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Why highly polluting methods are used to manufacture bricks in Bangladesh

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ABSTRACT

Brick kilns in Bangladesh use inefficient coal burning technology that generates substantial air pollution. We investigated the incentives of stakeholders in brick manufacturing in Bangladesh to help inform strategies to reduce this pollution. A team of Bangladeshi anthropologists conducted in-depth interviews with brick buyers, kiln owners, and Department of Environment employees. Brick buyers reported that bricks manufactured in traditional kilns worked well for most construction purposes and cost 40% less than bricks manufactured in more modern, less polluting, kilns. Brick kiln owners favored approaches with rapid high return on a modest investment. They preferred kilns that operate only during the dry season, allowing them to use cheaper low-lying flood plain land and inexpensive seasonal labor. The Department of Environment employees reported that many kilns violate environmental regulations but shortages of equipment and manpower combined with political connections of kiln owners undermine enforcement. The system of brick manufacturing in Bangladesh is an economic equilibrium with the manufacture of inexpensive bricks supplying the demand for construction materials but at high cost to the environment and health of the population. Low-cost changes to improve kiln efficiency and reduce emissions could help move toward a more socially desirable equilibrium.

Introduction

An estimated 5000 brick kilns operate across Bangladesh (World Bank, 2011) including approximately 1000 surrounding Dhaka, the capital city (Guttikunda et al., 2013). These brick kilns contribute substantially to poor air quality and poor community health in Dhaka and throughout Bangladesh. During the dry season, the season when they operate, brick kilns contribute 30%–50% of the <2.5 micron particulate matter (PM 2.5) in the air in cities near where they operate (Begum et al., 2011; Guttikunda, 2009; Hossain et al., 2007). These small particulate products of combustion are especially dangerous to human health because they are absorbed deep in the lungs (Squadrito et al., 2001) and are associated with cardiovascular and respiratory disease (Dominici et al., 2006) and mortality (Laden et al., 2000; Lepeule et al., 2012). Different modeling approaches estimate that the air pollution generated by brick kilns results in between 530 and 5000 premature adult deaths annually in Dhaka alone (Croitoru and Sarraf, 2012; Guttikunda, 2008, 2009). A study conducted in the Mirpur neighborhood of Dhaka found that during the dry season when brick kilns operate, ambient air contributed more to indoor PM 2.5 levels than did type of cooking stove (Gurley et al., 2013), and higher levels of PM 2.5 in households was associated with earlier onset of the first episode of acute lower respiratory infection among young children (Gurley et al., 2014). Lower respiratory infection is the leading cause of death among children in Bangladesh (NIPORT, 2013) and the youngest children are at the highest risk of death (Walker et al., 2013).

Manufacturing bricks using highly polluting kilns is common not only in Bangladesh but is widespread across India (Bhanarkar et al., 2002; Heierli, 2008; Pangtey et al., 2004), Nepal (Joshi and Dudani, 2008; Raut, 2003), Pakistan (Tahir et al., 2010), China (Lei et al., 2011; Zhang et al., 2007), and even Mexico (Blackman et al., 2006). Brick kilns are an important source of atmospheric black carbon (Reddy and Venkataraman, 2002; Weyant et al., 2014) which contributes disproportionately to global warming and by depositing on Himalayan glaciers reducing reflection of sunlight and increasing glacial melting (Menon et al., 2002; Ramanathan and Carmichael, 2008).

Bricks are central to construction in Bangladesh. Approaches to construction that substitute concrete for bricks increase costs because Bangladesh has to import limestone or clinker, essential raw material for making cement (Alam et al., 2009; Harder, 2008) since, to date, the identified limestone deposits within Bangladesh are too deep to mine profitably (Akhtar, 2005; Mohan and Dutta, 2006). Moreover, even when cement is imported, because there are limited stones naturally

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available in Bangladesh, pieces of fired bricks constitute the most common coarse aggregate for making concrete (Rashid et al., 2009). Indeed, brick aggregates produce concrete with higher strength than concrete made with stones (Rashid et al., 2009; Uddin, 2013).

Within Bangladesh, civil society and journalists have raised concerns about the environmental and health impacts of the use of highly polluting kilns to make bricks, but despite the promulgation of several brick kiln regulations (Table 1) and efforts to introduce various cleaner technologies, 91% of all bricks manufactured in Bangladesh are manufactured using highly polluting fixed chimney kilns (World Bank, 2011). Five percent of bricks in Bangladesh are manufactured in Hoffman style kilns (World Bank, 2011). Hoffman kilns have a fixed roof which contributes to energy efficiency and, if the owner has sufficient land to store unfired bricks, permits operation during the rainy season (Gomes and Hossain, 2003; Hossain et al., 2007). Hoffman kilns include a fan, which requires electricity, but provides a constant draught. The cleanest Hoffman kilns use natural gas for fuel, though most in Bangladesh burn coal. Hybrid Hoffman kilns are a lower cost variant of the Hoffman kiln that have thinner kiln walls, are constructed with regular bricks rather than lower thermal conductivity firebricks, and have no cover over the kiln (Hossain et al., 2007). Although zigzag kilns accounted for fewer than 1% of bricks manufactured in Bangladesh in 2009 (World Bank, 2011), the Government of Bangladesh has promoted using zigzag kilns as an alternative to fixed chimney kilns. In a zigzag kiln, the airflow through the kiln is directed by arranging the bricks in a series of zigzags and a draught fan helps move heated air more thoroughly through the bricks (Gomes and Hossain, 2003; Hossain et al., 2007). The efficiency of a zigzag kiln is heavily dependent upon appropriate design, construction, and operation (Hossain et al., 2007; World Bank, 2011).

Not only in Bangladesh, but in low-income countries generally, limited government capacity for monitoring and enforcement hinders implementing strategies that have been successfully deployed in high-income countries to control harmful emissions from industrial plants (Blackman and Harrington, 2000). Nevertheless, even in the setting of weak enforcement, many industrial plants located in low-income countries take substantive steps to abate pollution, often even meeting strict high-income country standards (Dasgupta et al., 2000; Hettige et al., 1996). Factors associated with active investment in pollution abatement by low-income country industrial firms include demands by the surrounding community, demands which are more effective when the community is less impoverished, when the pollution is visible, when the plants are more profitable and when the firm is not owned by the government (Hettige et al., 1996; Pargal et al., 1997).

To help design strategies to encourage brick-manufacturing processes that produce less damage to human health and the environment, we sought to understand the incentives that maintain the current equilibrium that produces low-price bricks in Bangladesh but generates high environmental and human health costs.

Methods

Because we were interested in mapping the incentives of the various operators throughout the system of brick production and use we deployed in-depth qualitative methods to explicate the perspective and worldview of the study subjects (Manning, 1997). Although closed-ended multiple-choice questions simplify mathematical summary of responses, such questions assume that study respondents share the researchers' cognitive framing. We wanted to avoid our preconceptions blinding us to our participant's viewpoint.

We conducted the study in two districts, Dhaka and Jessore, between November 2012 and March 2013 (Fig. 1). Although Dhaka was the main study site and has the largest number of brick kilns in the country, we selected one other city to look for differences in incentives for brick making.

Study population

A team of Bangladeshi anthropologists (led by DB) used standard qualitative methods to conduct in-depth interviews (DiCicco-Bloom and Crabtree, 2006) with brick buyers to explore their perspective on brick manufacturing in Bangladesh. The anthropologists targeted buyers who purchased many bricks, but also specifically included different types of buyers, including wholesalers, retailers, developers, and end users, to understand the perspective of various purchasers.

The anthropologists identified brick kiln owners for interviewing by using the anthropologists' own social networks and following recommendations from officials from the Bangladesh Brick Manufacturing Owners Association (BBMOA). Following the interviews, several brick kiln owners also provided contact information of additional kiln owners who would be willing to participate.

The study team met with the director general of the Department of Environment, Ministry of Environment and Forests of the Government of Bangladesh. The team requested information on the number and level of employees who were responsible for assessing compliance and enforcement of regulations of brick kilns and they requested access to frontline inspectors for interviews. The anthropologists interviewed all the employees available during the time of data collection of the Department of Environment in the Dhaka and Jessore offices who were responsible for enforcement of brick kiln regulations.

Data collection

The anthropologists conducted in-depth interviews with brick buyers, brick kiln owners, and government employees (Table 2). The anthropologists asked the brick buyers from whom they purchased bricks and their perspective regarding more environmentally friendly bricks.

Table 1
Government of Bangladesh brick kiln regulations and enforcement.

Year	Policy, law, regulation	Content[a]	Situation reported by study respondents
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 to be 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 certificates would not be renewed if kiln did not shift from coal to alternative fuel and improved technologies by 2010	Not enforced
2010	Government of Bangladesh Notification	Fixed chimney kilns banned by Dec 2012	Postponed

[a] From World Bank (2011).