International Journal of Occupational Safety and Ergonomics

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tose20

Do working and living conditions influence brick-kiln productivity? Evidence from Nepal

Sugat B. Bajracharya, Arabinda Mishra, Abid Hussain, Kamala Gurung, Luja Mathema & Bidya Banmali Pradhan

To cite this article: Sugat B. Bajracharya, Arabinda Mishra, Abid Hussain, Kamala Gurung, Luja Mathema & Bidya Banmali Pradhan (2021): Do working and living conditions influence brick-kiln productivity? Evidence from Nepal, International Journal of Occupational Safety and Ergonomics, DOI: 10.1080/10803548.2021.1899498

To link to this article: https://doi.org/10.1080/10803548.2021.1899498

Published online: 18 May 2021.

INTERNATIONAL JOURNAL OF OCCUPATIONAL SAFETY AND ERGONOMICS (JOSE)
https://doi.org/10.1080/10803548.2021.1899498

Do working and living conditions influence brick-kiln productivity? Evidence from Nepal

Sugat B. Bajracharya, Arabinda Mishra, Abid Hussain, Kamala Gurung, Luja Mathema and Bidya Banmali Pradhan

International Centre for Integrated Mountain Development (ICIMOD), Nepal

ABSTRACT

The brick-kiln (BK) sector in Nepal is largely an informal sector. This study investigated the influence of working and living conditions (WLCs) in BKs on productivity at two levels – BK level and workers' level – using primary data collected from 781 workers and 80 BK entrepreneurs in 12 districts of Nepal. WLCs were assessed based on the provision of nine amenities to workers at BKs. Correlation and regression analyses revealed that WLCs have a positive influence on both BK level as well as workers' level productivity. Moreover, large BKs with better investment in zig-zag technology and mechanization are more likely to spend on improving WLCs than small BKs, who are reluctant to invest in WLCs due mainly to a lack of financial resources. The study suggests an integrated approach emphasizing equally improved WLCs and cleaner technology in the BK sector to transform it into a healthier and socio-environmentally responsible industry.

KEYWORDS

working and living conditions; informal sector; brick-kiln workers; productivity; Nepal

1. Introduction

In Nepal, the brick-kiln (BK) sector remains an informal sector with very few government regulations in place, despite the rising importance of this sector in response to the growing population and the rapid urbanization rate [1]. Around one-fifth of the country's population is already living in urban areas, and this proportion is likely to increase sharply in coming years [2]. In urban areas, housing demand has driven up the demand for bricks as more and more housing constructions are underway [2]. A recent change in the governance system (establishment of several new municipalities) and the post-earthquake 2015 drive of 'build back better' are among the key factors that have further driven the demand for bricks in the country [3], leading to an increase in the number of BKs to an estimated 1294 operating in the country [4]. Around 1000 BKs were operating in Nepal with production capacities ranging from 15,000 to 50,000 bricks per day in 2016 [5].

There are several factors that may influence the productivity of BKs. However, in the context of Nepal, mechanization and technology advancement are considered the most important factors to improve the energy use efficiency and productivity of BKs [6]. BKs are seen as a major source of air pollution due to the use of coal that emits carbon dioxide (CO_2), black carbon and other harmful gases [7]. To address long-standing environmental concerns and improve energy use efficiency, BKs are gradually being shifted from relatively energy-intensive fixed chimney structures to more efficient and relatively cleaner technology 'zig-zag structure – vertical shaft and tunnel BKs' [8, p. 41].

A successful case in the Kathmandu Valley that shifted to a zig-zag structure has resulted in a 60% decrease in particulate matter, a 40–50% reduction in coal consumption and an increase in production of high-quality bricks (category A) accounting for 90% of total production [8]. The process of adoption of modern technology has been much slower [1], and requires more effort particularly to meet the targets set under the top 25 clean air measures outlined by the United Nations Environment Programme (UNEP) in the Asia and the Pacific region [8]. In addition to zig-zag technology, the rate of mechanization, particularly for brick moulding, also plays a vital role in BKs not only to improve productivity [6]. However, from our field observations, we find no robust evidence that mechanization has reduced the dependency on labourers in Nepal. One way or another, workers are required to mould, operate machines and transport the moulded/baked bricks.

In addition to cleaner technology, human well-being via addressing working and living conditions (WLCs) of workers is also vital in the BK sector. WLCs in BKs are not only important to promote socially responsible practices in the sector but can also contribute to the productivity of workers [9]. The BK sector with a combination of cleaner technology and improved WLCs can be transformed into a 'environmentally just and socially equitable industry' [10, p. 3]. A study of garment workers in Vietnam found that factories with better working conditions were up to 8% more productive and profitable than their counterparts [11]. A study from the construction industry in South Africa found linkages between working conditions and productivity on construction sites [12]. In BKs, WLCs are mostly overlooked and are not considered as a factor of productivity. The BK workers usually lack basic health and welfare services and social protection, and work in unhealthy and unsafe working environments [13]. For most of them, their homes and workplace are one and the same place. Some of the most prevalent problems faced by informal workers that are also relevant in the BK sector are poor lighting, lack of ventilation, excessive heat, poor housekeeping, inadequate workspace and working tools, lack of protective equipment, exposure to hazardous chemicals and dusts, and long hours of work [14].

CONTACT Sugat B. Bajracharya Sugat.Bajracharya@icimod.org

Moreover, the International Labour Organization (ILO) has categorized the construction industry, including brick-making, as dangerous and hazardous [13].

In addition, the poor WLCs are further worsened by the informality of the sector and lack of a regulatory framework [13]. In the case of Nepal, an Occupational Safety and Health (OSH) Directive for Brick Industry stipulates minimum WLCs in BKs such as drinking water access, temporary living shelters, rest areas, primary health care, toilet facilities and childcare centres [15]. However, these directives have not adequately been implemented in BKs by brick entrepreneurs. Typically, the BK owners do not give priority to investing in living and working conditions for workers at the kilns [2]. It is important to recognize that the workers play a major part in complementing technology and mechanization at BKs, and their well-being is equally important. In Nepal, over 300,000 workers are employed in the BK sector, who are mostly transient marginalized individuals [2]. These workers contribute to different stages of the brick production process as moulders, stackers, transporters, firepersons and coal persons [2].

In the existing literature on the BK sector, there is a dearth of good quality studies on the role of WLCs in improving workers' productivity. To the best of the researchers' knowledge, there is no such study that has so far been conducted in Nepal, despite a high importance of workers and working conditions in this informal sector. This study therefore attempts to investigate a link between WLCs and workers' productivity, using the primary data of two levels – BK level and workers' level. It is hoped that the findings of this study will not only significantly contribute to the existing literature on the BK sector, but will also provide policy directions to transform BKs into a socio-environmentally responsible sector.

2. Theoretical framework

WLCs are a broad term with multifactorial form. The ILO's working conditions laws report defines them as conditions with appropriate working hours, annual leave, maternity protection and minimum wages [16]. Robertson et al. [17] also emphasized the legal aspect – the compliance with national laws and international norms in addition to factors of working conditions. The Nepal OSH Directive for Brick Industry has its own definition for WLCs that are required to be ensured by the BK owner [15]. However, the informality of the sector and impracticality make the compliance to the laws difficult. This study adopted the grounded approach to define WLCs. This approach relied fully on field/ground facts (i.e., workers' perspective on the current situation and their needs, and researchers' observations) to identify factors to establish the criteria for WLCs (Table 1) rather than relying on existing literature. In this regard, before the main survey, rapid needs assessments (i.e., spending 6–8 h at each BK to interview different group of workers using non-structured checklists) were conducted at selected BKs to document the perspective of workers. Based on these assessments, a total of nine factors were identified that are key to determine WLCs at the BKs (Table 1).

'Labour productivity' has been defined as the rate of output per worker per day. In this study, the labour productivity is estimated at two levels – BK level and workers' level. BK level productivity is defined as the number of baked bricks produced by the BK in a season (from November to May). It takes into account all of the workers employed at the BK to estimate the productivity. For workers' level productivity, the study only focuses on 'brick moulders', and workers' productivity is defined as the number of raw bricks moulded by each moulder household per day. It is important to highlight that moulders alone do not mould bricks. Rather, their family members are also involved in the moulding work. Moulders, being the most important group of workers, constitute a major share of the total labour employed at BKs [2]. Their contribution to increasing the production of the bricks is most significant as they are the principal workers who are directly involved in making the raw bricks through the process of preparing and moulding the clay. They also tend to be the most vulnerable as they bring their families along in most cases. It has been observed that mostly women workers are involved in moulding bricks. Cognizant of these factors, this study only emphasizes moulders for workers' level productivity analysis, and has paid due attention to amenities related to women workers (i.e., provision of women's health services and child day-care) in the WLC assessment (Table 1).

Table 1. Working and living conditions.

Number	Amenities for working and living conditions
1	First-aid box provision
2	Health services access
3	Toilet facilities
4	Electricity at place of work
5	Provision of women's health services
6	Health insurance for workers
7	Child education or day-care centre at the kiln
8	Electricity at place of stay
9	Incentives provided by brick-kiln owners

Source: Rapid need assessments by International Centre for Integrated Mountain Development (ICIMOD) researchers.

Some studies indicate that WLCs positively influence the workers' productivity [9,12,14]. This study also hypothesizes that WLCs have an influence on workers' productivity. The theoretical framework of the study is based on the resource-based view (RBV), which states that an enterprise is a bundle of tangible and intangible assets and that intangible resources like human capital or workers are strategically important to a firm's success [18,19]. The fact that the workers or human capital are part of the assets is generally overlooked, and instead perceived as merely a cost rather than as a source of competitive advantage. The RBV approach has the capability to create competitive edge and superior financial performance for the firm that invests in training, development and welfare of its human resources [18,20]. The RBV also explains the differing capacities of the firms to face market challenges, particularly relating to the ability of small companies to use their social and personal capital to survive in the marketplace, as it largely dictates their willingness to invest [18]. Even if the firms are aware of the benefits of investing in WLCs, they may not be large enough or have the required time horizon to capture the expected benefits [17].

3. Methodology

3.1. Study area and sampling design

This primary study is mainly based on a survey design of research, and collected comprehensive primary data from selected BKs using a standardized data collection tool questionnaire. To administer the survey, the study targeted five provinces out of seven as the study areas as there were no reported kilns in province 6. In the provinces, BKs are mostly concentrated in the Terai (plain areas). In total, there were 958 BKs in Nepal distributed across five provinces as per data collected through the Federation of Nepal Brick Industries (FNBI) as of 2017. Among all, provinces 2, 3 and 5 have a higher number of BKs compared to the other provinces. In total, around 800 BKs are members of the FNBI, Nepal [21].

In the first step, a sample size of 80 BKs was determined using Cochran's method [22]. In the sample estimation, values of the estimate of variance (0.25), confidence level (95%) and margin of error (0.11) were used. In the second step, following the method of probability proportional to size (PPS), a sample of 80 BKs was distributed across six provinces (Table 2). In the next step, 12 study districts were selected purposively in consultation with the FNBI based on the density of BKs and repetitiveness of different types of BKs – labour intensive, mechanized and adopters of zig-zag technology [23]. Finally, sub-samples at province level were distributed across districts (within provinces), once again following the method of PPS. It is important to mention that only FNBI member BKs were selected for data collection in the districts because it was very difficult to obtain data from non-member BKs due to their owners' reluctance to interact with the external people such as researchers. Cognizant of this, it was decided to only consider FNBI member BKs to draw a sample size. In addition to BK level data from entrepreneur/owner BKs, it was also planned to target 7–10 workers in each BK to procure workers' level data. In this regard, a total of 781 workers were interviewed in 80 BKs.

3.2. Data collection

As already mentioned, a survey was carried out in 12 districts to collect primary data at two levels – BK level and workers' level (brick moulders). The data collection activities were carried out in February 2019 by enumerators from the field specialized organization Green Governance Nepal (GGN). Informed consent was acquired from both the workers as well as the BK owners prior to the start of the survey. At the BK level, data relating to production of bricks, estimated costs of operation, number of workers at different stages of the production process, technology used, transporting tools and mechanization were collected. At the workers' level, data were collected from only brick moulders because they were the key actors in the production process, constituting a large proportion of the total workforce at BKs. At the workers' level, data on WLCs, their socio-economic conditions, information on the number of bricks moulded by the family, remuneration per brick and the working schedule were collected. Survey data at both levels, BK and workers, were collected using standardized questionnaire tools that were structured, pre-tested before survey and adjusted to the local situation. To collect the aforementioned data, both quantitative (i.e., productivity, cost, working hours, etc.) and qualitative (i.e., single-response questions [yes/no] on the adoption of mechanization and zig-zag technology) questions were asked in the questionnaire. It is important to highlight that all nine amenities of WLCs identified in the rapid needs assessments (before survey) were further validated through list of questions in questionnaires at both BK and workers' levels.

In order to understand the opinion of other groups of workers (other than moulders) in relation to the WLCs at the kilns, one group discussion with 6–10 workers working in different stages (stacking, transporting and firing) of brick production was conducted at each surveyed BK using a non-structured checklist (open-ended questions). In addition, qualitative data pertaining to details of the workers' place of origin and OSH measures were also collected through discussions.

3.3. Data analysis tools

In the analysis, BKs are classified into three categories – small, medium and large – based on three different criteria: scale of production, total workforce and physical area of the BKs. This study has used both descriptive (i.e., percentage, score, frequency) and analytical (i.e., correlation analysis, regression model) statistics to analyse the quantitative data. To estimate the cumulative score of WLCs, the nine amenities (factors) presented in Table 1 were used. In data coding, a numeric value of 1 was assigned to BKs having a particular amenity, and 0 was assigned to those without that amenity. The following simple equation was used to estimate the cumulative score from coded data:

$$WLCs = \sum_{i=1}^{n} X_i, \tag{1}$$

where $WLCs$ = score of working and living conditions; $\sum_{i=1}^{n} X_i$ = summation from $i = 1$ to n (where $n = 9$ here).

The study used different measures of productivity for the BK level and the workers' level. The total number of bricks produced in a season at a BK was considered the productivity of that BK. However, the number of bricks moulded by the moulder's household per day was considered the worker's productivity (can also be interpreted as worker household's productivity).

To investigate the relationship of WLCs with productivity, the study used correlation analysis and the ordinary least squares (OLS) regression model. In the regression model, *WLCs* was considered the main independent variable. However, the study has not ignored some other important factors that can influence the productivity. At the BK level, in addition to *WLCs*, use of zig-zag technology (a zig-zag air flow technology that considerably improves combustion of fuel and heat transfer) and mechanization are considered the most important factors, and included as control variables in the regression model:

$$\ln P = \alpha + \beta_1 WLCs + \beta_2 \ln X2 + \beta_3 X_3 + \varepsilon, \tag{2}$$

where $\ln P$ = natural log of productivity (number of bricks produced in a season); α = intercept term in the model; β_1 = coefficient of variable $WLCs$;$WLCs$ = score of working and living conditions; β_2 = coefficient of variable $X2$;$X2$ = variable of mechanization (natural log); β_3 = coefficient of variable X_3; X_3 = variable (use of zig-zag technology); ε = error term in the model.

In the model, the average cost of machinery per day is taken as a proxy of mechanization.

At the workers' level, in addition to *WLCs*, the mechanization, household size and working hours are considered the most important factors, and are included in the regression model:

$$\ln Pw = \alpha + \beta_1 WLCs + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon, \tag{3}$$

where $\ln Pw$ = natural log of workers' productivity (number of bricks moulded by moulders' household in a day);

Table 2. Targeted brick-kilns in different provinces.

Province	Total number of BKs (N_i)	Proportion of total BKs ($P_i = N_i / 958$)	Number of sampled BKs (S_i) ($S_i = 80 \times P_i$)	Districts purposively selected by district associations
1	67	0.07	6	Sunsari, Morang
2	426	0.44	36	Bara, Parsa, Dhanusha and Mahottari
3	164	0.17	14	Dhading, Bhaktapur
4 and 5	233	0.24	18	Kapilbastu, Rupandehi and Banke
7	68	0.07	6	Kanchanpur
Total	958	1.00	80	–

Note: BK = brick-kilns.
Source: Province-wise total number of BKs acquired from the Federation of Nepal Brick Industries in 2017.

α = intercept term in the model; β_1 = coefficient of variable *WLCs*; *WLCs* = score of working and living conditions; β_2 = coefficient of variable X_2; X_2 = variable for mechanization; β_3 = coefficient of variable X_3; X_3 = variable for household size; β_4 = coefficient of variable X_4; X_4 = variable for working hours; ε = error term in the model.

4. Results

4.1. Key features of brick-kilns

The scale of BKs varies significantly in terms of their volume of production, workforce and operational area on which brick processing activities are carried out. Based on these three criteria, BKs were classified into three categories – small, medium and large (Table 3). In terms of volume of production, two-fifths of BKs were of medium size with production ranging from more than 2.9 million to 4.9 million bricks in a season. One-third of them were of small size with production of bricks up to 2.9 million per season. Only one-quarter of them were of large size with production of more than 4.9 million bricks per season (Table 3). In terms of workforce, around 60% of BKs were categorized as small, employing 150 or fewer workers in a season. One-quarter were of medium size, ranging from 151 to 250 workers, and only 16% of BKs were identified as large with more than 250 workers. In terms of operation area under brick production activities, around 40% of BKs were categorized as large (> 6.78 ha) and one-third were of medium size. Around one-quarter of them were classified as small (≤ 3.39 ha).

Descriptive statistics on amenities of WLCs reveal that workers at almost all BKs had access to some health services in nearby areas, and 60% of BKs also had a basic first aid box for immediate medical treatment of workers. Almost all BKs provided electricity to workers in their workplace to facilitate the workers who prefer to work in the evening or at night. Likewise, almost all BKs provided electricity to the living places of their workers (Table 3). More than 40% of BKs provided some monetary or non-monetary incentives (i.e., leave) for their work as a reward of their performance. Two-thirds of BKs provided toilet facilities for workers, which is a basic and extremely important facility. Very importantly, almost all BKs did not provide any health services for their women workers, and only one-fifth of them provided some child education and baby day-care services. One-tenth of BKs provided health and accidental insurance services for their workers (Table 3). An overall assessment of the WLCs level reveals that an overwhelming majority of BKs (71%) provided four to six amenities to their workers, and 16% of BKs only provided one to three amenities to their workers. Only a small proportion of BKs (13%) provided seven to nine amenities. This reveals that there is a lot of scope to improve WLCs in the BKs. In the surveyed BKs, 45% of them adopted zig-zag technology, and more than 80% had machinery for preparation of clay for moulding bricks (Table 3).

4.2. Relationship between WLCs and productivity

To investigate the relationship of WLCs with productivity, two types of analysis – correlation matrix and regression analysis – were conducted for both the BK level and the workers' level. Descriptive statistics of variables included in the analysis are presented in Table 4. Correlation analysis at the BK level reveal that WLCs have statistically significant positive correlation with BK productivity (Table 5). WLCs also have positive and statistically significant correlation (r = 0.32) with zig-zag technology, indicating that BKs with better WLCs are also likely to adopt zig-zag technology. Correlation analysis at the workers' level (Table 6) also reveal that WLCs have statistically significant positive correlation (r = 0.23) with workers' productivity. Other factors – mechanization in preparation of clay, working hours and moulders' household size – also showed statistically significant positive correlation with workers' productivity.

At the BK level, the results of the regression analysis reveal that WLCs have positive influence on BK productivity (Table 7). However, this influence is not found statistically significant. Despite this statistical non-significance, the positive relationship of WLCs with productivity is very meaningful. A recent study [24] has suggested that statistically non-significant variables in the model with positive or negative coefficients are still meaningful and should be interpreted like significant variables. Statistical non-significance may also appear because of the small number of observations (n = 69) considered in the regression analysis. The WLC coefficient value reveals that with an increase of workplace amenities by one, there will be an increase of 2% in BK productivity in a season.

At the workers' level, the results of the regression analysis reveal that WLCs have a statistically significant positive influence on workers' productivity (Table 7). The coefficient value of WLCs reveals that with an increase in amenities by one, there will be an increase by 3% in the number of moulded bricks per day by moulders (workers' productivity).

Overall, the regression results at both the BK level and the workers' level validate the general hypothesis that WLCs can contribute to the productivity of BKs, and they need to be considered seriously not only for economic gains (productivity) but also for transforming the BK sector into a socio-environmentally responsible sector.

Table 3. Key features of brick-kilns.

Indicator	Specification	Unit for specification	Frequency	%
Categories of brick-kilns by	Small ($\leq$ 2.9)	Million	27	34
production (number of bricks	Medium ($\geq$ 2.9 to $<$ 4.9)	bricks	32	40
produced per season)	Large ($>$ 4.9)		21	26
Categories of brick-kilns by	Small ($\leq$ 150)	Number	47	59
workforce (number of workers	Medium (151–250)	of workers	20	25
employed in a brick-kiln)	Large ($>$ 250)		13	16
Categories of brick-kilns	Small ($\leq$ 3.39)	Hectares*	22	28
Categories of brick-kilns	Medium ($\geq$ 3.39 to $<$ 6.78)		27	33
	Large ($>$ 6.78)		31	39
Brick-kilns with different	First-aid box	–	48	60
WLC amenities	Health services access	–	80	100
	Toilet facilities	–	52	65
	Electricity at place of work	–	76	95
	Provision of women's health services	–	2	2
	Health and accidental insurance for workers	–	9	11
	Child education or day-care centre	–	16	20
	Electricity at place of stay	–	77	96
	Incentives provided by brick-kiln owners	–	34	42
Categories of brick-kilns by	1–3	Number	13	16
range of WLC	4–6	of	57	71
amenities	7–9	amenities	10	13
Bick-kilns with zig-zag technology		–	36	45
Brick-kilns with machinery for preparing clay		–	69	86

*Local unit 'Bigha' is converted to hectares (1 bigha = 0.6779 ha).
Note: USD 1 = NPR 114.16 (Feb 6, 2020). WLCs = working and living conditions.
Source: Brick Kilns Survey (2019).

Table 4. Descriptive statistics of variables used in the regression models.

Variable	Type of variable	Specification	Mean	*SD*
Brick-kiln level				
Brick-kiln productivity	Dependent	Natural log of number of bricks produced in a year	15.07	0.45
Working and living conditions score	Independent	Summative score calculated based on nine variables (see Table 2)	4.92	1.36
Zig-zag technology	Control	Dummy variable: if a brick-kiln has adopted zig-zag technology = 1; if not = 0	0.45	0.50
Degree of mechanization	Control	Proxy variable: natural log of daily cost (NPR) of operating machinery	9.01	1.20
Workers' level				
Workers' productivity	Dependent	Natural log of number of green bricks moulded per day by the moulder household	7.26	0.53
Working and living conditions score	Independent	Summative score calculated based on nine variables (see Table 2)	4.73	1.57
Mechanization	Control	Dummy variable: if clay is prepared using machinery = 1; if clay prepared manually = 0	0.33	0.47
Working hours	Control	Number of hours worked in a day	10.20	3.20
Moulders' household size	Control	Number of members in the moulder household	1.90	0.96

Note: USD 1 = NPR 114.16 (Feb 6, 2020). NPR = Nepalese rupees.

4.3. Other factors influencing productivity of BKs

At the BK level, in addition to WLCs, adoption of zig-zag technology and mechanization also positively influence the productivity. The influence of zig-zag technology on BK productivity also showed strong statistical significance (Table 7). The coefficient values reveal that with the adoption of zig-zag technology, there will be a rise of 36% in BK productivity. Moreover, doubling the daily cost of machinery will result in an almost 7% rise in the BK productivity. At the workers' level, in addition to WLCs, mechanization, workers' (moulders) working hours and workers' (moulders) household size also positively influenced workers' productivity positively with strong statistical significance (Table 7). Coefficient values show that use of machinery for preparation of clay will result in an increase of 26% in the number of bricks moulded by moulders. Similarly, a 1 hour increase in working hours will result in a 2.23% increase in the number of moulded bricks. An increase in the moulders'

Table 5. Pearson correlation matrix: brick-kiln level.

Variable	Brick productivity	Zig-zag technology	*WLCs*	Degree of mechanization
Brick-kiln productivity	1	–	–	–
Zig-zag technology	0.5783*	1	–	–
WLCs	0.3193*	0.4601*	1	–
Degree of mechanization	0.4876*	0.4677*	0.1007	1

*$p < 0.05$.
Note: *WLCs* = working and living conditions score.

Table 6. Pearson correlation matrix: workers' level.

Variable	Workers' productivity	*WLCs*	Mechanization in preparation of clay	Working hours	Moulders' household size
Workers' productivity	1	–	–	–	–
WLCs	0.2296*	1	–	–	–
Mechanization in preparation of clay	0.3059*	0.1173*	1	–	–
Working hours	0.1722*	−0.0378	−0.019	1	–
Moulders' household size	0.711*	0.1843*	0.1082*	0.0664	1

*$p < 0.05$.
Note: WLCs = working and living conditions score.

Table 7. Relationship of working and living conditions to productivity in brick-kilns: results of regression models.

Variable	Coefficient	*SE*	*t*
Brick-kiln level			
Dependent variable: brick-kiln productivity (log)[a]			
Working and living conditions score	0.0213	0.0394	0.54
Zig-zag technology	0.368***	0.125	2.95
Degree of mechanization (log)	0.0758	0.0478	1.58
Constant	14.11***	0.476	29.65
Adjusted R^2	0.30	–	
Number of observations	69[b]	–	
Workers' level			
Dependent variable: workers' productivity (log)			
Working and living conditions score	0.0291***	0.008	3.63
Mechanization	0.257***	0.026	9.68
Working hours	0.0225***	0.003	5.84
Moulders' household size	0.367***	0.013	27.85
Constant	6.109***	0.060	104.56
Adjusted R^2	0.58	–	–
Number of observations	781	–	–

***$p < 0.001$.
[a]Natural log used for particular variable.
[b]Number of observations are less than the total surveyed brick-kilns because Stata 13.1 dropped 11 observations with missing values.

household size by one will result in a 37% increase in the number of moulded bricks.

The results have justified the inclusion of the aforementioned important factors in the regression analysis, and have highlighted the need for an adequate focus on all key factors of productivity in the BK sector.

4.4. Variation in productivity across size categories of BKs

At the BK level, WLCs and other key factors – the adoption of zigzag technology and degree of mechanization – had a statistically significant positive correlation with productivity (Table 5). The study further examined the variation in productivity, WLCs and other factors across size categories of BKs. It was quite expected that BK productivity would increase with increasing size of BKs (Table 8) because the size categorization criteria were established based on direct (number indicator of bricks produced in a season) or indirect (proxy) indicators (workforce and operational land area) of production volume. In simpler words, size categories can also be considered as a proxy for the volume of productivity at the BK level. However, it was interesting to examine the variation in WLCs, adoption of zig-zag technology and degree of mechanization across size categories. The results show that overall WLCs showed an improvement with the increasing size of BKs from small to large. Variation in WLCs across categories based on production volume showed that small and medium BKs have almost the same level of WLCs. However, in the case of large BKs, the level of WLCs showed a substantial improvement (Table

Table 8. Size of brick-kilns and associated factors.

Category of brick-kiln		% of brick-kilns with zig-zag technology	Degree of mechanization (average daily cost of operating machinery in NPR)	*WLCs*	Average brick production in a season (million)
Categories by production (number of bricks produced in a season)	Small ($\leq$ 2.9)	11.11	5651	4.74	2.167
	Medium ($\geq$ 2.9 to $<$ 4.9)	46.88	11,502	4.71	3.794
	Large ($>$ 4.9)	85.7	22,478	5.47	5.789
Categories by workforce (number of workers employed in a brick-kiln)	Small ($\leq$ 150)	23.4	8713	4.6	3.104
	Medium (151–250)	60	13,820	5.2	4.390
	Large ($>$ 250)	100	23,598	5.6	5.215
Categories of brick-kilns by operational area (hectares)	Small ($\leq$ 3.39)	18.2	6507	4.6	2.840
	Medium ($\geq$ 3.39 to $<$ 6.78)	33.3	12,977	4.9	3.267
	Large ($>$ 6.78)	74.2	16,102	5.4	4.864

Note: USD 1 = NPR 114.16 (February 6, 2020). NPR = Nepalese rupees; *WLCs* = working and living conditions score.
Source: Brick Kilns Survey (2019).

5). Similarly, WLCs showed a significant improvement with an increasing size of BKs based on workforce and operational land area. Adoption of zig-zag technology and the degree of mechanization also increased with increasing size of BKs in the case of all three criteria of categorization. Overall, the results reveal that productivity of BKs, WLCs, adoption of zig-zag technology and degree of mechanization improve with the size of BKs. This is a very encouraging finding because a combination of zig-zag technology (relatively cleaner option) with improved WLCs is key to transforming the BK sector into a socio-environmentally responsible sector.

5. Discussion

In Nepal, the importance of the BK sector is rising due to an increase in overall population, rapid urbanization and improved awareness of development planners on resilient building structure [2]. Recently, debates around the sector have increased because an improvement in efficiency and emission standards at BKs fall under the top 25 clean air measures outlined by the UNEP in the Asia and the Pacific region [8]. This sector has to improve its productivity with better WLCs for workers within BKs and reduced impacts on the environment in terms of emissions – CO_2, black carbon and other harmful gases. Cleaner productivity (with improved working conditions and reduced emissions) in the BK sector can contribute to national efforts towards achieving several Sustainable Development Goals (SDGs), i.e., SDG 3 (good health and well-being), SDG 5 (gender equality), SDG 8 (decent work and economic growth), SDG 12 (responsible consumption and production) and SDG 13 (climate action).

Around 45% of the surveyed BKs adopted a relatively cleaner technology – zig-zag structures (Table 3). BKs are seen as a major source of air pollution due to the excessive use of coal [7]. As a mitigation measure, a shift from a relatively energy-intensive fixed chimney kiln structure to a more efficient zig-zag structure – vertical shaft and tunnel kilns – mitigate the negative environmental impacts of the sector [8]. Findings also showed that more than 80% of BKs used machinery for preparation of clay for moulding bricks (Table 3).

However, technological innovations cannot achieve sustainable cleaner productivity in the long run if human well-being, through improving WLCs, is not paid due attention [25]. There is a gap in understanding the significance of the human factor in the production process in the BK sector. Findings revealed that only a small proportion of BKs had satisfactory level of WLCs with seven to nine amenities. Contrarily, an overwhelming majority of BKs provided one to six amenities for their workers. This implies that WLCs at BKs are not of a satisfactory level, and need to be improved particularly for provision of toilet facilities, childcare services, health insurance facility and women's health services. For instance, only one-tenth of BKs provided health insurance services for their workers. Almost all BKs did not provide any women's health services to the women workers. The provision of unsatisfactory WLCs in BKs is consistent with those found in other informal sectors in the Philippines, Nigeria, Senegal and Tanzania [14]. These conditions may pose risks to workers' health and the working efficiency of the workers [13], particularly when workers are not provided with adequate health insurance facilities. This study also found that only one-fifth of them provided some child education and baby day-care services (Table 3). WLCs without women's health services and childcare services cannot be considered gender friendly and sustainable in the long run when a significant proportion of workers are women. Moreover, these WLCs are well below the standards of working conditions defined by the Department of Labour and Occupational Safety in Nepal [15]. The informality of the sector and the lack of a regulatory framework are the possible reasons for unsatisfactory provision of WLCs at BKs [13].

Some evidence from the literature showed that a shift from a conventional structure to the cleaner zig-zag technology can significantly contribute to the productivity of BKs [8]. This may raise the share of high-quality bricks up to 90% in total production of bricks. Similarly, some studies [9,11,12,26] indicated that WLCs in the informal industry like BKs can contribute to workers' as well as overall industrial productivity. The correlation and regression analyses of this study also found that adoption of zig-zag technology, mechanization and WLCs have positive influence on BK level productivity (Tables 5 and 7). This implies that a combination of zig-zag technology with improved WLCs can play a vital role to transform the BK sector into a socio-environmentally responsible sector. Analysis at the workers' level also revealed that WLCs and mechanization significantly influence productivity of workers (moulders only) in the BKs. In addition, some other factors (working hours and household size of workers) also influence productivity positively (Tables 6 and 7).

The in-depth analysis also revealed that productivity of BKs, WLCs, adoption of zig-zag technology and degree of mechanization improve with the size of BKs. It seems that BK entrepreneurs with better investment and focus on cleaner technology like zig-zag stricture and mechanization are also investing in workplace amenities. From field discussions, the logic seems to be that both cleaner technology and usage of machines require skilled workers. By providing better workplace amenities, BK owners attract and retain skilled and more productive workers. This is more prevalent for large BK owners with better financial resources.

Overall, the discussions reach the point that an integrated approach with equal focus on both cleaner technology and improved WLCs is key to transforming the informal BKs sector in Nepal into a more socio-environmentally responsible and sustainably productive sector.

6. Conclusion

In Nepal, despite being an informal and labour-intensive sector, the importance of the BK sector is increasing due to a rising brick demand as a result of a growing population and a rapid urbanization rate. However, this sector is facing some critical questions on its inefficient energy use, substantial addition to air pollution and keeping risky working conditions for workers. BK entrepreneurs have gradually started to improve the WLCs, use machinery and adopt relatively cleaner and energy-efficient zig-zag technology at their BKs. This study primarily investigated the status of WLCs and their influence on productivity at workers' and BK levels. In addition, the study also analysed the influence of adoption of zig-zag technology and mechanization on BK productivity. The findings showed that nearly half of the surveyed BKs adopted the zig-zag technology, and four-fifths started using machinery for the brick preparation process. However, an overwhelming majority of BKs did not provide adequate workplace amenities for their workers. Most BKs did not provide essential services for women workers, i.e., women's health services and childcare facilities. Econometric analysis found that adoption of zig-zag technology, mechanization and WLCs have positive influence on overall BK productivity. Analysis at the workers' level also revealed that WLCs and mechanization significantly influence the productivity of workers (brick moulders) at the BKs. In-depth analysis revealed that productivity of BKs, WLCs, adoption of zig-zag technology and degree of mechanization improve with the size of BKs. This implies that BK entrepreneurs with better investment and a focus on cleaner technology like zig-zag structure and mechanization are also investing in workplace amenities.

Based on the findings, the study propose the following suggestions:

- There is an urgent need to create awareness among BK owners about the positive relationship of WLCs and cleaner technology with BK productivity. Currently, WLCs in particular are not considered as a contributor to productivity in Nepal and other countries in the region.
- There is a need to improve WLCs with more emphasis on small BKs. Special attention may be paid to amenities related to women workers, i.e., women's health services and childcare facilities. In this regard, an adequate awareness among BK owners and support by the Department of Labour and Occupational Safety in Nepal can play a very vital role. Small BKs can combine as a cluster and invest in workplace amenities. Overall, it can be adjudged that workplace amenities attract a productive and skilled workforce and are vital when using advanced cleaner technology and machinery. As a result of the workplace amenities being present, the BK owners are able to retain and hire a skilled workforce. Larger BKs are more inclined to invest in improving WLCs in addition to technology and mechanization. Small BKs need to be encouraged for this integrated approach.
- The government needs to have a proper institutional mechanism to observe and acknowledge the good practices (i.e., WLCs and cleaner technology) in BKs and encourage other BKs to follow by providing incentives in terms of technical support and subsidies on technology and machinery.

WLCs and cleaner technology can be emphasized equally through an integrated approach that is conducive to transform the informal BK sector into a more socio-environmentally responsible and sustainably productive sector. This will ultimately support national efforts to achieve multiple SDGs, i.e., SDG 3 (good health and well-being), SDG 5 (gender equality), SDG 8 (decent work and economic growth), SDG 12 (responsible consumption and production) and SDG 13 (climate action).

Acknowledgements

The authors are grateful for financial support from the Department of International Development (DFID). They acknowledge the continued support and feedback from colleagues in the Clean Brick Initiative and Atmosphere Initiative at the International Centre for Integrated Mountain Development during this study. They also thank Green Governance Nepal and associated colleagues for excellent field work for data collection.

Disclosure statement

No potential conflict of interest was reported by the authors.

Ethics approval

There is no institutional review board in Nepal to review and approve non-medical research with human subjects, but that research team have obtained consent for use of data from the workers and brick-kiln representatives, and other ethical standards have been upheld including: that no children were involved, that the work has not been published previously, and that this work does not reproduce any figure or table from previously published work.

Funding

The study received financial support from Department of International Development (DFID).

ORCID

Sugat B. Bajracharya http://orcid.org/0000-0002-7944-205X
Abid Hussain http://orcid.org/0000-0001-8703-4681

References

[1] MinErgy. Brick sector in Nepal national policy framework prepared by MinErgy in collaboration; Kathmandu: MinErgy; 2017 Aug. p. 1–42.

[cited 2018 May 15] Available from: http://www.ccacoalition.org/en/resources/brick-sector-nepal-national-policy-framework

[2] Sharma S, Gurung K, Mishra A, et al. Industry under the open sky: an exploration of the political economy of brickmaking in Nepal. Kathmandu: ICIMOD; 2019.

[3] Displacement Solutions. Lessons learned from post-earthquake policy in Nepal; Geneva: Displacement Solutions; 2019 Apr. [cited 2019 May 15] Available from: https://reliefweb.int/sites/reliefweb.int/files/resources/Nepal IDP and HLP Paper.pdf.

[4] Shrestha S, Thygerson SM. Brick kilns of Nepal: a non-governmental organization perspective. Open J Saf Sci Technol. 2019;9(1):1–6. doi:10.4236/ojsst.2019.91001

[5] Federation of Nepalese Chambers of Commerce and Industry (FNCCI). Factsheet: energy efficiency for brick industry [Internet]. Kathmandu: Energy Efficiency Centre in Federation of Nepalese Chambers of Commerce and Industry (Nepal); 2015 (cited 2018 May 15). Available from: http://eec-fncci.org/images/download/dGS03-brickfactsheet2017.pdf.

[6] Maskey-Manandhar U, Dangol SB. Study on evaluating energy conservation potential of brick production in SAARC countries. A report on Nepal. Kathmandu: MinErgy Nepal; 2013.

[7] SMS Environment and Engineering. Report on brick kiln stack emission monitoring in Kathmandu Valley. Kathmandu: Ministry of Population and Environment, Department of Environment (Nepal); 2017.

[8] United Nations Environment Program (Kenya). Air pollution in Asia and the Pacific: science-based solutions. Nairobi, Kenya: UNEP; 2018.

[9] Premchander S, Bloesch U, Tuladhar B, et al. External review of clean building technologies for Nepal VSBK-CESEF project 2008–2011. Evilard, Switzerland: Adansonia-Consulting; 2011.

[10] International Centre for Integrated Mountain Development (Nepal). Towards an environmentally just and socially equitable brick industry in South Asia: an overview of ICIMOD's interventions in the brick sector. Kathmandu: ICIMOD; 2019.

[11] International Labour Organization. Progress and potential: how better work is improving garment workers' lives and boosting factory competitiveness [Internet]; Geneva: International Labor Organization; 2016. [cited 2019 Jun 20] Available from: https://betterwork.org/blog/portfolio/impact-assessment/#1474553244648-438e0036-b404

[12] Abrey M, Smallwood JJ. The effects of unsatisfactory working conditions on productivity in the construction industry. Procedia Eng. 2014;85:3–9. doi:10.1016/j.proeng.2014.10.522

[13] Mitra D, Valette D. Brick by brick: unveiling the full picture of South Asia's brick kiln industry and building the blocks for change. Geneva: ILO; 2017.

[14] Forastieri V. Improvement of working conditions and environment in the informal sector through safety and health measures. Geneva: ILO; 1999.

[15] Department of Labor & Occupational Safety, Ministry of Labour, Employment & Social Security. OSH Directive for Brick Industry, 2074. Kathmandu, Nepal: Government of Nepal; 2017.

[16] Ghosheh N. Working conditions laws report 2012: a global review. Geneva: International Labour Office; 2013.

[17] Robertson R, Di H, Brown D, et al. Working conditions, work outcomes, and policy in Asian developing countries. Manila: Asian Development Bank; 2016.

[18] Croucher R, Stumbitz B, Vickers I, et al. Can better working conditions improve the performance of SMEs? Geneva: ILO; 2013.

[19] Wright PM, Dunford BB, Snell SA. Human resources and the resource based view of the firm. J Manage. 2001;27(6):701–721.

[20] De Saá-Pérez P, García-Falcón JM. A resource-based view of human resource management and organizational capabilities development. Int J Hum Resour Manag. 2002;13(1):123–140. doi:10.1080/09585190110092848

[21] Building brick kilns back better. The Kathmandu Post [Internet]; 2015 Sep 27 [cited 2020 Mar 4]. Available from: https://kathmandupost.com/valley/2015/09/27/building-brick-kilns-back-better

[22] Cochran WG. Sampling techniques. 3rd ed. New York: Wiley; 1977.

[23] Singh R. Brick kilns shifting to cleaner technology, but progress is slow. Down to earth [Internet]; 2017 Aug 28 [cited 2021 Feb 1]; News: [about 9 screens]. Available from: https://www.downtoearth.org.in/news/air/brick-kilns-shifting-to-cleaner-technology-but-progress-is-slow-58559.

[24] Amrhein V, Greenland S, Mcshane B. Retire statistical significance. Nature [Internet]. 2019;567(7748):305–307. Available from: https://www.nature.com/articles/d41586-019-00857-9 doi:10.1038/d41586-019-00857-9

[25] The role of human factors in the future of manufacturing. The Manufacturer [Internet]; 2016 Nov 27 [cited 2021 Feb 4]; Articles: [about 8 screens]. Available from: https://www.themanufacturer.com/articles/the-role-of-human-factors-in-the-future-of-manufacturing/.

[26] Bruhn M, Karlan D, Schoar A. What capital is missing in developing countries? Am Econ Rev [Internet]. 2010;100(2):629–633. Available from: https://www.aeaweb.org/articles?id = 10.1257/aer.100.2.629 doi:10.1257/aer.100.2.629