

# LAD CASE STUDY

## Brick Kilns in Bangladesh

Leo Kirby

# LAD

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# Brick Kilns in Bangladesh

## Introduction

Bangladesh is situated on the deltas of several large rivers passing into the Bay of Bengal. These include the Ganges, Brahmaputra and Meghna river systems. The country's location on this alluvial plain means there is little natural rock available for use in construction, necessitating use of bricks as the primary material for building. Bricks are used both directly and broken up into coarse aggregate for the production of concrete.<sup>1</sup> To supply this need there are approximately 5000 privately operated brick kilns within Bangladesh,<sup>2</sup> including 1000 around the capital, Dhaka.<sup>3</sup>

Brick kilns have severe negative consequences for health and the environment, across local and global scales. The material for making bricks - clay - is generally taken from surrounding agricultural land, reducing productivity and threatening livelihoods of local farmers.<sup>4</sup> The emissions created by brick production increase the <2.5 micron particulate matter (PM 2.5) in the air: in Dhaka, up to 40% of this fine particulate pollutant is contributed by brick production, resulting in up to 5000 premature adult deaths annually in the city.<sup>5</sup> Globally, the black carbon produced by incomplete combustion disproportionately contributes to climate change by reducing reflection of sunlight and increasing the melting rate of Himalayan glaciers.<sup>6,7</sup>

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*Leo Kirby conducted interviews and prepared this case under the supervision of Francis Fukuyama of Stanford University. This case was developed solely as a basis for class discussion. It is not intended to serve as a historical record, a source of primary data, or an illustration of effective or ineffective management.*

Technical innovation can mitigate some of the negative consequences of brick production. Developments in brick kiln design produce substantially less pollution. These include the Zig-Zag Kiln (ZZK), Vertical Shaft Brick Kiln (VSK), and Hybrid Hoffman Kiln (HHK). However, few of these advanced kilns are used in Bangladesh. Of the 5,000 kilns in the country, approximately 4,500 are Fixed Chimney Kilns (FCK), with fewer than 150 ZZK, fewer than 20 HHK, and 200 classified as “other.” The FCK designs produce approximately 50 times more suspended particulate matter ( $mg/m^3$ ) per unit of production than do HHK kilns, and use about 50% more fuel as input. See Appendix B for comparative statistics.

Complex geographical, social, economic, and political factors currently impede adoption of technologically improved kilns. These factors include the structure of the Bangladeshi economy, which favors seasonal production, technical and cultural familiarity with FCK, credit restraints on owners, and limited enforcement of government directives to upgrade.

As the key decision-maker in BRAC (an international development organization based in Bangladesh), *Nepal Dey* must decide whether the institution should offer financial support to brick kiln owners for upgrading their kilns. In order to produce lasting change, he must determine an appropriate strategy to align the varying interests of kiln owners and landlords, workers, nearby residents, brick buyers, and government officials.

## **Country Introduction**

### *History and Politics*

The modern state of Bangladesh emerged from the Bangladesh Liberation War in 1971. Since 1947, it had been East Pakistan, part of the non-contiguous country of Pakistan created during the partition of India. Under British rule, what is now Bangladesh formed the substantial part of Muslim-majority East Bengal.

Since its independence, Bangladesh has been politically unstable. It has been disrupted by three successful (and numerous failed) military coups. Democratic politics have been substantially dominated by two parties - the Awami League and Bangladeshi National Party. Their two leaders - Sheikh Hasina and Khaleda Zia respectively - have alternated as non-interim Prime Ministers since 1991.

However, the current political climate and electoral cycle is particularly volatile. Highly confrontational stances adopted by both parties, including frequent *hartals* (strikes) and parliamentary boycotts, have contributed to deepening polarisation. Divisions are worsened by a general lack of tolerance for dissent, suppression of political differences, and violent approaches by opposition parties.<sup>8</sup> The growing extent of partisan appointments to government bureaucracies, law enforcement, and the judiciary has weakened the legitimacy of state institutions.<sup>9</sup> There has been an increase in human rights abuses and criminal activities since 2012, including disappearances, extrajudicial killings, lynchings, gang rape, robbery, abduction, drug trafficking, attacks on women, and murder.<sup>10</sup>

#### *Poverty, Development and the Economy*

Since 1995, GDP has grown at an average of 6%, with an average annual increase of 4% in per capita terms. Since 2015, Bangladesh has been classified as a lower-middle income country by the World Bank, with a per-capita annual GDP PPP of \$3,340.<sup>11</sup> This placed it in 185th place globally.<sup>12</sup> Due to the continuing low levels of average income, businesses regularly select the cheapest operational techniques to reduce costs, despite potential inefficiencies.<sup>13</sup>

Bangladesh has seen remarkable success in many of its poverty alleviation programs, reducing the poverty rate from 57% in 1991/92 to 32% in 2010. Since 1971, the life

expectancy at birth has increased from 47 to 72, while under-5 mortality rates have fallen from 223 per 1,000 live births to 38. Birth rates have fallen from 6.9 to 2.1. The nation has met many of the Millennium Development Goals, including headcount poverty, the poverty gap ratio, the prevalence of underweight children, gender parity in education, under-five mortality, and numerous health initiatives.<sup>14</sup>

### *Corruption and Institutional Capacity*

Bangladesh has a low institutional capacity. Corruption is an endemic problem and permeates all levels of government.<sup>15</sup> The Corruption Perception Index ranks Bangladesh 145th out of the 176 countries and territories assessed.<sup>16</sup> It scores 26 on a scale from 0 (highly corrupt) to 100 (very clean). Bangladeshis consider their institutions highly corrupt. The judiciary, political parties, parliament and police are rated by Bangladeshis as the most corrupt institutions in the country.<sup>17</sup> In 2013, 76% of people surveyed considered corruption in the public sector a problem.<sup>18</sup>

### **Overview of Brick Production in Bangladesh**

The brick industry contributes 1% of the country's GDP and employs 1 million people.<sup>19</sup> It is highly seasonal, operating almost exclusively between November and April, and is considered an informal cottage industry.<sup>20</sup> Production is dominated by small-scale firms that are hard to monitor, limited technological development,<sup>21</sup> poor labor standards, and lack of pollution control.<sup>22</sup> Brick making is not recognized as an industry by the government of Bangladesh,<sup>23</sup> thus official support for the industry is limited.

The government has had some success in influencing methods of production. Prior to 2004, most of the kilns in Bangladesh were Bull's Trench Kilns (BTKs), a highly polluting and

inefficient design developed 150 years ago.<sup>24</sup> After the Revision of Brick Burning Rules (see Appendix A) in 2002, most BTKs were converted to FCKs, which are more energy efficient. The Department of Environment considered the conversion policy a “qualified success,” with more than 90% of BTKs converted to FCKs within a short period.<sup>25</sup> It should be noted however that a recent study found a lower compliance rate: in Savar - a northern sub-district of Dhaka - 20% of brick kilns were BTKs, with 43% FCKs.<sup>26</sup>

However, more recent government policies have had poor compliance rates (see Appendix A). Owners and operators consider the cost of compliance significantly greater than that of low (or non-existent) fines, particularly when combined with the low likelihood of inspection.<sup>27</sup> Nevertheless, Bangladesh currently has a raft of active regulations relating to brick kilns. These include directives on the type of fuel used, design of kiln, permissible distance to urban settlements, and technology. The directives, however, are imperfectly enforced by the government and have limited effect.

The reasons for limited compliance are complex and interrelated. First, changing policies create uncertainty and resentment. Brick kiln owners complain that there is no sustainable or long term policy. They point out that after 2001/02 they were compelled to invest in changing technology, and were asked to do so again a mere 5 years later. Given limited availability of credit, this represents substantial investment for uncertain returns. Second, the Department of Environment is seen as having extremely limited capacity. It lacks skilled technical personnel and suffers deficiencies in equipment: it has no air quality testing equipment of its own and no vehicles capable of demolishing illegal kilns. Third, corruption at the local level is allegedly common. Anecdotal evidence suggests that enforcement officers do not engage in improving kiln systems, but take bribes from brick kiln owners for allowing

violations to go unreported.<sup>28</sup> Finally, in interviews, it was suggested that the political connections of kiln owners prevent effective law enforcement. Multiple sources reported a recent case in which an enforcement officer known for refusing bribes was transferred from the Department of Environment to another department after less than a year-- at the request of brick kiln owners who maintained close relationships with politicians.

## **Proposed Solution**

### *Outline*

To circumvent weak capacity within the government, BRAC is considering providing direct financing to brick kiln owners. The owners will be offered competitive loans to switch their traditional Fixed Chimney Kilns to Zig-Zag, Hybrid Hoffman, Vertical Shaft, or Tunnel Kilns. It is hoped that such loans will adjust the incentives for kiln owners, better aligning their interests with those of the public. Moving from FCK technology to a cleaner option is likely to benefit brick kiln owners through reduced energy cost, and will also substantially benefit the wider society by reducing costs of air pollution on health.<sup>29</sup>

### *Drawbacks*

However, the approach under consideration by BRAC contains multiple potential problems and pitfalls. First, the issue of compliance is not addressed. Excluding government from the process may perpetuate governmental inability to enforce regulation. Second, regulation may already be overly burdensome for some brick kiln owners. For example, requirements to maintain prescribed distances from urban settlement or agricultural land are nearly impossible to fulfill in a country as densely populated as Bangladesh. Third, BRAC's solution may be difficult to deliver, given that many existing kilns are in low-lying land prone to flooding, but the most advanced kilns require dry land year-round. Fourth, brick

kiln owners are substantially risk-averse. They may not agree to moving from a business model that has reliably produced profit for decades. Fifth, if BRAC successfully encourages owners to take up Zig-Zag technology, the diffusion of superior technology, such as Hybrid-Hoffman or Tunnel Kilns may be inhibited. Finally, BRAC's institutional reputation is on the line. Given these potential problems, it may be wiser for BRAC to focus its limited capacity on more achievable policy objectives.

### **Stakeholders in Bangladeshi Brick Production**

#### *Brick Kiln Owners*

Brick kiln owners have low private incentives to upgrade their kilns. Simultaneously, government regulation has been ineffective in compelling them to do so. Acknowledging that government policy was not being followed, one brick kiln owner remarked, *“At this moment, 99% of brickfields are operating illegally, with no official documents.”* Owners regard this situation as a failure of government policy; they consider compliance with the government rules impossible. For example, brick kilns are not allowed within 3 km of urban settlement, nor are they permitted on agricultural land. Given the high population density throughout Bangladesh, there are no clearly optimal locations for kilns.

FCKs are preferred because they have the lowest installation cost and fastest return on investment.<sup>30</sup> The speed of this return is crucial. FCKs cost approximately \$70,000 in initial investment,<sup>31</sup> with typical owners earning profits after 2–3 years.<sup>32</sup> To upgrade a FCK to ZZK would cost an estimated \$62,500.<sup>33</sup> Upgrading to HHK (the most efficient type) costs approximately \$2 million.<sup>34</sup>

Kiln owners and operators reportedly consider pollution an inevitable part of brick manufacturing. Since their product meets a market need for construction materials, they

assert that externalities are not their responsibility.<sup>35</sup> Furthermore, FCKs generate less pollution than did the older Bull's Trench Kilns; owners and operators contend they have already made a recent update in technology.

Should owners wish to upgrade, they are restricted by credit limitations. Many kiln owners build on rented land and have no other collateral for a loan. Even when financing is available, private loans for a 12- month period are charged at 15-17% annual interest.<sup>36</sup> This is high enough to dissuade many operators, particularly when the technology is not widely used and is perceived as risky.

The Bangladesh Brick Manufacturers Owners Association (BBMOA) is concerned that stricter government regulation will arrive in the medium- to- long term, after a conversion has been completed. Such regulation would jeopardize the sunk cost of converting in the short term.<sup>37</sup> This is a real concern, with many brick kiln owners claiming that in 2002 the majority of kilns adhered to a requirement to upgrade from Bull's Trench to Fixed Chimney.

#### *Brick Buyers*

Brick buyers reportedly have little interest in the environmental implications of different brick production techniques, considering such regulation the responsibility of government.<sup>38</sup> Instead, buyers focus on obtaining appropriate quality at the lowest possible price. Brick buyers differentiate between the qualities of brick required for different projects. More advanced (and lower polluting) kilns generally produce higher quality bricks of a more consistent quality and shape. However, for the most basic uses (such as being broken up for use as aggregate), high quality bricks are unnecessary.

### *Brick Kiln Workers and Landlords*

FCKs largely operate during the dry season. This production cycle is the inverse of the agricultural season, meaning that laborers can transition from agricultural work to brick making. Generally, brick kiln workers travel to brick-making areas. Up to 75% of workers are estimated to be migrants.<sup>39</sup>

Brick kiln owners often opt for flood-prone land because it is cheaper to rent and they do not use it during the rainy season. Floodplain land can be rented for \$1,500–\$1,850 per ha per season, compared to \$8,100–\$14,000 per ha per season for land that does not flood.<sup>40</sup>

### *Bangladeshis Living Near to Brick Kilns*

There are two primary impacts on Bangladeshis living close to brick kilns. The first is on health. The small particles produced by incomplete combustion are particularly dangerous because they are absorbed deep in the lungs<sup>41</sup> and are associated with increased mortality.<sup>42</sup>

The six main kiln clusters surrounding Dhaka are estimated to discharge 23,000 tons of PM2.5; 15,500 tons of sulphur dioxide; 300,000 tons of carbon monoxide; 6,000 tons of black carbon; and 1.8 million tons of carbon dioxide emissions annually.<sup>43</sup> As mentioned in the introduction, in Dhaka, air pollution from brick kilns results in up to 5000 premature adult deaths annually.<sup>44</sup>

The second is impact on agricultural productivity and livelihoods. Kilns across Bangladesh consume an estimated 45 million tons of clay yearly.<sup>45</sup> This is often extracted from fertile topsoil,<sup>46</sup> with farmers in flood-prone areas reporting an average loss of income from crop of 71% in flood-prone areas the following year.<sup>47</sup> Farmers choose to sell topsoil for a variety of reasons, but politically connected kiln owners exploit farmers who have limited financial resources and no political connections.<sup>48</sup> In addition, heavy metals (such as arsenic) are

spread across neighboring locales, decreasing agricultural productivity.<sup>49</sup> Heavy metals cause crop yield loss by interfering with cellular processes; in China it is estimated that each hectare of land polluted with heavy metal has observed an average decline of half a ton in yield, with the effect particularly severe in the peri-urban zones where brick kilns are typically located.<sup>50</sup>

### *Department of Environment*

The institutional goals of the Department of Environment and the private goals of its employees are not aligned. Institutionally, the Department of Environment has an interest in ensuring high compliance. Privately, individuals within the department benefit from inconsistent enforcement. According to allegations, those within the department who worked diligently to improve enforcement have been deliberately transferred to other government jobs.<sup>51</sup>

The Department of Environment suffers from a clear lack of capacity. It has few skilled technical personnel, and no air quality testing equipment or bulldozer to demolish illegal kilns.<sup>52</sup> Vacancies limit monitoring and enforcement of regulations: 7 of 11 posts in the Department of Environment at the Jessore District Office were vacant at the time of an evaluation in 2015<sup>53</sup>. Lack of capacity to direct enforcement is aggravated by the reluctance of the police to enforce regulation, particularly if the kiln owner has political connections.<sup>54</sup>

### **Conclusion**

Nepal Dey must now determine whether BRAC should invest its funds and capacity in financing upgrades to brick kilns. BRAC must decide whether such action is an appropriate use of funds and whether it is likely to succeed. The extent to which BRAC should involve

the Department of Environment is a challenging question, given the department's divergent interests but integral role in promulgating regulation. Finally, if he/she decides to progress, BRAC must determine an appropriate strategy to align the differing interests of the many stakeholders.

## Appendices

### A. Existing brick kiln regulations and enforcement<sup>55,56</sup>

Year	Policy, law, regulation	Content	Situation reported 2015
1989	Brick Burning (Regulation) Act	Kilns required license; firewood banned as fuel	Firewood is used less commonly
2001	Revision of Brick Burning (Regulation) Act	Kilns not allowed within 3 km of urban areas, residential areas gardens, or government forest reserves	Not enforced
2002	Revision of Brick Burning Rules	37 m fixed chimney kilns required	Many kilns switched to fixed chimney kilns. Older-style kilns with shorter chimneys no longer published in government reports, but approximately 500 operating
2007	Government of Bangladesh Notification	Environmental clearance would not be renewed if kiln did not switch to alternative fuel and improved technologies by 2010	Not enforced
2010	Government of Bangladesh Notification	Fixed chimney kilns banned by Dec 2012	Postponed

## B. Comparison of selected brick kilns in Bangladesh<sup>57</sup>

	<b>Bull's Trench</b>	<b>Fixed- chimney</b>	<b>Zig-zag</b>	<b>Vertical shaft</b>	<b>Hybrid Hoffman</b>	<b>Tunnel</b>
<b>Emissions (mg/m<sup>3</sup>)</b>	>1,000	>1,000	500-800	78-187	20	<50
<b>Coal used /million bricks (tons)</b>	260	240	180-200	100-120	120-130	100-120
<b>Market share</b>	n/a	92%	3%	0.0%	0.2%	0.0%
<b>Installation cost (\$)</b>	35,000	70,000	80,000	250,000	2,000,000	4,000,000
<b>O&amp;M cost (\$)</b>	75,000	150,000	160,000	190,000	500,000	900,000
<b>Annual brick output ('000)</b>	2,000	3,000	3,000	4,000	15,000	30,000
<b>Quality (psi)</b>	<2,500	<2,500	<2,500	4,260	4,500-6,000	4,500-6,000
<b>Price (Tk.)</b>	5.0	5.5-6.0	5.5-6.0	6.0	7.0-7.5	7.5

## Endnotes

- <sup>1</sup> Rashid MA, Hossain T, Islam MA. Properties of higher strength concrete made with crushed brick as coarse aggregate. *J Civ Eng (IEB)* 2009;37:43–52.
- <sup>2</sup> World Bank. *Introducing Energy-efficient Clean Technologies in the Brick Sector of Bangladesh*. Washington DC: IBRD/World Bank; 2011
- <sup>3</sup> Guttikunda SK, Begum BA, Wadud Z. Particulate pollution from brick kiln clusters in the Greater Dhaka region, Bangladesh. *Air Qual Atmos Health* 2013;6:357–65
- <sup>4</sup> Debashish Biswas, Emily S. Gurley, Shannon Rutherford, Stephen P. Luby, The drivers and impacts of selling topsoil for brick making in Bangladesh, submitted to *Soil & Tillage Research* (2016).
- <sup>5</sup> Guttikunda, S. K., 2009. Impact analysis of brick kilns on the air quality in Dhaka, Bangladesh. SIM-Air Working Paper Series. New Delhi: ([www.urbanemissions.info](http://www.urbanemissions.info)).
- <sup>6</sup> Menon S, Hansen J, Nazarenko L, Luo Y. Climate effects of black carbon aerosols in China and India. *Science* 2002;297:2250–3.
- <sup>7</sup> Ramanathan V, Carmichael G. Global and regional climate changes due to black carbon. *Nat Geosci* 2008;1:221–7
- <sup>8</sup> Bertelsmann Foundation 2016: Bangladesh Country Report: [https://www.bti-project.org/fileadmin/files/BTI/Downloads/Reports/2016/pdf/BTI\\_2016\\_Bangladesh.pdf](https://www.bti-project.org/fileadmin/files/BTI/Downloads/Reports/2016/pdf/BTI_2016_Bangladesh.pdf)
- <sup>9</sup> Bertelsmann Foundation 2016: Bangladesh Country Report: [https://www.bti-project.org/fileadmin/files/BTI/Downloads/Reports/2016/pdf/BTI\\_2016\\_Bangladesh.pdf](https://www.bti-project.org/fileadmin/files/BTI/Downloads/Reports/2016/pdf/BTI_2016_Bangladesh.pdf)
- <sup>10</sup> U4 Anti-corruption Resource Center (2015a): Bangladesh: Overview of corruption and anti-corruption with a focus on the health sector
- <sup>11</sup> World Bank 2015: <http://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD?locations=BD&view=chart>
- <sup>12</sup> World Bank 2015: <http://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD?locations=BD&view=chart>
- <sup>13</sup> ADB (2012) Financing Brick Kiln Efficiency Improvement Project (RRP BAN 45273)
- <sup>14</sup> UNDP 2015: MDG Progress Report 2015 Bangladesh
- <sup>15</sup> Bertelsmann Foundation 2016: Bangladesh Country Report: [https://www.bti-project.org/fileadmin/files/BTI/Downloads/Reports/2016/pdf/BTI\\_2016\\_Bangladesh.pdf](https://www.bti-project.org/fileadmin/files/BTI/Downloads/Reports/2016/pdf/BTI_2016_Bangladesh.pdf)
- <sup>16</sup> Transparency International (2016): Corruptions Perceptions Index: [https://www.transparency.org/news/feature/corruption\\_perceptions\\_index\\_2016](https://www.transparency.org/news/feature/corruption_perceptions_index_2016)
- <sup>17</sup> Transparency International. 2013. Global Corruption Barometer. <http://www.transparency.org/gcb2013>
- <sup>18</sup> Transparency International. 2013. Global Corruption Barometer. <http://www.transparency.org/gcb2013>
- <sup>19</sup> Croitoru, L. and Sarraf, M. (2012) Benefits and Costs of the Informal Sector: The Case of Brick Kilns in Bangladesh. *Journal of Environmental Protection*, 3, 476–484. <https://doi.org/10.4236/jep.2012.360582012>
- <sup>20</sup> Darain KMU, Rahman ABMS, Ahsan A, Islam ABMS, Yusuf B (2013) Brick manufacturing practice in Bangladesh: a review of energy efficacy and air pollution scenarios. *J Hydrol Environ Res* 1(1):60–69
- <sup>21</sup> Darain KMU, Rahman ABMS, Ahsan A, Islam ABMS, Yusuf B (2013) Brick manufacturing practice in Bangladesh: a review of energy efficacy and air pollution scenarios. *J Hydrol Environ Res* 1(1):60–69
- <sup>22</sup> ADB (2012) Financing Brick Kiln Efficiency Improvement Project (RRP BAN 45273)
- <sup>23</sup> Bangladesh University of Engineering and Technology, “Small Study on Air Quality Impacts of the North Dhaka Brickfield Cluster by Modeling of Emissions and Suggestions for Mitigation Measures Including Financing Models,” Chemical Engineering Department, Dhaka, 2007
- <sup>24</sup> ADB (2012) Financing Brick Kiln Efficiency Improvement Project (RRP BAN 45273)
- <sup>25</sup> Department of Environment (2012) Air Pollution Reduction Strategy for Bangladesh. [http://old.doe.gov.bd/publication\\_images/60\\_air\\_pollution\\_reduction\\_strategy.pdf](http://old.doe.gov.bd/publication_images/60_air_pollution_reduction_strategy.pdf).

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- <sup>26</sup> Saha CK, Hosain J (2016) Impact of brick kilning industry in peri-urban Bangladesh. *Int J Environ Stud* :1–11 doi:[10.1080/00207233.2016.1179014](https://doi.org/10.1080/00207233.2016.1179014)
- <sup>27</sup> Haque, N. Technology mandate for greening brick industry in Bangladesh: a policy evaluation. *Clean Techn Environ Policy* (2017) 19: 319. doi:[10.1007/s10098-016-1259-z](https://doi.org/10.1007/s10098-016-1259-z)
- <sup>28</sup> Stephen P. Luby, Debashish Biswas, Emily S. Gurley, Ijaz Hossain, Why highly polluting methods are used to manufacture bricks in Bangladesh, *Energy for Sustainable Development*, Volume 28, 2015, Pages 68-74, ISSN 0973-0826
- <sup>29</sup> Guttikunda SK, Khaliquzzaman M (2014) Health benefits of adapting cleaner brick manufacturing technologies in Dhaka, Bangladesh. *Air Qual Atmos Hlth* 7:103–112. doi:[10.1007/s11869-013-0213-z](https://doi.org/10.1007/s11869-013-0213-z)
- <sup>30</sup> Stephen P. Luby, Debashish Biswas, Emily S. Gurley, Ijaz Hossain, Why highly polluting methods are used to manufacture bricks in Bangladesh, *Energy for Sustainable Development*, Volume 28, 2015, Pages 68-74, ISSN 0973-0826
- <sup>31</sup> ADB April 2012: Proposed Loans People’s Republic of Bangladesh: Financing Brick Kiln Efficiency Improvement Project: Report and Recommendation of the President to the Board of Directors. Project Number: 45273-001. Technical Due-Diligence.
- <sup>32</sup> Stephen P. Luby, Debashish Biswas, Emily S. Gurley, Ijaz Hossain, Why highly polluting methods are used to manufacture bricks in Bangladesh, *Energy for Sustainable Development*, Volume 28, 2015, Pages 68-74, ISSN 0973-0826
- <sup>33</sup> Stephen P. Luby, Debashish Biswas, Emily S. Gurley, Ijaz Hossain, Why highly polluting methods are used to manufacture bricks in Bangladesh, *Energy for Sustainable Development*, Volume 28, 2015, Pages 68-74, ISSN 0973-0826
- <sup>34</sup> Hashim SM (2014, March 25) No easy answer to air pollution. *The Daily Star*. <http://www.thedailystar.net/no-easy-answer-to-air-pollution-17077> (accessed June 29th 2017)
- <sup>35</sup> Stephen P. Luby, Debashish Biswas, Emily S. Gurley, Ijaz Hossain, Why highly polluting methods are used to manufacture bricks in Bangladesh, *Energy for Sustainable Development*, Volume 28, 2015, Pages 68-74, ISSN 0973-0826
- <sup>36</sup> Stephen P. Luby, Debashish Biswas, Emily S. Gurley, Ijaz Hossain, Why highly polluting methods are used to manufacture bricks in Bangladesh, *Energy for Sustainable Development*, Volume 28, 2015, Pages 68-74, ISSN 0973-0826
- <sup>37</sup> Haque, N. Technology mandate for greening brick industry in Bangladesh: a policy evaluation. *Clean Techn Environ Policy* (2017) 19: 319. doi:[10.1007/s10098-016-1259-z](https://doi.org/10.1007/s10098-016-1259-z)
- <sup>38</sup> Stephen P. Luby, Debashish Biswas, Emily S. Gurley, Ijaz Hossain, Why highly polluting methods are used to manufacture bricks in Bangladesh, *Energy for Sustainable Development*, Volume 28, 2015, Pages 68-74, ISSN 0973-0826
- <sup>39</sup> United Nations Development Programme (UNDP): Mid-Term Review, Bangladesh Green Brick Project, IKEBMI (Increasing Kiln Efficiency in the Brick Making Industry)
- <sup>40</sup> Stephen P. Luby, Debashish Biswas, Emily S. Gurley, Ijaz Hossain, Why highly polluting methods are used to manufacture bricks in Bangladesh, *Energy for Sustainable Development*, Volume 28, 2015, Pages 68-74, ISSN 0973-0826
- <sup>41</sup> Squadrito GL, Cueto R, Dellinger B, Pryor WA. Quinoid redox cycling as a mechanism for sustained free radical generation by inhaled airborne particulate matter. *Free Radic Biol Med* 2001;31:1132–8.
- <sup>42</sup> Lepeule J, Laden F, Dockery D, Schwartz J. Chronic exposure to fine particles and mortality: an extended follow-up of the Harvard six cities study from 1974 to 2009. *Environ Health Perspect* 2012;120:965–70.
- <sup>43</sup> Guttikunda SK, Begum BA, Wadud Z. Particulate pollution from brick kiln clusters in the Greater Dhaka region, Bangladesh. *Air Qual Atmos Health* 2013;6:357–65

- 
- <sup>44</sup> Guttikunda, S. K., 2009. Impact analysis of brick kilns on the air quality in Dhaka, Bangladesh. SIM-Air Working Paper Series. New Delhi: (www.urbanemissions.info).
- <sup>45</sup> Guttikunda, S. K., Khaliqzaman, M., 2014. Health benefits of adapting cleaner brick manufacturing technologies in Dhaka, Bangladesh. *Air Quality, Atmosphere & Health*, 7(1), 103-112. doi:10.1007/s11869-013-0212-z
- <sup>46</sup> Kathuria, V., Balasubramanian, R., 2013. Environmental cost of using top-soil for brick-making: a case study from Tamil Nadu, India. *Review of Market Integration*, 5(2), 171-201. doi:10.1177/0974929214521892
- <sup>47</sup> Debashish Biswas, Emily S. Gurley, Shannon Rutherford, Stephen P. Luby, The drivers and impacts of selling topsoil for brick making in Bangladesh, submitted to *Soil & Tillage Research* (2016).
- <sup>48</sup> Debashish Biswas, Emily S. Gurley, Shannon Rutherford, Stephen P. Luby, The drivers and impacts of selling topsoil for brick making in Bangladesh, submitted to *Soil & Tillage Research* (2016).
- <sup>49</sup> Kathuria, V., Balasubramanian, R., 2013. Environmental cost of using top-soil for brick-making: a case study from Tamil Nadu, India. *Review of Market Integration*, 5(2), 171-201. doi:10.1177/0974929214521892
- <sup>50</sup> Jie Chen, Rapid urbanization in China: A real challenge to soil protection and food security, *CATENA*, Volume 69, Issue 1, 2007, Pages 1-15,
- <sup>51</sup> Stephen P. Luby, Debashish Biswas, Emily S. Gurley, Ijaz Hossain, Why highly polluting methods are used to manufacture bricks in Bangladesh, *Energy for Sustainable Development*, Volume 28, 2015, Pages 68-74, ISSN 0973-0826
- <sup>52</sup> Haque, N. Technology mandate for greening brick industry in Bangladesh: a policy evaluation. *Clean Techn Environ Policy* (2017) 19: 319. doi:10.1007/s10098-016-1259-z
- <sup>53</sup> Stephen P. Luby, Debashish Biswas, Emily S. Gurley, Ijaz Hossain, Why highly polluting methods are used to manufacture bricks in Bangladesh, *Energy for Sustainable Development*, Volume 28, 2015, Pages 68-74, ISSN 0973-0826
- <sup>54</sup> Stephen P. Luby, Debashish Biswas, Emily S. Gurley, Ijaz Hossain, Why highly polluting methods are used to manufacture bricks in Bangladesh, *Energy for Sustainable Development*, Volume 28, 2015, Pages 68-74, ISSN 0973-0826
- <sup>55</sup> Content column from World Bank. *Introducing Energy-efficient Clean Technologies in the Brick Sector of Bangladesh*. Washington DC: IBRD/World Bank; 2011.
- <sup>56</sup> 2015 report from Stephen P. Luby, Debashish Biswas, Emily S. Gurley, Ijaz Hossain, Why highly polluting methods are used to manufacture bricks in Bangladesh, *Energy for Sustainable Development*, Volume 28, 2015, Pages 68-74, ISSN 0973-0826
- <sup>57</sup> ADB April 2012: Proposed Loans People's Republic of Bangladesh: Financing Brick Kiln Efficiency Improvement Project: Report and Recommendation of the President to the Board of Directors. Project Number: 45273-001. Technical Due-Diligence.