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Challenges of Low Carbon City Planning due to Emissions from Brick Kilns: A Case Study on Dhaka City of Bangladesh

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Abstract

In achieving environmental sustainability, planning of a city or region can be more functional and implementable by using low carbon city concept. Urban Planning through land use planning and planning control can play a vital role in implementing the idea of low carbon cities, particularly during the formulation of development plans. The study focuses on the issues of carbon emission and global warming due to emission from the brick fields of Dhaka in Bangladesh. The brick manufacturing in the Greater Dhaka region produces 3.5 billion bricks per year, and it has been estimated that about 23,300 tons of particulate matter having aerodynamic diameter <2.5 μm ($PM_{2.5}$), 15,500 tons of sulfur dioxide (SO_2), 302,000 tons of carbon monoxide (CO), 6,000 tons of black carbon (BC) and 1.8 million tons of carbon dioxide (CO_2) are emitted annually. This paper presents a case study of brick kilns on three unions (Aminbazar, Savar and Ashulia) of Savar Upazila under Dhaka District. The study provides a review of legal aspects on brick kilns in the context of Bangladesh. Finally, some recommendations have been provided for the improvement of urban environmental management due to emission from brick kilns.

Introduction

Planning of a city or a region can be more functional and implementable by using low carbon city concept. It also adopts patterns of consumption and behavior that are consistent with low levels of green house gas emissions in the urban areas. The study aims to explore implementation of the concept and vision of low carbon scenarios and examine the strategies toward the reduction of carbon emission. Planning of low carbon cities contribute toward low carbon emission by using sustainable development principles. Urban Planning through land use planning and planning control can play vital role in implementing the idea of low carbon cities, particularly during the formulation of development plans (Bruton, 2007).

Since 2008, the majority of people on earth are living in cities and towns than the rural area. By 2030, over 4.6 billion people will live in the urban areas and this poses important social and environmental challenges in the 21st century (IPCC, 2001, 2007). The rapid urbanization is particularly observed in the continent of Africa and Asia, where the urban population will double between 2000 and 2030. The urban development is

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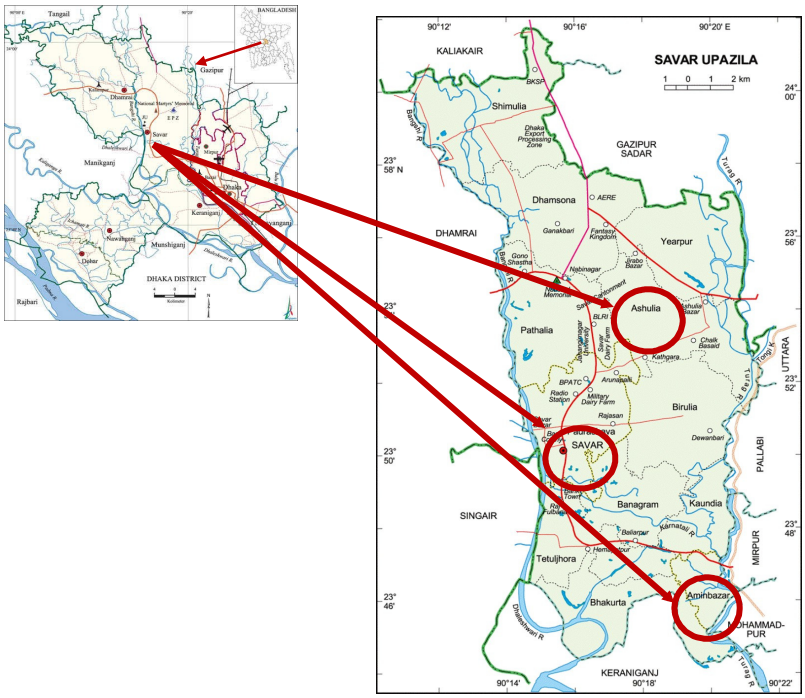
responsible for over 70% of overall carbon emissions. Hence, in order to tackle the issue of carbon emission, there is a need for global as well as national strategies for sustainability in urban environments in both developed and developing countries. Strong political will and leadership are needed to drive effective responses to address the climate change at global and regional levels (GL & Yuen, 2010) because of the concern of climate change policies that may affect economic growth.

Savar Upazila of Dhaka District has been selected as the study area because of its rapidly changing population density, socioeconomic phenomena and industrial and environmental concerns. Violation of environmental laws specifically Brick Burning Acts are very common. Government cannot enforce the laws and monitor the violation strictly due to its scarcity of resources and also lack of willingness. Residents are very much unaware about the rules and regulations. The study team visited Aminbazar, Savar and Ashulia unions under Savar Upazila to find out the present number of brick fields and physical condition of the areas. Location of study areas in Savar Upazila under Dhaka District in the context of Bangladesh are shown in Figure 1.



Source: Banglapedia and Author

Figure 1: Location of study areas (Aminbazar, Savar and Ashulia) in the context of Bangladesh

Objectives and Methodology

The main objective of this study is to explore implementation of the concept and vision of low carbon scenarios and examine the strategies toward the reduction of carbon emission. This research is founded upon both quantitative and qualitative data collection.

A reconnaissance survey was conducted during the initial stage of the study which helped to identify the physical condition of the existing brick fields located around Dhaka city. It was also helpful in selecting the study areas. The study commenced with extensive literature review to get insight into the problems. An attempt was made to review the available secondary sources which are published in various journals and websites. The primary data were collected through Key Informants Interview (KII) and Field Investigation. The field data were mostly collected from Bangladesh Brick Manufactures Owners Association (BBMOA) in Dhaka.

Existing Brick Kiln Technologies in Bangladesh

Brick manufacturing process in Bangladesh is being carried out in a very primitive way. To date traditional process is applied in Bangladesh. These age-old methods of manufacturing bricks are leading to environmental degradation. The demands for bricks continue to rise, as the population increases and people aspire to having better standards for housing and other developments. To meet this growing demand as well as to reduce fuel consumption and air pollution, it is necessary to develop new technologies and process of brick manufacturing. In the technological aspects, the existing kiln technology should be studied in details.

According to Hossain (2008), brick kilns can be classified into four main categories, on the basis of how they are operated:

Intermittent or periodic Kiln: Intermittent or periodic kiln that consists of a single firing chamber. The intermittent kilns are loaded with green bricks, which is fired and allowed to cool before unloading, in preparation of next loading and firing. These types of kilns are capable of firing only one loading of brick at a time.

Semi continuous kiln: Semi continuous kiln, where two or more intermittent kilns are interconnected by flues and dampers, to allow the heat from cooling bricks in one kiln to dry and pre-heat the bricks in another. The kilns are alternated being unloaded once the heat from the cooling bricks had been used to dry and pre-heat the bricks in the second kilns, which is then fired up to top temperature.

Continuous kiln: In the continuous kilns, the firing zone moves through the kilns without stopping. Green bricks are loaded in front of firing zone and fired bricks are removed behind it. These kilns run day and night, with the fire never going out except for seasonal or maintenance stoppages.

Tunnel kiln: In Tunnel kilns, the bricks are placed on trolleys and moved through the hottest part of the kiln at a predetermined rate. This is a form of continuous kiln, but with a stationary rather than moving firing zone.

Kilns can be further subdivided into three main classes, based on how they actually work.

- Up-draught kilns: Up-draught kilns where the heat travels naturally by convection, from the area of combustion up through the bricks.
- Down–draught Kiln: Down–draught Kiln, where the heat combustion is drawn down through the bricks by use of a chimney or forced draught system.
- Horizontal/cross draught kilns: Horizontal/cross draught kilns, where the heat of combustion is drawn sideways thought the bricks by the use of a chimney or forced draught system.

Table 1: Snapshot of Bangladesh's brick sector (2011)

Parameter	**Value**
Estimated total number of coal-fired kilns	5,000
Number of natural gas fired kilns	20
Annual brick production	17.2 billion
Value of output	Tk 83 billion (~US$1.2 billion)*
Contribution to GDP	~1%
Coal consumption	3.5 million tons
Value of imported coal	Tk 22.6 billion (~US$322 million)
Firewood consumption	1.9 million tons
Emissions CO2	9.8 million tons
Clay consumption	45 million tons
Total employment (incl. supply of clay and coal, transport of bricks)	~1 million people
Growth rate of the construction industry (1995-2005)	5.6%
Estimated future growth rate of the brick sector over the next ten years	2-3%

Sources: BUET (2007), Gomes and Hossain (2003) and World Bank (2011b)

**Estimated at per-brick price of Tk. 5.5*

Brick making is an important economic sector in Bangladesh, contributing about one percent to the country's gross domestic product (GDP) and generating employment for about one million people (BUET, 2007). Due to the unavailability of stone aggregate, brick is the main building material for the country's construction industry, which grew an average of about 5.6 percent per year (Arifur, 2006:15). Despite the importance of brick making, the vast majority of kilns use outdated, energy-intensive technologies that are highly polluting the environment. In the North Dhaka cluster, brick kilns are the city's main source of fine particulate pollution, accounting for nearly 40 per cent of total emissions (Biswas *et al.*, 2009) during the 5-month operating period (Figure 2 and 3). It leads to harmful impacts on health, agricultural yields and global warming.

Source: Field Survey, 2016

Figure 2 and 3: Existing Brick Kilns in Dhaka City.

The New technologies, such as the Vertical Shaft Brick Kiln (VSBK) and the Hybrid Hoffmann Kiln (HHK), are substantially cleaner than the Fixed Chimney Kiln (FCK) currently used. These improved technologies consume less energy and emit lower levels of pollutants and greenhouse gases (GHGs) (BUET, 2007; Heirli and Maithel, 2008:13). The existing brick kilns are the number one cause for fine particulate pollution in Bangladesh and its total greenhouse gas (GHG) emission is estimated to be 15.67 million tons of carbon dioxide (CO2) equivalent (tCO2e) per annum. Brick making significantly contributes to local air pollution including emission of various harmful gases, such as Sulphur Oxides (SOx), Nitrogen Oxides (NOx), Carbon dioxide (CO2) and Suspended Particulate Matter (SPM) and PM10 (Iqbal, 2007). About half of Bangladesh's bricks are baked with the use of coal, which is now considered the source of some 20 per cent of global greenhouse-gas emissions (Enters, 2000:15). A total of 4,880 (Butler *et al.*, 2004:62) brickfields are highly polluting Fixed Chimney Kilns (FCKs) because of a combination of low capital cost requirement and high investment return. The technologies that are available are shown in Table 2.

Table 2: Existing brick kiln technologies in Bangladesh (2009)

Kiln type	Number	Percent of total kilns (%)	Brick production4 (billion bricks)	Percent of total production (%)
FCK	≤ 4,500	92	15.8	91.4
BTK	n.a.	n.a.	n.a.	n.a.
Zigzag	≤ 150	3	0.6	0.0
Hoffman (gas)	≤ 20	0.4	0.2	3.5
HHK	≤ 10	0.2	0.2	1.4
Others	≤ 200	4.0	0.5	0.9
Total	**≤ 4,880**	**100**	**17.2**	**100**

Source: DOE 2010a. n.a. = not applicable

The Fixed Chimney Kiln (FCK) dominates the brick sector in Bangladesh, despite its highly polluting and energy-intnsive features. Such technologies as the Improved Fixed Chimney Kiln (IFCK), Improved Zigzag Kin (IZigzag), the Vertical Shaft Brick Kiln (VSBK), and the Hybrid Hoffmann Kiln (HHK) are substantially cleaner, consuming less energy and emitting lower levels of pollutants and greenhouse gases (Heirli and Maithel, 2008; World Bank, 2011a). But implementation of these technologies in Bangladesh is still at a pilot stage; thus, their financial viability still needs to be demonstrated.

- The North Dhaka brick kiln cluster consists of 530 closely spaced kilns, and are located in the Tangail, Gazipur and the northern Upazilas of Dhaka districts (BUET, 2007).
- Fine particulates refer to particulate matter (PM) with diameter of less than 2.5 μm, which is more harmful to health than PM with larger diameter (Pope et al. 2002).
- Based on average production for each kiln type, about 3.5 million bricks for the FCK, 4 million bricks for Zigzag, 12 million bricks for Hoffman, 1.5 million bricks for HHK and 2.5 million bricks for others are provided.

According to World Bank study (2011), the barriers that have contributed to the current state of the country's brick sector and its inability to bring about changes include:

Lack of supporting regulations, fiscal incentives and standards to encourage more energy efficient practices and technologies: Except for some efforts to regulate the sector, the government has made little effort to establish effective boundary limit emission standards;

Little and no governmental activity to assist the brick sector to undertake comprehensive programs so as it to make it cleaner and more profitable: Brick owners usually were left to bring in changes of their own which they have often failed to do, because of the vicious cycle of low efficiency – low income.

Lack of knowledge and access to energy efficient technology, which can lower production costs at the same time: Comprehensive dissemination programs that demonstrate the potential economic benefits of energy efficient technologies have yet to be carried out.

Lack of access to liquidity to finance modernization of brick making operations: As traditional brick kilns have seasonal employment, they have not been included in the list of recognized Small- and Medium-sized Enterprise (SME) and thus, are not eligible for concessional SME loan windows.

Lack of capacity in terms of technical and business skills at the enterprise level: It could bring changes towards improved efficiency and reduced pollution.

Limited experience of commercial lending institutions with SMEs and in particular, brick SMEs.

Major Pollutants Emission from Brick Fields

Huge amounts of hazardous materials are discharged from the brick manufacturing industry, which would have great impacts on the environment as well as on human health as discussed below.

Effects of particulates

Particulate is one of the major pollutants emitted from brickfields. Two types of particulate, settable and suspended are produced, both of which are harmful for human health and the surrounding environment (Croitoru and Sarraf, 2010).

Effects on human health

At high concentration suspended particulate matter poses health hazards to humans, particularly those susceptible to respiratory illness (WHO, 1999). As indicated in Table 1, the nature and extent of the ill effects that may be linked to suspended particulates depend upon the concentration of particulates, the presence of other atmospheric contaminants (notably sulfur oxides) and the length of exposure.

Effects on plants and animals

Dry brick kiln dust appears to cause little damage if deposited on a leaf surface, yet in the presence of moisture; such dust imparts damage and consequential growth inhibition to plant tissues. Dust coating of leaves reduces photosynthesis and the increased plugging of stomata reduces plant growth. Animals who eat plants coated with particulates may suffer from some ill effects (Jan et al, 2013, Fatima, 2011).

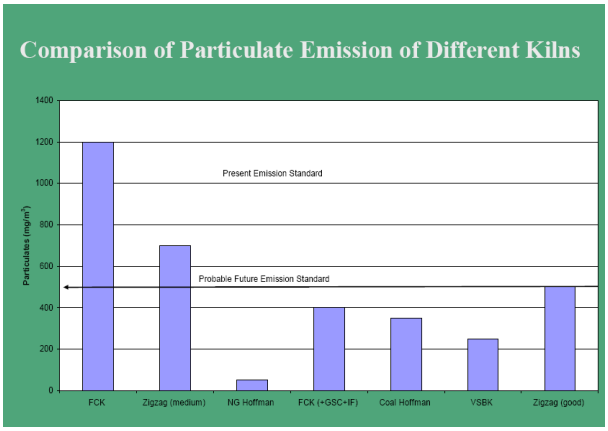
Effects of CO

CO at present ambient levels has little if any effect on property, vegetation or materials. At high concentrations, it can seriously affect human aerobic metabolism, owing to its high affinity for hemoglobin, the component of the blood responsible for transport of oxygen (US EPA, 1986). Hence, more blood need to be pumped to deliver the same amount of oxygen, resulting in strain on the heart. This is fatal when inhaled at very high concentrations, and heart disease patients, pregnant women, infants, senior citizens and those especially susceptible to respiratory problems may exhibit symptoms of poisoning at a relatively lower concentration. The WHO guideline for ambient CO concentration is 87 ppm (100) at a sampling time of 15 minutes (Jan et al, 2013, Fatima, 2011).

According to UNDP-GEF (2006), the major observations of brick kilns technologies can be illustrated as follows:

Zigzag Kiln –Assessment:

- The construction technology is not readily available, and expertise has to be procured from India
- Scrubbing water is not changed regularly
- Operation procedure is more sophisticated than FCK –a badly operated kiln has the same energy consumption and hence pollution
- Requires electricity and standby diesel generator
- Pollution –50% less assuming good design and proper operation



Source: UNDP-GEF Study, 2006

Figure 4: Comparison of Particulate Emission of Different Kilns in Dhaka

Hoffman –Assessment

- Initial investment 10 times that of the FCK (50% for land)
- Requires high land, natural gas connection, electricity and standby generator
- Requires more land compared to the FCK or Zigzag (at least 5 acres of high land close to a main road)

- Profitability low (IRR ~ 20%, 12-months operation needed to recover costs)
- Pollution –80-90% reduction compared to the FCK

FCK –Modifications

- Existing FCKs can be improved with one or all of the following

–Gravity settling chambers

–Improved coal feeding

–Internal fuel (up to 50%)

–Plugging air leakage

All of these options will require technical assistance in the early years. Once tried and tested, these can be easily replicated. Operation and maintenance of this aspect is not known. Some Indian data is available for gravity settling chamber modification along with improved coal feeding. The particulate emission can be reduced below 400 mg/m3 that would meet present and future emission standard.

Hoffman Coal (HHK) –Assessment

- The technology provider claims 80% coal can be mixed with clay. This needs to be demonstrated
- Operational and maintenance issues from Bangladesh perspective is not known yet
- Technology provider claims that the quality of the brick is better than FCK 1st class brick (but using extruder and drying chamber)
- It is claimed that Hoffman (coal) can reduce pollution by 50% to 80% compared to the FCK

VSBK –Assessment

- According to available literature sources, the bricks are of good quality. But, Bangladeshi brick makers have the following perception problems:

–Existence of cracks in bricks

–Bricks do not make a good ringing sound when banged

- About 70-80% reduction in emission compared to the FCK. Current standard is 1000 mg/m3for 120-feet chimney. Emission is 200-300 mg/m3for VSBK, but total height including chimney around 60 feet
- Significant efforts are underway for transforming the brick industry. Many of these will yield positive results in the next 2-3 years. The DoE should initiate a study to update standards, and gradually introduce tighter standards, and not hastily ban technologies and practices.
- Undertake project to determine the viability of using Gravity Settling Chambers and Internal Fuel in FCKs, because if these options prove successful then FCKs may be able to meet future emission standards.
- Undertake study to evaluate the popular Zigzag Kiln's design and emission.
- Undertake pilot projects of new technology (like VSBK) and assess operational (including product quality) and financial viability.

Study Area

The Greater Dhaka region, spread over an area of 1,500 km^2, includes the districts of Dhaka, Gazipur, Savar, Dhamrai, Rupganj, Manikganj, Kaliganj, and Narayanganj. The air quality in the Dhaka city has deteriorated over the last decade due to a rapid change in the vehicular fleet, increased congestion, and a large increase in the industrial activity, resulting in mortality and morbidity impacts (World Bank 2006, 2007; WHO 2011). The economic costs associated with mortality and morbidity due to poor air quality is estimated at US$500 million per year (World Bank 2006). World Bank (2007) presents an emissions inventory for the kilns located north of Dhaka, in the Gazipur district, including a measured emissions factor of 44.0g/s for total suspended particulates, which for an average production rate of 20,000 bricks per day translates to 190g per brick. The existing situation of brick kilns in the study area is shown in Figures 5-10.

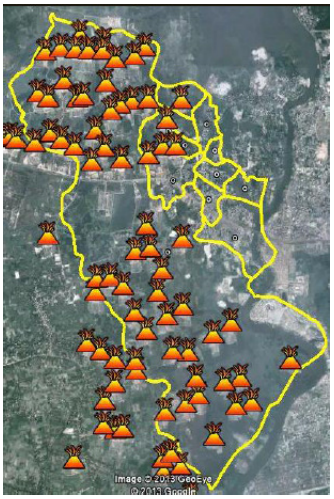


Figure 5: Location of brick fields in Ashulia

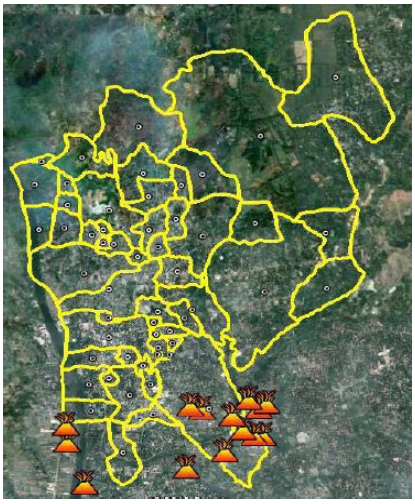
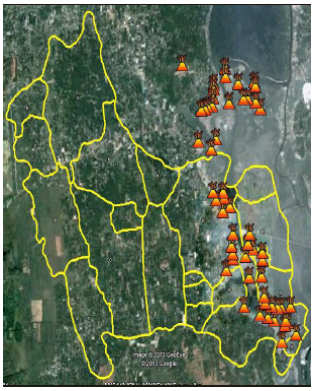


Figure 6: Location of brick fields in Savar Union



Source: Google Earth Image and Author

Figure 7: Location of brickfields in Ashulia Union

Savar is one of the most representative Upazilas in Bangladesh, showing the status of environmental governance, particularly the brickfields. Aminbazar is just adjacent to the Dhaka Metropolitan City. Unfortunately the entire union is mostly suffering of pollution for large number of brickfields. This union produces highest number of brickfields among other unions. All brickfields of Savar union are situated on Brahmaputra Floodplain. Among them only two is in very low land. Another five is in medium low land. All the brickfields are located only in Genda, out of 54 Mouzas, whose JL number is 196. Ashulia union is becoming new urban area, through the extension of Dhaka city and contains second highest number of brickfields (34).

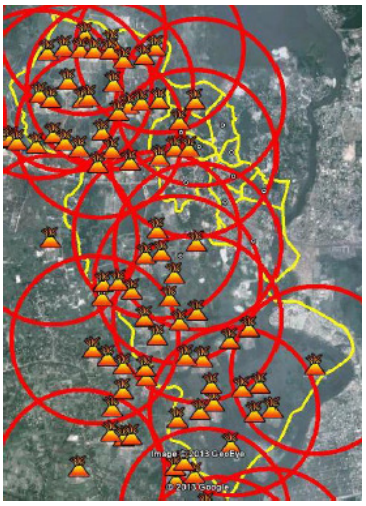


Figure 8: Vulnerable Area under 1 km radius in Ashulia Union

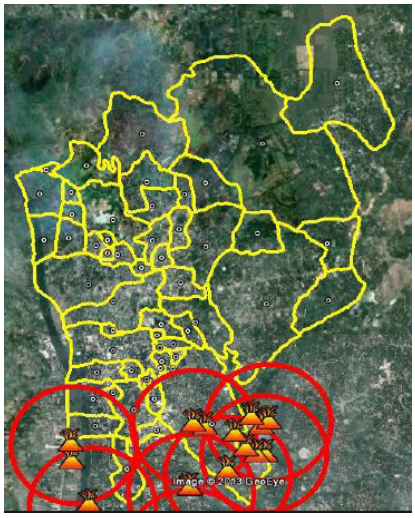
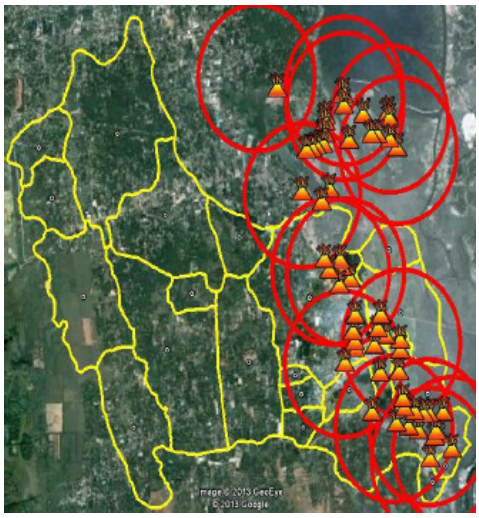


Figure 9: Vulnerable Area under 1 km radius in Savar Union



Source: Google Earth Image and Author

Figure 10: Vulnerable Area under 1 km radius in Ashulia Union

Legal Aspects of Brick Kilns in Bangladesh

The first act to regulate brick burning was formulated during 1989 which was named as Brick Burning (Control) Act 1989. That act was emendated (revised) twice and the revised versions were published as Brick Burning (Control) (Emendation) 1992 and Brick Burning (Control) (Emendation) 2001. In 2013, the Brick Manufacturing and Brick Kilns Establishment (Control) Act has been passed to establish control over brick manufacturing and brick kiln establishment for the interest of conservation and development of environment and biodiversity. This Act came into force from 1st July 2014, and permits two years' time limit to convert the brick kilns into modern technology and relocate thereof. After three years of enactment of this Act, now the question arises as regards feasibility and enforceability of the provisions of this Act. Following are the challenges to face for implementation.

The Act imposes prohibition on establishment of brick kilns within the boundaries of several areas, like residential, preserved or commercial area; City Corporation, Municipality or Upazila headquarters; public or privately owned forests, sanctuary, gardens or wetlands; agricultural land; Ecologically Critical Area (ECA); and areas adjacent to these areas. By analyzing this provision it is assumed that, after two years of enforcement (30 June, 2016) no suitable place can be found to establish brick kiln in Bangladesh. For instance: as per law no brick kiln can be kept or established in an ECA and within one kilometer distance from the boundaries of ECA. In 2009, Department of Environment (DoE) declared the four rivers around Dhaka city as ECA. On the other hand, almost all the brick kilns of Dhaka city are situated in the banks of these rivers. Again the law prohibits to keep or to establish brick kiln in the agricultural land and within one kilometer distance from the boundaries thereof.

The law provides mandatory provision to manufacture minimum 50 percent hollow brick in the brick kilns of modern technology which is less pollutant, energy efficient and with advanced technology. If all the brick kilns are converted into modern technology such hardship in site selection is not considered as reasonable to the experts. The law speaks about different areas or zones. In reality there is no complete land zoning in Bangladesh as a result some areas are expanding indiscriminately (residential area,

commercial area) and some are shrinking alarmingly (agricultural land). Without a comprehensive land zoning implementation of this provision is almost impossible. Now these aspects become burning issues among the city planners to prepare any type of development plan the city like Dhaka.

According to the law no person can use the soil as raw material in brick manufacturing, after cutting or collecting it from agricultural land, hill or hillock. Brick manufacturers can only cut or collect soil from dead pond, canal, swampland, creek, deep tank, rivers, haor-baor, char land and fallow land with the approval of appropriate authorities. But the law has not defined appropriate authorities and not prescribed the procedure. As a result most of around 7,000 brick kilns across the country use topsoil of agricultural land to make bricks, it takes around 127 crore cubic feet of fertile soil to manufacture 1,500 crore bricks per year (DAPA, 2009).

The law strictly prohibits the use of wood as fuel in brick kilns. Brick manufacturers can only use coal as fuel containing prescribed standard of sulfur, ash, mercury or similar

material. Till now the government has not determined any standard or quality for coal. As a result brick kilns in the study areas are illegally using firewood instead of coal (Table 5). About 2 million tons of firewood are burned in the brick kilns per year, which facilitates deforestation and extinction of biodiversity and pollutes the atmosphere (Jan et al, 2013, Fatima, 2011).

Only three Environment Courts in Dhaka, Chittagong and Sylhet have been so far established and functioning. Providing environmental clearance for brick kilns and monitoring the compliance of this Act with the primary responsibility of filing case and investigation thereof is vested to the DoE. Establishment and smooth functioning of Environment Courts depend on DoE. Though it is aimed to establish one or more Environment Court/s in 64 districts but in reality Department of Environment (DoE) has office only in 22 districts. It is practically impossible to establish Environment Court and effective implementation of this Act without office and manpower of DoE.

Discussion

The application of Environmental laws in Bangladesh starts from the 19th century, although these were remained either unenforced to a large extent or vaguely known to the people and the responsible public agencies. The Ministry of Environment and Forest was established in 1989, to address environment- related issues. The act related to brick fields should be amended in light with the field level study considering the issues mentioned with the participation of people. At the same time for the effective implementation of this Act concerned institutional frameworks should be strengthened and necessary by- laws should be framed. Health experts say that people living within five kilometres of a brick kiln, are exposed to various health risks. A high incidence of liver and stomach troubles have been reported among people living close to brick kilns (Islam, 2001).

However, except for restricting the use of coal, this ordinance does not talk about air pollution/air quality monitoring or control measures; neither has it described any punishment for the person/owner who pollutes the surrounding air. Though National Environmental Policy 2013 suggests undertaking the measure of emission tax, it does not implement this measure though this could have been a perfect sector of implementing this law. Moreover, as the procedure of producing bricks severely degrades the topsoil of the area, restrictions should be made more stringent, and alternative options should be encouraged Bangladesh's brick sector is characterized by outdated technologies with low energy efficiency and high emissions; low mechanization rate; dominance of small-scale brick kilns with limited financial capacity; and dominance of single raw material (clay) and product (solid clay brick). Adopting gas-based cleaner technologies is hampered by serious energy shortage and land scarcity. The following policy recommendations can be illustrated to face the challenges of low carbon city planning in Dhaka city.

In the Short-term

i. Recognize brick kilns as a ***formal industry.*** This would enable easier access to financial resources (which in turn will enable investment in cleaner technologies and access flood free land) and improved working conditions.

ii. Create a ***Brick Technology Center*** to raise awareness about the benefits of cleaner technologies. The center should: (a) disseminate information on the *social benefits* provided by cleaner technologies, new wall materials (e.g. perforated and hollow bricks) and alternative raw materials; (b) promote pilot projects of new technologies with improved provisions (e.g., mechanized, higher labor productivity and larger product lines); (c) improve use of existing dissemination channels (e.g., field visits to pilot plants, video demonstrations of the technologies, use of the Bangla language) and introduce new channels (e.g., newsletters, industry journals, conferences, and Internet blogs).

iii. Support ***research and development*** aiming at: (a) exploring alternative raw materials10 that are locally available, brick diversification, and use of higher level of mechanization; (b) conducting new studies such as energy consumption studies, land surveys, and brick technology surveys.

iv. Facilitate the availability of ***subsidized credit lines*** to account for reduced health impacts from pollution and of other ***economic incentives*** supporting the production of new wall materials and use of alternative raw materials (e.g. via specific funds and preferential tax policies, as in China).

v. Provide access to ***carbon markets***, on account of the carbon emission reductions provided by cleaner technologies.

vi. ***Train*** several stakeholders with regard to the benefits of adopting cleaner technologies (e.g. brick owners, workers and the financial sector).

In the medium term:

vii. ***Enforce the existing regulations and policies***, such as the ban of traditional high polluting kilns (e.g. FCK, BTK), particularly those located close to large population centers, upstream of the wind (north) in the dry season (November to April).

viii. ***Introduce regulations and policies that encourage adoption of cleaner technologies***, such as: (a) revise emissions standards for brick kilns under ECR 97 to make them technology independent and to encourage brick diversification (e.g., perforated or hollow bricks for partition walls); (b) establish proper emission monitoring for brick kilns; (c) impose an emission levy based on "polluter-pay principle"; (d) design rules and standards for the entire brick value chain: from raw materials to production processes and equipment and final products to building designs and construction processes.

ix. ***Develop industrial parks*** to accommodate a large number of industries on flood-free land. These parks would mean less cost for kiln owners, due to the economy of scale achieved by providing the basic infrastructure for all kilns (e.g. roads, electricity, water) and other facilities (e.g. schools for the employees' children). They would also require less land for kilns establishment compared to the current situation.

x. ***Improve working conditions*** by introducing higher levels of mechanization, social programs to reduce child labor, occupational safety and health measures in kilns.

The summary of the recommendations is framed in Table 3.

Table 3: Institutions concerned in preparing Low Carbon Dhaka City Plan

Recommendations	Institutions concerned
In the short term: 1. Recognize brick kilns as Small and Medium Enterprises 2. Create Brick Technology Centre 3. Support research and development 4. Facilitate the availability of subsidized credit lines and other economic incentives 5. Provide access to carbon markets 6. Train several stakeholders with regard to the benefits of adopting cleaner technologies	Ministry of Industries (MOI), Department of Environment (DoE) DoE, Bangladesh Brick Manufacturers Owners Association (BBMOA), Ministry of Environment and Forests (MOEF) DoE, Research and Academic Institutions MOEF, Ministry of Finance (MOF), Bangladesh Bank, Financing Institutions DoE Brick Technology Centre, BBMOA
In the medium term: 7. Enforce the existing regulations and policies 8. Introduce regulations and policies that encourage adoption of cleaner technologies 9. Develop industrial parks to accommodate a larger number of industries 10. Improve working conditions	DoE, MOEF, Bangladesh Standards and Testing Institutions (BSTI) DoE, MOEF Bangladesh Small and Cottage Industries Corporation (BSCIC), MOI, DoE DoE, Ministry of Labor and Social Welfare (MOLSW), Ministry of Women Affairs (MOWA), Entrepreneurs, BBMOA

Source: Authors

Conclusion

The paper has presented the existing condition of brick kilns and their adverse effects in the study area. It is hoped that the research will create awareness and encourage carrying out further researches in the future.

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