planning, is the way forward. Prime examples of remarkable land use planning can be found in Bogota (Colombia); Curitiba (Brazil); Hong Kong, China; and Singapore (Tanzania PO–RALG 2020). These cities have showcased integrating urban transport with land use planning, significantly reduces GHG emissions while improving public transport and congestions.

Proposed Policy Measures

A comprehensive approach, addressing both the demand and supply side of travel and transport, is recommended with broadly three levels of policy interventions. These are discussed below, together with the need for capacity enhancement and awareness raising and behavioral change.

1. First Level: Reduce Demand (Avoid)

This refers to a reduction in total motorized transport activity as transportation and land use are intricately linked in cities, and the extent, quality, and intensity of travel depend directly on the location of residential and other land uses. What is needed is a more comprehensive and integrated, rather than sectoral approach. Strategic land use and compact city development can reduce or shorten travel and increase the share of public transport. Perhaps the best medium- and long-term intervention could follow the transit-oriented development (TOD) model.

TOD in urban planning maximizes the amount of residential, business, and leisure space within walking distance of public transport, especially mass transit systems like Bus Rapid Transit (BRT) and urban railways. TOD supports a beneficial relationship between compact city and public transport use.

In general, eight TOD principles could be followed in city development (ITDP 2017):

- **Walk.** Develop activity-friendly neighborhoods, and have walkable streets that connect mixed land uses.
- **Cycle.** Prioritize nonmotorized transport networks, especially safe cycle lanes, etc.
- **Connect.** Create a dense network of streets and paths, to minimize the need for car travel.
- **Transit.** Locate development close to high-quality mass transit.
- **Mix.** Plan for mixed-use development for varying incomes, land uses, and demographics.
- **Densify.** Maximize densities with supportive land use regulations, matching the transit capacity.
- **Compact.** Develop compact regions with short transit commutes, minimizing sprawl and excessive land use.
- **Shift.** Increase nonmotorized and public transport mobility by regulating parking and road-use charges to discourage the use of private vehicles.

In addition, adopting demand management measures discourages the acquisition and use of private vehicles by imposing both non-pricing controls (i.e., restrictions on parking or days the car can be used) and pricing controls such as fuel taxes, parking fees, and congestion pricing.

2. Second Level: Promote the Use of "Low-Emission" Transport (Shift)

Nonmotorized modes of transport and public transport are included here. Cities may encourage walking and cycling by providing pavements and cycle lanes to increase safety and the desire to use these modes. In addition, cities could promote, develop, incentivize, and subsidize public transport, giving it priority over car-based transport. Steps that they could take include providing infrastructure as well as soft policy components that facilitate public transport. As their population grows and the demand for transport space increases, perhaps the most important priority for cities is to ensure that these spaces promote nonmotorized transport and efficient, reliable, cost-effective, and clean public transport.

3. Third Level: Use the Most Fuel-Efficient Vehicle Technology (Improve)

Adoption of technological measures that reduce the GHG emissions of motorized vehicles is critical. Among the possible measures is increasing the uptake of hybrid, plug-in hybrid, and electric vehicles, as well as the use of biofuel blends in conventional fossil fuel vehicles.

4. Enhance Capacity

The capacity of urban institutions to understand, measure, and manage climate change–related factors in urban transport could be strengthened. Most of the urban institutions managing transport were established decades ago, when climate change was nowhere on their agenda. Laws, rules, regulations, codes, standards, and guidelines all need to be geared toward addressing this challenge, and aligned toward sustainable urban transport.

5. Raise Awareness and Promote Behavioral Change

Improving public awareness of climate change through awareness raising and behavioral change communications is vital to the further reduction of GHG emissions from the transport sector.

AGRICULTURE-RELATED EMISSIONS AND THE URBAN SECTOR

Of the country's total emissions of around 342 million $MtCO_2e$ in 2012, the agriculture sector contributed 41%, second only to the energy sector's 46%. The 87% increase in GHG emissions between 1990 and 2012 was mainly due to the agriculture sector (USAID 2016).

GHG emissions from agriculture can be categorized into two main types. One type of emissions is due to cropping patterns, fertilizer use, and associated transport-related operations. The other type is cattle-related: Pakistan is among the world's top-10 cattle-producing countries (Hegde 2019).

Agriculture is a source of three primary GHGs: CO_2; methane (CH_4), with a global warming potential (GWP) at least 28 times that of CO_2; and nitrous oxide (N_2O), whose GWP is up to 265 times the GWP of CO_2 (Greenhouse Gas Protocol 2014). Agricultural fields can also be a CO_2 sink through carbon sequestration into biomass products and soil organic matter.

GHG emissions from agriculture have increased over the last few decades and are likely to increase further as population growth escalates and the country is rapidly urbanized. Over the 21-year period between 1994 and 2015, there was a 143.8% growth in agricultural emissions, from 71.6 to 174.6 $MtCO_2e$ (Ijaz and Goheer 2021). CH_4 accounted for 89.8 Mt of emissions in 2015, and N_2O, for 83.7 Mt. Various agricultural soil management practices resulted in 45.5% of the sector total; enteric fermentation, in 45.1%; and livestock manure management in 6.5%. Emissions from rice cultivation (1.7%) and the burning of crop residue (1.1%) made up the rest.

Because of GHG emissions, agricultural production, though usually taking place outside urban limits, could also have significant impact on the cities. More than 40% of the population of Pakistan lives in cities and peri-urban areas, and depends mostly on food produced in the rural areas. The hundreds of large and small urban settlements scattered across the country make it unnecessary, in most cases, to transport agricultural produce over long distances. But in the larger cities, where more than 50% of the urban population lives, there is little peri-urban or urban agriculture, and the food supply chain is relatively long and energy intensive.

Paradigm shifts are suggested in the literature to mitigate GHG emissions from agriculture, on the supply (production) and demand (consumption) side, and promote climate-smart agriculture. The suggested measures involve, among others: (i) structural changes on the production side to make the food supply chain more efficient, including improvements in food processing, preservation, and retail technologies; and (ii) large-scale dietary changes, and reduced losses and waste, on the consumption side. As these measures are related to urban systems, urban and peri-urban agriculture and forestry (UPAF) could assume a relevant role in food systems sustainability.

Proposed Policy Measures

The majority of Pakistan's population lives in the rural areas and more than 45% of its labor force works in the agriculture sector (Government of Pakistan, Finance Division, 2020), essentially the backbone of the national economy and food security. The government is encouraged to promote policies and investments to advance agricultural productivity.

Little effort was made in the past to contain GHG emissions in the agriculture sector. Environmental standards and policies have to be established and enforced together with agricultural policies. However, this balance necessitates a sound knowledge base and an adequate understanding of emissions for more balanced policy choices and targeted interventions, as reducing agricultural emissions without compromising food security is a real challenge.

All segments of agriculture have management options that can reduce the ecological as well as the climate footprint of the sector. While agriculture-related activities are mainly a function of rural areas, many urban-related policy measures could support the reduction of the related GHG emissions, especially in the medium to long term.

Some of the climate change solutions proposed below could be urban sector policy measures that contribute to meeting agriculture-related GHG emission reduction targets.

1. Benchmarking and Measurement Studies

There is still limited access to credible and detailed data on agriculture-related production and processing in Pakistan, the supply chain, and consumption patterns and proportional emission levels. Obtaining more objective and granular data is important for targeted emission control policies, strategies, and interventions. There is a need for better data on agriculture-related environmental impact on the urban sector. Collaboration between the provincial agriculture and livestock departments, local governments, and the Ministry of Climate Change (MOCC) at the federal level would be essential for the development of a credible database.

2. Urban Planning

Environment-friendly and sustainable urban planning could have several dimensions related to agriculture sector emissions and mitigation measures.

- **Peri-urban areas and greenbelts** around large cities could provide valuable food products for urban residents, thus reducing transport-related energy emissions and waste due to long supply chains.
- If properly incentivized, **urban farming** and kitchen gardening, especially in less dense areas, could provide some food components, such as fruits and vegetables, and lessen the need for long-distance transport and the use of inorganic fertilizers.
- Encouraging **mixed urban land use** makes cities more walkable and promotes local shopping, leading to shorter and less frequent trips to buy food, instead of the usual daily routine.

3. Urban Waste Management
Reducing food waste and using the organic fraction in urban farming and kitchen gardening would lessen dependence on inorganic fertilizers, with favorable effects on the reduction of CO_2 and N_2O emissions. Composting from municipal waste is an opportunity for nutrient recovery, reducing both the environmental impact of mineral fertilizer production and emissions from the landfilling of organic waste (Langemeyer et al. 2021).

4. **Urban Agriculture**
Urban agriculture provides an opportunity to transform and use phosphates and nitrogen recovered from urban wastewater and solid waste. This reduces negative externalities through the primary extraction of mineral fertilizers. Together with the use of efficient technologies, it can significantly reduce emissions like in hydroponics that cuts N_2O emissions by half (Massana et al. 2017). The agriculture sector, however, remains one of the most vulnerable to the impact of climate change. Addressing the climate risks to agriculture could also support better mitigation benefits overall.

The following steps may be considered by city governments to strengthen climate change adaptation and resilience through UPAF (Dubbeling, van Veenhuizen, and Halliday 2019):

- integrating food security and urban agriculture into urban development plans and strategies;
- developing and sustaining agriculture projects as part of green infrastructure;
- designating open spaces prone to floods and landslides as permanent agricultural and multifunctional areas;
- integrating UPAF into comprehensive city water(shed) management plans, and into social housing programs; and
- instituting ordinances for UPAF.

5. Sustainable Dietary Habits
Meat consumption in the cities tends to result in higher GHG emissions than the consumption of non-meat foods. A strong case can therefore be made for promoting a vegetarian diet.

6. Short Food Supply Chain
Promoting urban agriculture, apart from other benefits, shortens the food supply chain, with positive impact on reducing transport-related emissions as well as food waste (and consequently demand for production). But the reduction of climate and environmental impact depends greatly on how urban agriculture configures among cross-sectoral programs, as exemplified by the use of irrigation water.

INSTITUTIONAL BARRIERS TO IMPLEMENTATION

Implementing the foregoing policy measures within the given time frame could be an institutional challenge and a tall order for any government, owing to several issues, including the following:

- **Three tiers of government.** Pakistan has a three-tier governance structure—federal, provincial, and local. Policy setting and planning takes place at the national and provincial levels, but implementation is done at the local level, especially when building and environmental permits are issued and building regulations are enforced. Responsibility in the agriculture and industry sectors is shared between the local governments and departments at the provincial and federal levels. In a country with a total population of 220 million and hundreds of local governments, coordinated efforts toward a unified national goal are a formidable aspiration. With so many stakeholders, gaps and overlaps are likely and can weaken the system. Regulation in the industrial sector will be particularly arduous, as waste treatment processes are expensive and the export markets are becoming increasingly competitive.
- **Capacity.** Technical capacity for urban planning and management is a challenge, not only at the local level but also at the provincial level, especially for urban institutions.
- **Resources.** Human and financial resources are another weak link in the governance chain. Local governments and environmental protection agencies are barely capable of delivering a decent set of urban services. Expecting them to carry out these measures would require additional resources.
- **Long-term projects.** Most industrial investments are long-term commitments, and addressing power generation issues would require similar planning and interventions.

SUMMARY AND CONCLUSIONS

A country's greenhouse gas emissions are an important indicator of its economic activities. Cities for that matter are the optimum scale for integrated policy development and action on climate change mitigation as well as adaptation. More than half of Pakistan's economy is driven by cities (Government of Pakistan, Finance Division, 2020), and these can offer significant scope for GHG emission reductions.

A city's GHG emissions give a picture of its structure and priorities. Its resource use and waste generation are all interlinked and connected with GHG emissions. It is not urbanization per se that aggravates emissions. Rather, the way people move about the city, the extent of urban sprawl, the various uses of energy, and the way buildings are heated and cooled, determine how the city pollutes the environment and contributes to climate change.

There are a number of options to reduce GHG emissions from the industrial sector. These suggest improving energy efficiency, use of alternative and cleaner fuels, cogeneration of heat and power, use of renewable energy, and more efficient use and recycling of materials. There are existing low-emission alternatives that can be further improved to reduce emissions from industrial processes. However, new methods are currently being explored (Chandler 2019).

The large amount of GHG emissions generated in the transport sector makes emission reduction and tracking especially difficult. But the sector has the greatest potential for achieving dramatic reductions in emissions, leading to co-benefits such as less air and noise pollution and improvements in the lives of citizens through active travel.

Strategic options are available for cities to reduce their carbon footprints attributed to the transport sector. The avoid–shift–improve (A–S–I) approach presents viable measures on climate change mitigation, as it recommends demand- and supply-side interventions. Demand-side interventions aim to reduce the number of motorized vehicle trips, increasing the modal share of nonmotorized transport, and encouraging the use of public transport over private vehicles. Supply-side interventions are primarily based on policies that influence technology choices of consumers (e.g., increasing the uptake of more fuel-efficient cars, electric cars, and biofuels).

GHG emissions in the agriculture sector can be reduced through improvements in fuel efficiency—reduced transport distances, shorter supply chains, changes in dietary habits, sustainable urban planning, and more efficient use and recycling of urban waste, among other measures.

Managed urban development and governance with GHG emission reductions and other co-benefits in mind is the key to successful improvement. The whole system of urban governance should ideally move toward environment-friendly strategies, programs, and projects. Simply addressing technological issues will not be enough.

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