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SOLID WASTE RECYCLING: SUSTAINABILITY ISSUES IN DHAKA CITY

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ABSTRACT

The main objectives of this paper are to understand the nature of recyclable materials, the demand for these materials in the local market, business trends, and show how to maintain sustainable livelihoods in the context of Dhaka city – the capital of Bangladesh. This paper also emphasizes the contribution of the informal recycling sector to the national economy and provides some policy recommendations. Improper solid waste management in major cities such as Dhaka is harming human health and causing economic, environmental, and biological losses. The data used in this study is primary data through a face to face interview by using stratified random sampling survey carried out on 400 recyclers in Dhaka city between the months of September and November 2015. A pre-test was conducted on 30 petty recyclers in *Demra Thana* which was chosen because it is the site of government-approved landfill. Logistic regression model has been employed to determine the indicators of respondents probability of being poor regarding recycling. As expected, *age* was positive and highly significant at the 5% level,and *training program* and *items category* were also positive and significant at the 5% level. These results imply that if recyclers are to diversify their income sources by participating in non-scavenging activities, their probability of being poor will decrease. Training increases the skills of the scavengers, enhances their scavenging efficiency, and makes them more conscious of their health and the environment. The findings of this study imply that promoting organized and systematic waste management activities, planned, monitored, and supported waste-picking activities can be a viable option for reducing poverty among the urban poor.

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INRODUCTION

Dhaka, the capital city of Bangladesh, covers an area of 347 sq km and has more than 15 million inhabitants. It is one of the fastest-growing mega cities in the world.In Dhaka, solid waste generation amounts to 4624 ton/day (JICA, 2005), of which 1800 tons are collected and dumped by the Dhaka City Corporation (DCC). Improper solid waste management in major cities such as Dhaka is harming human health and causing economic, environmental, and biological losses (Moghadam et al., 2009) and presents the local authorities with a daunting task (Damghaniet al., 2008).

Scavengers (garbage collectors, junk chemical agents that neutralize or remove undesired substances, and habitual consumers of refuse) have different socio-economic and socio-demographic characteristics. Males, females, and children of all ages, poor migrants, and minorities are involved in the recovery of waste recyclables. Mobile purchasers – referred to in Dhaka as*pheriwalas*in local language –often purchase recyclable items from households and shops. Scavengers recover recyclable items directly from waste and sell these recyclables to junkshop dealers or contractors, which resell these to middlemen *(bhangari*) or recycling industries. Much of the recyclable material consists of paper, cardboard, scrap metal, plastics, PET bottles, dry breads, heels of shoes, and bones. The principal sources of solid wastes are residences, commercial establishments, institutions, and industrial and agricultural activities; domestic, commercial, and light industrial wastes are considered together as urban wastes.

Humans have been mass-producing solid waste since they first formed non-nomadic societies around 10,000 BC (Worrell and Vesilind2012).The health and environmental implications associated with Solid Waste Management (SWM) are mounting in urgency, particularly in the context of developing countries. While well-defined, engineered systems have been used to help SWM agencies in industrialized countries since the 1960s, collection and removal dominate the SWM sector in developing countries (Rachael and Khosrow, 2013).Several authors have highlighted the economic, political, and social conditions necessary for recycling success and have investigated the determining factors of households' participation in and attitudes towards recycling programs (Ball and Lawson, 1989; Martin et al., 2006; McDonald and Oates, 2003; Perrin and Barton, 2001; Tonglet et al., 2004).Solid waste recycling practices in Bangladesh are mainly dominated by the informal sector, and Afroze et al(2013)have shown that recycling income is playing an increasingly important role in the national economy of Bangladesh. Taking advantage of such linkages may improve the efficiency of the entire sector and create new opportunities for employment. In fact, the a fore mentioned studies also high lighted several reasons for developing the recycling sector and non-scavenging sector for middlemen who are dealing with recyclable items, as a means to reduce urban poverty. Non-scavenging employment, also referred to as recycling income,is generally recognized as having the potential to raise scavengers' household income, and therefore reduce urban poverty. There exist different types of petty recyclers that collect recyclable items from various locations – from households to the final dumping sites –and research has shown that the monthly income of these scavengers is between TK 3000 and TK 5000. In most developed countries, the origin of the recycling industry is to some extent related to the origin ofit has been shown that lower-income countries tend to lack the appropriate governance institutions and structures typically found in high-income (developed) countries, such as public policy research institutions, freedom of information laws, judicial autonomy, auditors general, and police academies (Bhuiyan, 2010), necessary to cope with the impacts of urbanization and increased solid waste generation.

Traditionally, the term "waste" has assumed a negative connotation, but it is a subjective concept – a label applied to something unwanted by the person discarding it (Dijkema et al., 2000; vande Klundert and Anschutz, 2001).The amount of solid waste generated in cities is much higher than in rural areas. Recycling is considered a key factor in reducing, re-using, and managing everyday generated wastes in a systematic manner.

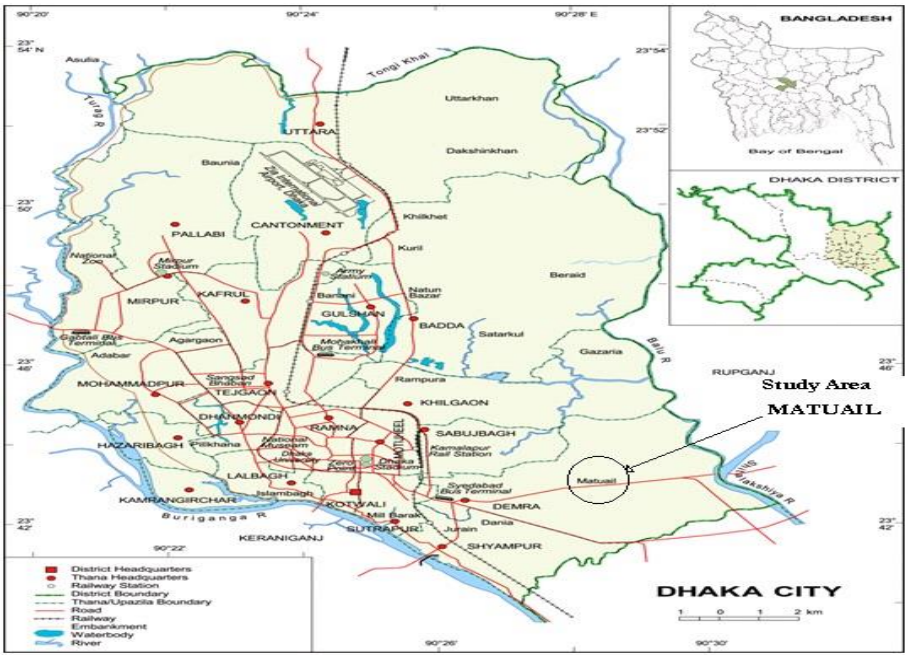
Recycling follows innovative, effective, and systematic processes for used materials that could be further utilized as the raw materials for producing new products, in order to prevent and reduce waste and decrease potential environmental risks. Nowadays, recycling is considered a key component of SWM. The objectives of this paper are to provide information on informal recyclers or scavengers, their socio-economic and socio-demographic characteristics and the benefits of their activities, and to identify their contribution to the national economy. More specifically, using primary data gathered from Dhaka, Bangladesh, this study aims to contribute to a better understanding of scavengers' waste collection by examining factors that affectthe SWM system and the alleviation of poverty.

DATA AND METHODOLOGY

A pre-test was conducted on 30 petty recyclers in Dhaka to uncover any misinterpretation of the questions and to identify the bid vector that should be used in the final study, which was carried out with a double bounded elicitation format. Three possible methods could have been used to conduct the survey: face-to-face interviews, telephone interviews, or mail (Yoo and Kwak, 2009). Telephone interviews was the least-preferred method in this study, because conveying complex information – particularly about hypothetical options –would be difficult over the telephone, partly because of the respondents' limited attention span and many having not used a phone due to financial constraints. Also, it is quite impractical to expect there would exist a telephone in all areas, and although some have a cell phone, many do not want to answer it. Mail surveys can be a risky data collection method to use, as they have an extremely low response rate and responses tend to be skewed with a bias toward one point of view (Yoo and Chae, 2001). Due to these issues, we chose to use face-to-face interviews for data collection. Previous studies have found that the quality of data obtained by this method is high and is the most complete, comprehensive, and meaningful (Yoo and Kwak, 2009). The survey response rate using this method was over 99%. Email and telephone data collection methods would not have been useful for this research because our respondents live in low-cost areasthat do have mobile access but no email. The data used in this study is primary data gathered through a survey carried out on 400 recyclers in Dhaka city between the months of September and November 2015. Face-to-face interviews were carried out with the respondents, who were selected through a stratified random sampling method. These petty recyclers are involved in unauthorized scavenging and resale of medical waste and many waste items like paper, tin, plastic, bottles, and bones. The respondents in our study are not "scavengers" as such but are petty recyclers whose income are greater than that of scavengers but below that of main recyclers – referred to in society as "businessmen".

The questionnaire used to gather the data contained three sections. The first section comprised some general questions regarding the respondents' daily recycling activities. The second section included questions about the knowledge and attitudes of respondents towards recycling and training programs organized by NGOs and government. The last part of the questionnaire collected socio-economic data on the respondents. The study area was the nearby Demra Thana of Dhaka city, which was chosen because it is the site of the sanitary landfill and has government-approved landfill, and these recyclers like to live near this area.Figure 1 shows a map of the study area.

FIGURE 1. MAP OF THE STUDY AREA (MATUAIL)



LOGISTIC REGRESSION MODEL

The logistic regression model (LRM) is a special form of the general log linear model and therefore has become increasingly important as a unifying framework for categorical data analysis. Logistic analysis provides an interpretable linear model for a categorical response and therefore offers a number of advantages over previous techniques such as log linear and linear probability. The "LOGIT" itself, from which the technique derives its name, is the natural logarithm of the odds or the "log odds". The odds indicate the relative probability of a variable of interest falling into one of two categories. The logit model describes the log of the odds ratio as a linear function of explanatory variables, and the slope coefficient gives the log of the odds ratio per unit change in the independent or explanatory variables.

The LRM is based on the cumulative logistic probability function and is specified as follows:

$$Pi = F(Zi) = F(\ + \beta\ Xi) = x = \frac{1}{1+e^{-zi}} = \frac{1}{1+\ e^{-(\propto+\beta Xi)}} \qquad (1)$$

In the above notation, e represents the base of logarithms, which is approximately equivalent to 2.718; Pi is the probability that an individual will make a certain choice, given knowledge of Xi; F is a cumulative probability function; and Zi is a theoretical index, which is determined by the set of explanatory variables Xi. The index

Zi is assumed to be a continuous variable, which is random and normally distributed for the usual econometric reasons. Thus, it can be written as:

$$Zi = \propto + \beta Xi \quad (2)$$

It can then be shown how the model specified in equation (1) can be estimated. In doing this, first, both sides of the equation have to be multiplied by $1+e^{-zi}$. The equation then takes the following form:

$$(1 + e^{Z}i)\ P\ I = 1 \quad (3)$$

Now, dividing both sides by Pi and then subtracting 1 leads to:

$$e^{-zi} = \frac{1}{Pi} - 1 = \frac{1-Pi}{Pi} \quad (4)$$

According to the definition, however, $e^{-zi} = 1/ e^{z} I$, so that:

$$e^{zi} = Pi/ 1- Pi \quad (5)$$

By taking the natural logarithm of both sides:

$$Z\ I = \log Pi/1-Pi \quad (6)$$

It can be written in the following form:

$$\text{Log } \frac{Pi}{1-Pi} = Zi = \alpha + \beta\ Xi \quad (7)$$

Where, the ratio Pi / (1- Pi) is known as the odds ratio, which is not only linear in Xi but also linear in the parameters from the estimation views. Moreover, in this case, the least squares estimation does not satisfy the condition 0<P i<1. Thus, the maximum likelihood method can be applied here as a suitable estimation technique. Accordingly, the next section discusses the maximum likelihood estimation technique of the LRM.

In this study, the LRM was selected as the evaluation method. It was assumed that the factors listed in Table 1 might affect the probability of scavengers being petty recyclers; thus, these factors were included in the model as independent variables. The model of the probability of being poor, $P(Y_i = 1)$, was represented as:

$$\text{Log } [P/(1 - P)] = \beta 1 + \beta 2X2 + \beta 3X3 \ldots + \beta kXk + \varepsilon \quad (8)$$

$$\text{Log } [P/(1 - P)] = \beta 1 + \beta 2\textit{Training} + \beta 3\textit{Education} + \beta 4\textit{Age of respondent} + \beta 5\textit{Working hours} + \beta 6\textit{Collection of recyclable items} \quad (9)$$

Where, *P* is the probability of the respondent being a petty recycler and the *X*s are explanatory variables hypothesized to influence the probability of recycling; βs are the coefficients of the explanatory variables; and ε represents the stochastic disturbance term. In the empirical exercise that follows, we only distinguish between who is a poor recycler and who is a non-poor recycler. Recycling is a relatively new idea in Bangladesh and respondents could not be expected to quantify the waste they recycled in a given time period. The dependent variable in the equation is dichotomous and measures whether the respondent recycles (value = 1) or not (value = 0).The study employed a binary choice

model based on the maximum likelihood method. Dummy dependence variables of 0 and 1 were used. The value of 1 is assigned to an informal poor recycler, and the value of 0 is assigned to a non-poor recycler. The independent variables used in the logit analysis and their expected signs are given in Table 1. It is worth noting that the sign of the estimated parameter is already sufficient to conclude whether the independent variable has a positive or negative impact on the dependent variable (Wooldridge, 2002). In addition, the impact of the independent variables on the dependent variable could be examined by looking at the odds ratio. Furthermore, given the value of the independent variables, the estimated value for the dependent variable could be interpreted as the probability of the scavenger being an informal poor recycler (Greene, 2000; Long dan Freese, 2006; Maddala, 1983)

TABLE 1. DESCRIPTION OF VARIABLES AND EXPECTED SIGN

Variable	Definition	Expected Sign
Dependent Variable		
Petty recyclers	Binary Yes=1 , No=0	
Independent Variable		
Training	(Continuous) (Continuous) To increase skill	+
Education	(Continuous) Level of education of the respondent	+
Age of respondent	(Dummy) Yes=1 No=0(more than 3 persons)	+
Working hours	(Continuous) working hours per day 1=3 hours 2=5 hours 3=8 hours	– +
Category of item	(Continuous) Types of collected items	+

RESULTS AND DISCUSSIONS

Table 2 shows the socio-economic characteristics of the respondents. The study found that 42.31% of the respondents had an average age of 31-35, with the youngest among them being 16-20 years (3.5%) and the medium age being 26-30 (34.27%). The coefficient of age shows a consistent, positive relationship with the probability of being a

poor (petty) recycler (Table 3). These results may be interpreted as follows: the younger respondents – i.e. those below 20 years of age – have not yet accepted the need to scavenge; while the older respondents (above 40 years of age) belong to a generation which has realized the need to scavenge.

TABLE 2. DESCRIPTIVE STATISTICS OF SOCIO-ECONOMIC CHARACTERISTICS OF THE RESPONDENTS

Item	Number of Respondents	Percentage
1. Training		
With training facility	160	40%
Without training facility	240	60%
2. Education		
No formal education	261	65%
Primary education	139	35%
3. Age (years)	Age range	
Young age (years)	16-20	3.5%
Upper young age (years)	21-25	18.18%
Medium age (years)	26-30	34.27%
Elder age	31-35	42.31%
4. Working hours (per day)	Number of respondents	
3 hours	108	27%
5 hours	173	43%
8 hours	118	30%
5. Collection of recyclable items		
Collection and sell	216	46%
No collection	184	54%

Four hundred respondents (questionnaires) were analysed in this study. Table 3 reports the results of the estimated LRM. The results of the logit model show that the variable *education* has a positive but insignificant impact on the probability of the recyclers being poor. *Working hours* has an in significant impact on the probability of the recyclers being poor at the 1% level of significance. The results also support previous findings that training and organizing informal recyclers into micro and small enterprises (MSEs) is a very effective way to upgrade their ability to add value to collected materials (Haan et al., 1998).

TABLE 3: RESULTS FROM THE LRM

Variables	Coefficient B	Standard Error	Significance	Exp(B)
Age of respondent	.515	.249	.038***	.597
Training program	.746	.122	.000***	2.109
Education level	.155	.140	.267	1.168
Items category	.143	.070	.053***	1.153
Working hours	-.130	.233	.576	.878
Constant	-4.068	.864	.000	.017

Significant at $p \leq 0.05$.***Significant at $p \leq 0.01$

As expected, *age* was positive and highly significant at the 5% level, and *training program* and *items category* were also positive and significant at the 5% level. These results support the hypothesis that the probability of the recyclers earning an income increases with recyclable item and training. As expected, the coefficient of *education* is positive, as normally the people who have undertaken training and education are more knowledgeable and skilled about their work and attempt to take appropriate methods to improve their living environment and process of work. The relationship between *education* and recycling is ambiguous. Saphores et al. (2006) found that higher education increases people's willingness to recycle, but several other studies reported that education has no significant effect on recycling behavior (Vining and Ebreo, 1990; Oskamp et al., 1991; Gamba and Oskamp, 1994; Meneses and Palacio, 2005). *Training* is significant at the 1% level;*working hours* was not statistically significant. Finally, the results show a consistent, positive relationship between age and the probability that a recycler is poor. This study found that the coefficient of *age* is positive, which means the respondent is more likely to undertake recycling activities as they get older. Studies in Holland, Germany, and Norway have indicated that older respondents are more devoted to recycling (cited in Fenech, 2002; Martin et al., 2006). Barr and Gilg (2005), Barr et al.(2001), Guerin et al.(2001), and Jenkins et al.(2000) reported similar findings. Blaine et al.(2001) and Fenech (2002), on the other hand, suggested that older people recycle simply because they have more time on their hands; after all, recycling is a time-intensive activity (Martin et al., 2006; Bruvoll et al., 2002). However, other studies failed to find a similar link between age and recycling (Schultz et al., 1995).The results of this estimated model were satisfactory and the predictions of the logit model were fairly accurate (67%).

Lastly, it was found that *training* playsa major role in non-scavenging recycling (β=.746) compared with the other two factors (β=.109 and β=.006). Therefore, the most effective method for increasing non-scavenging income (or recycling income) is by increasing ***n*** training programs among the scavengers. The results of this study show that education and recycle able item have an insignificant impact on the probability that a recycler is poor.

Some scholars have identified factors influencing the elements of waste management systems. According to Sujauddin et al. (2008), the generation of waste is influenced by family size, education level, and monthly income. Gender, peer influence, land size, location of household, and membership of environmental organizations explain household waste utilization and separation behavior (Ekere et al., 2009). These results

imply that if recyclers are to diversify their income sources by participating in non-scavenging activities, their probability of being poor will decrease. However, if they scavenge properly and in an organized way, they will be able to combat their poverty and contribute to the national economy. The results also show that if scavengers take part in training programs organized by the government and NGOs, they obtain knowledge about how to carry out scavenging and recycling activities properly so can reduce their level of poverty. Training increases the skills of the scavengers, enhances their scavenging efficiency, and makes them more conscious of their health and the environment.

POLICY IMPLICATION AND CONCLUSION

Through the use of a case study on the urban poor, specifically the waste pickers in Dhaka, Bangladesh, this research shows that training, and collection of recyclable items are the significant factors that determine the likelihood of a petty recycler's poverty status. Hence, the study's findings suggest that participation by the petty recyclers in non-waste-picking activities does not necessarily reduce their likelihood of being poor. The findings of this study support the view that planned, monitored, and supported waste-picking activities can be a viable option for reducing poverty among the urban poor. Organizing and training informal recyclers in Municipal Solid Waste Enterprises (MSWE) is a very effective way to upgrade their abilities and add value to the materials collected.

The involvement of the private sector in delivering Municipal Solid Waste Management (MSWM) services is a major theme in current efforts to improve MSWM in developing economies (Cointreau et al., 2000; GTZ et al., 2004; Wilson et al., 2001). If recyclers are skilled, they will earn more than unskilled personnel. Currently, NGOs are the main organizers of training for these petty recyclers; hence, the government should also take initiatives to organize training programs for the scavengers and petty recyclers in order to help alleviate their poverty.

For most developing countries, poverty alleviation is one of the government's main goals. For this to be successful, training in personal hygiene is necessary, as most waste collectors are unaware of the consequences of garbage sorting without adopting safety guidelines. Moreover, attention should be paid to improving the living conditions of the waste collectors. The observed increase in the share of non-scavenging income as a part of total income, as found in most studies, has led to the argument that the non-scavenging sector could play an important role in alleviating poverty. Some studies found a positive relationship between income level and recycling involvement (Vining and Ebreo, 1990; Oskamp et al., 1991; Gamba and Oskamp, 1994). This study provides evidence from a case study amongst urban poor, especially petty recyclers, in Dhaka, Bangladesh. The findings of this study therefore lend support to the view that a planned, monitored, and supportive recycling sector can be a viable means to reduce poverty among the urban poor households. Additionally, our results suggest that the economic structure of the local area where the scavengers live also has an influence on poverty. Many countries support waste pickers and recyclable businesses and recognize this as a formal sector, acknowledging their contribution to the national economy. The Bangladesh Government also needs to support this recyclable business sector and its activities. A significant number of people are involved in the recycling sector, from waste collection

to producing the end products. There are different stages where people are contributing financially at the national level, and it is well known that areas which have relatively higher industrial activities tend to have a lower likelihood of being poor. Thus, opening up opportunities for scavengers to participate in non-scavenging employment, through development of urban industrialization for instance, will have a positive impact on poverty reduction efforts among the urban poor households. Forming recyclers' cooperatives and associations can also enhance their position. The informal market sector is already indirectly contributing to the national economy by creating job opportunities and ensuring business investments from their own initiatives. The re-use of recycled materials has great potential to not only clean the city but provide a form of income for petty recyclers. However, the sector is not getting any kind of cooperation from the government or others. The time has come to change mindsets and take the necessary actions for promoting this sector's activities. The government has to take the lead role in this regard, which would simultaneously attract other stakeholders to contribute in the sector. The recycling of solid waste has not been included in the waste management policy of local authorities, despite it becoming a main source of income for several groups within the private sector.

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