Trade-offs between forest ecosystem services and fuelwood consumption of the brick making industry in Bangladesh.

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Introduction & Objectives

Rapid urbanization and associated rural to urban people migration, generating a huge demand for the bricks in Bangladesh for the construction of housing, educational and commercial complexes (Luby et al., 2015). An estimated 5000 brick kilns was in operation across the country producing about 17.2 billion bricks during 2009, which increased to around 7000 producing about 27.1 billion bricks during 2015 (DoE, 2015; World Bank, 2011). Annual increase in brick production is 5.6% to keep the pace of urbanization rate of 6% (Baum, 2010). Considering the population increase by 1.2% and 34.2 % of the population in urban areas (BBS, 2016), the demand for bricks will continue increasing. The sources of energy of Brick Making Industry (BMI) are coal, natural gas and fuel wood in Bangladesh (Luby et al., 2015). In spite of strict legal regime (figure 1), brick kilns are still using fuel wood as their energy source (figure 2), which is around 20% of the total brick kilns (DoE, 2015).

The objectives of this study are as follow:

1. **To assess the impact of BMI on GHG emissions from fuelwood consumption**
2. **To estimate the equivalent land area to provide fuelwood for BMI**
3. **To assess the cost for reducing emissions from fuelwood in BMI**

Methods

The conceptual diagram of the model is presented in Figure 3. Several national specific input data were used such as number of brick factory, brick production, aboveground biomass in different land use types, air purification potential and hypothetical prices for ecosystem services such as carbon sequestration or air purification.

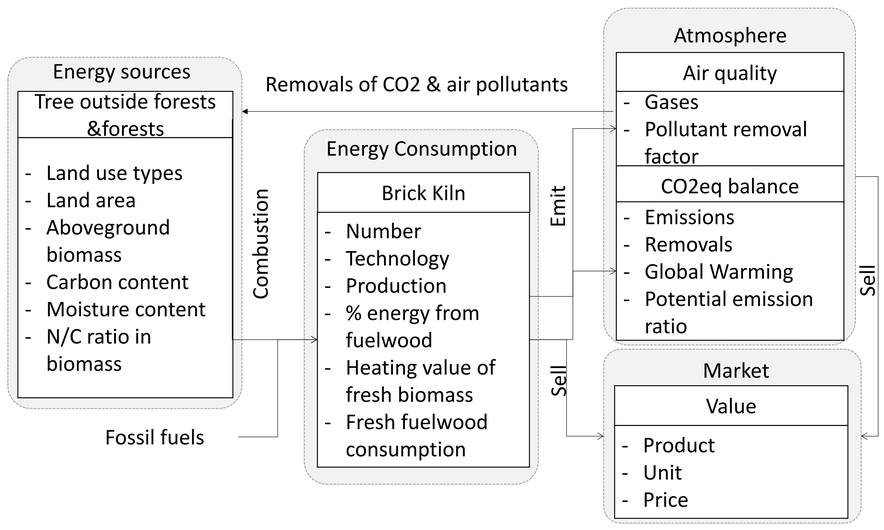

Figure 3: Conceptual diagram showing the principal components

Results

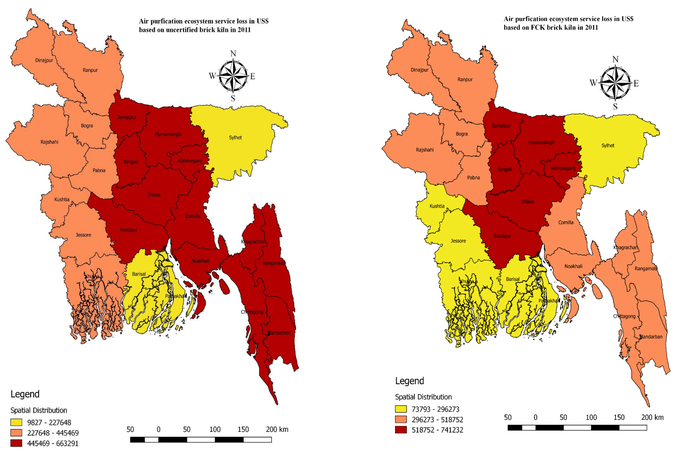

Figure 4: Spatial distribution of air purification ecosystem service loss in US$ for the year 2011 based on illegal (not having environmental clearance certificate) and presence of fixed chimney brick kiln.

The highest loss region in terms of air purification ecosystem service was observed in Dhaka, and Chittagong division, followed by Rajshahi & Khulna under the presence of illegal brick kiln criteria.
Based on the presence of FCK brick kiln criteria, highest loss observed in Dhaka, followed by Chittagong and Rajshashi.

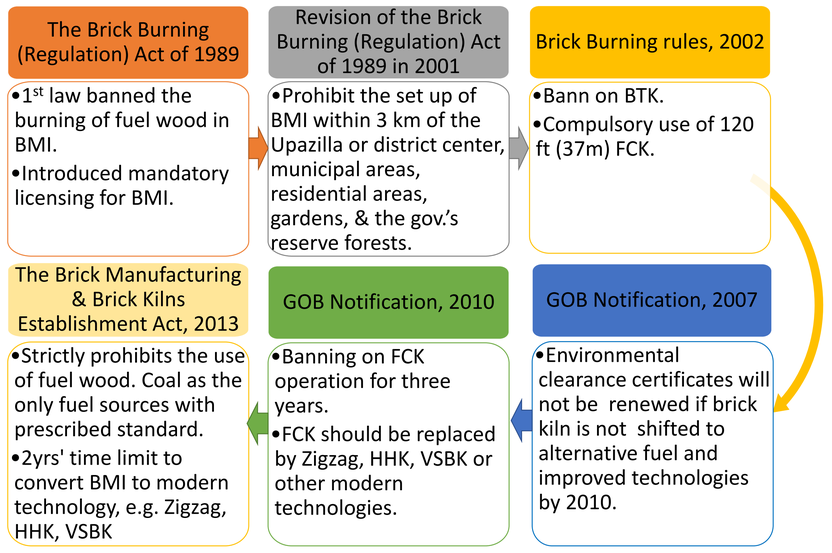

Figure 1: Evolution of legal regime related with BMI

Figure 2: Fixed chimmney kiln using fuel wood (source: The Daily Star)

Kiln Type	2009 [a]				2015 [b]			
	BMI		Brick production		BMI		Brick production	
	Number	%	billion bricks	%	Number	%	Billion bricks	%
FCK	4500	92.21	15.75	91.28	3453	49.68	12.0855	44.52
Zigzag	150	3.07	0.6	3.48	3363	48.39	13.452	49.55
HK/HHK	30	0.61	0.405	2.35	71	1.02	0.958	3.53
Tunnel	0	0	0	0	38	0.55	0.57	2.1
VSBK	0	0	0	0	2	0.03	0.024	0.09
Others	200	4.1	0.5	2.9	23	0.33	0.0575	0.21
Total	4880		17.255		6950		27.147	

Table 1: Brick production under different technologies Source: [a] World Bank (2011); [b] DoE (2015)

Gases	2011		2015	
	t yr^{-1}	CO_2-eq. yr^{-1}	t yr^{-1}	CO_2-eq. yr^{-1}
CO_2	1,254,000	1,254,000	582,955	582,955
N_2O	38	112	17	52
NO	887	-	412	
NOx	1,360	-	632	
CH_4	5,472	186,048	2,544	86,489
CO	27,360	82,080	12,719	38,157
Total		1,522,240		707,654

Table 2: Emissions due to the use of fuel wood

The total CO2 eq annual emissions were 1.5 and 0.7 MCO2eq yr^{-1} in 2011 and 2015 respectively. Fuel wood emissions reduced by 54% between 2011 and 2015. CO2 emissions represented 83% of total emissions while CH4 12% and CO 6%.

	Aboveground C stock	Equivalent land area lost (ha yr^{-1})	
	t C ha-1	2011	2015
Forest	96.5	3,938	1,831
Cultivated land	8.5	44,706	20,783
Villages	72	5,278	2,454

Table 3: Emissions due to the use of fuel wood

The equivalent loss of land was 3.938 ha, 44,706 ha and 5278 ha under scenario 1, 2 and 3 respectively.
The estimated stored carbon lost under scenario 1 was 380 and 177 Mt C yr^{-1} in 2011 and 2015 respectively.

Fuel wood source	Year 2011					Year 2015				
	Revenue	Emission reduction benefit $_{Max}$	Emission reduction benefit $_{Min}$	Opportunity costs $_{Min}$	Opportunity costs $_{Max}$	Revenue	Emission reduction benefit $_{Max}$	Emission reduction benefit $_{Min}$	Opportunity costs $_{Min}$	Opportunity costs $_{Max}$
	million US$									
Forest	1102.50	9.38	4.18	-1093.12	-1098.32	966.84	3.96	1.94	-962.88	-964.90
Cultivated land		29.20	4.54	-1073.30	-1097.96		9.00	2.03	-957.84	-964.81
Villages		10.04	4.20	-1092.46	-1098.30		4.12	1.94	-962.72	-964.90

Table 4: Opportunity costs of bricks production in FCK

The study estimates that opportunity costs of brick production in FCK range between US$ 1073 million to US$ 1098 million during 2011, which decreased in 2015 due to less fuel wood consumption in the brick kiln steaming from brick kiln technology shift more towards Zigzag, HK/HHK, etc.

Discussion and Conclusion

- **Stored carbon lost is highest when the source of fuel wood is from the surrounding villages .**
- **The opportunity cost of fuel wood use considered here from stored carbon lost and air purification ecosystem service, but valuation of other ecosystem services**
- **like micro climate regulation, noise reduction, rainwater drainage, recreational and cultural values may change the economic profit estimated for the BMI.**
- **BMI is one of the fastest growing sectors in Bangladesh, yet proper database related with technology and energy use is limited.**
- **CO_2 and other GHG emission from fuel wood burning is significant, in fact it is the largest stationary source of CO_2 emission. Hence, proper action should be initiated to reduce the GHG footprint of this sector.**

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