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Research paper

Environmental vulnerability of people to brick kiln hazards

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Abstract

The study aimed to assess the vulnerability to brick kilns hazards based on questionnaire surveys. It was conducted at 12 selected brick kiln clusters in Rajshahi and Gazipur Districts of Bangladesh. A total number of 700 respondents taking part in the survey from both the study areas. The study identified that most (75%) of the brick kilns were fixed chimney type kilns that impacted crop production, river grabbing, deforestation, solid waste generation, labors right violation, etc. The survey results illustrated that the emission of dust particles, harmful gases, and hot air cause several health hazards such as asthma, eye or skin irritation, etc. The brick kilns have exerted environmental stress on fruit plants such as mango, banana, jackfruit, etc., resulted declining in fruit production. The relationship between the brick kiln owners and community people is not well due to the negative impacts of brick kilns. About 69% of respondents thought that the brick kilns were a vital source of air pollution. Finally, the study concluded that the brick kilns caused threats to society, human health, and the environment around the kiln areas.

Keywords: *Awareness; Brick Kiln; Hazards; Impact; Vulnerability.*

1. Introduction

Environmental degradation is a burning issue altering the global environment rapidly at present. Climate change, ozone layer depletion, deforestation, desertification, air pollution, water pollution, etc., are serious problems threatening the earth's survival and existence. Generally, industrial pollutants often differ the physicochemical characteristics, for example, temperature, acidity, salinity, turbidity of water bodies, leading to ecology alterations resulting in water becomes brackish (Islam and Mostafa, 2020). Bangladesh is an agro-based country. Urbanization is one of the most important reasons for shrinking agricultural lands which requires brick produced in the brick kiln industries operated only during the dry season (November-April) and started as soon as the monsoon rain is over. The Government of Bangladesh has passed several laws towards improving environmental sustainability and encouraged people to adopt green technology in the brick production sector. Despite the aspiration of the government, it is not possible to take proper monitoring and action according to the law due to a lack of skilled human resources and logistic supports. Brick kilns are mostly situated on agricultural land as the brick manufacturer needs silty clay loam and silty loam soils having good drainage conditions, which renders productive agricultural lands unproductive. Brick kilns are spread all over the country which reduces soil fertility status by cutting topsoil. Moreover, the same locations were used for years and the biomass energy used for firing bricks resulted in serious environmental hazards and decreased soil nutrient status (Islam and Rahman, 2011). So, brick kilns are present major concerns for environmental degradation in Bangladesh.

The brick kiln is a booming industry as the demand for bricks is increasing almost universally due to fast economic growth, urbanization, and prosperity. A significant factor is that brick kilns are usually clustered near big cities in different parts of Bangladesh. But according to the Brick Kiln Control (amended) Act-2001, "there must be no establishment of brick kilns within a three-kilometer radius of human inhabitation or reserved forest". The hazardous elements are presently brought forward from the brick kilns every year. The elements mixed up with air, soil, and water resulting in changes of physical, chemical, and biological properties, and it causes environmental pollution. Water is a natural resource for domestic, industrial, commercial, and irrigation purposes and safe drinking water is absolutely essential for healthy living (Mostafa et al., 2017). Therefore, the parts of the city near the brick kiln clusters experience serious air, water, and soil pollution problems (Saha et al., 2021). Hazardous pollutants may originate in the soils around the kiln areas from various sources, i.e., coal, wood, and furnace oil burning, use of tires for initial firing in the brick kiln areas. The major pollutants which are emitted from the brick kilns are particulate matter (PM), some hazardous gases like CO_2, CO, NO_x, NO, and SO_2 (Saha et al., 2020a). The hazardous pollutants are of great concern due to their wide-ranging sources, toxicity, non-biodegradable properties, and accumulative behaviors. So, the brick kilns are the source of cause's soil pollution. Hassan et al., (2012) mentioned that most of the brick kilns use low-quality coal or other solid waste material and thus results in the production of SO_x, NO_x, CO, and PM along with many other organic pollutants due to the burning of substandard waste material. Therefore, with rapid but unstrained development, emissions from these sources are constantly increasing and favorably distressing the environment. So, the production of bricks caused by environmental degradations due to the emission of significant quantities of gaseous and particulate pollutants (Banglapedia, 2007). The releases of toxic substances from these

brick kilns are adversely affecting soil, plants, animals, and people in their surroundings being the most severe for human health. About 75 percent of the people are living in the village and they are directly or indirectly involved in agriculture.

The farmers of the country are the core of our agricultural sector. But they are not well aware of the environmental degradation because of the brick kiln. On one side, a brick kiln produces a large number of bricks which are essential for building, roads, construction but on another side, it affects the whole environment, reduces the yield of agricultural production. Jamatia et al., (2014) reported that the increase of brick kiln coupled with the haphazard manufactural set-up in a small area has resulted in a significant contribution to pollution load in the environment. A study conducted by Skinder (2013) reported that the brick kilns in District Budgam (J & K, India) showed some negative impacts on the vegetation. Air quality status was turned into severe hazards during the operation phase of the brick kilns. The results showed a negative impact of the brick kiln emissions on biochemical parameters like chlorophyll, pheophytin, carotenoids, carbohydrate, proteins, and lipids of the different vegetable species. So, the farmers become the ultimate victim of brick kilns establishment. The brick kiln emitted gases that caused huge pollution to the environment and harmed human health. The crusher machine created a high intensity of noise resulted in significant adverse human health impacts. However, most of them were not well aware of health-related compliances in the kiln areas (Saha et al., 2020b). It is necessary to know their awareness of agro-environmental degradation due to brick kiln operation. The extent of awareness may vary among farmers due to the influence of various factors. It is, therefore, very important to know the relative awareness of the farmers about environmental degradation caused by brick kilns. This study will provide a detailed scenario and a better understanding of the brick kilns impacts on the environment. The findings of this research will be useful to those who are concerned with the planning, policy-making, implementation, and evaluation of agricultural, rural development, and environment protection. Considering the above facts, the present study was undertaken to evaluate the respondent's awareness and vulnerability related to environmental degradation resulting from nearby the brick kilns.

2. Materials and methods

The study was carried out through a survey method. A detailed flow chart of the study is represented in the flow chart (fig. 1). The questionnaire survey was conducted through a personal interview schedule from the respondents of the selected kiln areas. The survey was conducted in two geographical locations because physiography, hydrology, land level about flooding, agro climate, and the cropping pattern is different in every unit.

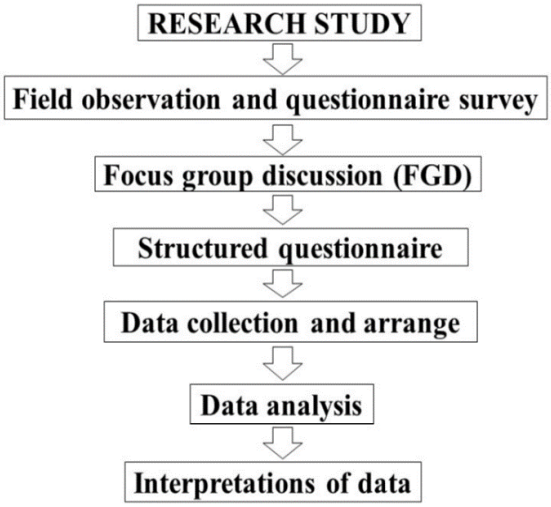

Fig. 1: Flow Chart of the Study.

The study area was Rajshahi and Gazipur districts because a large number of brick kiln clusters were located in those areas. The selection of the brick kiln was based on the proximity to agricultural lands and community as the study comprised determination of contamination in cropland and society, respectively. During the time of research design, twelve brick kiln clusters were selected for research among eight in Rajshahi district and the rest four in Gazipur district. According to Bangladesh Brick Manufacturer Owner's Association, the total no. of brick kilns in Rajshahi and Gazipur is 130 and 321, respectively. After completing the survey, the data were written in a master sheet and then complied, tabulated, and analyzed. The local units were converted into standard ones. The qualitative data were transferred into quantitative data one if required. The data were then analyzed with scientific software MS Excel 2013, Arc GIS, etc. The statistical measurements were made to categorize and describe the variables. The tables and figures were used to explore the findings.

2.1. Survey process

Data collection should be authentic to bring accuracy and precision to any research work. It helps to get the real scenario of the study area. The primary data are first-hand data which are collected from an onsite field questionnaire survey. A total of 150 brick kilns were visited and the people engaged in the manufacturing process were interviewed to get an insight into the current brick-making industry and the workers' response to the brick manufacturing procedure. About 700 respondents took part in the survey in both study areas. About half of the total respondents (350 respondents) were brick kiln workers, and the remaining respondents were the community people who lived nearby the brick kiln areas. About half of the respondents were interviewed from both districts. The questionnaire survey was conducted to get people's perception of the awareness and understanding on various environmental issues and their impacts resulting from brick kiln emissions. A structured interview schedule was used for the collection of relevant data for the study. Closed-form questions were included in the schedule. Firstly two focus group discussions (FGD) were done in two kiln areas to identify the problems of the farmers and get an idea of the field situation. Simple and direct questions were also included to ascertain the opinions of the respondents. The draft interview schedule was prepared following the objectives of the study. The interview schedule was pre-tested with five

respondents near the brick kiln from the study area. Necessary corrections, additions, and modifications were made in the interview schedule based on the pretest results. The modified and corrected interview schedule was then printed in the final form.

2.2. Sample size

Sample size determination is one of the most important problems in planning a survey work needed to estimate the authentic figure to meet the objectives of a study and is very significant for getting accurate research outcomes. An extra-large sample involves a huge cost, manpower, materials, and time, whereas several samples can lead to overturns or biased results of the survey. The study considered a small population, therefore, the sample size was determined using the following equation as outlined by Daniel, 1999.

Sample size, $n = \frac{Nno}{(N+no)}$

Where n_0 = desired sample size = $z^2 \frac{pq}{d2}$

z = Assumed standard, z - score usually set at 1.96, corresponds to the 95% confidence level,
p = Assumed standard deviation estimated to have a particular characteristics, usually set at 0.5,
d = Allowable margin of error (confidence interval),
q = 1 – p = for small population size,
N= Population size.

2.3. Data collection

Data were collected through a personal interview schedule from the respondents of the selected kiln areas. The interview was conducted individually with the respondents. The research took all possible care to establish rapport with the respondents so that they would not feel any hesitation during the interview. Wherever the respondents felt any difficulty in understanding any questions, the researcher took the utmost care to explain and clarify.

2.4. Independent variables

The independent variable is stable and unaffected by the other variables. These variables are controllable affect the dependent variables. Respondent's age, occupational identity, and educational attainment were considered as independent variables in the questionnaire survey.

2.4.1. Age structure

The age of the respondents was measured in terms of years from his birth to the time of interview (Mamun, 2004).

2.4.2. Occupational identity

The category of the respondent was divided based on the occupational identity of a respondent. Two types of respondents namely brick kiln workers and farmers and community people of nearby brick kiln areas were used in this interview schedule.

2.4.3. Educational attainment

Educational attainment was defined as the ability of an individual to read and write or formal education received from educational institutions for a period. Four types of literacy levels, namely i) Illiterate, ii) below secondary level, iii) up to SSC/HSC, and iv) graduate and above were used in this interview schedule.

2.5. Dependent variables

The dependent variable of the study was the awareness and vulnerability levels of the respondents. Several possible and major degradation issues of brick kilns were considered to measure their extent of awareness and vulnerability. The respondents were asked to indicate their extent of awareness and vulnerability as they faced several difficulties due to the establishment of a brick kiln. The awareness and vulnerability levels of the respondents were measured by considering four issues, namely natural environment, human health, agricultural degradation, and social system. Each dimension consists of different statements. The responses of the respondents to 48 questions showed the awareness and vulnerability levels to various types of degradation surrounding the brick kiln areas. Two target groups were interviewed during the field survey in Rajshahi and Gazipur districts, namely brick kiln workers and community people. The primary data of the field survey was calculated in percentage and mean percentage.

3. Results and discussion

The findings of the questionnaire survey and its interpretations are presented here. A total of 150 brick kilns being currently in operation were visited from different brick kiln clusters located around Rajshahi and Gazipur district during the study. The general features obtained through field visits and field surveys based on the questionnaire are summarized in Table 1. A very few numbers of brick kilns were in Rajshahi District, but comparatively, a large number of brick kilns were operating per cluster in Gazipur District. Both agricultural lands and community residences exist near the brick kiln clusters in Rajshahi, but those were absent in Gazipur. Hence, it is assumed that the brick kiln clusters in Gazipur District higher smoke compared to Rajshahi District. This higher amount of emissions may have some impact on the environment.

The brick kiln survey report illustrated that the Fixed Chimney Kiln (FCK) remains the (75%) dominant brick burning technology, but the number of Zigzag Kilns is increasing compared to Fixed Chimney Kiln in recent days. A report of the brick sector funded by ESMAP stated that the Fixed Chimney Kiln (FCK) dominates the brick sector in Bangladesh, despite its highly hazardous and energy-intensive features (World Bank, 2011). The study observed that black smoke emission from the Fixed Chimney Kilns was higher compared to the Zigzag Kilns (less black smoke is considered to be less hazardous). The Zigzag Kilns demonstrate a higher rate of brick production with a relatively lower rate of land and fuel (coal) consumption compared to those of the fixed chimney kilns.

Table 1: General Features of Brick Kiln in the Study Area

Parameter	Fixed Chimney Kiln	Zigzag Kiln
Height of chimney (ft.)	70-100	45-85
Status of smoke	Blackish and large quantity	Less blackish and sometimes white and less quantity compared to FCK
Production period	15th October – 15th June	
Production rate/season (lacs)	20 ± 5/kiln	35 ± 5/kiln
Land consumption (bigha)	20 -25	15 - 18
Cause of production loss	Due to rain	
Rate of production loss/season (%)	10 – 15 % from total production	

3.1. Measurement of independent variable

The analysis results of independent variables i.e., age structure, occupational identity, and educational attainment are described below.

3.1.1. Age structure

The age of respondents is a vital individual characteristic of any survey because it influences the dimension of the results. Based on respondents' age structure, the respondents were classified into three categories: young age (20 - 30), middle-age (31 - 50), old age (above 50). About 50.0% of the total respondents were young aged, followed by 34.28% of middle-aged, and the remaining 15.72% of old aged (Table 2). The results showed that half of the total respondents in the study area were comprised of young aged. Various reports in the methodological literature suggest that older respondents may answer with less precision than younger respondents in a survey research interview or may be more influenced by the particular format used for presenting questions or eliciting answers (Andrews and Herzog, 1986). It also indicated that the responses from the young age group of the respondents have a significant influence on the awareness and vulnerability levels about different environmental issues.

3.1.2. Occupational identity

Based on occupational identity, two categories of respondents were interviewed during the survey period. A total of 700 respondents took part in the survey in Rajshahi and Gazipur districts. About half of the total respondents (350 respondents) were brick kiln workers, and the remaining respondents were the community people who lived nearby the brick kiln areas. About half of the respondents from each category were interviewed from both districts (Table 2). The number of respondents was considered helpful in getting fruitful outcomes.

Table 2: Leading Features for Independent Variables of Respondents in the Study Areas

Independent variable	Sub-categories	Measurement of independent variable		
		No. of the respondents (n)	Total no. of the respondents (N)	Percentage (%)
Age structure	Young aged (20 -30)	350	700	50.00
	Middle aged (31 -50)	240		34.28
	Old aged (above 50)	110		15.72
Occupational identity	Brick kiln worker	350	700	50.00
	Community people near brick kiln areas	350		50.00
Educational attainment	Illiterate	390	700	55.72
	Below secondary level	230		32.86
	Up to HSC	80		11.42
	Graduate and above	00		0

3.1.3. Educational attainment

Education is the fundamental right of human beings. A nation cannot achieve the standard of living, social welfare, and sustainable development without education. The respondents were grouped into four categories according to their education is presented in Table 2. The analysis results showed that the percentage of illiterate, below secondary level, up to HSC and graduate were about 55.72, 32.86, 11.42, and 0, respectively.

3.2. Measurement of dependent variable

The dependent variables, i.e., awareness and vulnerability levels about four issues, namely environmental degradation, human health impact, agricultural degradation, and social system impact are described below.

3.2.1. Impact on human health

The respondents in the study area were assumed to face several health hazard issues surrounding the brick kiln areas. The people around the brick kiln areas were suffering from some common diseases including asthma, fatigue, headache, and eye irritation. There were six assessment parameters considered to assess their extent of awareness and vulnerability. The results showed that the highest mean percentage of awareness and unawareness was 97.86 and 85.72 found in the asthmatic disease and skin diseases, respectively. The lowest mean was 14.28 and 2.14 in the skin disease and asthmatic disease, respectively (fig. 2). The results showed that the respondents were aware of adverse health issues caused by brick kiln emissions.

The survey results illustrated that the highest mean percentage of a high, medium, and low vulnerability was 66.43, 35.72, and 25.00 found in the asthmatic disease, eye irritation, and skin disease, respectively. The lowest mean percentage of high vulnerability was 28.58 in the skin disease, and the percentage of medium and low vulnerability were 22.86 and 8.57 obtained in the asthmatic disease, respectively (Table 3).

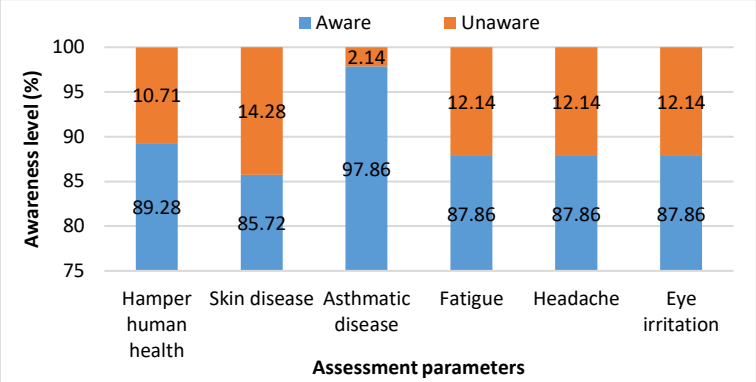

Fig. 2: Survey Responses to Awareness Level on Human Health Impact.

Table 3: Survey Responses to Vulnerability Level on Human Health Hampering

Assessment parameters	Assessment on vulnerability level			
	High (%)	Medium (%)	Low (%)	No comments (%)
Hamper human health	53.58	25.00	10.71	10.71
Skin disease	28.58	32.14	25.00	14.28
Asthmatic disease	66.43	22.86	8.57	2.14
Fatigue	35.72	30.71	21.43	12.14
Headache	35.72	35.71	16.43	12.14
Eye irritation	32.86	35.72	19.28	12.14

Some of the respondents made several comments indicating that emitted dust, smoke, and heat from the kiln were the vital causes of illness around the kiln areas. The survey observed that asthmatic disease is one of the major causes that hamper human health and the other parameters were also detrimentally affected human health around brick kiln areas. The selected health hampering parameters arise due to brick kiln emissions which influenced the level of vulnerability. Some other survey results also supported the present study. A similar type of survey was conducted at Bagatipara Upazila in Natore District showed that the majority of the respondents were suffering from various diseases like eye irritation, skin diseases, and respiratory problems due to brick kiln emissions (Jerin et al., 2016). Joshi and Dudani (2008) stated that people who are living near brick kilns were more possibility to suffer from several illnesses compared to people who are living away from the brick kilns. Therefore, it can be said that the respondents frequently meet with different adverse health issues because of brick kiln emissions.

3.2.2. Impact on agricultural sector

The respondents in the study area were assumed to encounter several issues which degraded the agricultural sector surrounding the brick kiln areas. There were five assessment parameters considered to assess their level of awareness and vulnerability. The responses of different agricultural degradation issues showed that the highest mean percentage of awareness was 75.00 found in agricultural sector damage, irrigation system problem, loss of soil fertility, and productivity. On the other hand, the highest mean percentage of unawareness was 67.85 in the decline of beneficial micro-organisms. The lowest mean percentage of awareness was 32.14 in the drop of beneficial micro-organisms. The lowest mean percentage of unawareness was 25.00 found in the agricultural sector damages, irrigation system problems, loss of soil fertility and productivity, and crops yield reduction, respectively (fig. 3). The results indicated that most of the respondents do not have proper knowledge about agricultural degradation due to the brick kiln emissions.
The survey results showed that the highest mean percentage of high, medium, and low vulnerability of the respondents was 38.57, 28.57, and 26.43 in the loss of soil fertility and productivity, irrigation system trouble, and agricultural sector impact, respectively. The lowest mean percentage was 24.28, 22.14, and 10.72 found in the crop yield reduction, agricultural sector, damage, and irrigation system loss, respectively (Table 4). The results indicate that the loss of soil fertility and productivity and irrigation system were the major causes that negatively impact the agricultural sector around the kiln areas. Some respondents attributed the decreased crop, vegetable, and fruit yields to the existing threatening conditions created by kiln emissions. The survey result revealed that the farmers near the brick kilns got lower food production due to brick kiln emissions. All types of agricultural plants near the kiln areas were in bad condition. Fruit farming in Rajshahi District, including mango, jackfruit, banana, litchi, date palm, and green coconut became more sensitive to brick kiln emissions. The fruit trees around brick kiln areas were affected by several diseases, including fruit splatter, damaged fruit stalk, affected growth, root damage, spotted leaves, and fruits, production loss, and immature fruits fall from trees. The study observed that the mango production near the brick kilns was extremely hampered due to an increase in ambient temperature near the kiln areas. Various gaseous and particulate matters emitted from the brick kilns show a negative impact on adjacent vegetation and crops. Especially the farmers of boro rice are mostly affected. In most cases, when the fire of brick kilns was properly extinguished at the end of the production season, left-behinds burned plants and vegetation near the kiln areas and emitted poisonous gas. Instantly many crops lost due to the effect of the harmful gases emitted from the kilns. Kudesia (2009) stated that brick kiln used low-quality coal seems to have high Cr concentration may be the cause of plant growth reduction, soil fertility loss, and some hazardous diseases of the human being. Some previous reports showed that evidence of reduced yields from orchards and crops due to air pollution is well-documented (Naqvi, 2004; Hossain and Shoaib, 2005). Dust deposition on leaves of plants (i.e., crops and orchards) hinders photosynthesis, which reduces productivity. The enormous impact of the dust emitted from the brick kilns hampered the watering plants and created spotted leaves on the vegetation. Zeiger and Taiz (2006) also observed that dust particles affected plant growth and crop production. The dust particles were usually generated from brick kilns, roadsides, construction sites, and other industrial areas. The extreme heat being released during the brick drying

process, severely affected the vegetation. Hossain et al., (2019) stated that brick kilns harm agricultural productivity and certainly affecting land potential.

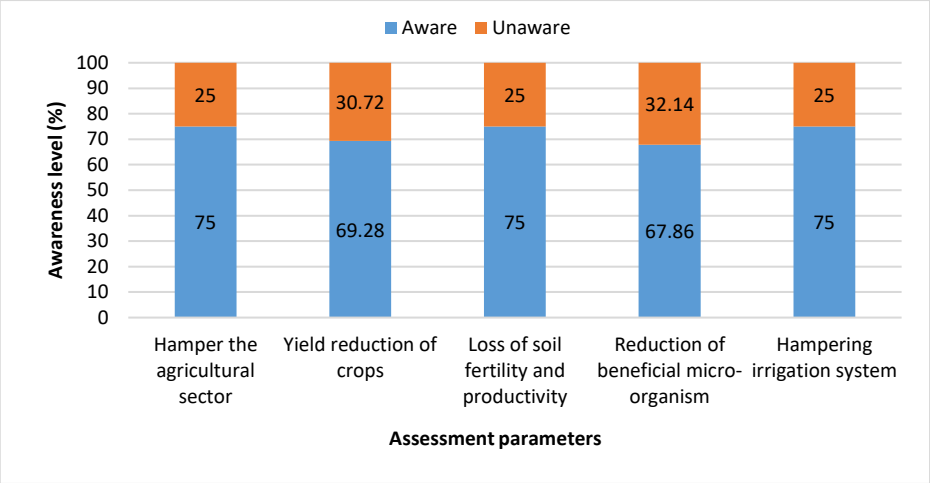

Fig. 3: Survey Responses to Awareness Level on Agricultural Degradation.

Table 4: Survey Responses to Vulnerability Level on Agricultural Degradation

Assessment parameters	Assessment on vulnerability level			
	High (%)	Medium (%)	Low (%)	No comments (%)
Hamper the agricultural sector	26.43	22.14	26.43	25.00
Yield reduction of crops	24.28	22.86	22.14	30.72
Loss of soil fertility and productivity	38.57	25.00	11.43	25.00
Reduction of beneficial micro-organism	27.00	24.00	16.86	32.14
Hampering irrigation system	35.71	28.57	10.72	25.00

The assessment of vulnerability level showed that the worsening condition of agricultural degradation issues i.e. the selected parameters was degraded due to the establishment of the brick kiln. Therefore, the awareness level of the respondents about agricultural degradation was good.

3.2.3. Sociological impact

The respondents in the study area were assumed to face various issues of social hazard in the surrounding brick kiln areas. Five assessment parameters were being considered to assess their extent of awareness and vulnerability. The results showed that the highest mean percentage of awareness and unawareness were 97.14 and 47.14 in the social system and child labor, respectively. The lowest mean percentage of awareness and unawareness was 52.86 and 2.86 in the child labor and social system impact, respectively (fig. 4). The results showed that most of the respondents were well aware of social system impact.

The survey results illustrated that the highest mean percentage of social system impacts on social conflict, social system impact, debt bondage labor, and gender discrimination of workers were about 94, 64, 32, and 32, respectively (Table 5). The lowest mean percentage of high vulnerability was 17.86 obtained in child labor and, the percentage of medium and low vulnerability were 1.43 and 0.71 in social conflict, respectively (Table 5). The survey revealed that the most vital problem was identified the complexity in social relationships. The social relationship between the kiln owners and community people was not always healthy, but sometimes they cruel to each other. The community people faced different types of problems like forcefully land grabbing, diseases, lower yields of crops, etc., due to brick kilns. The community people faced different types of problems like forcefully land grabbing, diseases, lower yields of crops, etc. due to brick kilns. Most of the community people believed that the major causes of their illness were heat, dust, and smoke emitted from the brick kilns.

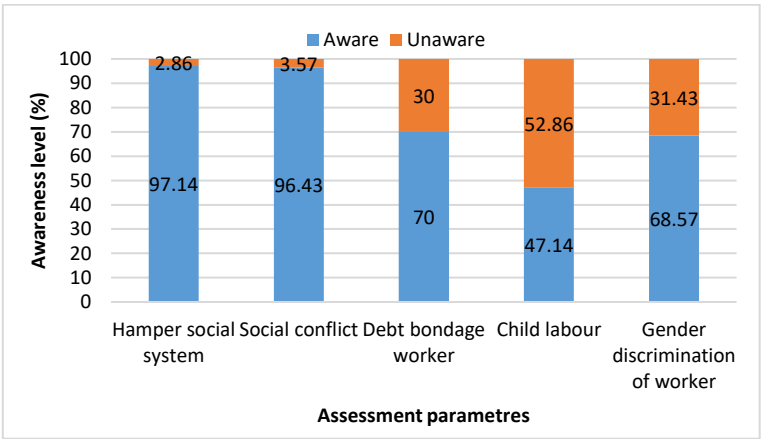

Fig. 4: Survey Responses to Awareness Level on Social System Impact.

The vegetation near the kiln areas was covered by a thick layer of brick dust that reduced the production due to continuous brick production over the years. The brick kiln could lead to cracks in the near croplands, loss of soil nutrients and thus caused reduced crop produc-

tion. As a result, the farmers are forced to sell their lands. Some of the brick kiln owners are also using their political influences for land buying to expand their kilns. Sometimes, the objection and the sufferings of the farmers are being neglected. A study report showed that the impacts of Joypurhat sugar mills in Bangladesh on the environment have deteriorated the relationship between sugar mill authorities and community peoples of nearby villages. Moreover, different social problems arise due to the discharge of sugar mill effluents (Rahim and Mostafa, 2021).

Table 5: Survey Responses to Vulnerability Level on Social System Impact

Assessment parameters	Assessment on vulnerability level			
	High (%)	Medium (%)	Low (%)	No comments (%)
Hamper social system	69.29	22.85	5.00	2.86
Social conflict	94.29	1.43	0.71	3.57
Debt bondage worker	32.14	16.43	21.43	30.00
Child labor	17.86	13.57	15.71	52.86
Gender discrimination of worker	30.00	21.43	17.14	31.43

A similar study reported that brick kilns of Palasbari Revenue Circle (Guwahati, Assam, India) were identified as a major contributor to environmental degradation and human rights violations due to the hazards created by these industries and other impacts on the land, air, and water. These industries adversely impacted on livelihoods of kiln areas threatens the two fundamental human rights (Mazumdar et al., 2018). The results indicated that social conflict being the major cause of hampered the social system at the kiln areas. The selected social parameters were hindered due to the establishment of a brick kiln. Hence, it can be stated that the respondents had sound knowledge about social system impact due to brick kiln emissions.

3.3. Environmental issues

There are some environmental issues raised in the brick kiln areas rather than the issues discussed above. The issues were the removal of topsoil, solid waste generation, deforestation, River grabbing, etc. These environmental issues are described in the following sections.

3.3.1. Removal of topsoil

The survey results observed that the brick kilns were mostly situated on fertile agricultural land. The topsoil of agricultural lands was used for the major brick-making raw materials and thus excavating of the topsoil indicating the loss of fertility of the lands. Hossain et al., (2019) reported that mostly fertile topsoil of agricultural land is exploited for making bricks. On average three (3) kilogram soil is required to make a brick. 150 billion kg soil is required to produce 50 billion bricks per annum in Bangladesh. Nusrat and Mahadev (1991) investigated that the loss of soil fertility due to the brick-making soil in Mysore in India. The brick manufacturers need good quality soils for brickmaking caused a change in the land use pattern. Local political power also plays a crucial role in the brick-making soil business. Thus a large amount of topsoil was removed leaving the fertile land turned into unfertile lands. Khan et al., (2007) reported that the loss of soil fertility occurred due to brick production in different regions of Bangladesh. The mineral nutrients like nitrogen, phosphorus, and potassium are considered the indicators of soil fertility being present at the top layer in the soils which is essentials for plant growth and crop yielding. However, it can be stated that the topsoil removal for brick making is the major cause of land degradation around the kiln areas. The survey results stated that the lands from where the topsoil has been removed became ditches and finally, it caused water-logging conditions in the entire area. These ditches are full of water and they became ideal breeding sites for different pests and mosquitoes during the rainy season. The excavated land can disrupt the entire irrigation system and the topography of the area as a whole. The land which was not excavated becomes higher in elevation and hence difficult to irrigate. It was observed that the brick kiln disrupted the entire buried pipe irrigation system at the irrigation command area of BMDA (Barind Multipurpose Development Authority) in Rajshahi meaning disruption in agricultural food production. Excavation takes place in the surrounding land, the remaining high land suddenly finds difficulties with the source of irrigation. Eventually, this process leads to the decision of the farmers to lease their lands. If the land is cultivated, the crop can be spoiled when it got by flood with swamped water. Consequently, the cultivation of the excavated lands can turn out riskier. In many cases, the crops are not being cultivated due to waterlogging problems. Mazumdar et al., (2018) reported that water logging is a serious problem around the brick kiln areas.

3.3.2. Solid waste generation

The survey results showed that the brick kiln produced different types of solid waste such as broken pieces of bricks, coal and wood residues, and so on. The coal ash and wooden trash also the source of solid waste in the brick kilns. Furthermore, over burnt and broken bricks also produce a substantial amount of waste. This excess amount of wastes gets dispersed throughout the neighboring areas by wind or by human activities. A study conducted by Das (2015) on brick kilns and stated that several negative impacts of the brick kiln were identified, among them, solid waste generation is one of the major pressing issues at Khejuri blocks, Medinipur, West Bengal in India. Hence, it plays a notorious role in the surroundings.

3.3.3. Deforestation

The survey revealed that the forest wood was used as a major fuel during brick production, especially in Rajshahi areas harms natural and social forestation. The wood is collected from different forests by violating environmental regulations. It led to the extinction of several local species such as palm and date trees, and unfortunately, the trend is still going on. The Indian date trees are mostly grown in Bangladesh and West Bengal (India) produced special kinds of juice and molasses. The delicious drink and molasses are not found elsewhere in the world. The owner of the brick kiln used to cut indigenous date trees get brick burning fuel. Morley (2012) showed that on average each kiln burns 350 tons of wood a year in Bangladesh, so more kilns mean having a devastating effect on the forests. This also poses threat to biodiversity. Moreover, the burning of wood causes emissions that take a heavy toll on the biodiversity in the surrounding areas. The wood-burning process in brick kilns produced huge toxic smoke and screwed throughout the environment, which lead to permanent damage to the surrounding biodiversity. The kiln owners are interested in using wood as fuel instead of coal and fossil fuels because woods are relatively cheap and easily affordable. The coal is usually imported from outside of the country, mainly from India and the kiln owners have to invest a big amount at the beginning of the production season. A report of FAO about the industrial wood consumption in Sudan-based brick kilns is the highest consumer, consuming about 51.5% of the total industrial wood consumption and according-

ly forest resources are being extensively exploited for this purpose (FAO, 2000). So, forest resource is being exposed to damage by brick kiln in Bangladesh.

3.3.4. Illegal river grabbing

The Barnai River flow located at the side of Madarigonj of Baghmara Upazilla in Rajshahi gets gradually obstructed by the brick kiln. There are about 4 brick kilns situated on the sides of the bridge of Barnai, connecting to the Mohonganj and Madarigonj. The owners of the brick kilns are constantly blocking the natural flow pattern of the river as they collected soil and water for various purposes of brick making leading to river erosion at different parts of the river. Thus, the brick kilns have a significant influence on the flowing path of Barnai Rivers in the study areas. The other rivers in the study areas such as Bongshai, Banar, and Shitalakhya River also were affected by the brick kiln operation. Khan and Vyas (2008) reported that the brick kiln wastes along with water flow back at the Kshipra River in Ujjain city, India. They also mentioned that brick kiln adversely degraded the river condition in many ways. However, it could be stated that another possible environmental threat may be a disturbance of the flow path of the natural stream due to the establishment of a brick kiln. Thus it can be concluded that the brick kilns present another threat by disrupting the natural flow of water bodies in the river.

3.3.5. Labors right violation

The survey results showed that bonded labors and child labors were forced to work at brick kilns due to the economic constraints of the poor people. The work is physically demanding and involves extraordinarily long hours without overtime or any protection from hazardous conditions. Saha et al., (2020b) observed that brick kiln emitted gases caused by huge hazards in the areas threatened the labors health. Most of the respondents thought that the sound quality of the study area was very hazardous for all living beings. The exposure time to stay at a high intensity of the noisy environment of brick kiln labors was also shocking (Saha et al., 2019). The study revealed that wage discrimination between male and their female counterparts and sexual abuse of female workers is prevalent in some brick kilns. Sometimes they have to work more than 15 to 18 hours a day to satisfy the owners of the kilns. According to some workers' spokesman, they suffer miserable working conditions and are forced to work under some kind of bond. Samra and Jilani (1997) reported that mainly bonded labors worked at the brick kilns in rural Sind and some parts of the Frontier province in Pakistan. Bonded Labor Research Forum conducted a study in 2004 on brick kiln workers in Pakistan and reported that about 70,000 bonded laborers are working in more than 5,000 brick kilns (NCABL, 2009).

4. Conclusions

The majority of the respondents have negative views about brick production that is going on at the expense of public health and the natural environment. Growing air and water pollution also led to harmful conditions because of the brick kiln. The study observed that 47.7% of respondents were in the medium awareness level category, and 16.9% were at a low awareness level on the environmental degradation nearby the brick kiln areas. It also observed that 60% of the farmers were illiterate. The study observed that the environmental degradation knowledge of the respondents had positive and significant relationships with their awareness of environmental degradation. The survey results revealed that about 66.43% of respondents were highly vulnerable to an asthmatic disease caused by the emission of pollutant gasses. The survey revealed that the most vital problem was identified the complexity in social relationships. The social relationship between the kiln owners and community people was not always healthy, but sometimes they cruel to each other. The community people faced different types of problems like forcefully land grabbing, diseases, lower yields of crops, etc., due to the brick kilns. The local inhabitants and farmers faced with difficulties associated with the brick kilns included decreased crop production, increased air, and water pollution, worsen soil erosion, and shrinking cattle grazing pasture. Hence, the publicity and awareness build-up programs for the farmers should be considered that would help to reduce the harmful effects of the brick kiln and minimize the extent of vulnerabilities faced by the inhabitants. Further study in this regard has to be conducted to get a closer view of the problems associated with brick kilns.

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