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Review

Environmental concern and its implication to household waste separation and disposal: Evidence from Mekelle, Ethiopia

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ABSTRACT

Proper understanding of the relationship among concern for the environment, waste separation and disposal can contribute to good waste management and safer environment. This is particularly vital in cities of developing countries (such as Ethiopia) where waste separation is poor and there is widespread illegal dumping, with dire consequences for the environment. In this study, household data are collected in the city of Mekelle in order to identify and analyze the relationship among concern for the environment, waste separation and disposal into communal waste containers. Bivariate probit and Heckman probit selection models are used as tools of analysis. Relevant covariates such as demographic features, waste attributes and environmental attitude are used to get an insight to environmental concern, waste separation and disposal behavior. Results show that the volume of waste generated, NIMBY and NIABY attitudes of households, municipal regulation over the proper use of waste containers and container distance from dwelling houses are positively associated with concern for the environment. Education level of household head, container access, shorter distance to waste containers and household income are found to increase the probability of disposal into containers. In another instance, results indicate that waste separation is positively related with recycling practice, longer container distance, family size and waste attitude. Findings and implications from the relationships can be used to influence and strengthen pro-environment household attitudes and better practices in waste separation and appropriate disposal.

Contents

1. Introduction

Although the volume of waste generated in developing countries does not exceed that of the developed world, institutional and technical management of wastes is traditional and poor (Cointreau, 1982; Charuvichaipong and Sajor, 2006; Manga et al., 2008). The poor techniques of waste management are particularly affecting the immediate environment and wellbeing of city households in developing countries. City households in developing countries rarely

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practice the hierarchical activities of waste management – waste reduction, source separation, reuse and recycling and appropriate disposal. Household waste separation at source is perhaps among the best ways for appropriate waste management and thereby avoid environmental and health hazards. The concern that households have for the environment (while separating, disposing and burning wastes) can also be a factor in the success for good waste management. One common method that city households in developing countries use to get rid of their wastes is dumping in unauthorized areas (Tadesse et al., 2008). Uncontrolled waste disposal by households in cities of developing countries not only harms the environment but it also inflicts health damages and disamenities, such as bad smell and non-clean landscape (Cointreau, 1982; Qdais, 1997; Al-Yaqout et al., 2002; Tadesse et al., 2008).

Some ways to curb this problem are promoting concern for the environment, controlling wastes at source such as waste separation and appropriate disposal. In this regard, different studies have examined the pattern of the effects of various factors and their predictive power on households' environmental attitudes and behaviors. In waste recycling studies, researchers indicate that younger age (Dunlap and Van Liere, 1978), higher educational level (Samdahl and Robertson, 1989), and higher socioeconomic status (Mohai, 1985) do have positive impacts on environmental concern by people. In other studies, marital status (Ebreo and Vining, 2001) is linked with increased environmental concern. Mainieri et al. (1997) concluded that women do have more pro-environmental attitudes than men, as they are likely to purchase environmentally friendly goods. A study linking recycling behavior and environmental responsible consumerism by Ebreo et al. (1999) argued that household socioeconomic variables such as household size and years of residence are unrelated to '*conservation behavior*' and '*kindness to nature*' while '*nature related attributes*' increased with age. They also showed that gender has a strong association with both '*conservation related attributes*' and '*nature related attributes*' in which case women are more sensitive to these environmental responsible attributes.

One important thing we understand is that the literature is more focused on the relationship between recycling and environmental attitudes (Dunlap and Van Liere, 1978; Samdahl and Robertson, 1989; Hong et al., 1993; Scott, 1999; Ebreo and Vining, 2001; Bruvoll et al., 2002; Li, 2003). While activities like waste separation, reuse and recycling could be motivated by economic benefits, environmental safety and judicial (tax) reasons; little is known about the extent to which household waste separation and appropriate disposal are motivated by concern for environmental safety. In reference to the widespread problems of waste management therefore, identifying and examining the relationships between concern for the environment, waste separation and disposal in cities of developing countries therefore merit attention. In spite of the fact that disposal is one of the major alternatives that households in developing countries use to get rid of their wastes, the attention given to disposal (and also the practice of waste separation at source) and its relationship with environmental attitude and concern has been scant. To my knowledge, there has not been a study examining the relationship between concern for the environment and disposal practice in developing countries. This dearth of knowledge is particularly severe in developing countries where the realities with regard to waste (treatment), environment and the economy are a lot different from that of the developed world. Some of the major findings and methodology in relation to concern for the environment are not that applicable to the realities in developing countries. In relation to this, the way environmental concern is 'measured' or indexed (by Dunlap et al. (2000)) particularly requires further attention, especially to the economic, environmental and social background in developing countries. Some of the entities in the New Ecological Paradigm simply do not make sense in the society of developing countries. The intention here is not to challenge entities or results of this paradigm. Rather, based on this paradigm and including some severe local environmental problems, this study aims to analyze the relationships among environmental concern, waste separation and disposal. A study by Tadesse et al. (2008) revealed that many poor households in cities of developing countries such as Mekelle use reusable items, which basically are considered to be waste by other households. It can be deduced therefore that economic motives may be behind this separation and reuse (and for that matter recycling) in developing countries. But, what other factors are involved in this? What household features, waste attributes and environmental realities determine concern for the environment, separation at source and appropriate disposal? How are waste separation and environmental attitudes related? These questions remain unexplored in the literature with regard to environmental attitude (concern), waste separation at source and appropriate disposal of household wastes in developing countries. This study therefore attempts to fill this gap by investigating how environmental concern of households, waste separation and disposal, among others, are related. Many factors can be considered and the relationships and findings are generally applicable to cities in Ethiopia and others in developing countries. The analysis of the objectives is based on household survey from a typical Ethiopian city, Mekelle. Econometric and statistical tools are used for analysis. The scope is limited to the study of solid wastes and the names wastes and solid wastes are interchangeably used in this study.

The paper is organized as follows. Section 2 presents the different ways in which environmental concern has been conceptualized in the literature. In Section 3, a concise description of the theoretical model and empirical (estimation) method is provided. Section 4 introduces and describes the data, study area and survey methodology. Analytical model results are presented and discussed in Section 5. Section 6 summarizes the main results with some insight of the study in the end.

2. Conceptual framework for concern for the environment

Increasing environmental problems have induced environmental concern on different societal groups such as scientists, interest groups, NGOs, and the global public at large. While 'environmental concern' has the meaning of care for the environment and its resources, it poses yet a heated debate (Göksen et al., 2002) over its conceptualization and operationalization. As a result, different studies have come with their own line of thought with regard to defining and measuring the environmental concern of households. In one line of approach, there is the New Ecological Paradigm (Dunlap et al., 2000). This thought emphasizes that environmental concern is conceptualized and stated in terms of ecological limits and catastrophe, balance of nature, and human rule over nature. It largely focuses on the environment or resource-related behavior where a 5-Likert scaling measurement of fifteen environment and resource-related questions attempt to elicit the environmental attitudes of people. Another strand of literature following the Altruistic Behavior concept (Corraliza and Berenguer, 2000) focuses on the personal norms, feelings of moral obligation, and altruism as the scale measurements to pro-environmental attitudes. Another concept in the literature used for scale measurement of environmental concern is the Post-materialist Index established from the works of Inglehart (1977). The Post-materialism line of thought asserts that individuals' socioeconomic environment and its improvement induces them to prioritize their different set of beliefs and attitudes (Göksen et al., 2002). The Post-materialism thesis distinguishes between '*objective*' and '*subjective*' environmental problems and states that individuals' environmental concern is associated with them. It could be thus the case that the different environmental

and economic realities in various parts of the world could lead to different priority settings. In line with this concept, it was established for individuals to prioritize their '*material goals*' such as providing strong national defense, controlling inflation and fighting crime while promoting economic growth. It is also advocated to prioritize and promote post-material goals such as protecting freedom of speech, providing people a greater role in decision making, and promoting an environment for people to have greater say in their work place and community (Blake, 2001). Because environment, resources, behavior and priority of people can differ in different areas, the approach to environmental safety could as well vary accordingly. An implication from these arguments is that environmental attitudes and concern in developing countries can be affected by the specific economic, social, natural and environmental settings that prevail, which are largely different from that of the developed world.

Yet, environmental concern, with all the lively debate over its nature and definition has been prominently associated with such extrinsic socioeconomic variables as age, education, gender and income (Göksen et al., 2002). Involving the post-materialist values, it is revealed that material security and '*post-materialist value*' variables have positive association with environmental concern. In addition, it is argued that concern for *local* environmental problems like sea pollution is significantly explained by '*post-materialist values*' and urbanity. A study by Ebreo et al. (1999) argued that the conceptual meaning of environmental concern is associated with overall attitudes of people towards the environment. As a result, people with such extrinsic behaviors as young age, good education, higher socioeconomic status (high income) and urban residence have positive association with concern for the environment. In a more elaborated way, as such, both intrinsic motivations such as increased self esteem, feeling of altruism, enhanced connection with one's community and extrinsic rewards for example financial rewards do play a major role in improving behaviors of environmental conservation.

3. Theoretical framework and econometric modeling

It is customary to establish any scientific study on a sound theoretical framework and construct a model from there. Although there is no a theory that clearly explains the relationship between environmental concern and waste separation (disposal as well), we can analyze the behavior that motivates households to separate wastes, properly dispose wastes and care for the environment. Households choose to participate in waste separation practice (as a matter of fact, a certain disposal practice as well) if the activity provides them a certain threshold level of utility. The choice that households have to make is based on the unobserved utility obtained from participation in waste separation and a certain disposal practice. This utility is not direct in that it is random utility. In other words, it is only the utility maximizing variables that could be observed and not the utility *per se*. These kinds of choice models (utility models) assume that an individual household's choice is the result of its preference. The point is that the household chooses to participate in waste separation and disposal practice (say, disposal to containers) if it provides utility explained by some observed variables (Soutukorva, 2005). Assuming that an individual household i participates in waste separation or chooses waste containers for disposal, the derived utility from the particular activity can be represented as:

$$U_i = \theta x_i' + \varepsilon_i \tag{1}$$

where, U_i is the utility derived by household i from participation in waste separation and disposal practice, x_i' is the vector of various household features, environmental factors and waste attributes explaining the utility, ε_i is the unobserved error component, and θ is the vector of parameters of the model. The household therefore aims to maximize the utility from an activity as expressed below by random utility function:

$$\max_{x,z} U_i(x_i, Z) \tag{2}$$

where Z indicates household features and x_i represents household-specific waste and environmental attributes. The household aims to maximize this utility, U_i from participation in waste separation and disposal to containers. The practice of waste separation and disposal by the household are thus explained by household features, environmental factors and waste attributes. The following functional form indicates this underlying relationship:

$$y_i = f(x, \theta) \tag{3}$$

And, mathematical stipulation of the households' waste separation and disposal practice is given by

$$y_i = \theta x' + \varepsilon_i \quad \varepsilon \approx NID(0, \sigma^2) \quad (i = 1, 2, 3, \ldots, n) \tag{4}$$

In this case, y_i represents the waste separation and disposal practice of households, which are explained by the vector of different household demographic features, waste and environmental attributes (x).

Such equations can be estimated to reveal the way waste separation and disposal are explained by various attributes, including environmental concern. One should however be cautious when estimating equations that involve unobserved variables. At times, regression phenomena are unique in such a way that one has to deal with some practical applications that do have the characteristics of discrete choice or limited alternative choices whereby the use of conventional regression methods such as linear regression model [for example, Ordinary Least Square, OLS estimator] for analysis is overall inappropriate (see Greene, 2002; Verbeek, 2004; Wooldridge, 2005). Some of the variables of concern in this study are discrete in nature and need to use the appropriate model for analysis. The variables and their measurements are provided in Table 2. One of these models that deal with the analytical explanation of dependent variables with the attribute of 'Qualitative Response' is, chief among which, the probit model together with its extension, the bivariate probit model and selection models.

3.1. How are concern and waste separation related? A bivariate probit model

One objective of this study is to examine the relationship between environmental concern and the practice of source separation of solid wastes. The main idea behind this model is to analyze the determinants of both source separation and environmental concern based on the joint utility obtained from both choices. The underlying functional relationship between household environmental concern and solid waste source separation is depicted as follows

$$y_{1i}^* = f(x_{1i}, \theta_{1i}) \quad \text{(Environmental concern)} \tag{5}$$

$$y_{2i}^* = f(x_{2i}, \theta_{2i}) \quad \text{(Source separation)} \tag{6}$$

Whereas y_{1i}^* and y_{2i}^* are the unobserved attributes of environmental concern and source separation respectively, x_{1i} and x_{2i} are the vector of explanatory variables, the θs are vector of parameters. Having the above underlying relationship, the specific equations of households' concern for the environment and solid waste source separation can be mathematically specified as follows in Eqs. (7)–(10). Bivariate probit model is used when two binary decisions are modeled together because their disturbances are assumed to be correlated. The binary decisions, environmental concern and solid waste

source separation respectively, y_{1i} and y_{2i} are such that

$$y_{1i} = \begin{cases} 1 & \text{if } y_{1i}^* = 1 \\ 0 & \text{otherwise} \end{cases} \quad (7)$$

$$y_{2i} = \begin{cases} 1 & \text{if } y_{2i}^* = 1 \\ 0 & \text{otherwise} \end{cases} \quad (8)$$

In which case, y_{1i}^* and y_{2i}^* are the unobserved variables for environmental concern and source separation respectively. Having depicted the individual household choice for both concern for the environment and source separation, the inter-relationship between the two can be illustrated by modeling and estimating jointly the two equations, as follows

$$y_{1i}^* = \theta_1 x_{1i}' + \varepsilon_{1i} \quad \text{(Environmental concern)} \quad (9)$$

$$y_{2i}^* = \theta_2 x_{2i}' + \varepsilon_{2i} \quad \text{(Source separation)} \quad (10)$$

In this case, ε_{1i} and ε_{2i} are the error terms of the bivariate probit model and there is an assumption that $[\varepsilon_{1i}, \varepsilon_{2i}] \approx \Phi(0, 0, 1, 1, \rho)$ where ρ is the coefficient of correlation between ε_{1i} and ε_{2i}. The probability of the occurrence of any level of the two dependent variables [source separation and environmental concern] (for example $P(y_1 = 1 \text{ and } y_2 = 1)$) can be computed with the bivariate normal cumulative distribution function since the error terms of those two models can be correlated with each other. Thus, the bivariate probit model is illustrated as

$$\begin{aligned} P(y_{1i} = 1, y_{2i} = 1) &= P(y_{1i}^* > 0, y_{2i}^* > 0\,; \rho) \\ &= P(x_{1i}'\theta_1, x_{2i}'\theta_2; \rho) \\ &= \int_{-x_1'\theta_1}^{\infty} \int_{-x_2'\theta_2}^{\infty} \Phi(\varepsilon_{1i,}\varepsilon_{2i}; \rho)\ \mathrm{d}\varepsilon_{2i} \cdot \mathrm{d}\varepsilon_{1i} \end{aligned} \quad (11)$$

The mathematical representation of Eq. (11) just depicts the generic form of a bivariate probit model in which case, Φ is cumulative distribution function of the bivariate standard normal distribution function (see Greene, 2002).

3.2. Concern for the environment and proper waste disposal: a sample selection model

Fundamental problems of improper waste disposal pose the question whether this occurs from inadequate waste facilities such as inadequate availability of containers (where disposal in to which is proper and considered 'safe' to the environment) or the lack of concern to the environment by households. The modeling in this section relates to analyzing this question.

Consider the case where we want to study the environmental attitude of households in relation to their waste disposal into waste containers provided by the municipality. Because waste containers are provided for disposal into them, the subsequent activity of households in relation to disposing their waste into these containers may be a condition for the concern to the environment. That is, households are considered to be concerned to the environment provided that they dispose their wastes on to the containers rather than dumping wastes in open areas and roadsides. In such a scenario, some of the factors that determine disposal may also influence the concern for the environment. Analytical estimation of the concern equation (environmental concern equation – see below) alone would be therefore biased in the presence of sample selection. Sample selection may occur as a result of self selection by research units (observation units – households in this case) or when a researcher does not observe a random sample of the population of interest. The resultant bias (sample selection bias) emanates from the correlation between the error term and independent variables (Heckman, 1979; Greene, 2002; Verbeek, 2004). All these problems basically may arise from endogenous relationship among variables, measurement error of variables and missing cases of variables. To keep with the application of environmental concern and household waste disposal, consider the following model-equations,

$$y_i^* = \theta x_i' + \varepsilon_i \quad (i = 1, 2, \ldots, n) \quad (12)$$

$$s_i^* = \lambda v_i' + u_i \Rightarrow s_i = \begin{cases} 1 & \text{if } s_i^* = 1 \\ 0 & \text{otherwise} \end{cases} \quad (i = 1, 2, \ldots, n) \quad (13)$$

Remember Eq. (13) is the selection equation (disposal into waste containers) (in reduced form) reflecting whether the equation of interest – (12), concern for the environment – is observed or not. The error terms ε_i and u_i are jointly normally distributed, independently of **X** and **V**, with zero expectations.

$$\begin{aligned} &y_i^* = \theta x_i' + \varepsilon_i \\ &y_i = y_i^* \text{ if } s_i = 1 \\ &y_i \text{ is not observed if } s_i = 0 \end{aligned} \quad (14)$$

The selection model implies that y_i is observed when $s_i = 1$. In such a model, sample selection occurs when the correlation between the error terms, $\mathrm{Corr}(\varepsilon_i, u_i) = \rho$ is different from zero. When selection bias occurs, probit models are inefficient and OLS estimation is biased. In order to eliminate the bias from sample selection, we need to account for it and use superior estimator. The essence behind the selection model is that the variable of interest y is observed on the condition that some criterion, defined with respect to a variable, say s, is met. In our case, the variable s (disposal into containers) determines whether y (concern for the environment) is observed. There are two stages in the basic outline of such models. In the first stage, a dichotomous variable s determines whether or not y is observed, y being observed only if $s = 1$. Here, we estimate the model with the vector of independent variables **V** and get some coefficient lambda (λ). In the second stage, the expected value of y is estimated, on the condition that it is observed. So, we observe s, a dummy variable, which is a realization of an unobserved continuous variable s^*. Depending on the nature of the variable of interest (y), we may use probit selection estimators or two-step Heckman selection model. If y is a dichotomous variable, the Heckman probit model is appropriate while the two-step estimator is used for continuous y variable.

4. Study area and data

The study area is the city of Mekelle located in Northern Ethiopia. It is one of the fastest growing cities in Ethiopia. Current rough figures indicate that the population has reached 250,000. At the time of data collection for this study in 2006 (first survey), there were a total of 47,000 households in the city (Tadesse, 2006). It is a typical city in Ethiopia characterizing similar economic activities, type and volume of waste generated and the methods of waste management with other parts of the country. Given the expansion of economic activities and high population growth in the city, waste generation, disposal and supply of waste infrastructure are seriously affected. The city municipality of Mekelle is the main actor involved in the collection and disposal of household wastes. There are also individual workers (such as street boys) and few private 'firms' involved in collection and disposal of wastes (mainly for the well-to-do households); yet their contribution remains negligible. Having collected wastes from households, the Municipality disposes them in open landfill sites outside the city. Yet, supply of waste infrastructure in the city remains inadequate. Households in the city use different alternatives to get rid of their waste. According to Tadesse et al. (2008), waste containers provided by the municipality and open (unauthorized) areas are the major disposal destinations of household wastes. Other alternatives available to households are burning and the recently introduced neighborhood collection service by the municipality. Households also rarely use small communal and

private landfill sites. Improper household waste disposal (such as dumping in unauthorized areas) and inadequate (sometimes lacking) waste collection and disposal services from the side of the Municipality are the major problems observed in the city. The city's immediate and surrounding environment is therefore going to carry the burden of the waste bulk and problems in managing wastes. Thus, promoting policies to check the generation of bulky waste and environmental safety requires a coordinated effort. The first steps in this case are to study the current trends in the hierarchy of waste management and attitude to the environment by households in the city.

Based on this motivation, household surveys from a sample of 400[1] households of the city were undertaken using a structured questionnaire in January 2006 and in April 2007. Sampled households were interviewed using the structured questionnaire. Four enumerators were sufficiently trained for the interview. The data collected pertain to household solid waste collection and disposal practices, environmental attitudes and municipal waste infrastructure. Data were collected from eight administrative sections of the city where each administrative area is considered as a stratum. In stratification, the difference in household economic status (roughly economic wealth), population (household) number, solid waste infrastructure and geographical settlement of households were considered. This helps to get representative sample of households. The data were then collected randomly from the selected household heads of 18 years of age and above.

4.1. Data attributes for environmental concern

Being one of the variables of concern (dependent variables) that enter the econometric analysis, the measurement of environmental concern needs crucial attention. This study follows the works of Dunlap et al. (2000) and Blake (2001) in trying to index environmental concern. A set of environmental problems – local, regional, national and international are considered. Severe local (national) environmental problems such as solid waste hazards, soil erosion and deforestation are among the items considered. International environmental catastrophes like biodiversity loss and balance of nature threat, which are highly relevant in the current global environmental agenda, are also included. Most of the questions envisaged to probe the environmental concern of households are based on the pioneer study in measuring environmental concern by Dunlap et al. (2000) known as the New Ecological Paradigm.

From the above set of environmental entities adopted to probe the environmental concern of households, an environmental concern index is computed by making use of the 5 point Likert-scaling to all of the statements needed to elicit environmental concern. The index is calculated by weighing serious local environmental problems – deforestation, soil erosion and waste hazards – twice as much as the general (global) environmental issues. It is the essence of this study that environmental concern of households in cities of (poor) developing countries like Mekelle can be better depicted by pragmatic environmental externalities than those externalities trying to address balance of nature or limits to growth. Having obtained the data from households, the environmental concern items were rearranged from 1 to 5 in accordance to the pro-environmental attitudes of the responses. Next, by giving twice as much weight to severe local environmental problems, the environmental concern index is computed. Apart from this, the dataset also includes a dichotomous variable that extracts the environmental concern of households by simply asking if they care for the environment. Some of the environmental items included in the original paradigm do not really foresee the economic, social and environmental realities in developing countries. In this study, three local environmental items (see Table 1) have replaced them in order to better explain environmental concern in the study area.

In Table 2, the statistical description of the variables is shown. It also portrays how the different variables are specified for analytical examination later in the study. Among the sample households, 60% are male-headed and 40% are female-headed. About 28.5% of the respondents are illiterate where the number of illiterate female household heads is twice the size of male household heads. The

Table 1
Items included in indexing environmental concern.

When people interfere with nature it often produces disastrous consequences
People have unlimited right to cut forests
People must live in harmony with nature in order to survive
People are severely abusing the environment
We are approaching the limit to the number of people that the earth can support
Plants and animals exist primarily to be used by humans
Soil erosion need to be controlled for better agricultural production
People have the right to modify the natural environment to suit their needs
People need not adapt to the environment because they can remake it to suit their needs
People have the right to dispose wastes wherever is suitable for them

Source: Blake (2001) and own adjustment.

Table 2
Descriptive statistics of variables.

Variable name and description	Mean	S.D.
Household head sex (1 = female; 0 = male)	0.40	0.49
Age of household head (years of age)	43.9	12.6
Household head education (years of schooling)	7.83	6.09
Family size (number of family members)	4.47	2.12
Years of stay by household head in the city	23.49	15.89
Home ownership (1 = own house; 0 = otherwise)	0.65	0.48
Household income per year (Birr) (1US$ = 9.078 birr)	13830	14910
Household source separation of wastes (1 if Yes; 0 if No)	0.17	0.37
Access to waste disposal containers by households (0 if none or not enough; 1 if enough access)	0.11	0.31
Municipal regulation if households are using the disposal containers properly (0 if none or weak regulation; 1 if strong regulation)	0.10	0.29
Index for environmental concern	0.56	0.07
Waste attitude (0 = useless; 1 = useful)	0.58	0.49
Waste size generated per year (0 = less than 200 kg; 1 = greater than 200 kg)	0.42	0.49
Primary waste destination (1 if waste containers; 0 otherwise)	0.81	0.39
Distance to waste containers (Meters)	288	451
Participation in recycling practice (1 if Yes; 0 if No)	0.19	0.40
Concern for environment-dichotomous (1 if Yes; 0 if No)	0.62	0.49
Do you agree with the placement of waste containers near your houses? (NIMBY) (1 if agree; 0 otherwise)	0.31	0.46
Do you agree with the placement of waste containers anywhere in the city? (NIABY) (1 if agree; 0 otherwise)	0.46	0.50

[1] Since the household size of the city is finite, with a 99% level of confidence and a 0.1 margin of error (e) the representative sample size of households has been determined as: $n = [(Z^2)(p)(q)(N)]/[e^2(N-1)+(Z^2)(p)(q)] = [(2.57^2)(0.5)(0.5)(47000)]/[(0.1^2)(47000-1)+(2.57^2)(0.5)(0.5)] \approx 165$here n is sample size, N is household size of the city (= 47000), Z is value of the standard variate at the given confidence level, p is estimated population proportion of a given characteristic (=0.5), $q = 1 - p$ and e is acceptable margin of error. Although the statistical figure gives a value of 165, two data sets were pooled to increase the sample size to 400 households.

Table 3
Relationship of waste separation and concern for the environment.

Variables	Environmental concern		Waste separation	
	Coefficient	S.E.	Coefficient	S.E.
Constant	0.36	0.76	−2.87	1.00***
Household head sex	−0.02	0.27	0.03	0.29
Household head education	0.04	0.03	0.03	0.03
Household head age	0.01	0.01	0.01	0.01
Household size	0.18	0.09**	0.15	0.08**
Years of stay	−0.02	0.01**	0.002	0.01
Waste attitude	0.14	0.19	0.43	0.18**
NIMBY	−0.80	0.26***	−0.01	0.27
NIABY	−1.04	0.25***	0.30	0.27
Container access	0.21	0.39	0.34	0.42
Regulation	0.97	0.27***	−0.38	0.26
Home ownership	0.19	0.29	0.01	0.34
Recycling	0.56	0.30*	0.58	0.29**
Numerical income	0.00	0.00	0.00	0.00
Distance in metres	0.00	0.00	0.002	0.001**
ρ	0.39	0.23*		

***1% Significance level; **5% significance and *10% significance level Likelihood-ratio test of $\rho = 0$: $\chi^2(1) = 2.90$, $p > \chi^2 = 0.08$.

average household size is 4.47 and the average age of the household head is 43.9 years. A good proportion of the respondents (42%) believe that wastes have some sort of usefulness through recycling and reuse. The majority of households are against the siting of waste containers, 69% for NIMBY[2] (near their houses) and 54% for NIABY (any part in the city). About 89% of the respondents feel that they have inadequate access to waste containers provided by the municipality and only 17% actually try to separate wastes at source.

5. Results and discussion

Primarily, let us attempt to examine how concern for the environment and waste separation at source are related. The analytical tool to elicit this relationship is discussed in Section 3.1. The results of the bivariate probit estimation are presented as follows. The estimated correlation coefficient of the error terms (ρ) in the bivariate probit model is positive and statistically significant. The calculated likelihood ratio test shows that the two variables of concern (or the two equations, Eqs. (10) and (11)) indeed have correlated error terms. This result indicates that household concern for the environment and waste separation at source are related. Hence, rather than separate estimation of univariate probit models for concern for the environment and waste separation, joint estimation of the models using a bivariate probit model is a more appropriate estimation procedure. This is because the correlation of the two error terms means that estimation of the model using bivariate probit produces efficient estimator. The results of this model are shown in Table 3, where the coefficients are allowed to vary although the same variables are used in both equations. Discrete choice models such as bivariate probit models share the property that their parameter estimates cannot be interpreted in a straightforward manner in terms of choice probabilities. Therefore, additional computations are required. It is also possible to extract information based on the signs that the estimates carry.

The varying significance of the explanatory variables involved is interesting. Some of the variables describing household concern for the environment, for example NIMBY, NIABY, household size, volume of solid waste generated, years of stay in the city, regulation and recycling have statistically significant influence on households' concern for the environment. In contrast, only household size, waste attitude, recycling and distance to waste containers have statistically significant effect over the practice of solid waste source separation. Results show that typical demographic variables such as gender, age and education of the household head have no statistically significant influence on waste separation. The expectation was that educated heads would have more motivation for separating wastes but the data indicates the absence of significant difference between the educated heads and those that are not. Having real observations among households in Mekelle and other cities in Ethiopia would make the results plausible. One interesting result with regard to household size is that it positively affects waste separation indicating that other members of the household may have something to contribute (see also Ojeda-Benítez et al., 2008). This is particularly the case in cities like Mekelle where children heavily participate in the collection, separation (for reuse) and final disposal of wastes into waste containers. An unpublished study in this regard by Tadesse and Hadgu (2007) revealed that teenage female household members particularly take care of household waste separation and collection where boys largely work on disposal.

The fact that many households do not want the placement of waste containers around their houses (as shown by NIMBY) indicates that they are concerned about their immediate environment, which is manifested by health hazards and Disamenities. These relationships are positive suggesting that the probability of concern for the environment increases as households increase their attitude of NIMBY and NIABY.[3] An implication from this is that households who resist (would not like to have) waste containers near their houses have concern to the surrounding or immediate environment. It emanates from the desire of households to have clean environment, which does not inflict health problems. Despite the results show this kind of relationship between concern for the environment and placement of waste containers, many households also want to have these waste containers in close proximity for access reasons. In fact, households who live far away from waste containers may not foresee the health hazards and disamenity inflicted by constant existence of containers full of wastes near houses. Households who have waste containers near their houses suffer from the externalities which prompt them to resist the siting of the containers in the vicinity of their dwelling houses. Households in this regard are effectively playing a game of maximizing benefits and minimizing negative externalities.

The attitude of households to wastes plays a positive role in the practice of waste separation. This is particularly revealing in that the knowledge by households that not all wastes are useless promotes waste separation. Better understanding of households about wastes could be pivotal in the successful management of solid wastes as a result. When they have better knowledge about the good and bad sides of wastes, they know which wastes are useful and which are not. This sensible understanding of wastes could be used as source of income. It can also increase households' knowledge of which wastes to separate, recycle, burn or where and how to dispose of. Therefore, policy measures to promote better understanding towards various solid wastes can be important in this case in improving waste management and even better environment. In another instance, recycling practice is positively associated with the practice of waste separation and concern for the environment. One implication is that separation and recycling go hand in hand. It could be argued that as far as there is no separation there might not be a room for recycling. One thing that should have a close scrutiny is the

[2] NIMBY refers to Not In My Back Yard – and reflects the idea of households resisting the placement of waste containers in their dwelling neighborhood. Whereas, NIABY, which refers to- Not In Anyone's Back Yard- is the attitude of not wanting the containers in any part of the city.

[3] Notice that households with NIMBY or NIABY view (If they agree with the placement of waste containers near their houses or anywhere in the city, respectively) carry the dummy 1 if they agree and 0 if they disagree. Therefore, the sign of the coefficient estimate carries the sign of the dummy 1.

Table 4
Parameter estimates for environmental concern and selection equations.

Variables	Environmental concern		Disposal in containers	
	Coefficient	S.E.	Coefficient	S.E.
Constant	0.52	0.03***	0.98	0.72
Household head sex	−0.003	0.01	0.29	0.28
Household head education	0.003	0.001**	0.05	0.03*
Household head age	0.001	0.0004*	−0.01	0.01
Household size	0.005	0.003*	−0.11	0.07
Years of stay	−0.001	0.0003***		
Waste attitude	0.01	0.007		
Waste volume	0.02	0.01*	0.22	0.25
NIMBY	−0.03	0.01***	0.24	0.26
NIABY	−0.04	0.01***	0.08	0.27
Container access			0.76	0.40*
Regulation	0.03	0.01***	0.18	0.29
Home ownership	0.001	0.012		
Separation	0.02	0.013	−0.31	0.33
Recycling	0.03	0.012**	−0.191	0.29
Numerical income	7.70e-07	3.34e-07**	0.00003	0.00001***
Distance in metres	0.0001	0.00001***	−0.001	0.0002***

*** 1% significance level; ** 5% significance and * 10% significance level. Likelihood-ratio test of $\rho = 0$: $\chi^2(1) = 5.96$, $p > \chi^2 = 0.015$.

positive relationship between recycling and concern for the environment. It may not be wise to definitively attribute the positive impact of recycling for environmental concern. Many households may practice recycling for economic reasons rather than for reasons of concern for the environment. This is particularly true among poor households (and to a certain extent among middle income households) in the city of Mekelle where these households separate reusable wastes (Tadesse et al., 2008).

Siting of solid waste containers does also have an interesting implication to waste separation. As it is shown in Table 3, longer distances of waste containers from houses have positive impact on waste separation. The longer the distance to waste containers, the higher the probability of separation and recycling of wastes so that less waste is transported to the containers. The defying truth to this argument is that households living nearby waste containers may learn from the scavenging and recycling activities around the waste facilities (containers), which encourage them to separate and recycle wastes. Another scenario is households may opt to dump their wastes in open areas and unauthorized places if they live in a distant place from waste containers. A positive relationship is also observed between concern for the environment by households and the regulation by the municipality over the appropriate use of waste containers. Results of the marginal effects also confirm that the probability of a household being concerned for the environment and separate wastes at source (=Pr(concern = 1, separation = 1)) is positively related with household size and waste container distance. The aforementioned bivariate probit analysis more or less shows the relationship between household concern for the environment and waste separation at source. On the other hand, we use the Heckman selection model to investigate the relationship between concern for the environment and disposal of wastes into (communal) containers. In this case, the intention is to examine the factors that determine environmental concern given that households dispose their wastes into containers.

The largest proportion of households in the city of Mekelle have access, though may be limited, to waste containers. Yet, it is not uncommon to see widespread open dumping (Tadesse et al., 2008). Thus, disposal by households into these waste containers is assumed to be environmentally responsible behavior. To this effect, selection model of concern for the environment (as outcome equation) and disposal into waste containers (as selection equation) is estimated and results are provided in Table 4. There are only two cases where selection bias (say, estimating by probit model) will not be a problem. This is the case when $\rho = 0$ on the one hand or if the correlation between the estimate of lambda (λ = coefficient of the selection equation) and any element of the matrix $\mathbf{X}$ is zero. However, Likelihood-ratio test, as shown in Table 4, of the correlation between the two error terms is significantly different from zero ($p > \chi^2 = 0.015$). This in fact shows that the relationship should be estimated using a selection model, where the correlation between the error terms in the outcome and selection equation is accounted.

The interpretation of the coefficients in the model depends on the appearance of a variable on the outcome or selection equation or both. Whereas the interest is to see the effect of the variables on the outcome equation, analyzing the impact on the selection equation also gives a good overview of the overall model. If a variable appears only in the outcome equation, the coefficient on it can be interpreted as the marginal effect of a one unit change in that variable on the dependent variable (indexed environmental concern). If, on the other hand, the variable appears in both the selection and outcome equations, the coefficient in the outcome equation is affected by its presence in the selection equation as well. Results show that demographic features such as education, age and household size are positively associated with environmental concern. All these are in harmony with logical expectation. More educated and older household heads display higher concern for the environment. As household size increases, household attitude to the environment changes positively. This could be the case that more household members bring and share pro-environmental knowledge. Results also show that years of schooling positively (at 10% significance level) affects disposal of waste into communal containers. It is usually the case that more educated household heads use paid individuals to take the wastes away from home and dispose of onto containers.

Interesting results also include the positive influence that waste volume, NIMBY and NIABY mentality of households have on concern for the environment. The NIMBY and NIABY attitudes particularly are significant in relation to the desire of households for safe immediate environment. A large proportion of households are against the placement of waste containers near their houses because of the sheer fact that these improperly managed waste containers and the subsequent negative externalities. Households are also alerted about environmental safety when the bulk of waste generated grows. Although there are growing concerns about open dumping when the volume of waste produced increases, it also encourages households to devise or adopt some sort of management technique for better waste treatment. This is indirectly instilled by concern for the immediate environment. In relation to the amount of waste generated, open dumping and waste facilities, stern regulation by the municipality in the proper use of waste containers also encourages households to change their attitude on the environment positively. This is particularly important as it also discourages unauthorized dumping and as a result promotes environmental safety. In this regard, access to waste containers encourages households to dispose their waste onto the communal containers. This result is also strengthened by the negative influence (negative coefficient) of distance to waste containers. When the distance to waste containers increases, households are discouraged to go as far and dispose their waste onto them. This in turn, however, has positive influence on the concern for the environment. When households are faced with inaccessibility to waste containers, they would either use alternative waste destinations or reduce waste generation or manage their waste properly, the result of which is partly attributed to concern for the environment. Household income has a positive influence over the use of communal containers. Richer households use paid waste pickers, which are largely informal individual workers and street boys to transport wastes to waste containers.

6. Conclusion

Analyses in the literature that focus on the relationship between waste management and environmental concern are limited to studying environmental attitude and recycling practice, mainly in developed countries. This study contributes to the literature by examining the relationship between concern for the environment and waste disposal (which happens to be the main household waste treatment mechanism) from the perspective of developing countries. While a bivariate probit model is used to examine the link between concern for the environment and waste separation, the overall attitude of environmental concern vis-à-vis disposal into waste containers is analyzed using the Heckman probit selection model. Results show that concern for the environment and waste separation are related. The joint estimation of concern for the environment and waste separation is therefore useful as the analysis accounts for the correlation between error terms and provides important joint relationships. In this regard, the size of waste generated, NIMBY and NIABY attitudes of households and municipal regulation over the proper use of waste containers are among the major factors that instill pro-environmental motives among households. The implications particularly with regard to volume of waste generated and regulation over the appropriate use of waste containers are duly important. Strong regulation does not only promote proper use of the waste containers but it also passes a strong message for households not to dump wastes on unauthorized areas, promoting in turn environmental safety. Tightening regulation also helps households to reduce volume of waste generation at source. Policy measures therefore that influence these relationships would work for bettering the environment and waste management practices.

Using selection model also gives an insight to the concern for the environment by households that use waste containers for final disposal of their refuse. This analysis shows that among households who use communal containers for waste disposal, some of the major variables such as household head age and education, household NIMBY and NIABY mentality, regulation by the municipality over the proper use of containers, household income and container distance from dwelling houses have positive relationship with concern for the environment. As it is argued, a good understanding can be obtained from the inter-relationship among concern for the environment, practice of waste collection and disposal, which provides important information to improve waste management and environmental quality in growing cities of developing countries. Therefore, specific measures that consider and strengthen the relationship and impact of the variables on environmental concern, waste disposal and separation should be sought. The demand-driven (such as age, education and income) and supply-driven (such as regulation, access and distance to waste containers) factors can also be considered for policy applications as they directly or indirectly influence the environmental attitude (concern) and waste management practices (such as appropriate disposal). It is true that household behavior (attitudes) in waste-related attributes, concern for the environment and waste management techniques in the developed countries are different from that of developing countries. The approach of this study has been to use data and realities from the perspective of a city in Ethiopia, Mekelle in order to identify and extract vital information about the relationships between concern for the environment, disposal and waste separation and the different factors that influence them. The results are therefore meant to provide vital implications to many other cities in developing countries.

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Appendix A. Covariates of the regression models

In order to organize the variables that enter the econometric analyses, one can start from economic theory and proceed to consider observation or logic, causal empiricism and previous research. Then, one can disaggregate the demand- and supply-driven factors that could possibly influence concern for the environment and disposal (separation) practices and the relationships between them. Of course, the starting point is economic theory, where separating the demand-driven and supply-driven factors enable us to include the important covariates and exhaustively examine the relationships. In this regard, one can consider the demand-driven factors such as household socio-economic and demographic features (such as age, education, income, size and gender issues). The effects of these variables are often the ones that many researchers want to analyze since information/relationships of these variables can be used to influence behavior. Supply-driven elements such as access to waste containers, distance to these waste containers and regulation over the appropriate use of these containers are also among the factors that are hypothesized to influence concern for the environment and disposal practices. The argument is that these variables influence waste management practices, which in turn can affect environmental attitude. Household attitudes (NIMBY and NIABY) and waste attributes (waste attitude and recycling) are also considered to affect the relationships among the variables of concern. Considering the study area as a showcase, particularly NIMBY mentality of households is hypothesized to influence the separation and disposal practices and the relationship with concern for the environment. As an example (which is also discussed in the paper), households often see the containers near their houses full over capacity and remain there unpicked for many days. There are consequences in fact for the nearby households (all sorts of negative externalities). Households thus consider such elements in decision making and can influence their behavior (attitude) on the environment and disposal (separation) practices. It is from this argument (reality) that such variables are considered. Previous research also considered such variables as years of stay and home ownership as influencing factors in the recycling behavior and its relationship with concern for the environment. In this study, it is also assessed the effect of these variables in disposal practice and concern for the environment.

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