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# Determinants of households' involvement in waste separation and collection for recycling in South Africa

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**Abstract** Urbanization and industrial development in many developing countries have brought along significant problem of waste management and other environmental concerns. Recycling is a veritable option already identified in the South Africa's Waste Act of 2008 as a way of reducing negative externalities that are associated with waste accumulation and its improper disposal. This study analysed the factors influencing households' involvement in waste separation/collection for recycling in South Africa within the modified framework of the Theory of Planned Behaviour. The data were the General Household Survey of 2014, which were analysed with descriptive statistics and two-stage probit regression. The results showed that waste bins that were provided by municipalities were used for waste disposal by 43.36% of urban households as compared to 1.54% for those from rural households. More than half of rural households had no means of storing wastes, while payment for disposal was reported by 58.95% of urban households. Also, 8.13% of all households separated wastes for recycling, but urban households had higher involvement with 11.18%. The main reasons for not recycling among urban and rural households were disposal into available bins (68.50%) and notion that it is not important (52.19%), respectively. The two-stage probit regression results showed that monthly income, being married, race (white, Indian, coloured), paying and willing to pay for waste disposal, existence of waste recycling programmes and facilities positively and statistical significantly ($p < 0.10$) influenced recycling, while perception of financial benefits and perception of the importance of recycling reduced it. It was concluded that initiatives to resuscitate recycling behaviours should focus on creation of proper awareness, attitudinal change and ensuring availability of recycling facilities, among others.

**Keywords** Theory of planned behaviour · Recycling · Waste disposal · South Africa

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## 1 Introduction

The African crusade for environmental safety and green economy started in 1970 (Zigegy 2015; Dunlap et al. 2000), given persistent environmental challenges among which inadequate waste management is notable (Brooks 2006; Comrade 1996). In 1992, several world's leaders in Rio de Janeiro accentuated to the notion of incongruous nexus of doom and perpetual gloom between the goals of economic development and environmental conservation. Similarly, after the Rio+20 'Earth Summit' in 2012, African leaders reached a consensus on the need to re-echo sustainable development as a pressing issue to be emphasized in the quests for economic growth and development (Kimanuka 2015). The dynamics of economic growth in many developing countries since the turn of twenty-first century poses significant concerns for environmental conservation and safety in a rapidly urbanized society (Tacoli 2012). Some estimates have shown that 60% of people in the world would live in urban centres by 2030, and developing countries would account for majority of this predicted growth (National Intelligence Council 2012). Similarly, projections have shown that urban transitions in many sub-Saharan Africa will persist in the twenty-first century with urban population being more than double from 298 million in 2010 to 697 million in 2035 (ACP-EC Joint Parliamentary Assembly 2014). Therefore, in many African countries, the worst may not have been witnessed in terms of rapid growth of urban population with its associated environmental challenges.

Although widely reckoned as one of the important parameters of civilization, urbanization comes with a lot of environmental problems, which if not well managed would ultimately result into complete erosion of benefits derived from economic development programmes. This is emphatically pathetic given the prime relevance of ensuring sustainable urban development as prescribed in the 6th and 11th Sustainable Development Goals (SDGs) (United Nations Economic Commission for Africa et al. 2014; United Nations 2015; International Council for Science (ICSU) and ISSC 2015). Presently, inappropriate disposal of wastes is a fundamental development challenge of our time as the quantities and spectrums of domestic and industrial wastes daily increase (Kamara 2006; Lumby 2005).

In South Africa, waste management initiatives graduated from the basic approach that emphasizes the need for a clean and safe environment through appropriate waste disposal methods, to integrated waste management practice with enactment of the Waste Act of 2008 (Act No. 59 of 2008). With effective date of 1 July 2009, the Act compels establishment of National Waste Management Strategy (NWMS) in order to achieve the stated objectives of promoting cleaner environment, reducing volume of generated waste, and invoking culture of waste reuse, recycling and treatment, while disposal is considered only as the option of last resort (South African Waste Information Centre (SAWIC 2014). The policy statement recognizes the fact that defective waste management practices are inimical to the goals of our collective harmonious co-existence. In the long-term period, such practices would compromise our ultimate rights to healthy living.

However, situating South Africa's waste management options within the global contextual practices unfolds some important facts. With the largest most industrialized economy in Africa (Turok 2012), the country faces environmental challenges similar to those of many developed countries. More precisely, Johannesburg is expected to grow to the status of a mega city in 2030 (United Nations et al. 2014). This implies a higher prospect for increase in environmental pollution. In terms of policy, South Africa subscribes to internationally acceptable best practices which are duly promulgated into

legislative laws from time to time. Similarly, initiatives for waste recycling are on ground although their effective utilization is sometimes questionable. The idea of turning waste into wealth is expected to induce involvement of public and private stakeholders in the whole chains of waste management (Republic of South Africa 2012). This is also considered as opportunity for job creation and poverty alleviation.

However, understanding the nature of wastes generated within a society and their quantity are foremost in the drive towards the design of appropriate waste disposal programme (Afroz et al. 2011). A major challenge, however, is that in South Africa, accuracy of waste data is contentious (Department of Environmental Affairs and Development Planning (DEADP) 2011). Some studies have attempted to characterize wastes that are generated in South Africa (Sibernagl 2011). Adoption of different approaches complicates the feasibility of utilizing many of these studies for any reasonable comparison (Wise et al. 2011). Some other technical issues include sampling limitations, small sample size and inability of evaluating relative accuracy of waste sorting procedures (Sol Plaatjie Local Municipality (SPLM). 2010).

In addition, another fundamental problem of waste management in South Africa relates to policy enforcement and monitoring effectiveness due to shortage of suitable waste management experts, deficiency of logistics and standard practices (Mannie, undated). Sustainable management of waste remains a fundamental subject of concern with periodic re-evaluation for service delivery effectiveness and sustainability. Presently, some municipalities are tasked with the responsibility of collecting wastes in some provinces, while private involvements are encouraged for areas where payment for waste disposal is mandatory. The prime efforts of the municipalities in providing conducive environment for all citizens as fundamental human right now require that most of the South Africa's solid wastes would end up in landfills (CSIR 2011a, b). This raises the questions of environmental safety in the long run given some associated health risks arising from possible contamination of ground waters.

South Africa presently faces a sanitation challenge encoded by perennial service breakdown and inadequacy, with not less than 3.2 million households at several environmental risks (Republic of South Africa 2012). In addition, an estimated 1.4 million households residing in the formal settlements are not having access to sanitation services, while about 584,378 households in the informal settlements are making use of some interim services which are very prone to sporadic service delivery failures (Republic of South Africa 2012).

Although institutional frameworks for ensuring landmark achievements in environmental safety are provided by government and other interested private stakeholders, individuals are at the centre point in ensuring successful policy implementation. Adoption of environmentally safe behaviour underscores perfect realization of policy objectives for promoting environmental conservation. This is also systematically linked to households' socio-economic and demographic characteristics, as well as their knowledge and perception of the importance of safe environment. This study therefore aims to determine the factors influencing waste separation/recycling behaviour in South Africa. This will assist in identifying policy interventions and programmes for promoting pro-environmental behaviour, which is a requisite for environmental conservation.

## 2 Theoretical framework and literature

Social science literature is replete with theoretical frameworks for analysing human pro-environmental behaviour. In many instances, boundaries within disciplines only exist for providing some specific definitions that are aimed at demarcating the contextual applications of proposed theories (Morris 2012). Be that as it may, the Theory of Planned Behaviour (TPB) has been extremely applied in empirical studies focusing on changes in individual's behaviour (Morris 2012). Proposed by Ajzen (1985), the theory underpins the interactions of attitudes (believe about behavioural outcomes), subjective norms (motivation to comply) and perceived behavioural control (believe about capability and control) in explaining human behaviour towards some pressing social issues. Furthermore, the theory places emphases on control beliefs, which focus on what a person feels about presence of requisite skills and factors such as time and finances that may be required for proper execution of some behavioural changes. Also, individual's evaluation of the perceived ease of carrying out specific behaviour was emphasized as the perceived behavioural control (Ajzen 1991; Ajzen and Madden 1986), the idea of which was obtained from concept of self-efficacy initially proposed by Bandura (1978,1982, 1986).

Armitage and Conner (2001) emphasized the efficacy of TPB judging from empirical findings from a meta-analysis consisting of 185 studies that were published in 161 articles. However, in some other studies, TPB had been criticized for placing more emphasis on intention rather than belief (Sniehotta et al. 2014) and ignoring the issue of inclined abstainers who may form the intention but fail to act (Orbell and Sheeran 1998). Among others, these criticisms have underscored the need to modify the theory in some empirical studies. Specifically, Sniehotta et al. (2014) noted that it is somehow difficult to defend the notion that TPB explicitly explains all behaviours. It was noted that when the variables of TPB are controlled, some other variables such are socio-economic characteristics of individuals, health status and some environmental factors can objectively predict some human behaviours (Sniehotta et al. 2013).

Understanding the correlates of pro-environmental behaviour is of interest to policy makers and researchers (Kollmuss and Agyeman 2002). Specifically, Department of Environmental Affairs and Tourism (1997) emphasized the need for a mechanism whereby every waste generator in South Africa is responsible for the associated environmental costs. Such policy concern cannot be effectively pursued without having in place studies that model the correlates of pro-environmental behaviours. However, many studies have adopted the TPB in modelling waste recycling behaviours with some modifications given the perceived importance of individuals' socio-economic and demographic variables. Hashim et al. (2015) proposed a modification to the TPB with inclusion of individuals' personality variables. In addition, Nigbur et al. (2010) applied the TPB to predict kerbside recycling behaviours but modified the model by including self-identity, individual norms, neighbourhood identities and social norms variables.

Some previous studies on waste recycling have modified the TPB with inclusion of some socio-economic and demographic variables. This became imperative as a result of inability of some models with strict emphases on TPB variables to adequately explain significant proportion of the variations in some pro-environmental behaviours. Some recent analyses have therefore integrated some attitudinal and beliefs variables into environmental behaviour modelling (Hoyos 2010; Spash et al. 2009) among the modifications proposed to the variables in the TPB given some contextual situations and policy relevance.

Generation of solid wastes is a function of people's economy and their income levels (Grover and Singh 2014). According to Richardson and Havlicek (1974), the quantity of

solid waste generated within a household depends so much on households' size and income. Therefore, it is expected that families with high socio-economic status would generate more waste than those with low socio-economic status (Visvanathan and Trankler 2003). Some other studies have analysed the linkages between recycling behaviour and households' incomes and educational attainments. Callan and Thomas (1997) found that based on some community-level data, the quantities of recycled wastes increased with income and education. Similar findings had been reported by Duggal et al. (1991). However, a study by Hong et al. (1993) found that although income was not significant determinant of recycling, education was. Using individual-level data, Ferrara and Missios (2005) found that income decreased involvement of households in recycling of newspaper and plastics, while attainment of graduate education increased newspaper, aluminium and glass recycling. Grover and Singh (2014) found that income was insignificantly correlated with generation of plastic, food, paper and glass wastes among some households in Dehradun City.

In some other previous studies, Oskamp et al. (1991) found that conservation knowledge predicted recycling behaviour, although none of the demographic variables did. Individuals with better information are likely able to participate in waste recycling, which is in line with several findings in the literature (Gamba and Oskamp 1994; Vicente and Reis 2008). In some other studies, demographic variable included in recycling models gave some inconsistent and inconclusive results (Ebreo et al. 1999; Guerin et al. 2001).

However, Samdahl and Robertson (1989) found higher socio-economic status and education to have significant influences on recycling behaviour. In some other studies, contradictory findings were reported by McGuire (1984) and Oskamp et al. (1991). Vaske et al. (2001) and Hunter et al. (2004) found positive environmental conservation attitudes among female-headed and educated households. Other results have indicated better conservation attitudes among residents in urban areas (Mohai and Twight 1987; Arcury and Christianson 1990) and some occupational status (Ebreo and Vining 2001), while there was no conclusive result in relation to age of individuals (Tindall et al. 2003). However, some studies have reported more conservation behaviour among younger people (Hong 2005; Harris 2006; Hong and Xiao 2007). In some studies, conservation attitudes are related to positive behaviour (Hong 2006; Gong and Lei 2007).

This study seeks to fill the major gap in application of TPB to assessment of waste recycling—pro-environmental behaviour—in South Africa. The introduced modifications similarly reflect relative flexibility of the theory and the fact that such additions may unequivocally promote robustness of estimated econometric parameters. In addition, understanding the nature of data that were used in the study confirms significant national representativeness which many of the previous few studies lack. Therefore, induction of policy mechanisms to address waste disposal in South Africa requires some empirical evidences, which this study seeks to provide.

## 3 Methods

### 3.1 The study area

With total land area of 1,219,602 km square, South Africa is one the largest countries in Africa. It lies between latitude 22°S to 35°S and longitude 17°E to 33°E. The country is administratively divided into nine provinces, which alphabetically arranged are Eastern

Cape, Free State, Gauteng, KwaZulu-Natal, Limpopo, Mpumalanga, Northern Cape, North West and Western Cape. Statistics South Africa (2015a, b) indicated that Gauteng and Kwazulu-Natal provinces are with highest population, while Northern Cape has the lowest population. Ironically, the highest land area belongs to the Northern Cape, while Gauteng has the lowest land area (Alexander, undated).

### 3.2 Data and sampling procedures

This paper used the dataset generated from the General Household Survey (GHS) for 2014. The survey is annually conducted by Statistics South Africa in order to collect vital socio-economic information that could inform some specific economic development policies in South Africa. There are ten different sections into which the 2014 survey questionnaire was divided. Waste disposal methods and other associated questions were in section five tagged information and service delivery. The questionnaire probed into different issues relating to waste disposal, including recycling, which is the focus of this paper. The survey's detailed sampling procedures have been explained by Statistics South Africa (2016). However, it should be re-emphasized that the sampling was implemented with selection of the primary sampling units (PSUs) and dwelling units (DUs) at the first and second stages, respectively. The 2001 population census data were used for stratification of the provincial sample allocation using some geographical and population attributes. Samples were selected based on probability proportional to size and a total of 25,363 households completed the survey using face-to-face interviews. Sample weights were also provided in the data. These made it possible to compute parameters for both weighted and non-weighted data. Weighted parameters were computed by including the sampling weight variable in the course of carrying out the analyses. These weights were automatically used in the computation of the weighted parameters by the software.

## 4 Estimated model

Two-stage probit model was used for estimating the parameters of variables in the specified models. This is a slight modification to the standard Probit model given that income variable in the waste recycling model was suspected to be endogenous. The underlying assumption of estimated parameters being best linear unbiased estimate (BLUE) would be truncated if the standard probit model is used. However, the modelling procedures begin with specification of a latent variable $Y^*$ depicting the likelihood of $Y$ assuming the value of 1. Following Moore (Undated), suppose

$$Y^* = \alpha + \beta X + \varepsilon. \tag{1}$$

$$Y_i = \begin{cases} 1 & \text{if} \quad Y^* > \gamma \\ 0 & \text{if} \quad Y^* \leq \gamma \end{cases}. \tag{2}$$

Note that $\gamma$ is a particular threshold, and since we are unable to observe $Y^*$, the error's distributional pattern is not known. In order to use maximum likelihood estimation (MLE), some assumptions about the error term are made. This presupposes that the distribution follows a standard normal distribution specified as:

$$\Phi^{-1}(\mathrm{P_i}) = \sum_{k=0}^{n} \beta_k X_{ik}. \tag{3}$$

The model which was estimated can be specified as:

$$\mathrm{Y_i} = \sum_{k=0}^{n} \beta_k X_{ik} + \varpi I_i + \varepsilon_i. \tag{4}$$

The model was estimated with for the dependent variable being involvement in recycling from wastes separated or collected. The dependent variable takes the value of 1 if households separate or collects wastes for recycling based on responses to Question 535a in the questionnaire, and zero (0) otherwise. Sensitivity of the results to inclusion of some variables was tested in order to also deduce the robustness of the parameters across the different analyses. It was noted that the results were robust given consistency in the signs of the parameters and their levels of statistical significance (Mcfadden 1999). Based on Heckman's test that was described by Nagler (1999), households' income variable $(I_i)$ was the only variable that was found to be endogenous in the model among those suspected. $X_{ik}$ are the other included exogenous variables presented in Table 1. Therefore, if standard Probit model was used, the parameters would not be BLUE.

Two-stage probit model was suggested by Rivers and Vuong (1988) for endogenous variable with continuous values and use of some instruments. However, the parameter estimated through this two-step method will be inefficient though consistent (Adkins 2009). Newey (1987) proposed the Amemiya's Generalized Least Squares (AGLS) estimator to address endogeneity in limited dependent variable models. This approach was followed in STATA 10.0 software and upward under the two-step method denoted as probit regression with endogenous covariates (Adkins 2009).

In applied econometric analysis, implementation of two-stage probit regression requires proper selection of instruments. This must also be guided by theories. Given that inability to secure sufficient income to meet basic needs predisposes individuals to poverty, this study lends its theoretical anchor on the structural theory of poverty. This theory emphasizes the role of unemployment, low level of education and poor health (Elesh 1970). Conventionally, macro-economic proposition emphasizes the fact that persistent rise in unemployment would reduce the bargaining power of labour through the fear of redundancies (Glyn 2006). Therefore, in this study, the selected instrument for income was looking for job variable. The software also provides Wald test of exogeneity statistics, which, if found to be statistically significant ($p < 0.10$), implies that endogeneity problem had been addressed by the selected instruments and standard probit regression modelling would not be appropriate.

## 5 Results and discussion

### 5.1 Demographic characteristics of respondents

Table 2 shows the racial distribution of the respondents. It reveals that 78.78% of all the respondents were black Africans, 10.12% were coloured, 9.07% were white, and 2.03% were of Indian/Asian origin. These results are in line with findings by Statistics South Africa (2015a, 2015b) that the black population constitutes the majority of South African

**Table 1** Variables included in the model and the expected signs

| | Specification | Expected sign |
|---|---|---|
| Total monthly income | Rands | +ve/-ve |
| Gender of households head (male) | Male = 1, 0 otherwise | −ve |
| Household head age | Years | +ve |
| Household head married | Married = 1, 0 otherwise | +ve |
| Race of household head—white | White = 1, 0 otherwise | +ve |
| Race of household head—coloured | Coloured = 1, 0 otherwise | +ve |
| Race of household head—Indian | Indian = 1, 0 otherwise | +ve |
| Household head formally educated | Formal education = 1, 0 otherwise | +ve |
| Limpopo Province | Limpopo = 1, 0 otherwise | −ve |
| Eastern Cape Province | Eastern Cape = 1, 0 otherwise | −ve |
| Northern Cape Province | Northern Cape = 1, 0 otherwise | −ve |
| Free State Province | Free State = 1, 0 otherwise | −ve |
| KwaZulu-Natal Province | KwaZulu-Natal = 1, 0 otherwise | −ve |
| North West Province | North West = 1, 0 otherwise | −ve |
| Mpumalanga Province | Mpumalanga = 1, 0 otherwise | −ve |
| Household size | Number of people | +ve |
| Paying for waste disposal | Paying = 1, 0 otherwise | +ve |
| Willing to pay for waste disposal | Willing to pay = 1, 0 otherwise | +ve |
| Selling wastes | Selling waste = 1, 0 otherwise | +ve |
| Recycling is important | Yes = 1, 0 otherwise | +ve |
| Financial benefits from recycling | Yes = 1, 0 otherwise | +ve |
| Irregular waste removal as an environmental problem | Yes = 1, 0 otherwise | +ve |
| Littering as an environmental problem | Yes = 1, 0 otherwise | +ve |
| Water pollution as an environmental problem | Yes = 1, 0 otherwise | +ve |
| Air pollution as an environmental problem | Yes = 1, 0 otherwise | +ve |
| Land degradation as an environmental problem | Yes = 1, 0 otherwise | +ve |
| Noise pollution as an environmental problem | Yes = 1, 0 otherwise | +ve |
| Wastes not removed weekly | Yes = 1, 0 otherwise | +ve |
| Wastes removed by communal arrangements | Yes = 1, 0 otherwise | +ve |
| Existence of waste recycling programme | Yes = 1, 0 otherwise | +ve |
| Recycling services easily accessible | Yes = 1, 0 otherwise | +ve |

population with about 80%. However, the table reveals that rural/tribal areas were largely inhabited by the black people with 96.23%, as compared to 68.52% for urban areas. This can be linked to previous deprivations suffered under the apartheid government (Potts 2012) during which majority of the black population were forcefully confined to reside in homelands with less productive land. Residence in urban area is also motivated by possession of some requisite skills which many black South Africans did not have before abolition of apartheid. The table further reveals that majority of the respondents (62.98%) were residing in urban areas (formal and informal), while 37.02% resided in tribal or rural areas. These results go in line with the assertion of Prinsloo (2014) that South Africa is

**Table 2** Demographic characteristics of households' heads in urban and rural South Africa. *Source*: author's computations from 2014 GHS data

| | Urban | | Rural | | All | |
|---|---|---|---|---|---|---|
| | Freq (mean) | % (SD) | Freq (mean) | % (SD) | Freq (mean) | % (SD) |
| *Gender* | | | | | | |
| Male | 9740 | 60.99 | 4478 | 47.70 | 14,218 | 56.07 |
| Female | 6230 | 39.01 | 4909 | 52.30 | 11,139 | 43.93 |
| *Race* | | | | | | |
| African/black | 10,942 | 68.52 | 9033 | 96.23 | 19,975 | 78.78 |
| Coloured | 2388 | 14.95 | 179 | 1.91 | 2567 | 10.12 |
| Indian/Asian | 506 | 3.17 | 8 | 0.09 | 514 | 2.03 |
| White | 2134 | 13.36 | 167 | 1.78 | 2301 | 9.07 |
| *Employment* | | | | | | |
| Looking for job | 1234 | 7.73 | 617 | 6.57 | 1851 | 7.30 |
| Employed | 9984 | 62.52 | 3685 | 39.26 | 13,669 | 53.91 |
| Unemployed | 1171 | 7.33 | 576 | 6.14 | 1747 | 6.89 |
| *Education* | | | | | | |
| Literate | 14,965 | 93.71 | 7053 | 75.14 | 22,018 | 86.83 |
| *Other socio-economic variables* | | | | | | |
| Age | (47.95) | (15.04) | (51.49) | (17.32) | (49.26) | (16.01) |
| Household size | (3.40) | (2.15) | (4.05) | (2.78) | (3.65) | (2.43) |
| Income | (9082.27) | (9290.58) | (4078.02) | (5234.94) | (7229.53) | (8386.99) |

about 63% urbanized. However, urbanization is one of the major drivers of environmental problems in many developing countries due to increasing pressure on the limited land resources and social services as rural–urban migration persists (Lumby 2005; Kamara 2006).

The results in Table 2 further show that 7.30% of all the respondents indicated to be looking for job, while 6.89% was not employed. However, 62.52% of urban resident indicated to be employed as against 39.26% for rural areas. The results further show that 86.83% of all the respondents indicated to be literate. In urban and rural areas, 95.31 and 75.15%, respectively, indicated to be literate. Education is critical for securing gainful employment in the formal sector of South Africa (Statistics South Africa 2015a, b). Unemployment is currently one of the major problems in South Africa (Malakwane 2012), although recycling initiatives are expected to be driven towards job creation (Njoroge et al. 2013). Joblessness portends a situation of economic deprivation which affects attitudes of the victims to environmental conservation. Although illiteracy is a major barrier to embracing environmentally benign practices in the face of persistently growing environmental problems, sometimes, it takes some efforts for individuals whether educated or not to inculcate habits that promote sustainable environmental management (World Bank 1992).

The results further show that there were more male-headed households (56.07%) than female-headed households (43.93%). In addition, 60.99 and 47.70% of the households in urban and rural areas were headed by males, respectively. These results are in alignment

with the assertion of the Department of Health et al. (2007) that almost half of South African households is headed by women. It should be noted that persistence of rural–urban migration of able bodied men in South Africa is redefining the demographic compositions in rural and urban areas, with the former having more female-headed households (Posel 2001). It also underscores persistence of rural poverty and vulnerability to social exclusion, which are often concentrated among female-headed households (O'Laughlin 1996).

The average age of all the respondents was 49.26 years with standard deviation of 16.01. This is quite higher than average age of 39.4 years that was reported by Mamady (2016) for Guinea. However, respondents from rural areas were older with average age of 51.49 years and standard deviation of 17.32 as compared to their counterparts from urban areas with average age of 47.95 years and standard deviation of 15.04. Similarly, respondents from rural areas had higher average household size (4.05) as compared to 3.40 for urban dwellers. Average income was higher in urban areas with R 9082.27, while their rural counterparts had average of R 4078.02. Anderson et al. (2013) noted that some aged black South Africans were involved in waste collection for recycling during apartheid government due to their precariously deplorable socio-economic status. Involvement in recycling wastes might now be perceived as painful retention of the sad memories of deprivation experiences under apartheid. This contradicts the expectation in some other developed countries where aged people see recycling as performance of important social responsibility (Anderson et al. 2013).

### 5.2 Households' perception of environmental problems

Perception of environmental problems is a major step towards adoption of pro-environmental behaviours (Eilam and Trop 2012). Some form of linear relationship was assumed between individuals' attitudes and pro-environmental behaviours in some earliest environmental education models (Burgess et al. 1998; Kollmuss and Agyeman 2002; Eilam and Trop 2012). Figure 1 shows the perceived environmental problems across rural and urban South Africa. It reveals that the most perceived problems among urban dwellers were littering (30.95%), land degradation (27.28%), outdoor/indoor air pollution (19.54%) and irregular or no waste removal (19.29%). However, among rural dwellers, land degradation, littering, irregular or no waste removal and outdoor/indoor pollution were indicated as environmental problems perceived by 50.95, 35.44, 34.94 and 18.77% of the households, respectively. In the combined data, land degradation (36.35%), littering (32.61%) and irregular or no waste removal (25.09%) were the most reported environmental problems by the households.

Littering and other forms of environmental pollution are critical externalities resulting from households' and firms' consumption and production activities (Nahman et al. 2009). Inability to properly direct the cost of cleaning environment or pollution resulting from human activities incentivizes polluters to release pollution above the level that is socially optimal (Randall 2008). The most pathetic issue in discharge of man's environmental stewardship role is inability to properly coordinate activities for bringing about restoration of degraded natural resources. Specifically, persistence of erosion (wind and water), overgrazing and low investment in soil management practices are among the fundamental drivers of land degradation in South Africa (Kotze and Rose 2015). Water pollution become inevitable where there is inadequate sanitation and irregular collection of accumulate wastes from dump sites. Given that in South Africa, about 91% of the ecological zones is classified and arid or semi-arid, desertification and soil degradation are further aggravated by climate change (Gbetibouo and Ringler 2009).

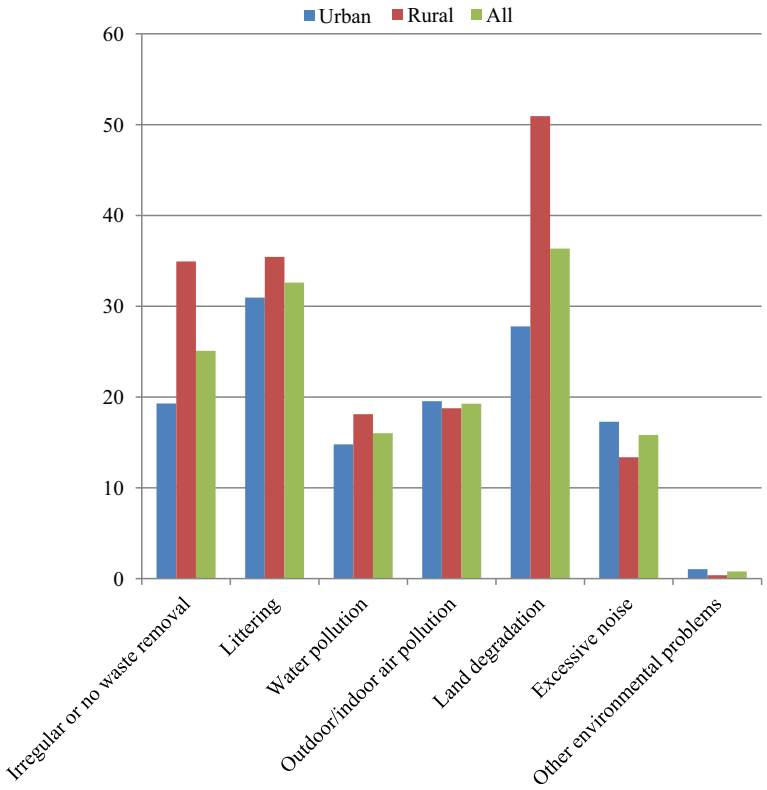


**Fig. 1** Percentage distribution of perceived environmental problems in urban and rural South Africa

### 5.3 Solid waste storage, disposal methods and recycling

Figure 2 shows the different means of storing waste before disposal in urban and rural South Africa. It reveals that waste bins provided by municipality were used by 43.36% of urban households as compared to 1.54% by those from rural areas. The results point at the tendency of municipalities to take waste collection in urban centres more seriously than they would do for rural areas (CSIR 2011). However, plastic bags were used by 30.91 and 15.62% of urban and rural residents, respectively. Since government banned offering of free plastic bags to buyers in order to reduce littering of the environment, plastic bags of higher quality and durability are now sold in every shop. Therefore, these plastic bags are used by many households for storing wastes for final disposal (Agen 2008) given that consumers prefer to buy new bags every time they visit supermarket. However, more than halve (56.50%) of respondents from rural areas indicated non-usage of any waste storage containers or bag as against 3.43% in urban areas.

The means of disposing domestic solid wastes are presented in Table 3. The table shows that 84.99% of urban households disposed of their waste through local authority/private companies at least once a week against 5.88% by rural dwellers. However, 77.95% of rural dwellers were dumping rubbish anywhere as compared to 4.19% in urban areas. The proportion of the respondents that was paying for waste disposal among all the respondents is 37.91%. However, urban residents constituted 58.95% as against 2.11% for rural

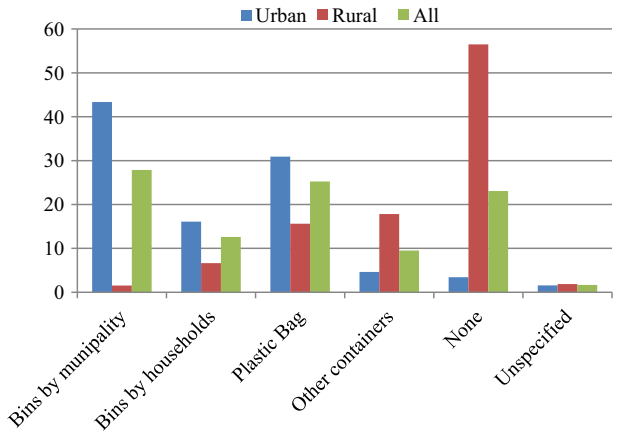


**Fig. 2** Percentage distribution of households' means of storing wastes before disposal in urban and rural South Africa

dwellers. These results underscore indiscriminate waste disposal attitudes of rural dwellers. This can be explained from low socio-economic status of many of these households, which could have made it difficult for them to afford paying for waste disposal through any private arrangements.

**Table 3** Means of solid waste disposal by households and paying in urban and rural South Africa. *Source*: author's computations from 2014 GHS data

| Sector | Urban | | Rural | | All | |
|---|---|---|---|---|---|---|
| Frequency/percentage | Freq | % | Freq | % | Freq | % |
| Removed by local authority/private company at least once a week | 13,573 | 84.99 | 552 | 5.88 | 14,125 | 55.70 |
| Removed by community members, contracted by the municipality | 560 | 3.51 | 47 | 0.50 | 607 | 2.39 |
| Removed by community members, contracted by the municipality | 319 | 2.00 | 121 | 1.29 | 440 | 1.74 |
| Removed by community members, contracted by the municipality | 32 | 0.20 | 43 | 0.46 | 75 | 0.30 |
| Removed by community members at least once a week | 11 | 0.07 | 31 | 0.33 | 42 | 0.17 |
| Removed by community members less often than once a week | 12 | 0.08 | 8 | 0.09 | 20 | 0.08 |
| Communal refuse dump/communal container | 181 | 1.13 | 127 | 1.35 | 308 | 1.21 |
| Own refuse dump | 161 | 1.01 | 95 | 1.01 | 256 | 1.01 |
| Dump or leave rubbish anywhere | 669 | 4.19 | 7317 | 77.95 | 7986 | 31.49 |
| Other (specify) | 194 | 1.21 | 404 | 4.30 | 598 | 2.36 |
| Do not know | 18 | 0.11 | 32 | 0.34 | 50 | 0.20 |
| Unspecified | 240 | 1.50 | 610 | 6.50 | 850 | 3.35 |
| *Paying and willing to pay* | | | | | | |
| Paying for waste disposal | 9414 | 58.95 | 198 | 2.11 | 9612 | 37.91 |
| Willing to pay | 1712 | 10.72 | 190 | 2.02 | 1902 | 7.50 |

Table 4 shows that although 8.13% of all the respondents separated wastes for recycling, participation in urban areas is higher with 11.18% as compared to 2.93% for rural areas. However, out of the 11.18% who separated waste for recycling in urban areas, 3.87% were involved in collection of wastes from place to place for recycling. Similar findings had been reported by CSIR (2013) indicating that given some constraints, the target of ensuring that by 2016, all South African households would be separating their wastes for recycling purposes is unachievable. It was noted that in some preliminary results reported by CSIR, due to deficiency in creating public awareness as emphasized in the Waste Act of 2008 (Republic of South Africa 2009), only 3.3% of urban residents recycled their recyclable waste on a regular basis in 2010.

Items separated and collected for recycling by the households are presented in Fig. 3. The figure shows that in urban areas, plastic bags/bottles and glass/glass bottles were with highest percentages of 7.42 and 6.84, respectively. However, in rural areas, the highest percentages were for aluminium cans and metals and glass/glass bottles with 1.70 and 1.32%, respectively. In the combined data, plastic bags/bottles and glass and glass bottles are with highest percentages of 5.02 and 4.80, respectively. At households' level, the wastes that could be easily recycled are plastic bags and bottles.

Figure 4 further shows the nature of items collected by households for recycling. It reveals that glass/glass bottles and plastic/plastic bags/plastic bottles were collected for recycling by 2.33 and 2.09% of the households from urban areas. In rural areas, the highest proportions of the households were recycling metal/aluminium cans (1.89%) and glass/-glass bottles (1.03%). However, in the combined data, glass/glass bottles (1.85%) and metal/aluminium cans (1.69%) were with highest percentages.

Plastic bags are essential items for carrying purchased items during shopping, while plastic bottles and glass bottles could become households' wastes through consumption of alcohols, soft drinks, bottled water, medications, etc. Because some of these products would take very long time to decompose, recycling becomes a reasonable option (CSIR 2013). Specifically, plastic bottle takes about 700 years to fully decompose (Anonymous, no date). Aluminium and steels are recyclable materials that could save the economy significant cost, energy and manpower. The fundamental advantage in recycling aluminium and steel is that they could be reused and re-recycled repeatedly (Anonymous, no date). Sometimes, for those collecting wastes for sale, preferences are given to aluminium and steel because they command more money.

Table 5 shows the reasons indicated by the households for getting involved in recycling. Urban households were largely recycling in order to reduce wastes (6.88%), reduce litter and pollution (5.37%), save energy and natural resources (4.20%) and save landfill spaces (3.67%). However, in rural areas, the most common reasons for recycling were to sell wastes (1.35%) and to reduce waste (1.00%). Couch et al. (1979) and Luyben and Bailey

**Table 4** Separation of waste for recycling and type of wastes separated by households in urban and rural South Africa. *Source*: author's computations from 2014 GHS data

| Sector | Urban | | Rural | | All | |
|---|---|---|---|---|---|---|
| Recycling | Freq | % | Freq | % | Freq | % |
| Separate wastes for recycling | 1786 | 11.18 | 275 | 2.93 | 2061 | 8.13 |
| Collect waste for recycling | 618 | 3.87 | 232 | 2.47 | 850 | 3.35 |
| Sell any collected waste | 267 | 1.67 | 181 | 1.93 | 448 | 1.77 |

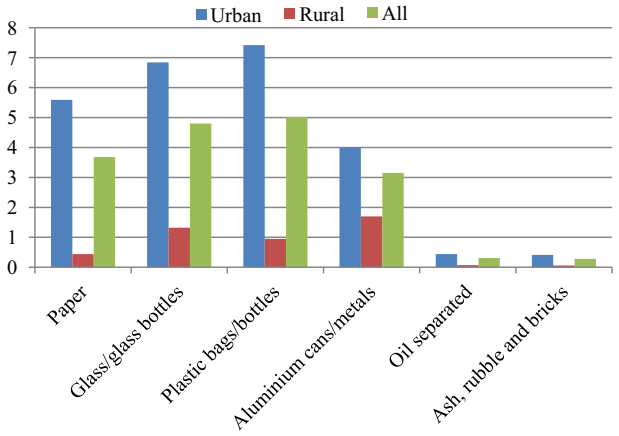


**Fig. 3** Percentage distribution of items separated for recycling in urban and rural South Africa

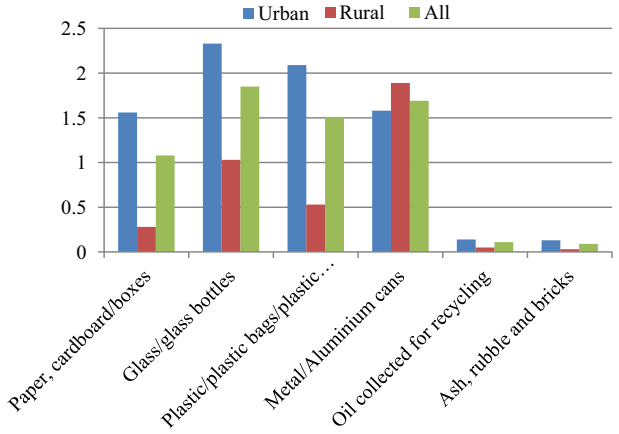


**Fig. 4** Percentage distribution of items collected for recycling in urban and rural South Africa

(1979) noted that motivating recycling behaviour among households had been emphasized by some behavioural psychologists through creation of some monetary incentives, while punishment is conceived as threat to people's freedom (Geller 1989). DeYoung (1985-86) found that monetary incentives are not primary determinants of decision to recycle. It was further noted that intrinsic motivations and satisfactions are critical in explaining households recycling behaviour. In another study by Churchard (2007), it was highlighted that two-thirds of respondents pointed as monetary rewards as important motivator for recycling. In the combined data, reduction of wastes (4.70%), reduction of litter and pollution (3.65%) and saving energy and natural resource (2.78%) were among the most common reasons for recycling.

Omran et al. (2012) submitted that participation in recycling could be enhanced if policy makers possess proper understanding of the reasons why households are reluctant to recycle wastes. Therefore, Table 6 presents the reasons why households were not recycling in urban and rural South Africa. It shows that in the combined data, 48.69% of the households did not recycle wastes because they were thrown inside dust bins to be

**Table 5** Reasons why households separated wastes for recycling in urban and rural South Africa. *Source*: author's computations from 2014 GHS data

| Sector | Urban | | Rural | | All | |
|---|---|---|---|---|---|---|
| Recycling | Freq | % | Freq | % | Freq | % |
| To reduce waste | 1098 | 6.88 | 94 | 1.00 | 1192 | 4.70 |
| To save energy/natural resources | 670 | 4.20 | 35 | 0.37 | 705 | 2.78 |
| To save landfill space | 586 | 3.67 | 41 | 0.44 | 627 | 2.47 |
| To reduce litter and pollution | 857 | 5.37 | 69 | 0.74 | 926 | 3.65 |
| Because a recycling service is easily accessible | 509 | 3.19 | 26 | 0.28 | 535 | 2.11 |
| To support a community/school recycling programme | 499 | 3.12 | 46 | 0.49 | 545 | 2.15 |
| To sell waste | 222 | 1.39 | 127 | 1.35 | 349 | 1.38 |

collected by some designated people. Specifically, in urban and rural areas, 68.50 and 14.99% of the households were not recycling because of this reason. In addition, majority of respondents from rural areas (52.19%) indicated that they were not recycling wastes because they do not think it is important. This proportion can be compared with 29.12% that gave the same reason in urban areas. However, in the combined data, 37.66% of the respondents indicated non-participation in recycling as a result of not thinking that it is important. The results are pointing to the submission of Perrin and Barton (2001) that because of their fundamental role in recycling processes, households must be properly carried along in understanding the importance of recycling programmes. Harland et al. (2007) emphasized that households that held strong and positive notions on the benefits on recycling were more involved in recycling.

Furthermore, inadequate facilities for recycling were indicated as reason for not recycling by 31.78 and 38.44% of the respondents from urban and rural areas, respectively. Also, in the combined data, 34.24% of the respondents indicated inadequate facilities as reason for not recycling. Similarly, in urban and rural areas, 28.95 and 34.84% of the respondents were not recycling due to availability of too few recyclables. In the combined data, 31.13% of the respondents indicated this reason. It should be further noted that non-

**Table 6** Reasons why households were not recycling wastes in urban and rural South Africa. *Source*: author's computations from 2014 GHS data

| Sector | Urban | | Rural | | Total | |
|---|---|---|---|---|---|---|
| Reasons for not recycling | Freq | % | Freq | % | Freq | % |
| Throw out into dustbin for refuse collection | 10,940 | 68.50 | 1407 | 14.99 | 12,347 | 48.69 |
| Do not think it is important | 4651 | 29.12 | 4899 | 52.19 | 9550 | 37.66 |
| Do not have adequate facilities | 5075 | 31.78 | 3608 | 38.44 | 8683 | 34.24 |
| Too few recyclables | 4623 | 28.95 | 3270 | 34.84 | 7893 | 31.13 |
| No/not enough financial benefit | 4055 | 25.39 | 2805 | 29.88 | 6860 | 27.05 |
| Takes too much time to separate | 5268 | 32.99 | 3211 | 34.21 | 8479 | 33.44 |
| No recycling services available | 4529 | 28.36 | 4771 | 50.83 | 9300 | 36.68 |
| Recycling drop-off points not conveniently located | 3984 | 24.95 | 2513 | 26.77 | 6497 | 25.62 |
| Community programme for recycling | 2437 | 15.26 | 406 | 4.33 | 2843 | 11.21 |

existence of recycling services was indicated as reason for not recycling by 50.83% of respondents from rural areas, while 28.36% indicated same reason in urban areas. The perception of households on effectiveness of recycling programmes was emphasized by Nigbur et al. (2004). A study by Gamba and Oskamp (1994) found that positive perception of recycling effectiveness was correlated with recycling behaviour in California.

Similarly, approximately one out of four respondents indicated that they were not recycling because drop-off points for recycling were not located in convenient places. Approximately one out of every three respondents indicated time-consuming nature of waste separation for recycling as reason for not being involved in recycling exercises in urban areas, rural areas and the combined data, while about one out of four complained about inadequacy of the financial benefits. Such inconveniences would amount to nothing if households hold some concerns for the state of the environment. Specifically, Gamba and Oskamp (1994) and Meen-Chee and Narayanan (2006) noted that positive concerns for environmental conservation are critical motivations for recycling. Therefore, recycling is positively associated with higher concerns for the environment (Oskamp et al. 1991).

## 6 Determinants of waste separation and collection for recycling

Tables 7, 8 and 9 show the results of weighted and non-weighted parameters of the two-stage probit regression for the estimated models of waste separation/collection for recycling in the combined data, urban households and rural households, respectively. The included variables in all the models were first subjected to multicollinearity test using the variance inflation factor (VIF). The results that were initially obtained warranted removal and reformulation of the proposed models, although some due considerations were given to the need to guard against committing specification errors. The results as shown in the last column of the tables reveal that multicollinearity was properly addressed in the model with all variables having high tolerance levels and overall average VIFs were 1.42, 1.32 and 1.26 for combined data, urban and rural data, respectively. Also, estimation of income through instrumentation was justified by statistical significance of the Wald statistics ($p < 0.10$), except in weighted model for rural households (Table 9). This implies that detected problem of endogeneity had been adequately addressed by the selected instrument, and estimation of Eq. 4 using standard probit regression method would have produced parameters that would violate the BLUE assumptions.

The results in Table 7 show that probability of separating/collecting wastes for recycling decreased significantly ($p < 0.10$) as the total monthly income increased in the weighted and non-weighted parameters. In Table 8 (results for urban households), income did not show statistical significance, while Table 9 (results for rural households) only shows statistical significance ($p < 0.05$) for the non-weighted model. This implies that among urban households, income was more or less irrelevant in the decision to be involved in waste separation/recycling. It should also be noted that the magnitudes of impacts were very small in all the models. These findings go contrary to the findings of Guerin et al. (2001). Household heads' incomes can influence recycling negatively through several channels. Specifically, where involvement in recycling is primarily motivated by the income gains, rich people would not participate. However, Jenkins et al. (2000) noted that in some other context, households' income may increase waste recycling because of likely positive correlation between income and consumption of recyclable materials such as newspapers. In some instances, recycling facilities and collection channels may be closer to wealthier households, thereby enhancing their participation (Kamara 2006). The finding

**Table 7** Weighted and unweighted estimated parameters of waste recycling behaviour using two-stage probit regression. *Source*: author's computations from 2014 GHS data

| Variables | Recycling involvement | | Recycling involvement | | Tolerance |
|---|---|---|---|---|---|
| | Unweighted coefficient | *t*-stat. | Weighted coefficient | *t*-stat. | |
| *Socio-economic characteristics* | | | | | |
| Total monthly income | −0.00,003* | −1.68 | −0.00004* | −1.82 | 0.6213 |
| Gender of households head (male) | −0.06124 | −1.43 | −0.03259 | −0.61 | 0.7355 |
| Household head age | 0.00136 | 1.02 | 0.00313* | 1.81 | 0.7795 |
| Household head married | 0.25339*** | 4.26 | 0.26760*** | 3.42 | 0.6733 |
| Race of household head—white | 1.03529*** | 8.01 | 1.13082*** | 8.35 | 0.6803 |
| Race of household head—coloured | 0.24086*** | 4.55 | 0.30896*** | 4.89 | 0.7709 |
| Race of household head—Indian | 0.92766*** | 7.81 | 0.98739*** | 7.65 | 0.8732 |
| Household head formally educated | −0.12785* | −1.88 | −0.15707* | −1.93 | 0.8179 |
| Limpopo Province | −1.03339*** | −9.93 | −1.00708*** | −8.36 | 0.5429 |
| Eastern Cape Province | −0.98479*** | −16.59 | −0.90172*** | −12.18 | 0.6383 |
| Northern Cape Province | −0.64748*** | −8.40 | −0.60052*** | −6.28 | 0.8400 |
| Free State Province | −0.65103*** | −9.00 | −0.54311*** | −5.60 | 0.7477 |
| KwaZulu-Natal Province | −0.52328*** | −8.94 | −0.46481*** | −7.46 | 0.5940 |
| North West Province | −0.48755*** | −7.95 | −0.39907*** | −5.55 | 0.7041 |
| Mpumalanga Province | −0.31140*** | −4.69 | −0.22085*** | −2.78 | 0.6204 |
| Household size | 0.01478 | 1.43 | 0.02069 | 1.60 | 0.8300 |
| Urban | 0.01155 | 0.20 | −0.02081 | −0.29 | 0.4243 |
| *Attitudes (believe about behavioural outcomes)* | | | | | |
| Paying for waste disposal | 0.56601*** | 7.55 | 0.62801*** | 6.85 | 0.4487 |
| Willing to pay for waste disposal | 0.35443*** | 5.25 | 0.36059*** | 4.32 | 0.8082 |
| Selling wastes | 2.82888*** | 20.87 | 3.00840*** | 14.33 | 0.9649 |
| Recycling is important | −0.52749*** | −12.77 | −0.40187*** | −8.07 | 0.8381 |
| Financial benefits from recycling | −1.52013*** | −24.66 | −1.75668*** | −16.71 | 0.7086 |
| *Subjective norms (motivation to comply)* | | | | | |
| Irregular waste removal as an environmental problem | −0.07310 | −1.49 | −0.13423** | −2.35 | 0.6643 |
| Littering as an environmental problem | −0.02014 | −0.47 | 0.00907 | 0.17 | 0.6274 |
| Water pollution as an environmental problem | −0.37465*** | −6.68 | −0.38817*** | −5.69 | 0.6994 |
| Air pollution as an environmental problem | 0.13424*** | 2.63 | 0.02939 | 0.46 | 0.6334 |
| Land degradation as an environmental problem | 0.18109*** | 4.35 | 0.17647*** | 3.59 | 0.6777 |
| Noise pollution as an environmental problem | 0.02950 | 0.63 | −0.03051 | −0.56 | 0.8003 |
| Wastes not removed weekly | 0.18467* | 1.80 | 0.16187 | 1.25 | 0.9402 |
| Wastes removed by communal arrangements | −0.18729 | −1.50 | −0.23226 | −1.51 | 0.9729 |
| Existence of waste recycling programme | 0.83322*** | 20.08 | 0.77067*** | 14.98 | 0.9183 |

**Table 7** continued

| Variables | Recycling involvement | | Recycling involvement | | Tolerance |
|---|---|---|---|---|---|
| | Unweighted coefficient | *t*-stat. | Weighted coefficient | *t*-stat. | |
| *Perceived behavioural control (capability and control)* | | | | | |
| Recycling services easily accessible | 0.12840*** | 3.03 | 0.26703*** | 4.74 | 0.7472 |
| Constant | −0.98669*** | −7.70 | −1.05813*** | −6.08 | |
| *Diagnostic indicators* | | | | | |
| Athrho | 0.28005** | 2.46 | 0.35458** | 2.41 | |
| lnsigma | 8.78688 | 1978.78 | 8.81839 | 1003.05 | |
| Rho | 0.27296 | | 0.34044 | – | |
| Sigma | 6547.76100 | | 6757.34200 | – | |
| Mean VIF | 1.42 | | 1.42 | | |
| Number of observations | 25347 | | 25347 | | |
| Log likelihood | −262497.52 | | −162110. | | |
| Wald Chi-square | 3746.90*** | | 2655.54*** | | |
| Wald test of exogeneity (/athrho = 0): | 6.03*** | | 5.83*** | | |

* Significant at 10% level of significance; ** Significant at 5% level of significance; *** Significant at 1% level of significance

from these results generally indicates low involvement of wealthy people in waste recycling. This could have resulted from high likelihood of rich people having organized arrangement for timely waste disposal.

The results further show that many of the parameters of gender and age in all the models presented in Tables 7, 8 and 9 did not show statistical significance ($p > 0.10$). The only exceptions were in the weighted results for the combined data (Table 7) where age was significant ($p < 0.10$) and unweighted results for urban households (Table 8) where gender showed statistical significance ($p < 0.10$). It should also be noted that while gender parameters for urban households were with negative sign, those for rural households had positive sign. The statistical significance of one gender parameter for urban households implies that male-headed households in urban areas had significantly lower probability of separating/recycling waste. More precisely, exploring gender factor in waste recycling decision is of significant relevance to waste management policies and programme design (Dube-Matutu 2017; Mohai 1992). Because women are primarily responsible for handling wastes, their relevance in separation and recycling cannot be overemphasized. Specifically, urban poor women may explore opportunities in wealth generation through involvement in waste recycling activities.

Except in weighted parameter for rural households, being married variables showed statistical significance ($p < 0.05$) in all the results in Tables 7, 8 and 9. These results imply that households with married heads had higher probability of separating/collecting wastes for recycling, other variables being held constant. Marital status is expected to be positively associated with waste generation (Sankoh et al. 2014), thereby necessitating recycling. The results of Al-Khatib et al. (2009) also pointed at the fact that marital status was one of the variables with strong correlations with littering behaviour and some practices that are

**Table 8** Urban weighted and unweighted estimated parameters of waste recycling behaviour using two-stage probit regression. *Source*: author's computations from 2014 GHS data

| Variables | Recycling involvement | | Recycling involvement | | Tolerance |
|---|---|---|---|---|---|
| | Unweighted coefficient | *t*-stat. | Weighted coefficient | *t*-stat. | |
| *Socio-economic characteristics* | | | | | |
| Total monthly income | −0.00001 | −0.80 | −0.00002 | −1.18 | 0.6366 |
| Gender of households head (male) | −0.08176* | −1.67 | −0.05189 | −0.84 | 0.7083 |
| Household head age | 0.00167 | 0.87 | 0.00330 | 1.32 | 0.7869 |
| Household head married | 0.22293*** | 2.95 | 0.26914*** | 2.72 | 0.6162 |
| Race of household head—white | 0.93184*** | 7.07 | 1.07254*** | 7.50 | 0.6695 |
| Race of household head—coloured | 0.26765*** | 4.71 | 0.34553*** | 5.01 | 0.7866 |
| Race of household head—Indian | 0.80872*** | 6.40 | 0.89144*** | 6.41 | 0.829 |
| Household head formally educated | −0.07685 | −0.83 | −0.12157 | −1.06 | 0.9018 |
| Limpopo Province | −1.17753*** | −5.03 | −1.16621*** | −3.88 | 0.9475 |
| Eastern Cape Province | −1.08593*** | −14.73 | −0.99607*** | −11.37 | 0.8035 |
| Northern Cape Province | −0.62257*** | −7.52 | −0.55947*** | −5.02 | 0.8755 |
| Free State Province | −0.68114*** | −8.58 | −0.53278*** | −4.80 | 0.7738 |
| KwaZulu-Natal Province | −0.41362*** | −6.22 | −0.35837*** | −5.06 | 0.7349 |
| North West Province | −0.48957*** | −6.44 | −0.45307*** | −5.01 | 0.8737 |
| Mpumalanga Province | −0.46787*** | −5.26 | −0.36521*** | −3.29 | 0.8069 |
| Household size | 0.01450 | 1.13 | 0.02311 | 1.39 | 0.8322 |
| Urban | – | – | – | – | – |
| *Attitudes (believe about behavioural outcomes)* | | | | | |
| Paying for waste disposal | 0.51122*** | 6.38 | 0.56205*** | 5.64 | 0.5978 |
| Willing to pay for waste disposal | 0.38529*** | 5.06 | 0.35846*** | 3.88 | 0.7988 |
| Selling wastes | 2.94820*** | 19.56 | 3.27811*** | 13.32 | 0.957 |
| Recycling is important | −0.48943*** | −10.86 | −0.37027*** | −6.58 | 0.8053 |
| Financial benefits from recycling | −1.84700*** | −26.76 | −2.09928*** | −17.21 | 0.6631 |
| *Subjective norms (motivation to comply)* | | | | | |
| Irregular waste removal as an environmental problem | −0.07290 | −1.18 | −0.14716** | −2.04 | 0.6616 |
| Littering as an environmental problem | −0.06108 | −1.18 | −0.00638 | −0.10 | 0.6053 |
| Water pollution as an environmental problem | −0.36384*** | −5.36 | −0.39725*** | −4.85 | 0.6547 |
| Air pollution as an environmental problem | 0.19005*** | 3.05 | 0.06587 | 0.86 | 0.6077 |
| Land degradation as an environmental problem | 0.18760*** | 3.77 | 0.17679*** | 2.95 | 0.6905 |
| Noise pollution as an environmental problem | −0.01698 | −0.31 | −0.08367 | −1.34 | 0.8066 |
| Wastes not removed weekly | 0.33310*** | 3.02 | 0.26789* | 1.88 | 0.8996 |
| Wastes removed by communal arrangements | −0.24478* | −1.65 | −0.42701** | −2.56 | 0.9531 |
| Existence of waste recycling programme | 0.85062*** | 19.28 | 0.78301*** | 13.73 | 0.9327 |

**Table 8** continued

| Variables | Recycling involvement | | Recycling involvement | | Tolerance |
|---|---|---|---|---|---|
| | Unweighted coefficient | *t*-stat. | Weighted coefficient | *t*-stat. | |
| *Perceived behavioural control (capability and control)* | | | | | |
| Recycling services easily accessible | 0.24865*** | 5.11 | 0.38965*** | 5.95 | 0.7148 |
| Constant | −1.04730*** | −6.66 | −1.15009*** | −5.24 | |
| *Diagnostic indicators* | | | | | |
| Athrho | 0.21757* | 1.72 | 0.31345* | 1.90 | |
| lnsigma | 8.89964*** | 1590.47 | 8.91192*** | 925.22 | |
| Rho | 0.21420* | 1.77 | 0.30358** | 2.03 | |
| Sigma | 7329.34 | 178.71 | 7419.890*** | 103.82 | |
| Mean VIF | 1.32 | | 1.32 | | |
| Number of observations | 15969 | | 15969 | | |
| Log likelihood | −167678.11 | | −112754.27 | | |
| Wald Chi-square | 2704.33*** | | 2097.68*** | | |
| Wald test of exogeneity (athrho = 0): | 2.95*** | | 3.61*** | | |

* Significant at 10% level of significance; ** Significant at 5% level of significance; *** Significant at 1% level of significance

potentially able to reduce littering among some households in Palestinian. In another study, Mamady (2016) found that marital status influenced waste disposal decision in Guinea.

The parameter of race (white) in all the results in Tables 7, 8 and 9 (weighted or not) showed statistical significance ($p < 0.01$). These indicate that white South Africans had significantly higher probability of separating/collecting wastes for recycling when compared to black South Africans (the reference group). In addition, the parameters of South Africans of Indian origin and coloured citizens had positive and statistically significant parameters in Tables 7 and 8. These imply that in the combined and urban models, Indian and coloured people had higher probabilities of separating/collecting wastes for recycling. These results are in line with that of Anderson et al. (2013) who noted that economic and social deprivations that were suffered by majority of black South Africans under the apartheid government may still reflect low involvement in waste recycling today.

The results in Tables 7 and 8 also show that for the combined data and urban households, compared to Gauteng and Western Cape, residents from Limpopo, Eastern Cape, Northern Cape, Free State, KwaZulu-Natal, North West and Mpumalanga had significantly lower probability ($p < 0.01$) of separating/collecting waste for recycling. The results in Table 9, however, reveal that in the weighted model, rural households from North West and Mpumalanga provinces had higher probabilities of separating/collecting wastes for recycling ($p < 0.01$). Provincial differences are expected in terms of waste recycling in South Africa due to differences in the degrees of urbanization. The findings can be buttressed from the fact that Gauteng Province which is generating about 45% of all the municipal wastes in South Africa and Cape Town which is contributing about 70% of all municipal wastes in the Western Cape are facing some limitations in getting enough landfills (Brand South Africa 2013). Conventional wisdom therefore requires that these two provinces should engage more in recycling activities. However, within rural areas, motivation for income generation often dominates any environmental concerns in recycling behaviour.

**Table 9** Rural weighted and unweighted estimated parameters of waste recycling behaviour using two-stage probit regression. *Source*: author's computations from 2014 GHS data

| Variables | Recycling involvement | | Recycling involvement | | Tolerance |
|---|---|---|---|---|---|
| | Unweighted coefficient | *t*-stat. | Weighted coefficient | *t*-stat. | |
| *Socio-economic characteristics* | | | | | |
| Total monthly income | −0.00009** | −1.99 | −0.00008 | −1.46 | 0.7843 |
| Gender of households head (male) | 0.06436 | 0.78 | 0.11136 | 1.28 | 0.7974 |
| Household head age | 0.00257 | 1.10 | 0.00404 | 1.47 | 0.7674 |
| Household head married | 0.26713*** | 2.82 | 0.16584 | 1.38 | 0.7773 |
| Race of household head—white | 2.14690*** | 4.39 | 1.79631*** | 2.86 | 0.8258 |
| Race of household head—coloured | 0.24835 | 1.03 | 0.09075 | 0.34 | 0.8979 |
| Race of household head—Indian | – | – | – | – | 0.9926 |
| Household head formally educated | −0.25179** | −2.36 | −0.27797** | −2.28 | 0.7919 |
| Limpopo Province | – | – | – | – | – |
| Eastern Cape Province | −0.10721 | −0.92 | −0.02837 | −0.19 | 0.6377 |
| Northern Cape Province | −0.08165 | −0.32 | −0.12341 | −0.49 | 0.8635 |
| Free State Province | 0.49582** | 2.45 | 0.28285 | 1.22 | 0.8937 |
| KwaZulu-Natal Province | −0.14120 | −1.01 | −0.12161 | −0.78 | 0.6775 |
| North West Province | 0.30680** | 2.66 | 0.44104*** | 3.18 | 0.7212 |
| Mpumalanga Province | 0.54731*** | 4.70 | 0.57663*** | 4.64 | 0.6640 |
| Household size | 0.02720 | 1.32 | 0.02273 | 1.10 | 0.8358 |
| Urban | – | – | – | – | – |
| *Attitudes (believe about behavioural outcomes)* | | | | | |
| Paying for waste disposal | 0.82352*** | 4.12 | 0.86550*** | 3.59 | 0.9189 |
| Willing to pay for waste disposal | 0.59710*** | 3.54 | 0.62726*** | 3.67 | 0.9126 |
| Selling wastes | 2.37478*** | 7.30 | 2.41126*** | 7.35 | 0.9641 |
| Recycling is important | −0.74166*** | −5.92 | −0.65108*** | −5.58 | 0.8988 |
| Financial benefits from recycling | −0.46732*** | −4.85 | −0.52394*** | −4.30 | 0.7756 |
| *Subjective norms (motivation to comply)* | | | | | |
| Irregular waste removal as an environmental problem | −0.05397 | −0.65 | −0.04761 | −0.47 | 0.6591 |
| Littering as an environmental problem | 0.10133 | 1.24 | 0.11365 | 1.25 | 0.6496 |
| Water pollution as an environmental problem | −0.26522** | −2.65 | −0.24558** | −2.09 | 0.7419 |
| Air pollution as an environmental problem | 0.12120 | 1.23 | 0.11022 | 0.86 | 0.6367 |
| Land degradation as an environmental problem | 0.09144 | 1.14 | 0.07071 | 0.83 | 0.7278 |
| Noise pollution as an environmental problem | 0.09771 | 0.96 | 0.09060 | 0.74 | 0.7603 |
| Wastes not removed weekly | −0.74710 | −1.34 | −0.87880 | −1.19 | 0.9633 |
| Wastes removed by communal arrangements | 0.19967 | 0.89 | 0.41777* | 1.79 | 0.9520 |
| Existence of waste recycling programme | 0.60617*** | 4.90 | 0.57417*** | 5.04 | 0.9411 |

**Table 9** continued

| Variables | Recycling involvement | | Recycling involvement | | Tolerance |
|---|---|---|---|---|---|
| | Unweighted coefficient | *t*-stat. | Weighted coefficient | *t*-stat. | |
| *Perceived behavioural control (capability and con*trol) | | | | | |
| Recycling services easily accessible | −0.53670*** | −4.23 | −0.51225*** | −3.65 | 0.8112 |
| Constant | −1.71841*** | −5.63 | −1.85586*** | −5.96 | |
| *Diagnostic indicators* | | | | | |
| Athrho | 0.47333* | 1.76 | 0.37945 | 1.25 | |
| lnsigma | 8.43415 | 1155.20 | 8.43431 | 411.15 | |
| Rho | 0.44089** | 2.03 | 0.36223 | 1.37 | |
| Sigma | 4601.53000 | 136.97 | 4602.29000 | 48.75 | |
| Mean VIF | 1.26 | | 1.26 | | |
| Number of observations | 9380 | | 9380 | | |
| Log likelihood | −93118.63 | | −48357.636 | | |
| Wald Chi-square | 809.04*** | | 839.50*** | | |
| Wald test of exogeneity (/athrho = 0): | 3.09* | | 1.57 | | |

* Significant at 10% level of significance; ** Significant at 5% level of significance; *** Significant at 1% level of significance

Furthermore, in all the results in Tables 7, 8 and 9, education parameter had negative sign but only showed statistical significance ($p < 0.10$) in the combined and rural models. This implies that being literate reduces the probability of being involved in separating or collecting wastes for recycling in the combined results for South Africa at large and among rural households. This also underscores the fact poor people often take recycling as job. Most of the times, such people belong to the most deprived group in the society. It should be noted that education is expected to increase awareness about environmental safety. However, development of positive attitude and compliance with environmentally benign practices are different issues entirely, which in some other studies were found to be strongly correlated with education (Kamara 2006)

Out of the variables included to capture attitude, paying for waste disposal had positive and statistically significant parameters in all the models ($p < 0.01$). This implies that probability of separating/collecting wastes for recycling increased among those who were paying for waste disposal. Willingness to pay for waste disposal variable also had positive and statistically significant parameters ($p < 0.01$). This implies that households that were willing to pay for recycling had higher probabilities of separating/collecting wastes for recycling. In addition, those who were selling wastes had significantly higher probability of separating/collecting wastes for recycling ($p < 0.01$) in all the results. The other variables on the perception of importance of recycling and the financial benefits accruing from it are with negative sign and statistically significant ($p < 0.01$). This implies that having the knowledge of importance of recycling and its associated financial benefits is not sufficient for involvement in separating/collecting wastes for recycling.

In this study, paying and willing to pay for waste disposal and selling wastes are among the variables taken as proxies for environmental attitudes. Paying for waste disposal can be seen as a commitment to promote environmental safety since those wastes may otherwise be disposed in a manner that would pose some environmental problems to the society.

Similarly, involvement in selling waste materials relates directly to environmental conservation since such waste products may not otherwise have reached recycling points were it not for the efforts of waste collectors. Jekria and Daud (2016) submitted that environmental concern is very important for developing positive environmental attitude, while such attitude would boost willingness to participate in waste recycling activities. Specifically, literature emphasizes that possession of positive attitude would enhance pro-environmental behaviour like recycling (Domina and Koch 2002; Torgler and García-Valiñas 2007). Tucker and Speirs (2002) noted that individuals that are showing acceptable social behaviour can have the right attitude towards environmental conservation. More importantly, Blake (1999) noted that possession of environmental concerns often dilutes the impacts of other conflicting attitudes such as being lazy to be involved in pro-environmental behaviour. Such indulgence in laziness and inability to create the required time could explain why households' perceptions of the importance of recycling and associated financial benefits were not promoting involvement in recycling.

Some variables were included to capture subjective norm which emphasizes some motivations to comply as important factors in behaviour change. Contrary to expectation, in the results in Tables 7 and 8, the parameters of perception of irregular waste removal as an environmental problem had negative sign but statistically significant ($p < 0.05$) in the weighted models. Therefore, households that perceived irregular waste removal as an environmental problem had significantly lower probability of collecting waste for recycling. Similarly, contrary to expectation, in all the models presented in Tables 7, 8 and 9, parameters of perception of water pollution as environmental problem showed statistical significance ($p < 0.05$). These results, however, imply that households that perceived waste pollution as environmental problem had lower probability of separating/collecting wastes for recycling. As expected, perception of air pollution increased the probabilities of separating/collecting waste for recycling ($p < 0.05$) with the combined and urban households. In Tables 7 and 8, households that perceived land degradation as environmental problem had significantly higher probabilities of separating and collecting waste for recycling ($p < 0.01$). In the results for urban households, the parameters of waste not removed weekly showed statistical significance ($p < 0.10$). These imply that urban households that indicated wastes not being removed weekly had higher probability of separating/collecting wastes for recycling. However, urban households that removed wastes by communal arrangements had significantly lower probability of separating/collecting wastes for recycling. It should be noted that some of these results are contrary to expectations. They, however, indicate that environmental consciousness may not be a sufficient factor for promoting pro-environment behaviour in the form of waste recycling. Irregularity in waste removal also promotes recycling behaviour, although communal arrangements reduce it.

The results in Table 7, 8 and 9 further show that the parameters of existence of waste recycling programme in all the models are with positive sign and statistically significant ($p < 0.01$). These results imply that households that were living in places where waste recycling programmes exist have higher probabilities of separating/collecting wastes for recycling. Similarly, in Tables 7 and 8, the probabilities of separating/collecting wastes for recycling increased significantly among those who indicated that recycling services were easily accessible. This result is in line with previous emphasis place of recycling facilities and programmes by Nigbur et al. (2004), Gamba and Oskamp (1994). However, the parameters of availability of recycling services are with negative sign for the model estimated for rural households (Table 9). This is a reflection of the fact that recycling facilities are mostly concentrated in urban areas.

## 7 Conclusions

Addressing environmental degradation and other related problems associated with urbanization is a fundamental prerequisite for realigning the economy towards achievement of Sustainable Development Goals (SDGs) of having sustainable cities and communities. This paper focused on waste disposal issue by analysing the determinants of involvement in waste separation and collection for recycling purposes in South Africa. The results highlighted that although majority of the respondents were literate, recycling behaviour did not increase with education. This emphasizes the need for integrating proper education of environmental conservation and management within the framework of media programmes and other activities at the different levels of governance in South Africa. This would enhance awareness of individuals on critical environmental challenges in their society.

Given that the results point at awareness of some environmental problem as significant factors for waste separation and collection for recycling, such environmental awareness programmes hold significant contribution to pro-environmental behaviour. In addition, when properly channelled, they hold the potentials of assisting households to have positive attitudes, substantial motivation to comply and behavioural control. These issues were found to be important within the framework of TPB which was implemented in this study.

In addition, waste separation and collection for recycling behaviour was lower among black South Africans when compared to other races. This underscores the fact that present environmental concerns could be reflections of previous deprivations suffered by the black South African population. Given the highest proportion of the black in South Africa, efforts to address waste problem should earmark some specific interventions for ensuring compliance with environmental policies and other development initiatives among the black majority. This is critical given persistent increase in urbanization as a result of drift of black South Africans to urban areas as government continues to emphasize equitable distribution of opportunities for education and employment.

Similarly, residents in Gauteng and Western Cape provinces have higher compliance with waste separation and collection for recycling. This emphasizes the need for properly evaluating distribution of waste recycling facilities across South Africa. It also underscores the need for evaluating efficacy of waste recycling initiatives in terms of accessibility of recycling bins, availability of trash for cash initiatives, among others. The result indicated that waste collection was motivated by financial gains. Therefore, the notion of collecting recyclable waste free of charge from households should be jettisoned in South Africa. This is pertinent when households realize that their wastes would translate into significant wealth for somebody.

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## References

ACP-EC Joint Parliamentary Assembly (2014). *Urbanisation challenges, waste management, and development*. Retrieved March 15, 2016. http://www.europarl.europa.eu/intcoop/acp/2014_mauritius/pdf/un_habitat_presentation_en.pdf.

Adkins, L. C. (2009). An instrumental variables probit estimator using gretl. In *Econometrics with gretl, Proceedings of the gretl conference* (pp. 59–74), May 28–29, 2009.

Afroz, R., Hanaki, K., & Tudin, R. (2011). Factors affecting waste generation: a study in a waste management program in Dhaka City, Bangladesh. *Environmental Monitoring and Assessment, 179,* 509. doi:10.1007/s10661-010-1753-4.

Agen, D. (2008). *Personal communication with the low-income retailer manager, October 20*. https://econrsa.org/papers/p_papers/pp18.pdf.

Ajzen, I. (1985). From intentions to actions: A theory of planned behaviour. In J. Kuhl & J. Beckman (Eds.), *Action-control: From cognition to behaviour* (pp. 11–39). Berlin: Springer.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Process, 50,* 179–211.

Ajzen, I., & Madden, T. J. (1986). Prediction of goal-directed behavior: Attitudes, intentions and perceived behavioral control. *Journal of Experimental Social Psychology, 22*(5), 453–474.

Alexander M. (undated). *South Africa's nine provinces*. Retrieved March 16, 2016 from http://www.mediaclubsouthafrica.com/landstatic/163-provinces_new.

Al-Khatib, I. A., Arafat, H. A., Daoud, R., & Shwahneh, H. (2009). Enhanced solid waste management by understanding the effects of gender, income, marital status, and religious convictions on attitudes and practices related to street littering in Nablus—Palestinian territory. *Waste Management, 29*(1), 449–455.

Anderson, B. A., Romani, J. H., Wentzel, M., & Phillips, H. E. (2013). *Recycling behavior among urban South Africans: The role of race and social status, population studies center research report 13-790*.

Anonymous (no date). *South African waste facts*. Retrieved June 5, 2016 from http://www.monkeyland.co.za/south-african-waste-facts_article_op_view_id_2790.

Arcury, T. A., & Christianson, E. H. (1990). Environmental worldview in response to environmental problems: Kentucky 1984 and 1988 compared. *Environment and Behavior, 22,* 387–407.

Armitage, C. J., & Conner, M. (2001). Efficacy of the theory of planned behaviour: A meta-analytic review. *British Journal of Social Psychology, 40*(4), 471–499.

Bandura, A. (1978). Reflections on self-efficacy. In S. Rachman (Ed.), *Advances in behavioral research and therapy*. Oxford: Pergamon Press.

Bandura, A. (1982). Self-efficacy mechanism in human agency. *American Psychologist, 37*(2), 122–147.

Bandura, A. (1986). Social foundations of thought and action: A social cognitive theory. In J. Beckmann (Ed.), *Action control: From cognition to behavior* (pp. 11–39). Englewood Cliffs: Prentice-Hall.

Blake, J. (1999). Overcoming the 'value–action gap' in environmental policy: Tensions between national policy and local experience. *Local Environment, 4*(3), 257–278.

Brand South Africa (2013). *South Africa's household recycling target.* https://www.brandsouthafrica.com/governance/sustainable/waste-070113. Accessed Feb 26, 2017.

Brooks, M. (2006). *Capitalism and the environment*. Retrieved March 13, 2016 from http://www.marxist.com/capitalism-environment-ecology-marxism210806.htm.

Burgess, J., Harrison, C. M., & Filius, P. (1998). Environmental communication and the cultural politics of environmental citizenship. *Environment and planning A, 30,* 1445–1460.

Callan, S. J., & Thomas, J. M. (1997). The impact of state and local policies on the recycling effort. *Eastern Economic Journal, 23,* 411–423.

Churchard, C. (2007). *Two thirds of people favor financial rewards for recycling, says poll. Recycling and waste management news and information*. RWM, 22, August 2007.

Comrade, A. (1996). *On capitalism and the environment*. Retrieved March 13, 2016 from http://www.prisoncensorship.info/archive/etext/mt/mt12capenv.html.

Couch, J. V., Garber, T., & Karpus, L. (1979). Response maintenance and paper recycling. *Journal of Environmental Systems, 8,* 127–137.

Council for Scientific and Industrial Research (CSIR) (2013). *South Africa's household recycling target*. Retrieved June 5, 2016 http://www.southafrica.info/about/sustainable/waste-070113.htm#.V1O6KdIrLMy.

CSIR (2011a). *Municipal waste management—Good practices, 1st ed*. CSIR: Pretoria. Retrieved August 7, 2015 from http://www.csir.co.za/nre/docs/Waste_Management_Toolkit.pdf.

CSIR (2011b). *Municipal waste management—Good practices*, 1st ed. CSIR: Pretoria.

Department of Environmental Affairs and Development Planning, Western Cape) (DEADP) (2011) *Status quo report: Integrated waste management plan for the Western Cape Province*. Cape Town: DEADP

Department of Environmental Affairs and Tourism (1997). *White paper on the conservation and sustainable use of South Mrica' s biological diversity*. Retrieved from https://www.environment.gov.za/sites/default/files/legislations/biodiversity_whitepaper_18163_gen1095.pdf.

Department of Health, Medical Research Council, OrCMacro. Department of Health; Pretoria (2007) *South Africa demographic and health survey 2003*.

DeYoung, R. (1985-86). Encouraging environmentally appropriate behavior: The role of intrinsic motivation. *Journal of Environmental Systems, 15,* 281–291.
Domina, T., & Koch, K. (2002). Convenience and frequency of recycling: implications for including textiles in curbside recycling programs. *Environment and Behavior, 34,* 216–238.
Dube-Matutu, S. (2017). *Women turn waste into wealth*. Accessed June 9, from http://www.chronicle.co.zw/women-turn-waste-into-wealth/.
Duggal, V. G., Saltzman, C., & Williams, M. L. (1991). Recycling: an economic analysis. *Eastern Economic Journal, 17,* 351–358.
Dunlap, R. E., Van Liere, K. D., Mertig, A. G., & Jones, R. E. (2000). Measuring endorsement of the new ecological paradigm: A revised NEP scale. *Journal of Social Issues, 56,* 425–442.
Ebreo, A., Hershey, J., & Vinning, J. (1999). Reducing solid waste: Linking recycling to environmentally responsible consumerism. *Environment and Behavior, 31*(1), 107–124.
Ebreo, A., & Vining, J. (2001). How similar are recycling and waste reduction? Future orientation and reasons for reducing waste as predictors of self-reported behavior. *Environment and Behavior, 33,* 424–448.
Eilam, E., & Trop, T. (2012). Environmental attitudes and environmental behavior—Which Is the horse and which is the cart? *Sustainability, 4,* 2210–2246. doi:10.3390/su4092210.
Elesh, D. (1970). *Poverty theories and income maintenance: Validity and policy relevance*. http://irp.wisc.edu/publications/dps/pdfs/dp8370.pdf Accessed Feb 25, 2017.
Ferrara, I., & Missios, P. (2005) Recycling and waste diversion effectiveness: Evidence from Canada. *Environmental and Resource Economics*, *30*(2), 221–238.
Gamba, R., & Oskamp, S. (1994). Factors influencing community residents' participation in commingled curbside recycling programs. *Environment and Behavior, 26,* 587–612.
Gbetibouo, G. A., & Ringler, C. (2009). *Mapping South African farming sector vulnerability to climate change and variability: A subnational assessment. IFPRI discussion paper 885*. International Food Policy Research Institute (IFPRI). http://www.ifpri.org/sites/default/files/publications/ifpridp00885.pdf.
Geller, E. S. (1989). Applied behavior analysis and social marketing: An integration for environmental preservation. *Journal of Social Issues, 45,* 17–36.
Glyn, A. (2006). *Capitalism unleashed. Finance globalization and welfare*. Oxford: Oxford University Press.
Gong, W., & Lei, J. (2007). An analysis of gender difference in the environmental concern and environmentally friendly behaviors of Chinese urban residents. *Humanities and Social Sciences Journal of Hainan University, 25,* 340–345. **(in Chinese)**.
Grover, P., & Singh, P. (2014). An analytical study of effect of family income and size on per capita household solid waste generation in developing countries. *Review of Arts and Humanities, 3*(1), 127–143.
Guerin, D., Crete, J., & Mercier, J. (2001). A multilevel analysis of the determinants of recycling. *Behavior in the European Countries Social Science Research, 30,* 195–218.
Harland, P., Staats, H., & Wilke, H. A. M. (2007). Situational and personality factors as direct or personal norm mediated predictors of pro-environmental behavior: Questions derived from norm-activation theory. *Basic Applied of Social Psychology, 29*(4), 323–334.
Harris, P. G. (2006). Environmental perspectives and behavior in China—Synopsis and bibliography. *Environment and Behavior, 38,* 5–21.
Hashim, Z., Alias, R., Mariam, S., & Farzana, N. (2015). Understanding recycling behaviour using personality traits. *Global Journal of Business and Social Science Review, 1*(2), 581–587.
Hong, D. (2005). Environmental concern of the Chinese urban residents. *Jiangsu Social Sciences, 1,* 127–132. **(in Chinese)**.
Hong, D. (2006). *Measurement of environmental concern: Application of the NEP scale in China, 26,* 71–92. **(in Chinese)**.
Hong, Seonghoon, & Adams, Richard M. (1993). An economic analysis of household recycling of solid wastes: The case of Portland, Oregon. *Journal of Environmental Economics and Management, 25,* 278–282.
Hong, D., & Xiao, C. (2007). Sociological analysis on gender difference of environmental concern. *Sociological Studies, 2,* 1–19. **(in Chinese)**.
Hoyos, D. (2010). The state of the art of environmental valuation with discrete choice experiments. *Ecological Economics, 69,* 1595–1603.
Hunter, L. M., Hatch, A., & Johnson, A. (2004). Cross-national gender variation in environmental behaviors. *Social Science Quarterly, 85,* 677–694.

ICSU and ISSC (2015). *Review of the sustainable development goals: The science perspective. Paris: International Council for Science (ICSU)*. Retrieved June 28, 2015 from http://www.icsu.org/publications/reports-and-reviews/review-of-targets-for-the-sustainable-development-goals-the-science-perspective-2015/SDG-Report.pdf.

Jekria, N., & Daud, S. (2016). Environmental concern and recycling behaviour. *Procedia Economics and Finance., 35,* 667–673.

Jenkins, R. R., Martinez, S. A., Palmer, K., & Podolsky, M. J. (2000). *The determinants of household recycling: A material specific analysis of recycling program features and unit pricing. April 2000*. Discussion paper 99-41-REV. Retrieved May 21, 2016 from http://ageconsearch.umn.edu/bitstream/10798/1/dp990041.pdf.

Kamara, A. J. (2006). *Household participation in domestic waste disposal and recycling in the Tshwane Metropolitan area: An environmental education perspective*. Masters dissertation submitted in partial fulfillment of the requirements for the Degree of Master of Education in Environmental Education at the University of South Africa. Retrieved August 5, 2015 from http://uir.unisa.ac.za/bitstream/handle/10500/1460/dissertation.pdf?sequence=1.

Kimanuka, O. (2015). *Why Africa should champion the crusade on green economy*. The new time, 30th January 2015. Retrieved February 7, 2015 from http://www.newtimes.co.rw/section/article/2015-01-30/185451/.

Kollmuss, A., & Agyeman, J. (2002). Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research, 8,* 239–260.

Kotze, I., & Rose, M. (Eds.). 2015. *Farming facts and futures: reconnecting South Africa's food systems to its ecosystems*. WWF-SA, Cape Town, South Africa. Retrieved June 3, 2016 from http://awsassets.wwf.org.za/downloads/wwf006_ffl_report_low_res.pdf.

Lumby, A. (2005). Government and sustainable development in South Africa. *South African Journal of Economic History, 20*(1), 65–82.

Luyben, P. D., & Bailey, J. S. (1979). Newspaper recycling: The effects of rewards and proximity of containers. *Environment and Behavior, 11,* 539–557.

Malakwane, C. T. (2012). *Economic and social effects of unemployment in South Africa: Prospects for the Future*. Submitted in partial fulfilment of the requirement for the Degree, Magister Technologiae: Joint African Masters in Comparative Development. Retrieved June 2, 2016 from http://www.kga.org.za/wp/wp-content/uploads/2016/01/Economic-and-social-effects-of-unemployment-in-south-africa.pdf.

Mamady, K. (2016). Factors influencing attitude, safety behavior, and knowledge regarding household waste management in Guinea: A cross-sectional study. *Journal of Environmental and Public Health*. doi:10.1155/2016/9305768.

Mannie, N. (undated). *Sustainable solutions to South Africa's waste challenges*. Retrieved March 16, 2016 from http://www.aurecongroup.com/en/thinking/archive/sustainable-solutions-to-south-africas-waste-challenges.aspx.

McFadden, D. (1999). *Robust methods in econometrics*. Accessed June 11, 2017 from https://eml.berkeley.edu/~mcfadden/e240b_f01/ch7.pdf.

McGuire, R. H. (1984). Recycling: Great expectations and garbage outcomes. *American Behavioural Scientist, 28,* 93–114.

Meen-Chee, H., & Narayanan, S. (2006). Restoring the shine to a pearl: Recycling behavior in Penang. *Malaysia. J. Devel. Chan., 37*(5), 1117–1136.

Mohai, P. (1992). Men, women, and the environment: An examination of the gender gap in environmental concern and activism. *Society and Natural Resources, 5*(1), 1–19.

Mohai, P., & Twight, B. W. (1987). Age and environmentalism: An elaboration of the Buttel model using national survey evidence. *Social Science Quarterly, 68,* 798–815.

Moore, C. (Undated). *An introduction to logistic and probit regression models*. Retrieved April 23, 2016 from https://www.utexas.edu/cola/prc/_files/cs/Fall2013_Moore_Logistic_Probit_Regression.pdf.

Morris, J., Marzano, M., Dandy, N., & O'Brien, L. (2012). *Theories and models of behaviour and behaviour change*. Retrieved April 16, 2016 from http://www.forestry.gov.uk/pdf/behaviour_review_theory.pdf/$FILE/behaviour_review_theory.pdf.

Nagler, J. (1999). *Notes on simultaneous equations and two stage least squares estimates*. Retrieved June 8, 2017 http://www.nyu.edu/classes/nagler/quant2/notes/2slsnotes_oh.pdf.

Nahman, A., Wise, R., & de Lange, W. (2009). Environmental and resource economics in South Africa: Status quo and lessons for developing countries. *South African Journal of Science, 105,* 350–355.

National Intelligence Council (2012). *Global trends 2030: Alternative Worlds*. Retrieved March 15, 2016 from https://globaltrends2030.files.wordpress.com/2012/11/global-trends-2030-november2012.pdf.

Newey, Whitney. (1987). Efficient estimation of limited dependent variable models with endogenous explanatory variables. *Journal of Econometrics, 36,* 231–250.

Nigbur, D., Lyons, E., & Uzzell, D. (2010). Attitudes, norms, identity and environmental behaviour: Using an expanded theory of planned behaviour to predict participation in a kerbside recycling programme. *British Journal of Social Psychology, 49*(2), 259–284.

Nigbur, D., Lyons, E., Uzzell, D. L., & Leach, R. (2004). *The Surrey scholar research project in waste recycling report*.

Njoroge, K., Wokabi, M., Ngetich, K., & Kathuri, N. (2013). Influence of informal solid waste management on livelihoods of urban solid waste collectors: a case study of Nakuru Municipality, Kenya. *International Journal of Humanities and Social Science, 3*(13), 95–108.

O'Laughlin, B. (November 1996). *Missing men? The debate over rural poverty and women-headed households in Southern Africa*. Paper presented at Institute of Social Studies, The Hague.

Omran, A., Sarsour, A. K., & Pakir, A. H. K. (2012). An investigation into the factors influencing the participation of households in recycling of solid waste in Palestine. *International Journal of Health Economics, 2,* 4–19.

Orbell, S., & Sheeran, P. (1998). Inclined abstainers: A proble of predicting health related behaviour. *British Journal of Social Psychology, 37,* 151–165.

Oskamp, S., Harrington, M., Edwards, T., Sherwood, D., Okuda, S., & Swanson, D. (1991). Factors influencing household recycling behavior. *Journal of Environmental Behaviour, 23*(4), 494–519.

Perrin, D., & Barton, J. (2001). Issues associated with transforming households attitudes and opinions into materials recovery: A review of two kerbside recycling schemes. *Journal of Resource Conservation, Recycling, 33*(1), 61–74.

Posel, D. R. (2001). Who are the heads of household, what do they do, and is the concept of headship useful? An analysis of headship in South Africa. *Development Southern Africa, 18*(5), 651–670.

Potts, R. (2012). Social welfare in South Africa: Curing or causing poverty? *Penn State Journal of International Affairs, 2*(1), 74–92.

Prinsloo, D. A. (2014). *Urbanisation and the impact on future shopping centre development in Africa and South Africa*. Retrieved May 28, 2016 from http://www.urbanstudies.co.za/wp-content/uploads/2014/08/2662-SAC-Urbanisation-Report-Sept-2014-T3-2.pdf.

Randall, A. (2008). Is Australia on a sustainability path? Interpreting the clues. *Australian Journal of Agricultural and Resource Economics, 52,* 77–95.

Republic of South Africa (2009). *National environmental management: Waste Act, 2008 (Act No. 59 of 2008).* https://www.environment.gov.za/sites/default/files/legislations/wasteclassification_management_g35572_GN614.pdf. Accessed April 5, 2006.

Republic of South Africa (2012). *Report on the status of sanitation services in South Africa*. Retrieved March 8, 2016 from http://www.gov.za/sites/www.gov.za/files/Sanitation%20Report_a.pdf.

Richardson, R. A., & Havlicek, J. (1974). An analysis of seasonal household waste generation. *Southern Journal of Agricultural Economics., 06*(02), 143–153.

Rivers, D., & Vuong, Q. H. (1988). Limited information estimators and exogeneity tests for simultaneous probit models. *Journal of Econometrics, 39,* 347–366.

Samdahl, D. M., & Robertson, R. (1989). Social determinants of environmental concern: Aspecification and test of the model. *Environment and Behavior, 21,* 57–81.

Sankoh, F. P., Yan, X., & Tran, Q. (2014). Assessment of solid waste management in Freetown, Sierra Leone towards sustainable development. *Journal of Applied Sciences, 14,* 2909–2924.

Sibernagl, P. (2011). What's the composition of your domestic waste stream? Is there value in recycling? *The Waste Revolution Handbook, 1,* 136–141.

Sniehotta, F. F., Gellert, P., Witham, M. D., Donnan, P. T., Crombie, I. K., & McMurdo, M. E. T. (2013). Psychological theory in an interdisciplinary context: How do social cognitions predict physical activity in older adults alongside demographic, health-related, social, and environmental factors? *International Journal of Behavioral Nutrition and Physical Activity, 10*(1), 106. doi:10.1186/1479-5868-10-106.

Sniehotta, F., Pressueau, F. J., & Araujo-Soares, V. (2014). Time to retire the theory of planned behaviour. *Health Psychology Review., 8*(1), 1–7.

Sol Plaatjie Local Municipality (SPLM). (2010). *Sol Plaatjie local municipality integrated waste management plan*.

South African Waste Information Centre (SAWIC) (2014). *Approach to waste in South Africa*. Retrieved March 8, 2016 from http://sawic.environment.gov.za/?menu=60.

Spash, C. L., Urama, K., Burton, R., Kenyon, W., Shannon, P., & Hill, G. (2009). Motives behind willingness to pay for improving biodiversity in a water ecosystem: economics, ethics and social psychology. *Ecological Economics, 68,* 955–964.

Statistics South Africa (2015). *Labour market dynamics in South Africa, 2014 report-press statement*. Retrieved June 2, 2016 from http://www.statssa.gov.za/?p=4445.

Statistics South Africa (2015). *Mid-year population estimates 2015*. Retrieved March 16, 2016 from https://www.statssa.gov.za/publications/P0302/P03022015.pdf.

Statistics South Africa (2016). Mid-year population estimates 2015. Retrieved May 29, 2016 from https://www.statssa.gov.za/publications/P0302/P03022015.pdf.

Tacoli, C. (2012). *Urbanization, gender and urban poverty: paid work and unpaid carework in the city*. Human Settlements Group, International Institute for Environment and Development (IIED). Retrieved March 14, 2016 from https://www.unfpa.org/sites/default/files/resource-df/UEPI%207%20Tacoli%20Mar%202012.pdf.

Tindall, D. B., Davies, S., & Mauboules, C. (2003). Activism and conservation behavior in an environmental movement: The contradictory effects of gender. *Society and Natural Resources, 16,* 909–932.

Torgler, B., & García-Valiñas, M. A. (2007). The determinants of individuals' attitudes towards preventing environmental damage. *Ecological Economics, 63*(2–3), 536–552.

Tucker, P., & Speirs, D. (2002). *Model forecasts of recycling participation rates and material capture rates for possible future recycling scenarios*. Paisley: University of Paisley Environmental Technology Group.

Turok, I. (2012). *Urbanisation and development in South Africa: Economic imperatives, spatial distortions and strategic responses*. International Institute for Environment and Development, United Nations Population Fund. Retrieved from http://pubs.iied.org/pdfs/10621IIED.pdf.

UNICEF and WHO (2015). *Progress on sanitation and drinking water—2015 update and MDG assessment*. Retrieved March 9, 2016 from http://www.unicef.org/publications/files/Progress_on_Sanitation_and_Drinking_Water_2015_Update_.pdf.

United Nations (2015). *The millennium development goals report 2014*. Retrieved June 29, 2015 from http://www.un.org/millenniumgoals/2014%20MDG%20report/MDG%202014%20English%20web.pdf.

United Nations, Department of Economic and Social Affairs, Population Division (2014). *World urbanization prospects: The 2014 revision, highlights (ST/ESA/SER.A/352)*.

United Nations Economic Commission for Africa, African Union, African Development Bank and United Nations Development Programme (2014). *Assessing progress in Africa toward the millennium development goals analysis of the common African position on the post-2015 development agenda*. Retrieved June 29, 2015 from http://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/MDG_Report_2014_11_2014.pdf.

Vaske, J. J., Donnelly, M. P., Williams, D. R., & Jonker, S. (2001). Demographic influences on environmental value orientations and normative beliefs about national forest management. *Society andNatural Resources, 14,* 761–776.

Vicente, P., & Reis, E. (2008). Factors influencing households' participation in recycling. *Waste Management and Research, 26,* 140–146.

Visvanathan, C., & Trankler, J. (2003). Municipal solid waste management in Asia: A comparative analysis. In *Proceedings of workshop on sustainable landfill management, 3–5 December, 2003, Chennai*, pp. 3–15.

Wise, C. C., Emery, R. C., & Coetzee, J. A. (2011) Composition of waste land filled at metropolitan landfills and the impact of the new draft waste regulations. In *Proceedings of the landfill 2011 seminar, "Waste Management Facilities—The New Order", 18–20 October 2011, Durban, South Africa*.

World Bank. (1992). *World Development report*. New York: Oxford University Press.

Zigegy, Z. (2015). *Capitalism, environmental crisis, and socialism*. Retrieved March 13, 2015 from http://houstoncommunistparty.com/capitalism-environmental-crisis-and-socialism/.