**KEY POINTS**

- Greenhouse gas (GHG) emissions in the waste sector for Pakistan are expected to increase with the rapid population growth and urbanization. Updated Nationally Determined Contributions (NDCs) should provide particular focus on the waste sector by studying its quantity, composition, and disposal methods.

- The waste sector has limited data in Pakistan and challenges in improving data management on waste generation and estimating GHG emissions are considerable.

- Lessons learned and best practices from the private sector and related donor-funded initiatives highlight sound solid waste management and GHG mitigation strategies.

- A streamlined institutional arrangement for the sector is required to bring information together into a sustainable and functional system with defined responsibilities and coordinated participation with stakeholders.

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**Waste Sector Inclusion in the Revised Nationally Determined Contributions of Pakistan**

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**INTRODUCTION**

Pakistan ratified the United Nations Framework Convention on Climate Change (UNFCCC) in June 1994 and has since submitted two National Communications on climate change (MOCC 2018). Each of these contained an updated inventory of the country’s greenhouse gas (GHG) emissions and information about mitigation and adaption measures, planned or being implemented; steps that the government has taken to integrate climate change considerations into relevant social, economic, and environmental policies; and the related financial, technical, or capacity-building needs. Pakistan is now preparing its third National Communication.

Under the Paris Agreement, each country is expected to outline and communicate its post-2020 climate actions in the form of a Nationally Determined Contribution (NDC). Pakistan submitted its Intended NDC (INDC) to the UNFCCC in 2015 (Government of Pakistan 2015). It stated that Pakistan intended to reduce up to 20% of its projected GHG emissions by 2030, subject to the availability of international grants to cover the total abatement cost.

Estimates of GHG emissions from the waste sector in Pakistan are found in the country's National Communications and NDC. For the waste sector and others, the country used the Tier 1 (gain–loss) methodology—the simplest—and Intergovernmental Panel on Climate Change (IPCC) default emission factors in arriving at the estimates. The latest year for which emission estimates have been compiled is 2015.

Note: The authors are grateful for the insights of Esmyra Javier (Senior Climate Change Officer, Asian Development Bank [ADB]), Mian Shafi (Senior Program Officer, Pakistan Resident Mission, ADB), Mohammad Irfan Tarq (Director General, Ministry of Climate Change, Government of Pakistan) and Syeda Hadika Jamshaid (Climate Change Specialist, Ministry of Climate Change, Government of Pakistan). The authors also acknowledge the Global Change Impact Studies Centre and the German Agency for International Cooperation (or GIZ) for the data and information provided in developing this brief.
A review of Pakistan’s Second National Communication (2NC), however, seems to cast doubt on the reliability of the historical emission estimates for the waste sector, for the following reasons:

- The 2NC cites 15.65 million metric tons of carbon dioxide equivalent contributed by GHG emissions from the waste sector in 2014–2015, versus the 12.29 million metric tons of carbon dioxide equivalent reported in the NDC for the same period. The contribution of waste to Pakistan’s total GHG emissions is also rendered uncertain because of a lack of data on the amount of municipal solid waste (MSW) generated each year. The MSW emission estimates assume that only 60% of municipal waste is collected and dumped at disposal sites, and the 2NC estimates are confined to methane (CH\textsubscript{4}) emissions, suggesting that only landfilled waste is taken into account. Because of the lack of reliable data on the fraction of waste that is disposed of through open dumping, the resulting carbon dioxide (CO\textsubscript{2}), nitrous oxide (N\textsubscript{2}O), and CH\textsubscript{4} emissions are not considered. The 2018 GHG Inventory (under preparation) for Pakistan’s First Biennial Update Report (BUR1), however, includes emissions from waste burning as well.

- No estimates for rural waste emissions have been prepared because there is no collection and disposal system on which those estimates can be based.

- The emission estimates are based on the Revised 1996 IPCC Guidelines (IPCC 1996), which have since been superseded by the 2006 Guidelines (IPCC 2006) and the 2019 Refinement to the 2006 Guidelines (IPCC 2019). The IPCC inventory software used to generate the emission estimates (IPCC 1996) had not yet been updated to incorporate the 2006 Guidelines. The latest version of the software (released in October 2019), however, takes those guidelines into account.\(^2\)

GHG emissions from the waste sector are expected to increase substantially in the coming years, with rapid population growth and urbanization. But no mitigation actions are suggested for the waste sector in the country’s NDC. More accurate emission estimates are urgently needed and mitigation actions must be promptly put in place to reduce emissions from the waste sector.

The following sections give an overview of waste management in Pakistan, the activity data currently available for the compilation of GHG emission estimates, and recommended improvements.

WASTE MANAGEMENT IN PAKISTAN

The Ministry of Climate Change (MOCC) is responsible for solid waste management in urban areas. At the provincial level, waste management is handled by local government departments. This responsibility in large cities has been delegated to public sector waste management companies, following some institutional reforms over the last decade. In Punjab province, for example, the solid waste management function has been allocated among eight waste management companies, and in Khyber Pakhtunkhwa province, seven water and sanitation services companies manage waste on behalf of the local governments. In Sindh province, the Sindh Solid Waste Management Board has been created in a bid to increase technical and professional capacity.

These companies and boards have relatively reliable databases and waste management companies, following some institutional reforms over the last decade. In Punjab province, for example, the solid waste management function has been allocated among eight waste management companies, and in Khyber Pakhtunkhwa province, seven water and sanitation services companies manage waste on behalf of the local governments. In Sindh province, the Sindh Solid Waste Management Board has been created in a bid to increase technical and professional capacity.

These companies and boards have relatively reliable databases and waste measurement equipment, including weigh bridges at the landfill sites. The companies can provide real-time data on waste collection and disposal, once a framework for data management is established. Data collection through this route is recommended, to improve the accuracy of emission estimates.

WASTE DISPOSAL ROUTES

The country has hardly any managed landfill sites. Most of its urban waste is dumped on open ground or left uncollected—a state of affairs that calls to mind the unmanaged shallow (<5 meters deep) landfill site category in the IPCC guidelines. In the rural areas, municipal waste disposal follows a similar pattern, although the dumping sites are more dispersed across open areas.

No estimates are available for waste burned illegally by the municipalities. Waste burning as a method of disposal is not commonly practiced in any of the cities. In the rural areas, the waste is mostly organic (agricultural waste, cow dung) and is mostly dumped locally on open ground and not collected or disposed of at dumping sites. In some cases, agricultural waste is burned in the fields to clear the ground for the next growing season (Ahmed and Ahmad 2014).

ACTIVITY DATA REQUIRED TO ESTIMATE GHG EMISSIONS FROM THE WASTE SECTOR

In the IPCC guidelines, GHG emissions from the waste sector are grouped into the following categories, each one with different data requirements for estimating GHG emissions, in accordance with the Tier 1 methodology.\(^3\)

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1 Since this paper was first drafted, it has become apparent that the differences in the emission estimates are due to the fact that the NDC is based on preliminary results, and the 2NC, on revised figures incorporating comments from stakeholders.

2 Before the United Nations Climate Change Conference in Katowice, Poland, in 2018, non–Annex I parties (mostly developing countries) could use either the 1996 or the 2006 Guidelines when preparing their national GHG inventories. They generally chose to use the 1996 Guidelines for consistency with previously reported inventories. For Pakistan’s BUR1, however, the 2006 IPCC Guidelines are being used, in line with the Katowice decision.
Waste Sector Inclusion in the Revised Nationally Determined Contributions of Pakistan

- **Solid waste disposal (IPCC code 4A).** This refers to the disposal of municipal solid waste in managed anaerobic or semi-aerobic, and unmanaged deep or shallow, landfill sites. Information about the amount of waste remaining in the landfill and its composition is needed.

- **Biological treatment of solid waste (4B).** This is likely to be a very small source of GHG emissions in Pakistan, and only a few pilot projects are currently in progress.

- **Incineration and open burning of waste (4C).** Incineration of municipal waste does not occur in Pakistan. There are incinerators for infectious hospital waste in most of the large hospitals, however many lack this facility and the waste is com mingled with municipal waste. But the open burning of waste does, and emissions from this source should therefore be estimated. As noted earlier, waste disposal using this method appears to be excluded from Pakistan’s inventories. Data on the annual quantity of openly burned waste and (ideally) its composition are required.

- **Wastewater treatment and discharge (4D).** The 2NC report contains limited information about how emission estimates for this sector were generated. If the IPCC inventory software (IPCC 1997) was used, as is thought to be the case, the estimates are based on default information from the region and are likely to be reasonable. They are not discussed further here.

### QUANTITIES OF WASTE GENERATED IN PAKISTAN

There are various estimates of the amount of waste generated each year in Pakistan. These include statistics from the Government of Pakistan, a World Bank report (Kaza et al. 2018), Pakistan’s Country Commercial Guide (ITA 2019), and the Punjab Municipal Fund Development Fund Company (PMDFC) under a World Bank–funded project (PMDFC 2018b). According to the 2NC, urban waste generation amounts to 0.65 kilograms (kg)/capita/day. This figure is considered a reasonable estimate for Karachi, the largest city, but waste generation rates are believed to be lower in smaller cities (0.42–0.55 kg/capita/day) and even below that level in semi-urban and rural areas. Data on the amount of waste generated in rural areas are more difficult to obtain, but this has been estimated at 0.33 kg/capita/day (Ilyas et al. 2017). There is also another category of human settlements—one that is neither urban nor rural but somewhere in between. Waste generated in these areas would count as rural for classification purposes, but is more urban in composition and generation figures per capita. More accurate estimates demand further work.

In summary, the waste sector is the most data-scarce in Pakistan. No central authority or agency responsible for waste management serves as the repository of waste-related data. To provide a regular GHG inventory, the Global Change Impact Studies Centre is strengthening its links with the organizations concerned, and the waste sector is being given due consideration.

Table 1 provides passable estimates of current waste generation quantities. With better data collection and future studies, the accuracy of these estimates should improve.

### WASTE COMPOSITION

Information about the composition of municipal waste is available from several studies done in the last 3–4 years in various cities in Pakistan (Table 2). The figures present a reasonable split in composition for urban waste generation.

### THE WAY FORWARD

There are at least four ongoing donor-funded urban sector projects across Pakistan:

- World Bank–funded Punjab Cities Program (PMDFC 2018a), which covers 16 small and medium-sized cities in Punjab province (Bahawalnagar, Burewala, Daska, Gojra, Hafizabad, Jaranwala, Jhang, Jhelum, Kamalia, Kamoke, Khanewal, ...

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**Table 1: Estimated Waste Generation in Pakistan, 2020**

<table>
<thead>
<tr>
<th>Type of Human Settlement</th>
<th>2020 Population (million)</th>
<th>Waste Generated Per Day</th>
<th>Waste Generated Per Year (million tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Total Amount Generated (tons)</td>
<td>Per Capita(kg)</td>
</tr>
<tr>
<td>Large cities (11)</td>
<td>52</td>
<td>28,600</td>
<td>0.55</td>
</tr>
<tr>
<td>Medium and small cities</td>
<td>32</td>
<td>13,440</td>
<td>0.42</td>
</tr>
<tr>
<td>Rural areas</td>
<td>126</td>
<td>41,580</td>
<td>0.33</td>
</tr>
<tr>
<td>Total</td>
<td>210</td>
<td>83,620</td>
<td></td>
</tr>
</tbody>
</table>

kg = kilogram.
Source: Global Change Impact Studies Centre, Pakistan.

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3 Although GHG emissions from solid waste disposal are likely to be a key category and a higher-tier method should ideally be used for this reason, a complete inventory for the waste sector is more important at this stage and should be given priority.
Table 2: Composition of Municipal Waste in Pakistan, 2020

<table>
<thead>
<tr>
<th>Type</th>
<th>Gujranwala</th>
<th>Islamabad</th>
<th>Koha</th>
<th>Mardan</th>
<th>Mingora</th>
<th>Mirpur</th>
<th>Muzaffarabad</th>
<th>Peshawar</th>
<th>Sahiwal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green kitchen waste</td>
<td>62.50</td>
<td>59.95</td>
<td>55.82</td>
<td>62.96</td>
<td>49.21</td>
<td>62.33</td>
<td>68.24</td>
<td>53.74</td>
<td>56.90</td>
</tr>
<tr>
<td>Paper</td>
<td>15.30</td>
<td>7.26</td>
<td>8.20</td>
<td>3.91</td>
<td>13.10</td>
<td>4.46</td>
<td>4.95</td>
<td>7.32</td>
<td>5.22</td>
</tr>
<tr>
<td>Textile</td>
<td>3.87</td>
<td>1.81</td>
<td>2.75</td>
<td>3.71</td>
<td>3.53</td>
<td>3.05</td>
<td>2.71</td>
<td>2.35</td>
<td>3.71</td>
</tr>
<tr>
<td>Dry grass and wood</td>
<td>1.63</td>
<td>0.00</td>
<td>0.15</td>
<td>1.05</td>
<td>4.66</td>
<td>1.43</td>
<td>1.32</td>
<td>10.29</td>
<td>1.70</td>
</tr>
<tr>
<td>Plastic</td>
<td>7.70</td>
<td>7.49</td>
<td>21.70</td>
<td>7.36</td>
<td>14.69</td>
<td>10.51</td>
<td>10.22</td>
<td>9.34</td>
<td>9.54</td>
</tr>
<tr>
<td>Leather and rubber</td>
<td>0.77</td>
<td>0.00</td>
<td>0.72</td>
<td>0.61</td>
<td>0.33</td>
<td>0.84</td>
<td>1.09</td>
<td>0.63</td>
<td>0.88</td>
</tr>
<tr>
<td>Metal</td>
<td>0.23</td>
<td>0.68</td>
<td>0.03</td>
<td>0.20</td>
<td>0.46</td>
<td>0.31</td>
<td>0.26</td>
<td>0.72</td>
<td>0.38</td>
</tr>
<tr>
<td>Bottle and glass</td>
<td>1.16</td>
<td>2.79</td>
<td>0.03</td>
<td>0.87</td>
<td>0.74</td>
<td>1.03</td>
<td>1.31</td>
<td>2.32</td>
<td>0.75</td>
</tr>
<tr>
<td>Ceramic, stone, soil, etc.</td>
<td>1.10</td>
<td>0.00</td>
<td>0.90</td>
<td>3.09</td>
<td>1.30</td>
<td>0.59</td>
<td>0.24</td>
<td>12.32</td>
<td>2.51</td>
</tr>
<tr>
<td>Domestic hazardous waste</td>
<td>0.60</td>
<td>0.82</td>
<td>0.40</td>
<td>0.45</td>
<td>0.50</td>
<td>0.37</td>
<td>0.47</td>
<td>0.00</td>
<td>1.03</td>
</tr>
<tr>
<td>Sieve remnants &gt;6mm</td>
<td>3.23</td>
<td>0.00</td>
<td>0.76</td>
<td>0.00</td>
<td>2.86</td>
<td>1.61</td>
<td>0.78</td>
<td>0.00</td>
<td>3.06</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>1.91</td>
<td>19.20</td>
<td>8.54</td>
<td>15.79</td>
<td>8.62</td>
<td>13.47</td>
<td>8.41</td>
<td>0.97</td>
<td>14.33</td>
</tr>
</tbody>
</table>

mm = millimeter.

Note: Based on various recent city-level studies.
Source: Asian Development Bank compilation.

Kot Addu, Muridke, Okara, Vehari, and Wazirabad); Asian Development Bank (ADB)–funded Punjab Intermediate Cities Improvement Investment Program (Government of Punjab 2020), involving nine medium-sized cities in Punjab province (Bahawalpur, Dera Ghazi Khan, Multan, Muzaffargarh, Rahimyar Khan, Rawalpindi, Sahiwal, Sargodha, and Sialkot); ADB–funded Khyber Pakhtunkhwa Cities Improvement Projects (ADB 2019), worth around $380 million and covering five large cities in Khyber Pakhtunkhwa province (Abbottabad, Kohat, Mardan, Mingora, and Peshawar); and

• World Bank–funded urban development project for the city of Karachi (World Bank 2021).

All four projects have significant solid waste management aspects. Almost all of them will entail waste analysis and characterization studies (WACS). An opportunity therefore exists to guide the project managers toward a fuller appreciation of the importance of

• accurate data on waste generation, composition, and disposal;
• a methodology for the regular compilation and transmittal of updated waste data, possibly through an institutional coordination framework; and
• disposal options aligned with the objectives stated in the revised NDC.

SUGGESTED IMPROVEMENTS IN WASTE EMISSION PROJECTION ESTIMATES

Once more accurate GHG emission estimates for the historical time series are available, these will feed into improvements in emission projections.

SUGGESTED GHG MITIGATION OPTIONS FOR THE WASTE SECTOR

As stated above, no GHG mitigation strategies are suggested in Pakistan’s revised NDC. Options that could be considered include the following:

• mixed municipal waste sorting facilities at the city or regional level;
• recovery of recyclables and reuse in the economy (a strong scavenging network in the informal sector serves the purpose, but no reliable data are available);
• anaerobic digestion and biogas recovery;
• composting of the organic fraction of waste and use as soil nutrient (as agriculture makes up a large part of Pakistan’s economy, this option merits consideration); waste-to-energy (WtE) technologies, wherever feasible (given the high organic and high moisture content of mixed municipal waste, and its
low calorific value, direct incineration for WtE conversion is not a viable option); strategies for reducing waste, especially plastic waste;
• improved waste collection services to maximize managed disposal, and the use of transfer stations to reduce vehicular emissions;
• regional disposal facilities to ensure that all urban and rural waste is collected and disposed properly;
• Institutional strengthening and capacity building to improve the overall waste management system, and adoption of mitigation methodologies; and
• a focus on environment-friendly waste disposal options, instead of landflling, among donor-funded projects.

RECOMMENDED INSTITUTIONAL ARRANGEMENTS FOR WASTE EMISSION MEASUREMENT, REPORTING, AND VERIFICATION

To improve the accuracy of historical and projected emission estimates and track progress toward GHG mitigation, a measurement, reporting, and verification (MRV) system is required. This would bring information together into a sustainable and functional system by identifying institutional arrangements for coordinating the participation of stakeholders and giving them defined roles and responsibilities to ensure the smooth flow of information. Transparent output for planning and tracking action can thus be produced.

The current institutional setup for waste emission MRV in Pakistan is as follows:
• The MOCC is the government’s lead focal agency for the preparation of the country’s Intended NDC and its revised NDC (MOCC 2021).
• The steering committee includes representatives of the following ministries, as well as the provincial governments:
  » Planning, Development, and Reform;
  » Water;
  » Energy;
  » Industries and Production;
  » Commerce;
  » National Food Security and Research;
  » Communications;
  » Science and Technology;
  » Finance and Revenue;
  » Economic Affairs;
  » Statistics;
  » Housing and Works; and
  » Foreign Affairs.

• The INDC Working Team in the MOCC compiled Pakistan’s draft INDC report in close association with relevant agencies and organizations of the federal and provincial governments, universities, research organizations, nongovernment organizations, United Nations organizations, Leadership for Environment and Development (LEAD) Pakistan, and the private sector. The World Bank facilitated this process.

SUMMARY AND CONCLUSIONS

Opportunities for waste-related mitigation are important and should be explored. Alternative approaches to solid waste management are available that could reduce GHG emissions. For example, using anaerobic decomposition to produce renewable energy from organic waste could directly reduce GHG emissions. Similarly, recycling aluminum would reduce the need to produce it, thereby conserving energy and indirectly reducing emissions.

The estimation of GHG emissions from solid waste disposal, biological treatment of solid waste, and incineration and open burning of solid waste begins with the collection of activity data from waste generation, composition, and management. Solid waste generation is the common basis for these activity data (IPCC 2006).

Currently available data suggest that the country generates around 28 million tons of municipal waste annually, with at least a 50% organic fraction. Very little biological treatment or disposal at engineered landfill sites is done. There is an urgent need to generate more accurate and segregated data to improve the accuracy of the waste emission estimates. Providing data at the national level requires data to be collected from more than 500 local councils—a challenging task in the light of the limited technical capacity available. However, various ongoing donor-funded projects in the urban sector could provide much useful information and capacity building on the links between solid waste management options and GHG emissions.

Data show that the contribution of the municipal waste sector to overall GHG emissions must be taken seriously. Given the quantities of waste generated and the current disposal scenario, there is a strong case for focusing on improved data management and mitigation technologies in deciding disposal options. The sector has the potential to help the country meet its emission reduction commitments, especially since the waste sector gives rise to methane emissions, with high global warming potential, and the existing system is quite basic.
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