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Estimation of Socioeconomic Status and Rainwater Consumption in Ibadan Metropolis, Nigeria

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Abstract

The study examined the influence of socioeconomic factors on the utilization of rainwater among households in Ibadan metropolis, Oyo-State, Nigeria. Primary data were collected through a semi-structured questionnaire from 126 randomly selected households. A double-hurdle estimation model using Ordered Probit with sample selection and Probit-Truncated Negative Binomial model were used. The findings of the study indicated that the sex of the household head, marital status, female household size, education, occupation, size of rainwater collection material, root-top structure are important determinants of extent of rainwater usage. Male headed household, education, and size of rainwater collection material positively and significantly influenced the frequency of rainwater usage, while sex and occupation inversely and significantly influenced the frequency of rainwater usage. Likewise, education, size of rainwater collection material, roof-top structure positively associated with the number of uses of rainwater. The study concludes that the socioeconomic status of the household is an important determining factor in the harvesting and utilization of rainwater. Therefore, policy on rainwater harvesting and usage should consider the significant socioeconomic factors of the household as a starting point in the decision process.

Key words: double-hurdle model, socioeconomic of rainwater utilization.

Introduction

Water plays a crucial role in the survival of human existence and development as well as an indispensable renewable resource that serves various uses for households. Water occupies about 70% of the earth's surface of which only 2% is freshwater (Mohammad *et al*., 2017). The need for water usage continues to increase as the population increases. It is expected that by 2050 the withdrawal of water will increase by 15% (FAO, 2017). There are different sources of water for human usages such as well, boreholes, taps, rivers, and lakes for both domestic and commercial purposes. However, the one that is most simple, less stressful, accessible, and almost costless to rural and urban households is rainwater which can be collected directly from the household's rooftop. Due to increasing water demand, many households in urban areas now resort to rainwater collection for domestic uses (Amin, Mahmoud and Alazba, 2016; Peters, Baroud and Hornberger, 2019).

Accessing water is still a major problem in rural and peri-urban areas as the populations lack access to a good source of water. More so, fluctuation in precipitation is expected due to climate variability (Fröhlich-Nowoisky *et al*., 2016). This is important to consider in adapting to the challenges of shortage of water facing must rural and urban residents as demand for potable water increases on daily basis in Nigeria. In most developing countries, Nigeria inclusive, the level of water supply is inadequate for domestic water needs as only 47% of the total population has access to quality water sources (Mercer and Hanrahan, 2017). More so, the current water supply coverage in Nigeria is put at about 58%, representing 87 million people. It is estimated that about half of the Nigerian population [70 million people], do not have access to a potable water supply (Akoteyon, 2019). More so, low investment and weak policy in the water sector have been responsible for the country's low performance (Akoteyon, 2019).

Rainwater is commonly used particularly by rural and peri-urban households in developing countries and is fast becoming the most common alternative source of water for domestic use during the rainy season and plays an important role in water security as it is affordable, usable, and readily available particularly during the rainy season (Christian, Rahman and Mwangi, 2016; Alim *et al*., 2020). Rainwater provides an opportunity to combat scarcity and shortage of water. Some households also store rainwater against the dry season. Moreover, rainwater is not expensive to maintain and it requires minimal storage to make it available when it is needed (Bailey *et al*., 2018). For instance, in countries like Bangladesh, rainwater has been the most sustainable and affordable source of water (Bashara, Karimb and Imteaz, 2018). This has been recognized by the government and the necessary policy is now in place to encourage households' rainwater harvesting (Bashara, Karimb and Imteaz, 2018). According to Singh and Turkiya (2017), many rural households have access to rainwater as drinking water compared to pipes borne water and bole holes, and it has become a significant safe water supply. Rainwater can be used for different purposes such as domestic (cooking, cleaning, drinking), agricultural, and wetting of the home garden.

Although the use of rainwater has been in existence for decades, there is a paucity of literature on the influence of socio-economic characteristics of households on its usages. Many factors contribute to household's use of rainwater in rural and urban areas and it is important to identify and examine such factors for future policy decisions in Nigeria. Despite the important of rainwater, Nigeria's government is yet to make any policy that encourages its harvesting, usage and storage. Even though, this has been done in other countries like Bangladesh and India. (Bashara, Karimb, Imteaz, 2018; Akoteyon, 2019). An increase in rainwater usage also associates with some important socio-economic features of the people. Therefore, the paper identifies different uses of rainwater and determines the socio-economic factors that may influence the usages in the study area.

Methodology

Ibadan consists of eleven local government areas (LGAs) for administrative and governance purposes with a population of about 4 million (National Population Commission (NPC), 2006). About 6 LGAs are located in the peri-urban of Ibadan city (Akinyele, Egbeda, Ido, Lagelu, Ona-Ara and Oluyole). It is located at longitude 70º 20’ and 70º 40’ East and latitude 30º 55’ and 40º 10’ North.

A multi-stage sampling procedure was applied in the selection processes. Firstly, Ido LGA was randomly selected from LGAs with peri-urban characterizations in Ibadan. Secondly, six peri-urban communities were randomly selected from the list of peri-urban communities in Ido LGA. Thirdly, 21 households were randomly selected from each of the six peri-urban communities to make a total of 126 households as sample size. Although, some households who do not harvest and use rainwater fell into the sample frame (i.e., households who do harvest and use rainwater and households who do not are made of the randomly selected sample size), however, the sample selection model was further employed to take care of such mixed selections resorting to the use of hurdle model. Although 126 questionnaires were administered to the respondents, only 123 were properly filled and returned. The head of the households or representative of head of households were interviewed to give information about rainwater consumption within the households.

The data were collected through a semi-structured questionnaire to obtain some important socioeconomic features and information on rainwater usage from the households. Data on rainwater consumption, access to rainwater, and usefulness of rainwater were collected from the selected households in Ido LGA in Ibadan.

Model specification

Hurdle count data model, Probit and zero-truncated negative binomial regression was applied to analyze the socio-economic factors that may influence the different uses of rainwater within the households. Ordered Probit with sample selection was used to analyze the socio-economic factors that may be responsible towards the extent of rainwater usage. Since data was collected from households that harvest rainwater and the ones that do not, it is important to apply a sample selection model to address the selectivity problem.

Probit and Zero-Truncated Negative Binomial regression

This model is applied to analyze count data with selectivity inherence. Although, the two models are estimated separately, yet, they still provide consistent estimates without bias (Cameron and Travedi, 2005). It is envisaged in the study that different

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uses of rainwater depend on whether households harvest rainwater or not. Thus, the decision to harvest rainwater is defined as dummy variable (Y_i) which is given by a set of explanatory variable X_i, such that:

$$Y_i = \beta X_i + e_i \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Where Y_i is a binary decision whether households harvest rainwater or not and it represents 1 if household harvests rainwater or 0 otherwise. Where e_i is the random error term.

Thus,

$$Y_i^* = \begin{cases} 1 \text{ if household harvest rainwater} \\ 0 \text{ otherwise} \end{cases}$$

Y_i^* = 1 if Y_i > 0 and $Y_i^* = 0$ *otherwise*

The probabilities for each alternative are given by:

$$P(Y_i^* = 1/X_i) = P(Y_i > 0) = \frac{1}{1+e^{-X_i\beta}} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

$$P(Y_i^* = 0/X_i) = P(Y_i \leq 0) = 1 - \frac{1}{1+e^{X_i\beta}} \dots\dots\dots\dots\dots\dots\dots\dots\dots (3)$$

The second stage models the number of things rainwater is used within the household. From the field data collected, the following number of uses were identified: (1) Drinking (2) Cooking (3) Washing clothes (4) Washing dishes (5) Bathing (6) household floor cleaning (7) Spiritual healing (8) Medical purpose. Following the study of Wang, Wang and Huo (2019) Zero-Truncated Negative Binomial model was used based on the fact that if a household decides to harvest rainwater, it must put it to at least one of the uses listed which indicates a positive outcome. Thus, it is important to truncate the distribution of the exogenous variable.

Thus,

Number of uses*/X_i ~ Zero-Truncated Negative Binomial

$$Prob(Y_i = y/y > 0 = U_{TNB}(y) = \frac{\Gamma\left(\varrho+\frac{1}{\eta}\right)}{\Gamma(\varrho+1)\Gamma(1/\eta)} (\eta Y_1)^{\varrho} \left[1+\eta Y_1\right]^{-(\varrho+1/\eta)[1-U_p(0)]^{-1}} \dots\dots\dots (4)$$

Where U_{TNB} is the density function of the zero-truncated negative binomial distribution. ɲ is an auxiliary parameter to be estimated from data. Γ is the gamma function and U_p is the density function of the Poisson distribution. The estimation is run using maximum likelihood.

Ordered Probit with sample selection

Ordered Probit with sample selection (OPSS) is an extension of Heckman's selection model (Heckman, 1979), to account for selectivity (i.e the two-stage decision driving the frequency of rainwater usage, including first decision to harvest rainwater and frequency of rainwater usage). In the OPSS model, we assume that the error terms of both equations (selection and frequency of usage) follow a bivariate normal distribution (Alemi *et al*., 2019). The model is estimated in two stages. Firstly, a binary Probit model to estimate the decision of whether to harvest rainwater or not (Alemi *et al*., 2019). Secondly, the parameters of the frequency of rainwater usage are estimated with the explanatory variables (Graells-Garrido, Ferres and Bravo, 2017). In this study, respondents were asked to rate the frequency of their rainwater

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usage on a scale of 1 to 10. The scale was discretely categorized into 1 for a rating between 0 to 2 (use less frequently), 2 for a rating between 3 to 4 (use sometimes), 3 for a rating between 5 to 6 (use more frequently), 4 for a rating between 7 and above (use most frequently). This was adapted from the rating scale used in Silva, Matos and Martinez-Pecino, (2017) study.

According to Graells-Garrido, Ferres and Bravo (2017), the sample selection model has been extended to Ordered Probit choice models. Graells-Garrido, Ferres and Bravo (2017) described the OPSS as follows:

The first stage takes a binary model approach:

$$d_i^* = \beta' Z_i + e_i \dots\dots (5)$$

$d_i = 1$ if $d_i^* > 0$ and 0 otherwise

$[y_i, z_i]$ is observed if and only if $d_i = 1$

Where e_i is the error term, z_i is the explanatory variable to be estimated and β is the vector of explanatory variable.

Following the suggestion of Mckelvey and Zavoina (1975), we applied OPSS to model our categorical response variable as follows:

$$y_i^* = \beta X_i + \mu_i \dots\dots (6)$$

$$y_i = \begin{cases} 0 \ if \ y_i^* \leq \mu_0 = 0 \\ 1 \ if \ \mu_0 < y_i^* \leq \mu_1 \\ 2 \ if \ \mu_1 < y_i^* \leq \mu_2 \\ . \\ . \\ . \\ j \ if \ y_i^* > \mu_{j-1} \ and \ 0 < \mu_1 < \mu_2 < L < \mu_{j-1} \end{cases}$$

Where y_i^* is observed rating categories for ith individual. y_i^* is a continuous unobserved index of the frequency of rainwater usage. Β is unknown vector of parameters, μ_i is a standard normal error and the unknown threshold points μ_1, μ_2 μ_{j-1} satisfy $\mu_1 < \mu_2 < \mu_{j-1}$. X_i is a vector of explanatory variables for individual ith.

For five response levels (i.e. rating categories, j + 1 = 5), the probabilities are given by:

$$P(y = 0) = \theta(-\beta X_i) \dots\dots (7)$$

$$P(y = 1) = \theta(\mu_1 - \beta X_i) - \theta(-\beta X_i) \dots\dots (8)$$

$$P(y = 2) = \theta(\mu_2 - \beta X_i) - \theta(\mu_1 - \beta X_i) \dots\dots (9)$$

$$P(y = 3) = \theta(\mu_3 - \beta X_i) - \theta(\mu_2 - \beta X_i) \dots\dots (10)$$

$$P(y = 4) = 1 - \theta(\mu_3 - \beta X_i) \dots\dots (11)$$

Where, ϴ(•) is the cumulative normal distribution function. In the Ordered Probit model with selection, the correlation (ρ) between the standard error of the decision to harvest and frequency of rainwater usage equations can be obtained (Silva, Matos and Martinez-Pecino, 2017).

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Results and Discussion

Different Uses of Rainwater

Regarding drinking, about 78.48% of households who harvested rainwater indicated that they drink it. While about 81.91% of rainwater harvested households use it for cooking. Regarding washing dishes and bathing, 87.91% and 71.28% of households indicated that they use it to wash their dishes and bathing respectively. Regarding cleaning of house floor, 91.49% of respondent used it to clean the floor of the house (Struck-Sokolowska *et al*., 2020).

Table 1: Household uses of rainwater

Uses	Percentage
Drinking	78.49
Cooking	81.91
Washing dishes	87.91
Bathing	71.28
House floor cleaning	91.49
Medical uses	4.26
Spiritual uses	29.79

Determinants of Extent of Rainwater Usage

The result shows that some variables significantly influenced the frequency of rainwater usage as the chi^2 value of 71.89 at 0.01 level of probability was higher than the tabular value of 24.99. Since selection bias is expected, additional explanatory variables were added in the second stage of the double-hurdle model. From the Table 2, sex, education, female household size, occupation, and size of rainwater collection material were important factors influencing the frequency of rainwater usage. The result shows that sex of the household head negatively and significantly influenced the frequency of rainwater usage. The finding further suggests that a household with male as the head may not likely use rainwater most frequently compared to the female headed households who take decisions most times on what water is use for within the household. This agrees with the findings of Khandker, Gandhi, and Johnson (2020) that female headed household takes decision on what water is used for within the household. This means there 12.3% probability that a male headed household will less likely use rainwater most frequently. This aligns with our apriori expectation as women use more water within the household and also take decisions on what water is used for. This is also in line with the findings of Hossain and Rahman (2017) that women are in charge of household water management activities. The result shows that education positively and significantly influenced the frequency of rainwater usage. This agrees with the findings of Baiyegunhi (2015) that educational level is an important factor as to what how much water is used within the household. This implies that having a form of education promotes rainwater usage. The reasons may be that an educated household may have the knowledge of treating rainwater and have the assurance that it will cause no harm. The result shows that female household size positively and significantly (at 1% probability level) associated with the frequency of rainwater usage. This indicates that households with a higher number of women use rainwater most frequently. This means that there is a 4.7% probability that households with a higher number of females will use rainwater most frequently. This is expected as more women make use of water within the household. This may be because, household shores are mostly gender-based in the study area as women are mostly into household domestic chores like cooking, washing, and cleaning the house. This supports the finding of Staddon *et al*. (2018) that females within the household have proximity to the practical daily burden of water collection and management. The result shows that occupation negatively and significantly was associated with the frequency of rainwater usage. This suggests that the occupation of the household head may not likely increase the frequency of rainwater usage (Muriu-Ng'ang'a *et al.,* 2017). The result shows that size of rainwater collection material positively and significant (at 5% probability level) influenced the frequency of rainwater usage. This is expected as having a large space to store rainwater is likely to increase the frequency of usage. This implies that household with a large drum will likely use rainwater most frequently (Staddon *et al.,* 2018).

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Table 2: Parameter estimation of frequency of rainwater usage

Variable	Probit	Ordered probit	Marginal effect (use less frequently)	Marginal effect (use sometimes)	Marginal effect (use more frequently)	Marginal effect (use most frequently)
	Coefficient (robust standard error)	Coefficient (robust standard error)	dy/dx (standard error)	dy/dx (standard error)	dy/dx (standard error)	dy/dx (standard error)
sex	-0.771 (0.371)	-1.268*** (0.405)	0.454*** (0.142)	-0.092 (0.103)	-0.238*** (0.075)	-0123*** (0.047)
Marital status	1.066 (0.411)	0.434 (0.692)	-0.147 (0.256)	-0.003 (0.055)	0.092 (0.145)	0.057 (0.069)
No education	-0.272 (0.607)	0.689 (0.672)	-0.180 (0.133)	-0.084 (0.148)	0.121 (0.087)	0.143 (0.183)
Primary	-0.411 (0.667)	1.330** (0.679)	-0.272*** (0.097)	-0.220 (0.174)	0.139** (0.068)	0.352 (0.237)
Secondary	0.427 (0.429)	1.145*** (0.318)	-0.325*** (0.097)	-0.091 (0.100)	0.203*** (0.066)	0.212*** (0.076)
Female household size	-0.106 (0.072)	0.311*** (0.106)	-0.099*** (0.029)	-0.014 (0.032)	0.066** (0.028)	0.047** (0.021)
Male household size	0.035 (0.080)	-0.066 (0.084)	0.021 (0.025)	0.003 (0.008)	-0.014 (0.018)	-0.010 (0.013)
Age	0.031 (0.017)	0.013 (0.014)	-0.004 (0.005)	-0.001 (0.001)	0.002 (0.003)	0.002 (0.002)
Trading	-6.881 (0.974)	-1.558*** (0.606)	0.483*** (0.184)	0.031 (0.113)	-0.273*** (0.095)	-0.241** (0.094)
Civil servant	--	-1.149* (0.610)	0.396* (0.219)	-0.035 (0.112)	-0.224** (0.109)	-0.136** (0.061)
Artisan	-7.168 (1.052)	-2.113*** (0.808)	0.706*** (0.169)	-0.278** (0.137)	-0.296*** (0.008)	-0.131*** (0.046)
Income	--	0.041 (0.035)	-0.013 0.011	-0.002 (0.004)	0.009 (0.008)	0.006 (0.005)
Special roof-top structure	--	-0.125 (0.319)	0.040 (0.099)	0.005 (0.021)	-0.026 (0.068)	-0.019 (0.050)
Size of rainwater collection material	--	0.001*** (0.001)	-0.000** (0.000)	-0.000 (0.000)	0.000** (0.000)	0.000** (0.000)
Years of collection of rainwater	--	-0.009 (0.0124)	0.003 (0.004)	0.000 (0.001)	-0.002 (0.003)	-0.001 (0.001)
Cons_	5.783*** (0.791)					
Cut 1		0.421 (1.140)				
Cut 2		1.516 (1.089)				
Cut 3		2.481** (1.069)				
athrho		0.432 (0.457)				
rho		0.407 (0.381)				

Wald chi^2 (15) = 71.89, prob > chi^2 = 0.000, log pseudo likelihood = -139.092
Probability level represents: ***, for 0.01, **, for 0.05 and *, for 0.1

Determinants of Different Uses of Rainwater

Table 3 presents the results of Hurdle-Truncated Negative Binomial regression with a chi^2 of 32.78 at 0.01 significant level and 320.38 at 0.01 significant level for a decision to harvest rainwater and different uses of rainwater respectively. From Table 3, sex, marital status, age, occupation are important variables responsible for the decision to harvest rainwater. Likewise, education, occupation, special roof-top structure, and size of rainwater collection material are important variables responsible

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for different uses of rainwater. The result shows that sex negatively and significantly (at 5% probability level) influenced the decision to harvest rainwater. This indicates that a male headed household may likely not decide to harvest rainwater compared to female headed household. The finding suggest that male headed household is 19.5% less likely to decide to harvest rainwater. This also aligned with our expectation that a female headed household will likely want to harvest rainwater considering enormous uses of water within household. Likewise, women are the main decision maker on what water is used for within the household. Therefore, the female headed household will likely have serious concern when it comes to rainwater harvesting (Tong, Fan and Niu, 2017). The result shows that marital status positively and significantly (at 1% probability level) influenced the decision on rainwater harvesting. This agrees with our apriori expectation that a married household will like harvest rainwater due to much needs for water as a result more people that need to use water, and are likely to harvest rainwater particularly where there is no alternative. The findings suggests that, there is 25.2% probability that a married household will likely harvest rainwater when it falls. The result shows that occupation inversely and significantly influenced the decision to harvest rainwater within the household. This implies that being employed may likely make the respondents unavailable during raining time to harvest water since they may not be at home. The result shows that age positively and significantly (at 10% probability level) influenced the decision to harvest rainwater. This suggests that a household with an older household head will like to harvest rainwater (Staddon *et al.,* 2018).

Table 3 shows that education positively and significant (at 5% probability level) influenced the numbers of things rainwater is use for within the households. This indicates that having some level of education may likely increase the number of things rainwater is used for within the household. This agrees with the findings of Mekuria, Amede, and Mekonnen, (2020) that education may spurs the knowledge on the treatment of rainwater thereby increase its usage. The result shows that special roof-top structure positively and significantly (at 5% probability level) influenced the number of things rainwater is use for within the household. This agrees with our expectation that having a roof-top structure for collecting water will likely aid the quantity of water collected and what it can be used for (Xu *et al*., 2018). The result shows that size of rainwater collection material positively and significantly (at 10% probability level) influenced the number of things rainwater is used for. This suggests that having a large size of collection materials may likely increase the volume of water collected and number of what is use for. This was expected because large collection materials enable storage of large quantities of water which invariably leads to more uses (Staddon *et al.,* 2018). The result shows that occupation (civil servant) inversely and significant (at 5% probability level) influenced the number of things rainwater is use for. This suggests that someone who is a civil servant with a high level of education may think it is not appropriate or safe to use rainwater for certain domestic shores. This means that someone with an occupation like civil servant will likely use rainwater for less purpose within the household (Muriu-Ng'ang'a et al., 2020).

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Table 3: Parameter estimates of determinants of different uses of rainwater

Variable	Probit Coefficient (robust standard error)	Marginal effect dy/dx (robust standard error)	Truncated NB Coefficient (robust standard error)
sex	-0.844** (0.371)	-0.195* (0.107)	-0.115 (0.135)
Marital status	1.068*** (0.392)	0.252** (0.115)	0.074 (0.102)
No education	-0.215 (0.637)	-0.041 (0.133)	--
Primary	-0.507 (0.642)	-0.111 (0.172)	0.193** (0.084)
Secondary	0.431 (0.406)	0.070 (0.060)	0.048 (0.082)
Female household size	-0.106 (0.073)	-0.018 (0.014)	0.009 (0.017)
Male household size	0.046 (0.075)	0.007 (0.013)	-0.000 (0.021)
Age	0.031* (0.016)	0.005* (0.002)	0.000 (0.002)
Trading	-5.965*** (0.779)	-0.979*** (0.021)	-0.089 (0.111)
Civil servant	-5.827*** (0.692)	-0.993*** (0.008)	-0.231** (0.093)
Artisan	-0.624*** (0.727)	-0.980*** (0.008)	-0.431 (0.271)
Income	0.006 (0.041)	0.001 (0.007)	--
Special roof-top structure	--	--	0.191** (0.076)
Size of rainwater collection material	--	--	0.000* (0.000)
cons	4.798*** (0.689)	--	1.538*** (0.169)
lnalpha	-17.587 (0.111)	--	--
alpha	2.3e-8 (2.55e-9)	--	--
	Wald chi^2 (12) = 320.38 Prob > chi^2 = 0.000 Pseudo R^2 = 0.327 Log pseudolikelihood = -45.19		Wald chi^2 (12) = 32.78 Prob > chi^2 = 0.001 Pseudo R^2 = 0.042 Log pseudolikelihood = -187.56

Probability level represents: ***, for 0.01, **, for 0.05 and *, for 0.1

Conclusion and Recommendations

The use of water is indispensable within the household as water is used for different domestic activities. Likewise, water is still one of the scarce resources most needed by households. The socioeconomic status of the household is a determining factor in

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the harvesting and use of rainwater and an important factor to be considered when making policy decisions regarding the harvesting and the use of rainwater. When initiating policy, the first and important factor to consider is the socioeconomic characteristics of the people concern.

Conflict of interest

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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