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Assessing the Current Situation and Economic Feasibility of Eco-Friendly Materials: Example from Thakurgaon, Bangladesh

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ABSTRACT

In contrast to traditional bricks, the study investigated the propensity of microentrepreneurs to use and conduct business with eco-friendly building products. Through key informant interviews and focus groups, we investigated the inclination to choose eco-friendly materials. A total of one hundred microentrepreneurs were surveyed, and eight key interviews and four group discussions were conducted in the research region. However, the data revealed that only a small percentage of microentrepreneurs have a basic awareness of pollution and environmental issues. A sizable fraction of the MEs were unable to successfully adopt waste management. Additionally, the survey found that a minimal percentage of MEs use environmentally friendly production and marketing techniques. For the production of traditionally fired bricks, dirt was the main ingredient in all brick kilns, which used firewood as fuel. They were not skilled enough to use fly ash as a raw material to make bricks and other building supplies. Furthermore, the participation rate of women in these enterprises was incredibly low, and their remuneration was extremely inadequate. Businesses should place a high priority on fostering a positive work environment for women and enacting fair wage laws that increase the pay of female employees. A sizable fraction of the microentrepreneurs (MEs) did not follow proper safety procedures and lacked training. Therefore, microbusiness owners should organize safety- and security-focused training for themselves as well as for employees.

INTRODUCTION

In the construction industry, “green” or sustainable construction is a nascent and swiftly growing area of research. Global initiatives, whether in Bangladesh or elsewhere, signify a new epoch in which sustainability-focused design may emerge as the principal aim in the constructed environment. The building industry recognizes the need to be more environmentally conscious and is working to reduce its negative environmental effects. The energy crisis of the 1970s prompted the contemporary environmentalization of the construction industry. These awful experiences have led to a significant push for conservation, energy efficiency, and alternate energy sources. The 2nd wave of water shortage problems in recent years prompted the development of a more water-conscious design. We have been compelled to reevaluate the use of landscape chemicals and eliminate toxins from our interior spaces Due to indoor air quality, sick building syndrome, and groundwater contamination. Water, steel, wood, aggregate, cement, and sand are among the materials used in construction. This building material is produced by nature or is derived directly from it. The construction sector consumes half of the world's non-fuel wood and half of its energy and materials. Building consumes one-third of freshwater resources (Roodman and Lenssen, 1995). Climate change has been seen as one of the major issues of the twenty-first century due to the release of greenhouse gases into the atmosphere, mostly carbon dioxide. India contributes to environmental degradation by emitting 0.90 tons of carbon dioxide for each ton of cement produced. The National Institute of Building Sciences reports that buildings in the United States contribute 35% of atmospheric carbon dioxide, 49% of Sulphur

dioxide, and 25% of nitrogen oxide emissions (Statista, 2023). Natural resource availability is being diminished by overexploitation, and prices are gradually rising. Non-toxic and unconventional materials can be used to reduce CO2 emissions and reliance on natural resources. With consideration for availability, price, and usefulness, this journal attempts to compile research on smart and green materials (Singh et al., 2017). However, the objective of this article is to assess the current situation of eco-friendly construction material production and its economic feasibility for marketing.

Aspects of Sustainable Construction

Sustainable construction involves using sustainable development concepts across the whole building life cycle, including waste management, raw material extraction, and the production of building materials. This extensive process seeks to maintain equilibrium between natural ecosystems and constructed settings by enabling appropriate human habitation, promoting economic fairness, and enhancing the overall quality of life (Omardin et al., 2015; Yilmaz and Bakis, 2015). Numerous construction projects in emerging nations are unsustainable. Projects, whether undertaken by international firms, non-governmental organizations (NGOs), or armed forces, are sometimes excessively vast for local people to manage, sustain, or culturally connect with.

Well-intentioned non-governmental organizations frequently fall short of their goals in developing nations. These failures have occurred in a number of contexts and circumstances, such as military operations in Afghanistan, water projects in America, and non-profit groups in Africa. These programs fail because they are not "socially sustainable", meaning that the intended audience does not support them, rather than because of the usual issues with money, schedule, or quality (Pococka et al., 2016). According to the UNWCED, "Humanity has the power to make development sustainable to ensure that it serves the needs of the present without compromising the ability of future generations to meet their own needs" (Bruntland, 1987). Edward Barbier recognized the social, economic, and environmental dimensions of sustainable economic development as early as 1987 (Barbier, 1987). To reconcile these three dimensions of sustainability, John Elkington proposed a "triple bottom line" that encompasses the responsibilities of social justice and environmental integrity alongside profit (Elkington, 1999). The contemporary notion of sustainable development encompasses the "triple bottom line" economic, environmental, and social dimensions. Sustainable construction is defined by Agenda 21 for Sustainable Construction in Developing Countries as "a holistic process aimed at restoring and maintaining harmony between the natural and built environments, as well as creating settlements that affirm human dignity and encourage economic equity" (Du Pleissis et al., 2002).

Factors including the unemployment rate, the ratio of women in the workforce, the percentage of the displaced population (Natsios, 1997), average trip duration, per capita violent crime rate, and health-adjusted life expectancy, the literacy rate (Slaper and Hall, 2011), and the rate of unemployment can all be used to measure the impact of sustainable development. The social and human sustainability issues need to be addressed in developing nations, even if these sustainability indicators are applicable worldwide. A three-year study conducted by the International Institute for Sustainable Development demonstrated that its programs improved community cohesion and institutions through participation, strengthened food security, elevated the status of marginalized groups, enhanced access to health and education, and developed local technical skills (Paas et al, 2012). One could consider these advantages to be trustworthy indicators of a sustainable society. The 17 ambitious SDGs include eradicating hunger, encouraging partnerships, minimizing disparities, maintaining excellent health, offering high-quality education, and improving infrastructure, which are all made possible by these benefits (UNSDGs, 2015). Furthermore, high-performance, green, intelligent, and energy-efficient buildings are frequently combined with automated control systems and sustainable architecture (Yilmaz & Bakis, 2015). However, the term "sustainable construction" is the most inclusive when talking about building challenges pertaining to social, economic, and environmental elements of communities (Kamruddin et al., 2020).

Country Context

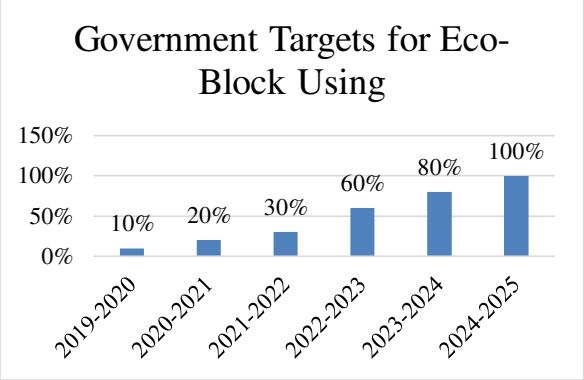
Currently, environmentally friendly building materials are used to create multistory structures in

Bangladesh. Most of these materials are resistant to earthquakes. According to experts, using these environmentally friendly building materials will reduce construction expenses and pollution. Experts also believe that if the government provides incentives, more individuals will be interested in starting enterprises in this sector. Over the last three years, the Housing and Building Research Institute (HBRI) has been developing sustainable construction materials. A new kind of portable and reasonably priced brick has been developed by HBRI. Bricks are made by combining cement and river mud.

Additionally, HBRI has developed distinctive materials for floors, walls, and roofs. According to the institute, the newly produced bricks would result in a halving of brick prices. The officials also claimed that the particular wall, which is made of the fiber of jute and cement, is sturdy and erosion-resistant. "Our engineers and architects designed the facility", stated the Director of HBRI (Staff Correspondent, Prothom Alo, 2017). This type of structure is 30% less expensive than traditional builds. The country produces an estimated 25 billion bricks a year. 60 million tonnes of topsoil are required to accommodate the demand. Approximately 3 million tons of wood and 5 million tons of coal are combusted to produce these bricks, resulting in the emission of 15 million tons of carbon dioxide into the atmosphere (Prothom Alo, 2017). By employing soil from river beds to produce these newly designed bricks, topsoil and the ecology will be preserved. The people will be invigorated to embrace this technology if more government agencies that are involved in the building come forward. The primary source of air pollution in the capital is the brick kilns. Brick kilns are responsible for 58% of the city's pollution, according to the environment agency, with dust and traffic accounting for the remaining portion. The administration has committed to reaching zero pollution by 2020 in the country's seventh five-year plan. However, the administration doesn't care about the deadline, according to Staff Correspondent of Prothom Alo (2017).

Government Initiatives for Eco-Block Production

The soil is the planet's most important component. This aspect allows us to live and move as we need to. Unfortunately, Earth's soil has been misused by more people than is necessary. The most unpleasant use pattern of excessive soil use is brick making, which uses the soil from cultivable land. The amount of land that may be farmed is therefore gradually decreasing. Pollution and ecological harm have been caused by the installation of conventional earthen brick producers and land utilization. As a result, the living spaces are becoming increasingly smaller each day. However, the Bangladeshi government has mostly acknowledged the detrimental consequences of excessive or improper soil use in traditional soil brick producers. Because of this, the government of Bangladesh has begun to use blocks in its buildings and offices. Reducing the amount of soil used in construction projects is the main objective of this notification.



Source: MOEF, 2023

In accordance with Section 5 (3a) of the Brick Making and Installation of Tiles Regulation Act, 2013 amended in 2019, it is essential to recognize that the objective of all government construction, repair, and restoration initiatives is to systematically eliminate the utilization of soil. This covers the building's walls and perimeter walls. According to a notice dated November 24, 2019, dollars must be used in place of bricks in Herring Bond Road and village road type B in compliance with the deadline and goals specified in subsection 2(99) of the above-stated Act (MOEF, 2023). This paper examines the current situation and economic feasibility of the eco-materials for construction in the study area.

METHODS

The paper assessed the current situation and economic feasibility of environmentally friendly construction materials compared to the traditional construction materials in the Thakurgaon district. This work was designed as a mixed-method study,

although qualitative data predominated in the interpretation. There is a high prevalence of brick kilns in the three upazila like Thakurgaon Sadar, Baliadangi, and Ranisankail under the Thakurgaon district of Bangladesh, which was chosen as the study area. A substantial number of individuals utilized blocks in their construction endeavors. Therefore, the researcher employed a purposive sampling method, calculating it based on the unknown population. The researcher surveyed a total of 100 microentrepreneurs who were producing blocks and also conducted 04 group discussions and 08 key interviews using purposive sampling to explore the field data. The interview schedule served as a research tool for collecting data from key interviews. Furthermore, data collecting was performed through a focus group discussion that resulted in the formulation of questionnaire recommendations.

RESULTS AND DISCUSSION

Categories of Businesses

Most business owners in the investigated area were owners of factories that produced rings, slabs, or pillars. The Ring, Slab, and Pillar facility has the largest percentage of businesses in the study region that manufacture green construction products, at 64 percent, according to the data collected. The least lucrative factory produced tiles, hollow blocks, and eco-bricks. Some businesses dealt in sand, cement, and rods, but they also made machinery. Supplying environmentally friendly building materials and increasing awareness of their use require the establishment of manufacturing facilities for hollow blocks and eco-bricks. Similar opinions were voiced by a ME of cement pillar and sanitary materials FGD, for instance, they predominantly produce sanitary ware and pillars, including items such as slabs, rings, toilet lids, and similar products. Along with other building materials, they started producing eco-bricks, tiles, stoves, ventilators, pillars, and sanitary supplies, added another FGD participant. Since these are used in almost every home in the study area. According to government officials, Micro Enterprises generally produce tallies, bamboo items, sanitary ware, tiles, flower pots, pipes, and pillars, in addition to sand, cement, and rods for commercial purposes.

Ownership and Labour Patterns Across Several Businesses

A single person owns 94% of enterprises, according to statistics from the field survey. While the remaining MEs were patriarchally owned, the bulk of these entrepreneurs obtained their ownership by self-purchasing. Only 6% are joint ventures. According to the statistics, the vast majority of factories that produce eco-friendly materials were found as individual proprietorships. According to the study's statistics, most of the workers in production places that make environmentally responsive building materials were men, suggesting that all of the production places had male employees. There weren't many women working for the enterprises. About 86 enterprises out of 100 did not have any female employees. Given the information above, females in this field do not currently have entrance to positive thinking, awareness, and job opportunities due to limited access and financial inability. Because they have not received all of the required training or instruction, the employees lack the competence to perform the activities associated with their jobs. Some MEs and their staff were given access to a limited number of training sessions, but not enough to meet their needs. Young made up the majority of the employees, as stated by a participant in the focus group discussion. Aside from that, the majority of the staff lack training; thus, not all of them had experience. The product quality is usually off since they approximate rather than use a precise procedure, as reported by the key informants.

Training, Growth Rate, and the Causes

A key element in improving one's skills in a given field is training. Enhancing one's capacity to carry out specific jobs accurately is essential. According to the statistics on their training status, the maximum portion of MEs had no training in their respective working field. Only 29% received training in a variety of expertise relevant to the inquiry's topic like using protection equipment during production, mixing process, operating the machine, and taking first aid. Most respondents to the survey claimed that their expansion was made possible by capital help and financial support from multiple sources. These aids, which are provided by banks including financial institutions and NGOs, are used to promote the growth of large businesses.

According to the study's findings, an entrepreneur who receives grants, and financial and technical assistance could significantly accelerate the rate of business promotion. According to data on the fastest growth rate, the most crucial element in promotion that fastened the growth rate was infrastructural assistance. However, the majority of MEs argued that the most important determinants affecting the maximum rate of business expansion in the research region were government assistance and services, skilled labor, raw materials, loans, aid, capital support, technological assistance, and infrastructure assistance. According to the study's findings, microenterprises (MEs) highlighted several viable directions for the business's future growth. These strategies involve ensuring competitive markets, growing value chains, and networking, increasing productivity, cultivating a competitive mentality, and creating a workforce with the required competencies. On the other hand, a focus group participant stated that the growth of sanitary products was high and people used these products on a daily basis, therefore government and NGO subsidies to business owners with low interest in helping enterprises to promote their business. According to a participant in KII, eco-bricks and hollow blocks are expanding daily, despite sanitary enterprises expanding rapidly. The businesses that produce eco-materials will be the most growth in demand in the near future since government action with legislation forbids the traditional coal and wood burning in brickyards, as expected by a participant of FGD sessions.

Impact of Business on Family Income

Income is the most important aspect of business since it is required for both the operation of the company and the subsistence of the MEs family. Micro enterprises operate businesses in a variety of categories, like producers and suppliers of eco-friendly building products, to generate and expand their profits. However, according to the data, the bulk of MEs (73 percent) earned below one lac each month. It is clear from the available data that the business owner uses the money their companies make to cover a variety of expenses. The majority of them can provide for their families' necessities, and they use the money they earn to buy homes, farm, and raise various crops. Nonetheless, most MEs believed that their businesses contributed to meeting the demands for sustenance by promoting land acquisition, domestic animal husbandry, farming, and agricultural production. Therefore, MEs played a crucial role in ensuring access to the resources needed to meet their wants as well as their basic needs. However, according to a FGD participant, making enough money from their building materials business to support my family is very important. Despite the presence of many owners managing distinct companies, this significantly affects the overall situation as the enterprise produces the majority of revenue reported by a KII participant.

According to the study, most MEs claimed to be informed about environmental contamination and Enterprise's environmental condition. Many of them believed that the main sources of environmental contamination were pollution from sound, air, and black smoke. However, some of the MEs thought that environmental contamination was caused by the occasional soil spill. Black smoke, natural calamities, atmospheric and auditory pollution, and inappropriate dirt handling are all factors that the MEs who were conscious of environmental contamination took into consideration. Almost every enterprise has a social safety and environmental safety system in place. Wearing face masks, maintaining physical distance, administering first aid, and properly disposing of garbage were the safety precautions adopted by the enterprises. However, a remarkably high proportion of enterprises followed safety procedures. Keeping the environment safe and suitable for all life on earth depends on effective waste management.

According to the studies, a significant portion of the world's population lacks information about waste management, which leads to them managing waste in their enterprises in an unsuitable manner. The number of enterprises that produced trash within their establishments is not negligible, albeit being quite low. The contaminants produced by the MEs in the study area differed, according to an analysis of the waste management techniques used by the MEs. A significant portion of MEs had adopted the proper disposal technique. Data on waste management practices showed that most MEs (74.7%) kept trash and waste in different places. Environmental constraints, including adverse meteorological conditions, natural calamities, insufficient disaster preparedness support, recurrent precipitation, and heightened scrutiny from

governmental environmental agencies, were found to present a wide range of ecological challenges to the MEs in the study area. Albeit with the abovementioned challenges, the majority of industrial processes are ecologically favorable. Environmentally harmful components were not used in the production of building materials at the micro-enterprise level. Therefore, there is less possibility to get contaminating the soil, air, or anything else by this kind of enterprise. According to KII participants, many MEs believed that the businesses were only partially to blame for the environmental harm brought on by black smoke, air, and sound pollution.

Input and Output Challenges

The majority of MEs had issues with carrying or transportation facilities; serious pricing issues; and service availability for high-class raw materials. To put it in perspective, the cost of transportation infrastructure is extremely high. The investigation's findings demonstrated that the MEs' input level problems were complex. The MEs faced numerous challenges related to the availability of raw resources for manufacturing. From marketing to manufacturing, MEs faced a variety of challenges. The study revealed that several MEs were grappling with significant challenges within their respective product markets. According to the findings, the biggest problems facing micro, small, and medium-sized businesses were transportation facility prices, poor product pricing, and exorbitant costs related to product promotion.

However, KII participants reported that the prices of manufactured goods were increasing more rapidly than those of raw materials. The inability to obtain certain raw materials locally results in elevated shipping expenses. Initially, the growth and development of environmentally friendly construction materials-producing enterprises in the study area were hindered by a lack of funds, a lack of experience, a shortage of skilled personnel, and limited access to financial institution loans. Moreover, the growth and development of MEs require a wide variety of different types of assistance. These support options include technical assistance and assistance with infrastructure construction, as well as financial assistance e.g., loans and credit. Many SMEs realized they required capital as their businesses grew. According to survey data collected in the research region, most of the MEs had less experience of problems at the credit market level. However, a KII participant stated that obtaining a bank loan is a difficult and time-consuming procedure. It might be difficult for a small business owner to meet their stringent production criteria when they initially start their businesses.

Future Requirements

The entrepreneurs set a number of goals for the expansion and administration of their enterprises. Supporting funding for future economic support, which could include grants, loans, or other financial aid, as well as funding for infrastructure construction, which could involve the opening of factories, businesses, or storage facilities. However, a relatively small percentage of participants had never required this kind of assistance. On the other hand, most MEs expected to help their employees improve human capital by providing training. The MEs urgently required assistance with economic development, infrastructure development, training, and environmental protection. The most important issue is the government's attitude and cooperation toward micro-enterprises that are producing construction materials. Government initiatives must highlight the importance and benefits of using these materials in building construction and development. The KII participants contended that the government ought to offer support and establish training facilities for the production of eco-construction products to aid MEs in extending and advancing their business in the future. The technical and financial assistance provided by large NGOs may have a major impact on the development and growth over time.

Government Moves Forward with EFB

Over the past few decades, brick kilns have proliferated all across the world in part due to the lack of any legally binding activities. This is not to argue that laws do not regulate the production of bricks. Because of its shortcomings, the 1989 Brick Burning (control) Act made it difficult to apply terms, and enforcement gaps for certain compliance concerns made matters worse. As a result, there was little opposition to the practice of building brick plants. The environment department estimated that there were around 6,500 brickfields over the country. According to environmentalists, this number might rise to 10,000, with half of them concentrated in and around the nation's capital. An

Asian Development Bank (ADB) estimate from a long time ago states that the nation produces 2271 crores of bricks a year (Mmojica, 2018). According to a World Bank report, brick kilns produce 98 lac tons of greenhouse gas emissions each year and consume 35 lac tons of coal and 19 lac tons of firewood (Eco-friendly brick making, 2021). One of the depressing facts, according to experts and environmentalists, is that brick fields are encroaching more and more on the nation's limited arable land. The heat, corrosive smoke, and dust generated by the brick manufacturing businesses are especially harmful because they are located near agricultural areas. According to the aforementioned regulation, brickmakers must adhere to a number of stringent standards. Due mostly to the demandable structure of the construction industry and a lack of regulation, this did not operate as it does now.

Laws enacted by the government many years ago regulate the production of bricks. The goal was to stop widespread environmental contamination while maintaining arable land and forests. To control brick production, a new law known as the Brick Making and Brickfield Establishment (control) Act of 2013 was passed. The Brick Burning (Control) Act of 1989 was superseded by a new law with more stringent rules in 1992 and 2001. The new law mandates trials for offenses is one of the stricter measures for brick manufacturing. The charges have already been heard by the environmental court. It seems that those who are breaching the law have so far escaped capture. Experts say the law covers all aspects of brick production in a fairly comprehensive way and specifies which areas shouldn't have brick factories. Although the law has been in place for some time, it is still blurred as to what specifically complicates to comply with. Except for the rare newspaper article about brick factories being demolished, there hasn't been any genuine effort to enforce the law thus far. Does the demand-driven component make leniency more appealing than enforcement? If so, the government must come up with alternative solutions.

In this context, it is noteworthy that the promotion of substitute bricks, in contrast to bricks of traditional kilns, is a commendable initiative to fulfill the demand for bricks. This corresponds with the government's aim to progressively diminish the production of traditional bricks. In several countries, clean bricks—termed green bricks—are utilized in construction as a more cost-effective substitute for kiln-baked bricks. Compressed earth blocks, made of cement and mud, were recently mentioned in a local newspaper as a possible alternative to bricks made in kilns. According to experts, using these bricks will save construction costs by about 25% to 30% in addition to being environmentally beneficial. The publication credits HBRI with starting the campaign by emphasizing the advantages of utilizing clean bricks. These bricks are made by combining cement and riverbed soil rather than cooking them in kilns, which lessens contamination as well as lessens harm to agriculture.

For some years, the HBRI has been creating alternative bricks, which are now being used by both public and private institutions. The fact that these bricks are pollution-free due to their production without the usage of soil or fuel is their most significant feature. With the advent of green technology, everything has changed. The alternative brick is likely to be used more often due to its improved technology and affordable pricing, and at the absolute least, it offers the possibility of producing ecologically friendly bricks. According to reports, the initial cost of the technology is significant. Given its effectiveness, affordability, high production capacity, and—most importantly—an emission-free system, the government should systematically eliminate outdated kilns and provide necessary support through long-term loans to encourage the adoption of green technologies. Additionally, adding a clause allowing the use of green bricks to the national building code can help promote the uptake of this cutting-edge technology.

EFB's Economic Feasibility

An economic study of a construction project aids in assessing equally technically competent construction solutions by establishing if the capital being used are viable for initial investment and ongoing maintenance costs. Many of the decisions made during a building project's planning, design, and construction phases are solely pecuniary in nature. Nevertheless, other factors including politics, society, the environment, and aesthetics are taken into account while making decisions. It is crucial to recognize that a building's design significantly affects its overall cost, operations, and maintenance costs, and future performance. To

facilitate decisions that influence the building's utilization, life cycle cost should be integrated from the initiative's inception. The degree of detail in this research will depend on the owner's desires and objectives; it may involve a careful examination of the concept of the building or the choice of possible construction procedures (Liliana Filipa, 2023).

According to a UNDP, firewood accounts for more than 33% of the fuel utilized in the nation's seasonal brick kilns. According to the BMOA, the nation is home to about 8,000 brick farms that produce bricks of various grades. More than 60% of the bricks manufactured in the nation each year are used by government departments such as Public Works, Local Government Engineering, and Roads & Highways. Users in the private sector use the remainder. According to BMOA, the brick production business employs about 20 lac people during the crowning season and 8 lac during the off-season. According to UNDP, the nation manufactures about 866 crore bricks annually, and over the past ten years, the industry has expanded at a rate of 5.3% annually. However, there is evidence to suggest that the nation generates about three times as many bricks each year. In Bangladesh, brick kilns constitute a substantial source of greenhouse gas emissions, generating six to nine million tons of CO2 each year. The use of antiquated methods and inferior fuels such as tires, high-sulfur coal, and wood, are the causes of these elevated emission levels. As additional brickfields are created each year, the problem worsens. Even with technology that has been demonstrated to produce superior bricks utilizing merely one-third of the fuel in comparison to traditional FCK or BTK, replacing old brick kilns with new ones in a timely manner is a challenging task. The installation of a zigzag kiln incurs an expense of approximately Tk 30 lac, which is double that of a fixed chimney brick kiln (excluding site costs and rental fees) The installation of a hybrid Hoffman kiln may incur expenses from Tk 80 to Tk 100 million if land costs are not taken into account (Iqbal, 2016). Because they are seasonal kilns, BTK, FCK, and Zigzag brick kilns may function in high and low places. The highlands are typically where brick kilns, Hoffman and Hybrid Hoffman, are constructed.

Moreover, UNDP began offering support with funding from the Global Environment Facilities initiative to enhance brick kiln technology in Bangladesh. According to this design, 7 Hybrid Hoffman Kilns are spread out throughout the nation and run all year long to create premium bricks with a significantly lower coal consumption. These initiatives encourage aspiring business owners to copy the environment brick kiln technology. The Chinese Xian Design Institute of Wall and Roof Materials helps to successfully implement the HHK technology. Green bricks are made by HHK using pulverized coal and clay, among other materials. When burning bricks, this technique can assist in lowering greenhouse gas emissions and fuel use. According to reports, the clay mixture and coal used to make green bricks provide more than 80% energy needed for bricks in HHKs. The uniquely constructed hybrid Hoffman Kiln receives its 20% residual coal from outside the fire chambers (Iqbal, 2016). The kiln's efficient air circulation ensures that nearly all the coal necessary for combustion and brick production is consumed within it. The method includes preheating mechanisms for the eco-bricks in the insulated dryer chambers, utilizing exhausts from the latest kiln fire directed into these chambers.

With its efficient drying and burning process, HHK can produce 100,000 high-quality bricks using just 13–14 tons of coal. Between 50,000 and 45,000 bricks might be produced each day by a single HHK device. Because an HHK can run all year round, it can therefore be utilized in place of 5-10 traditional FCK, BTK, or Zigzag kilns. The initial expenditure required by HHK, including the cost of the land, is between Tk 100 and 110 million. The HHK enables the business to acquire carbon credits from the global carbon market while burning 100,000 bricks, it uses 9–10 tons of coal less than FCKs or BTKs. An HHK can generate more than Tk 7 lac carbon credits a year by making 15 million bricks internally (Iqbal, 2016). In addition to the typical financial gains, making and selling bricks also helps to reduce carbon emissions. Financial viability is a prerequisite for implementing an environmentally friendly brick production initiative.

Quality Comparison

It was challenging to assess the quality of the bricks in the study area because there were no testing protocols in place. The need for testing to ensure product quality was unknown to the owners of each brick kiln in the study locations. The local brick kilns were emitting toxins in the environment,

but the owners of the kilns didn't care. The negative impacts of traditional brick kilns were unknown to them. Most of them thought that the environmental impact of conventional brick kilns was minimal. They were not bothered by the haphazard use of the surface of the soil as raw materials for production by the combustion of trees for fuel. Additionally, there were no testing facilities at the research locations because none of the brick kiln operators had implemented testing procedures for their products. If the brick was tested, the owners of the brick kiln thought they would lose business. Additionally, they prioritized commercial success over environmental conservation. However, after examining a few bricks, the following conclusions were reached:

Category	Block Size	Test Name	Results
Solid Block	(9.5x4.5x3) Inch	Compressive Strength (psi)	395psi
		Water Absorption (%)	10.45%
Hollow Block	(16x8x4.5) Inch	Compressive Strength (psi)	675psi
		Water Absorption (%)	11.54%
		Compressive Strength (psi)	405psi
		Water Absorption (%)	10.95%
Hollow Block	(400x200x113) mm	Compressive Strength (psi)	1850psi
		Water Absorption (%)	12%
Solid Block	(238x113x75) Inch	Compressive Strength (psi)	480psi
		Water Absorption (%)	10%

After testing, eco-brick was found to be more resilient to pressure than existing products. Additionally, eco-bricks like solid and hollow blocks absorb a lower amount of water than traditional blocks. For example, take the eco-brick, which is 238 by 113 by 75 inches and has a compressive strength of 1850 psi and a 12% water absorption capacity while burned brick has below 1000 psi (HBRI, 2022).

CONCLUSIONS

There have been severe safety issues in the building sector, which have had disastrous outcomes. A sustainable building industry must confront environmental issues head-on. Obtaining raw materials, access to production, marketing, packaging, and operational concerns are just a few of the difficulties faced by micro-entrepreneurs (MEs) in the paper sector. Their growth is influenced by marketing, supply, demand, and awareness. Because of government awareness efforts, consumer demand, availability, sales rate, and subsidies, makers of sanitary products are in great demand. Companies that produce environmentally friendly cooking stoves, tiles, and pillars are growing. MEs have safety precautions in place and are conscious of environmental pollution. Nonetheless, non-governmental organizations provide government support. Entrepreneurs borrow money or get loans from a variety of sources during pandemics or economic downturns, frequently running into problems with costs, carrying capacity, and transportation. Financial assistance with minimal service fees and training for owners and employees in the manufacturing of ecologically friendly building materials are the primary demands placed on MEs.

REFERENCES

Ahmed, Wasi. (2021). Eco-friendly brick making. *The Financial Express*, March 23, 2021,

Alam, M.M., Molla, R.I., and Hossain, M.M. (2010). Microentrepreneurship Development in Bangladesh: Achievements and Shortcomings, LAP Lambert Academic Publishing: Saarbrucken, Germany (1) (PDF) Microentrepreneurship Development in Bangladesh: Achievements and Shortcomings.

Al-Athel, S. A., Fadika, L. M., István, L., Shijun, M., De Botero, M. M., Singh, N., Noqueira-Nato, P., Ramphal, S., Ruckelshaus, W. D., Sahnoun, M., & Соколов, В. В. (1987). Report of the World Commission on Environment and Development: "Our Common Future." United Nations.

Barbier, E. B. (1987). The concept of sustainable economic development. *Environmental Conservation*, 14(2), 101–110.

Bora, Garima (2022). Women's Day: From construction to cosmetics, women entrepreneurs lead the way in sustainable business. *The Economic Times, Rise, Entrepreneurship*, March 07, 2022. Last retrieved on May 22, 2022.

Bruntland, G. (1987). *Report of the World Commission on Environment and Development: Our Common Future*, United Nations.

Business (2020). "Bangladesh: A Tough Place to Be a Woman Entrepreneur." *The Daily Star*, 24 Nov. 2020,

Business Finance for the Poor in Bangladesh (2017, February). *Diagnostics of Micro-enterprise Lending by MFIs in Bangladesh: Opportunities and Challenges*. Institute for Inclusive Finance and Development (InM) for the Business Finance for the Poor in Bangladesh (BFP-B) Project.

Du Plessis, C. (2002). Agenda 21 for Sustainable Construction in Developing Countries; CIB and UNEP by CSIR Building and Construction Technology: Pretoria, South Africa, 2002. (1) (PDF) Carbon Neutrality in the Building Sector of the Global South—A Review of Barriers and Transformations.

Eco-friendly brick making (2017). Ahmed, Wasi in The Financial Express (2017).

Elkington, J. (1999). Cannibals with forks: the triple bottom line of 21st century business. *Choice/Choice Reviews*, 36(07), 36–3997.

Iqbal, M. (2016). Financial feasibility of environment friendly brick manufacturing in the context of Bangladesh. BRAC University.

Jaafar et al., (2018) cited in Rauf, A., Shakir, S., Ncube, A., Abd-Ur-Rehman, H. M., Janjua, A. K., Khanum, S., & Khoja, A. H. (2022). Prospects towards sustainability: A comparative study to evaluate the environmental performance of brick making kilns in Pakistan. *Environmental Impact Assessment Review*, 94, 106746.

Jayachandran, S. (2021). *Microentrepreneurship in developing countries*. In Springer eBooks (pp. 1–31).

Kamaruddin, T., Hamid, R. A., & Ghani, S. (2020). Social aspect implementation in sustainable construction. IOP Conference Series. *Materials Science and Engineering*, 849(1), 012036.

Khan et al., (2019) cited in Rauf, A., Shakir, S., Ncube, A., Abd-Ur-Rehman, H. M., Janjua, A. K., Khanum, S., & Khoja, A. H. (2022). Prospects towards sustainability: A comparative study to evaluate the environmental performance of brick making kilns in Pakistan. *Environmental Impact Assessment Review*, 94, 106746.

Khan, L. M. S., & Omran, A. (2009). Sustainable development and construction industry in Malaysia. *Manager*, 10(1), 76–85.

Liliana Filipa Viana Soares (Retrieved on 2023). Economic Feasibility Analysis of Sustainable Construction Measures. Portugal SB10: Sustainable Building Affordable to All.

Marlow, S., Hart, M., Levie, J., & Shamsul, M. K. (2012). Women in enterprise: a different perspective. Gender and Entrepreneurship, Global Entrepreneurship Monitor UK.

Mmojica. (2018, November 29). Microenterprise Development Project: Report and recommendation of the President. Asian Development Bank.

Natsios, A. S. (1997). NGOs and the humanitarian impulse: some have it right. *Ethics & International Affairs*, 11, 133–136.

Nelson, Keistin (2021). Entrepreneur Report: Women committed to a sustainable Future. Means and Matters, From Bank of the West, Sustainable Business, Entrepreneurship. Last retrieved on May 23, 2022.

Omardin, M. A., Abidin, N. Z., & Ali, W. D. W. (2015). Concept of Environmental Sustainability Awareness Strategies in Pre-Construction Stage. *Journal of Tropical Resources and Sustainable Science/Journal of Tropical Resources and Sustainable Science*, 3(1), 103–116.

Paas L. (2012). A Three-Year Investigation into the Triple Bottom Line Performance of Small and Micro Social and Environmental Enterprises in Developing Countries (Canada: International Institute for Sustainable Development) (1) (PDF) Sustainability Design on Use of Biomass

Waste Gasification Technology for Small Industry of Palm Sugar in Sinarlaut Village.

Paas, L. et al. (2012). A Three-Year Investigation into the Triple Bottom Line Performance of Small and Micro Social and Environmental Enterprises in Developing Countries, Part 2: Case studies on the progress of nine winners of the SEED Award, SEED Initiative, *International Institute for Sustainable Development*, 2012.

Pocock, J. B., Steckler, C., & Hanzalova, B. (2016). Improving socially sustainable design and construction in developing countries. *Procedia Engineering*, 145, 288–295.

Rauf, A., Shakir, S., Ncube, A., Abd-Ur-Rehman, H. M., Janjua, A. K., Khanum, S., & Khoja, A. H. (2022). Prospects towards sustainability: A comparative study to evaluate the environmental performance of brick making kilns in Pakistan. *Environmental Impact Assessment Review*, 94, 106746.

Roodman, David Malin and Lenssen, Nicholas (1995). World Watch Paper #124: A Building Revolution: How Ecology and Health Concerns Are Transforming Construction, World Watch Institute,

Singh A, Atul P, Vikas S. (2017). Smart and Eco friendly construction materials. National Conferenceon Environment Friendly Materials & Technologies and Efficient Energy Consumption 3(1) :20-25 (1) (PDF) OSB (Oriented Strand Board Green Building): Utilization of OSB Betung Bamboo (Dendrocalamus asper (Schult. F.) Backer ex Heyne) by Testing Physical and Mechanical Properties to Optimize Eco-Friendly Construction in Indonesia.

Slaper, T. F., & Hall, T. J. (2011). The Triple Bottom Line: What Is It and How Does It Work? Indiana University Kelley School of Business, Indiana Business Research Center.

Staff Correspondent (2017, September 12). Bangladesh makes eco-friendly building materials. Prothom Alo.
https://en.prothomalo.com/bangladesh/Bangladesh-makes-eco-friendly-building-materials

Statista (2023). Carbon dioxide emissions from the manufacture of cement in India from 1960 to 2022.

Terry, M. E. (1999b). The economic and social significance of the handicraft industry in Botswana.

The Constructor (2021). What are construction materials are used in Construction?

The Financial Express (2019). Female entrepreneurship in Bangladesh. The Financial Express.

Women Micro Entrepreneurship in Bangladesh | Female Entrepreneurs Asia. (2016). Microentrepreneursasia.com. https://www.microentrepreneursasia.com/women-micro-merchants-in-mangladesh

Yılmaz, M. K., & Bakıs, A. (2015). Sustainability in construction sector. *Procedia: Social & Behavioral Sciences*, 195, 2253–2262.