UMR 201

D&S

Développement et Sociétés

Poverty Eradication by Improving Waste Collection: an African Case Study

Anne Briand, Noukignon Koné

UNIVERSITÉ PARIS 1
PANTHÉON SORBONNE

iRD Institut de Recherche
pour le Développement
FRANCE

Poverty Eradication by Improving Waste Collection: an African Case Study

Anne Briand[1]

CREAM, Université Rouen Normandie et UMR 201 IRD Développement et Sociétés, IEDES, Université Paris 1 Panthéon Sorbonne (France)

Noukignon Koné[2]

CREAM (Centre de Recherche en Economie Appliquée à la Mondialisation), Université Rouen Normandie (France)

Abstract

The article analyzes data from a Contingent Valuation survey that we conduced in 2014 among 402 households in low-income settlements of Abidjan in order firstly, to identify the determinants of stated demand for an informal waste collection service and secondly, to evaluate the benefits of using this service on different impact variables linked to human development. Indeed, households are exposed to negative externalities (odours, insects, health risks, loss of quality of life) that could lead them wish to offset the loss of utility with an individual investment in the informal service. The article contributes to the academic literature and gives recommendations in terms of economic policy applied to the waste sector in Africa. Firstly, our study identifies the determinants of stated demand for the informal service and the ability of households to finance an improved service. Secondly, the article evaluates the beneficial effects of using the informal service by the propensy score method. We evaluate the impact of the use of the informal service on the monthly amount that households are willing to pay for the improved service. We quantify the benefits in terms of socioeconomic and human development.

---

[1] CREAM, 3 avenue Pasteur 76000 Rouen France. anne.briand@univ-rouen.fr. phone : +33232769789

[2] CREAM, 3 avenue Pasteur 76000 Rouen France. Noukignon.kone@yahoo.fr.

1. Introduction

According to the World Bank (2016), over half the world's population does not have access to a household waste collection service. About 4 billion people use unregulated or illegal dumps, which contain more than 40% of the world's waste. The World Bank is thus helping countries and municipalities to implement sustainable waste management programs to collect, remove, reduce, reuse, and recycle household waste. In 2012, the World Bank alerted the public to the extent of the world waste crisis[3] as it predicted a 70% increase in urban waste by 2025[4]. Due to demographic growth, galloping urbanization, and economic development, waste management has become a priority. Generally municipalities are responsible for solid waste management, so building sustainable cities means establishing good solid waste management, which cannot be reduced to simple technical solutions. Good waste management must also take into account impacts on the environment and health of the surrounding population[5] as well as social impacts such as inclusion of waste collectors and behavioural incentives that encourage households to recycle and produce less waste[6].

This challenge is even greater for developing countries; authorities there need to take the economic precarity of the population into account. The Sustainable Development Goals (SDGs) as redefined in 2015 illustrate the various components of the fight against poverty: education, health, and access to basic services, among others. Improved access to water and sanitation services as well as waste collection is a crucial socioeconomic and health issue for the poor. The expected benefits include poverty reduction and sanitary living conditions in the home and neighbourhood, improving public health.

The World Bank thus made available substantial loans to support waste management programs. The objective of these programs is to support the financing of infrastructure for simple waste collection and evacuation systems or more sophisticated reuse and recycling programs designed to change behaviour. Waste management is a major expense, making up

---

[3] Documentary: Trashed (http://www.trashedmovie.com/trailer.html).

[4] What a Waste (http://www.worldbank.org/en/news/feature/2012/06/06/report-shows-alarming-rise-in-amount-costs-of-garbage).

[5] http://www.iswa.org/home/news/news-detail/browse/2/article/wasted-health-the-tragic-case-of-dumpsites/109/programmes/.

[6] http://blogs.worldbank.org/sustainablecities/organic-waste-aluable-resource-call-action.

20-50% of a city's budget (World Bank, 2016). There are few developing countries with a tax or fee structure that would allow them to finance their waste management while encouraging behaviour changes in households that still dispose of their waste in open-air dumps (Thonart *et al.,* 2005). Given the negative externalities arising from these unregulated dumps (odour, bacteria, etc.) it is essential to consider the opportunity to implement services financed in part by an incentive-based tax and fee structure.

The Republic of Côte d'Ivoire is fully committed to this goal; the authorities there are working to improve sanitation as part of its citizens' quality of life. Among these projects, an emergency urban infrastructure program is to be implemented by the Côte d'Ivoire government. The project aims to improve access to urban infrastructure such as drinking water, sanitation, solid waste management, and roads in major urban centers and to improve the environment and public health by making the residents aware of the dangers of unregulated dumps and the importance of recycling.

In the context of both the SDGs and the increased rationing of international aid in which the effectiveness of projects is carefully scrutinized, this article proposes to provide insight to development actors about the economic and social benefits to residents of low-income settlements in Abidjan from this plan to improve urban infrastructure. More precisely, we hope to evaluate the impact of informal waste collection services on the improvement of quality of life for these residents. To this end, we carried out our own survey of 402 households in low-income settlements in Abidjan in 2014. This survey allowed us to observe on-site household waste management practices and also to learn about willingness to pay for the establishment of a service improvement program[7]. Households were interviewed about the amount they would be willing to pay to benefit from this new service as well as their ability to

---

[7] The households were informed about the intentions of the environment ministry to improve their health and quality of life. The improvement in the waste management system was presented in the survey as follows: "The provision of two trash containers (in two different colours to encourage sorting and recycling) with twice-weekly collection" The households were also given the following information: "The government will pay for the implementation of this program, but households, shops, and businesses will need to pay to maintain it. Your contribution will be used to maintain the 120-liter trash containers and make sure the trash is collected regularly." Households that chose to continue with their current arrangement were not asked about their willingness to pay, while those that stated their interest in the new program were then asked how much they were willing to pay for it.

pay a fee for each kilogram of waste produced. The results thus shed light on the feasibility of the project, especially in terms of household financial contribution to this program. In addition, by applying an econometric method of impact evaluation, our study helps us determine whether the current waste collection service is a factor in reducing household poverty. We show in fact that household use of an informal waste collection service is a step forward in the fight against poverty. We evaluate to what extent informal waste collection helps improve economic, social, and sanitary conditions in the informal settlements surveyed in the Ivory Coast capital. As this waste collection service has up to now been carried out by informal operators (there was no official service), our study's results lay the groundwork for considering the risks and opportunities of institutionalizing this private service.

The evaluation was carried out using a quasi-experimental method, the propensity-score matching method, which offers the advantage of forming two population groups that only differ in their choice of using an informal waste collection service (selection bias having been controlled for). This method has been used in studies of other countries to evaluate the benefits of different types of development projects (Pattanayak *et al.,* 2010; Roushdy *et al.,* 2012; Blehaut, 2014; Briand and Laré-Dondarini, 2017). No study has yet evaluated the microeconomic impacts of a waste management service improvement project in Africa; our study is thus original and its results make a contribution to the literature.

This paper is structured as follows: Section 2 presents a literature review on the demand for household waste management services and on methods for evaluating improved access to basic services. Section 3 describes the context of the study, the sample, and the questionnaire as they relate to the contingent valuation study carried out among households in informal settlements in Abidjan. Section 4 explains the econometric procedure, and section 5 analyzes the determinants of the expressed demand for the informal waste collection service and the results of the impact evaluation method. The final section concludes.

2. Literature related to the demand for waste management services and methods for evaluating the impact of improved access to basic services

The literature on household waste generally focuses on analyzing demand (actual or hypothetical) and specifically on its determinants (cf. Koné, 2016, for a more complete review). These studies generally use the contingent valuation method (CVM) to look at the

question of setting fees for services. Several researchers have analyzed the determinants of willingness to pay for various levels of service (Gramlich, 1977; Jin *et al.,* 2006; Afroz *et al.,* 2009; Banga *et al.,* 2011; Dadson *et al.,* 2013). Their results show that households are generally in favour of service improvements; their willingness to pay depends on their socioeconomic characteristics (Afroz *et al*., 2009). In a study carried out in Dhaka, Bangladesh, Afroz *et al.* (2009) show that households' reported willingness to pay differs depending on the services offered and their socioeconomic characteristics. In Oyo State, Nigeria, Yusuf *et al.* (2007) show that willingness to pay depends principally on the price that households pay for the service they are using at present and on their monthly expenses (proxy for revenue). These studies provide valuable information to decision-makers about urban waste management services and how to charge for different levels of services. These studies also show the influence of age, number of children, household size, education level, and residency status on whether households are willing to adopt new services and how much they are willing to pay for them (Jin *et al.*, 2006 in Macao, China; Dadson *et al.,* 2013 in Kumasi, Ghana; Mustafa *et al.,* 2014 in an applied study in Pakistan).

As of yet there has been no study evaluating a waste management service improvement project. While several impact evaluation studies have been carried out for development projects in areas such as health, education, and microcredit (e.g., Aiga *et al.,* 1999; Galiani *et al.,* 2005; Gubert *et al.,* 2005; Olivier, 2006; Roushdy *et al.,* 2012), there are much fewer applied studies in the sanitation sector (Pattanayak *et al.,* 2010), which waste management is directly linked to. There have been some impact evaluation studies on improvement projects for basic services such as access to drinking water. Among the studies cited in Briand and Laré-Dondarini (2017), Galiani *et al.* (2005) showed that privatizing the drinking water provider in Argentina reduced infant mortality in children under 5 years old. Pattanayak *et al.* (2010), using a propensity-score matching method, found that a service improvement program for drinking water and sanitation services had a positive effect on the reduction of direct and indirect household expenses in India (expenses related to these services, such as the time to collect water from alternative sources). Roushdy *et al.* (2012), using the same matching method, showed that using flush toilets connected to a sewer system in Egypt reduced diarrhoea in children under 3. In this same general area of drinking water and sanitation, Briand and Laré-Dondarini (2017) studied the impact of a service improvement project to provide drinking water to four informal settlements in Ouagadougou, Burkina Faso, in 2011. The households surveyed in this study gave information about their access to services, such as

the average cost of a cubic meter of water; the average percentage of the family budget spent on water; and the average time spent collecting water per day. Using the matching method, the study found that the improvement project cut the cost of water neighborhood-wide by 94 CFA francs per cubic meter, reduced the portion of this expense by 1% of the average household budget, and cut the daily time to collect water by 10-13 minutes. Begum *et al.* (2013) studied the impact of improved access to water and sanitation on the prevalence of diarrhoea in children in Bangladesh. Using the same matching method, the authors identified the household socioeconomic characteristics that influenced their decision to improve their access to water and sanitation: wealth, level of education (secondary education), and household size. The authors then measured the average impact of the program to improve access to water on the treatment group. According to their findings, improved access to water and sanitation led to a 41.8% reduction in diarrhoea rates.

Very little research looks at the impact of having access to a waste collection service. The existing studies are generally epidemiological and focus on a qualitative view of the health risks to populations who live near landfills, incinerators, compost sites, and nuclear power plants. These studies show a wide range of diseases that residents can contract from these sites (Misra *et al.,* 2005; Giusti, 2009; Hossain *et al.*, 2011). On the other hand, there are no quantitative microeconomic studies of the impact of household waste management services.

We therefore are presenting a study based on a 2014 survey we carried out in low-income settlements in Abidjan using a two-step matching method to quantify the quality of life of households that use an informal waste collection service. The first step identifies the determinants of household demand for an informal waste collection service; the second step evaluates the beneficial effects on households that use this service, measured by five different impact variables. The first two variables relate to household financial participation in the improvement of their environment and quality of life; the other three measure benefits in terms of socioeconomic and human development.

3. Waste management services in low-income settlements in Abidjan

3.1 Survey context and selection of samples

Household waste collection in Abidjan can be either official or informal. Official waste collection is under the responsibility of the District of Abidjan, but is actually carried out by

private companies that have signed concession contracts with the district. This service collects household waste at residences or waste collection sites and brings it to the official disposal site. Informal waste collection entails collecting waste at the residence and bringing it to the dump. This service requires the use of containers (bags, trash containers, crates, etc.) to collect household waste. In Abidjan, informal waste collection, which was once a practice only in areas inaccessible to official services, has spread to all the new settlements. This remains an informal activity in most parts of Abidjan, performed most often by local youth (73%), private companies (8%), and municipalities (2%). The municipalities that perform this activity generally have a service contract with the waste collectors, which varies in price by how often waste is collected every week (BURGEAP, 2011).

According to an urban waste characterization study in the District of Abidjan (DGSCV, 2010)[8], 48% of households subscribe to an informal waste collection service, and 18% bring their waste to official waste collection sites (municipal sites where households can leave their trash to be taken to the dump). The remaining households (about 30%) dump their waste in open-air dumps, canals, and roadsides. In 2012, the Côte d'Ivoire government and the World Bank[9] developed an emergency urban infrastructure project with the following objectives: improving access to urban infrastructure (drinking water, urban sanitation, solid waste management, urban roads, and municipal contracts) in Abidjan, Boake, and other cities in Côte d'Ivoire; and improving the environment and public health through preventative measures and waste sorting. In order to understand the current practices as well as household socioeconomic characteristics before the project began, we carried out a field survey in low-income settlements of Abidjan. The first objective of the survey was to establish a baseline of reported waste disposal and sanitation practices; the second was to determine households' willingness to pay for improved services, using a hypothetical scenario as part of a contingent valuation. We carried out this survey in 402 households living in 20 low-income settlements in Abidjan during the months of May-July 2014.

With the support of the National Statistics Institute (INS) of Côte d'Ivoire, the survey was carried out in 20 low-income settlements within the district of Abidjan (of the 183

---

[8] DGSCV, (2010). Urban waste characterization study for the District of Abidjan, Office of Health and Quality of Life.

[9] The World Bank, report N° ISR13285; Project title: RCI- Emergency Urban Infrastructure (FY08) (P110020); project period: 2008 – 2014.

neighbourhoods declared by the INS to be low-income). The sample was calculated based on the latest Population and Habitat Census (RGPH) supplied by the INS (2013). The surveyed settlements are part of the Abidjan blueprint (1996) that defines eight different types of habitat in order to classify types of household by quality of life. These 8 habitat types fall into three groups: informal or low-income settlements, developing areas, and established residential areas. Our study focuses primarily on the informal or low-income settlements, which are defined as a group of houses or shanties built on vacant land, with no formal leasing or ownership arrangements (Terrabo, 2010). Our study was carried out in enumeration areas[10] defined during the latest census with the help of random sampling: we randomly selected 20 of the 183 low-income settlements (enumeration areas) defined by the INS. Since all 183 low-income settlements contain 577,136 households, we surveyed 402 households in the 20 settlements (see Appendix 1). We carried out face-to-face interviews that lasted 20-30 minutes each.

3.2 Survey questionnaire and impact variables chosen for evaluation

The survey questionnaire was divided into six sections. The first set of questions was related to the respondent's identity: gender, age, and relationship to other household members. The second section defined the socioeconomic characteristics of the head of household: gender, age, education level, professional activities, and ownership status. In the third section, we asked about the household's access to various basic services and their waste disposal practices. We also asked households about their awareness of risks associated with improper waste disposal (mostly related to disease) as well as their willingness to pay for improved services as described in a contingent valuation. The fourth and fifth sections discussed household sanitation practices (managing wastewater and fecal matter) and drinking water. We collected data on various household expenses in the last section of the survey.

Our goal is to evaluate the impact of the use of an informal, fee-based waste collection service in order to have a clearer picture of the factors that would facilitate the implementation of the waste management service improvement project proposed by the government and the World Bank (not yet initiated at the time of the survey). From this perspective, it is interesting to

---

[10] An enumeration area is the geographical area assigned to a census taker. The areas represent low-income settlements as defined by the INS.

identify the positive effects of household use of informal waste collection services compared to the households that do not use these services and thus use open-air dumping practices.

Given the survey data collected, we chose to perform an econometric impact evaluation of these five variables: 1) The *amount* households would be willing to pay for each kilo of waste produced (in order to improve upon the current informal waste collection system); 2) Household *willingness to pay* a monthly fee to benefit from the improved service offered (provision of 2 rubbish bins and curb-side collection twice a week); 3) Household *monthly utility budget* (for water, gas, and electricity) (*budget_utilities*); 4) Household *monthly per-capita budget for food, health, and education* (*budget_devp_hum_t*); 5) The *score assigned for improved water, sanitation, and legal electricity facilities* (*score_equip_EAE*).

4. Econometric estimation procedure and sample segmentation

In this section we describe our econometric procedure, which allows us to correct for auto-selection bias between the two groups of households (service users or not) and to estimate the impact of the use of informal waste collection services.

4.1 Econometric estimation procedure

The matching method is one of four so-called quasi-experimental approaches (the others are difference-in-differences, regression discontinuity, and instrumental variables: see Parienté, 2008 for a complete review and Briand and Laré-Dondarini, 2017 for a synthesis of the theoretical framework). The matching technique strives to construct two groups from the given sample: a group of service users for which the impact is to be evaluated (treatment group) and a group of non-users (control group). The objective is to construct "twin" pairs of households with the same socioeconomic characteristics that differ only in their use of the informal waste collection service: this matching controls for selection bias.

The impact evaluation has two steps. The first step involves constructing these pairs of households that differ only in their use of waste collection services. Given the data collected for our sample, we have several observable characteristics[11]. Even though unobservable

---

[11] While we can control for observable characteristics (thanks to our survey data), there will always be unobservable characteristics that we cannot take into account.

characteristics such as motivation could influence the decision to use an informal waste collection system, we can reasonably hypothesize that there are enough observable characteristics to explain the households' decisions (Gertler *et al.*, 2011)[12]. We use a probit model to estimate the socioeconomic determinants of the households that currently use informal waste collection services to calculate their propensity score (represented by probability). This probit model can be formalized as follows: $P_i = Proba(d = 1 | X = x_i)$ where P_i: the propensity score of household i (probability of using the current informal waste collection service); d: the explanatory variable with value 1 if the household uses the service and 0 if not; x_i: the explanatory variables of the probit model that represent the observable socioeconomic characteristics of the household or its environment.

In the second step, we estimate the effect of using informal waste collection services on five impact variables by estimating the ATT (Average Treatment Effect on the Treated) written as:

$$\Delta^{ATT} = E(Y_1 - Y_0 | d = 1, X) = E(Y | X, d = 1) - E(Y | X, d = 0)$$

where

Δ^{ATT}: the average impact value of using an informal waste collection service for the treatment group

Y: the impact variable

d: the household uses (1) an informal waste collection service or not (0)

X: individual observable characteristics of the households

Using a matching algorithm that uses the propensity scores estimated in the first step allows us to match the user (treatment) group to the non-user (control) group. Each treatment household thus has a control household "twin", and the characteristics of the control group are as similar as possible to those of the treatment group. According to the literature, there are several commonly used matching algorithms; the two we use are nearest-neighbour matching and kernel matching[13]. Finally, we perform a test for good matching to check the robustness of the results. This test verifies that the characteristics of users and non-users are not

---

[12] It is impossible to completely exclude a potential selection bias that is based solely on unobservable characteristics.

[13] For each treatment household, a weighted average of the propensity scores of the control households is calculated. Weighting is based on the distance between the propensity scores of the treatment and control groups, with the greatest weight given to control households with the closest scores to those of treatment households.

significantly different. In other words, the matched households in the treatment and control groups need to be statistically comparable. We use a balancing test to compare the average of all the x_i variables included in the propensity score. This test determines whether the averages of the different variables are statistically similar between the two groups. According to Rosenbaum and Rubin (1985), the test shows whether selection bias has been controlled for.

4.2 Descriptive statistics

To carry out the impact evaluation, we divide our sample of 402 households into two groups: the treatment group, which uses an informal waste collection service (138 households or 34.3% of the sample) and the control group, which does not use the service (264 households or 65.7% of the sample). The control group uses either public dumpsters (29.9%) or illegal waste disposal methods: dumping in open areas (23.9%), canals or lagoons (45.1%), or in a neighbour's trash container (1.1%).

In our sample, 21% of the heads of households in the treatment group are women (as opposed to only 14.4% among the control group). The distribution of material wealth into quartiles (Appendix 2) shows that relatively more wealthy households use informal waste collection services (29%). Of the treatment group, 89.9 % have a source of treated water as opposed to 88.2 of the control group. Only 44.2 of the treatment group have improved sanitation systems as opposed to 53.4% of the control group. It is interesting to note that 70.3% of treatment households have improved wastewater systems, as opposed to only 38.3% of control households. Only 17.8% of control households have a legal electricity connection as opposed to 36.2% of treatment households.

Households that pay for an informal waste collection service pay an average of 848 CFA francs per month for the service. The amounts differ very little between communities (from 500 CFA francs in Abobo and Adjamé to 890 CFA francs in Yopougon) and according to wealth quartile (from 745 CFA francs for poor households to 908 CFA francs for wealthy households). Statistical analysis of willingness to pay indicates that users of the informal waste collection service report being prepared to pay 671 CFA francs (as opposed to 480 CFA francs for non-users) to receive the service scenario described in the contingent valuation. The analysis by quartile is interesting because it shows that among the treatment group, poor households report the highest monthly amount they are willing to pay (896 CFA francs).

The statistical analysis of the implementation of a fee for each kilogram of household waste produced shows that households that now use an informal waste collection service would be willing to pay an average of 153 CFA francs per kilo as opposed to 96 CFA francs for households that do not use this service.

5. Analysis of the econometric impact evaluation of using an informal waste collection service

5.1 The determinants of reported demand for an informal waste collection service

We estimate two models to identify the determinants for using an informal waste collection service in the low-income settlements of Abidjan we surveyed. The results of the two probit models and the marginal effects of the different explanatory variables are presented in Table 1 below.

The variables tested in the first probit model are wealth index (Score_total), a female head of household (CM_Femme), having a traditional latrine as sanitation system (Latsimples), having an improved wastewater drainage system (Ecoul_Amel), being dissatisfied with the official waste collection system (Pas_Satisf), perceiving the public dumpster as far from the residence (Bac_Pub_Loin), believing that disease is the biggest problem associated with waste disposal (Maladie), wanting any improved waste collection service to be privately provided (Prive_RespPrg), and sorting household waste (Tri). This is the model that was used to calculate the propensity scores needed to proceed to matching according to the econometric procedure described above. All the explanatory variables tested in probit model 1 prove to be significant (except sorting household waste) and positive (except being dissatisfied with the official waste collection system, which has a negative influence).

These results are interesting because they shed light upon the determinants of household use of informal waste collection services in the low-income settlements we surveyed in Abidjan. The model applied to our survey data shows that as the wealth index increases, so does the probability that the household uses an informal waste collection service. This result is not surprising since this is a fee-based service; household purchasing power thus has a result on whether the household chooses to use an informal waste collection service. Studies carried out in Dhaka, Bangladesh (Afroz *et al.,* 2009) and Macao, China (Jin *et al.,* 2006) also show that

the level of household wealth has a positive influence on the probability a household will contribute to waste management service improvements. There are other determinants besides pure economics that explain waste disposal behaviour. When the head of household is female, it is more likely to use an informal waste collection service. Dadson *et al.* (2013) similarly showed that women in Ghana are more likely to favour paying for improved waste management services. There are many potential reasons for this finding. First, female heads of households need to participate in income-generating activities as well as domestic tasks to satisfy the needs of their family. Going to dispose of waste in public dumpsters that are far from the residence takes time and thus generates an opportunity cost that may explain the preference to use an informal waste collection service. In fact, our model also shows that the probability of using this service increases when the household believes the public dumpster is far from the residence. This result is in line with results found by Dadson *et al.* (2013) and Nkansah *et al.,* 2015 who show that as the distance of public dumpsters from the residence increases, the willingness to pay for them decreases. Similarly, the literature on household demand for drinking water in West Africa shows the effects of opportunity costs linked to distance that explain the preference for piped water in the home as opposed to standpipes (Churchill *et al.,* 1987; Calkins *et al.,* 2002; Briand *et al.,* 2009). Opportunity costs are evaluated by Nauges and Strand (2017) who indicate a significant negative relation between girls' school attendance and water hauling activity.

Second, women may have stronger feelings about the environment and health, as they tend to worry more about the health consequences of their family's exposure to waste. Milanesi *et al.* (2003) have also shown a positive gender effect on willingness to pay for improved sanitation in Moshi, Tanzania. This result could be explained by the value the household places on the costs and benefits linked to the adoption of various sanitation systems (more privacy, better hygiene, and recovery of dried sludge for use as fertilizer). The model also shows that the probability of using an informal waste collection service increases somewhat if the household believes that diseases are a major problem linked to waste. Koné (2016) shows in another study in Abidjan that when households consider waste a hazard to their health, they are more inclined to participate in a waste management service improvement project.

Sensitivity to sanitation in daily life seems to influence household preference for an informal waste collection service. Households that use a traditional latrine (even if it is not an improved latrine as mentioned in the SDGs) are more likely to use an informal waste collection service; this is also true for households with improved wastewater drainage

systems. This result is in line with studies like those of Lauria *et al.* (1997) and Milanesi (2003), who show that willingness to pay for improved infrastructure is associated with awareness of issues related to wastewater and fecal matter disposal.

Finally, it is interesting to note that households wanting any waste management service improvement project to come from the private sector (as part of the contingent valuation) are more likely to use an informal and thus privately run waste collection service. This shows potential confidence in private providers, which are seen as capable of satisfying waste management needs, and possibly also a certain suspicion of official service providers, which are seen as failing in their public service mission. Gunsilius (2010) has shown that successfully integrating informal workers into official waste management systems depends on several factors. Specifically, the informal sector needs to be able to organize and efficiently manage its activities, coordinate with other actors, and influence public and political opinion to drive the willingness to be integrated into the institutional structure. Our probit model shows an R2 pseudo equal to 0.18, which shows good robustness. The model also correctly predicts 70.9% of cases.

Given the richness of the data from the questionnaire, we wanted to test other variables. The results of a second probit model (a variation of the first) are presented in Table 1. In this variation, we kept the same explanatory variables except for the following exceptions. We deleted the "Maladie" variable (belief that disease is the biggest problem linked to waste) and added two new variables instead: whether the household believes waste constitutes a hazard to the health (DchMen_Sant) and the average duration of waste accumulation by neighbourhood (D_Sto_Quart). The results show that the first new variable does not prove to be significant (even though the "Maladie" variable in the first model was). The second variable sheds light on individual waste management behaviour. In fact, as the average duration of waste accumulation by neighbourhood increases, so does the probability that the household will use an informal waste collection service. Having more exposure to household waste (as is the case when the duration of waste accumulation increases in the neighbourhood) creates negative externalities for the area's residents (odours, insects, health risks, loss of quality of life). These negative externalities could thus lead to a household's wish to offset the loss of utility with an informal waste collection service. The remaining variables in the model remain significant and retain the same direction of influence on the stated household demand for an informal waste collection service, except for the "Tri" variable related to sorting of trash. In the first probit model, this variable was not significant, while in the second, it is at the 15% threshold. More precisely, when a household sorts its trash, the probability of it using an

informal waste collection service decreases. This result could seem surprising in that Afroz *et al.* (2009) show that when households sort their trash, they are more likely to participate in waste management service improvement. In our area of study (low-income settlements in Abidjan), however, we believe that the households that sort their trash do so to dispose of it in the public dumpsters or to reuse or resell recyclable materials. In fact, our study shows that among the households that sort their trash, 66.4% do not use an informal waste collection service. This second probit model shows an R2 pseudo close to 0,21, which points to good robustness. The model also correctly predicts 74.6% of cases. The results from the two models are similar, which points to the robustness of the analysis of the determinants of demand for an informal waste collection service. We have chosen to keep the first probit model as we continue the analysis; we will use the propensity scores from that model in the second step, which will quantify the effects of the use of the service on the maintained impact variables.

Table 1: Propensity score calculation – Probit models

VARIABLES	Model 1		Model 2	
	Probit	mfx 1	Probit	mfx 1
CM_Femme	0.354*	0.130*	0.361*	0.133*
	(0.187)	(0.071)	(0.188)	(0.072)
latsimples	0.652***	0.226***	0.667***	0.231***
	(0.158)	(0.053)	(0.160)	(0.053)
Score_total	0.082***	0.029***	0.085***	0.030***
	(0.023)	(0.008)	(0.023)	(0.008)
Ecoul_Amel	0.792***	0.273***	0.807***	0.278***
	(0.148)	(0.048)	(0.150)	(0.049)
Pas_Satisf	-0.399***	-0.141***	-0.370**	-0.131**
	(0.146)	(0.052)	(0.146)	(0.052)
Bac_Pub_Loin	0.563***	0.212***	0.469**	0.175**
	(0.201)	(0.079)	(0.209)	(0.081)
maladie	0.499*	0.154**		
	(0.296)	(0.077)		
Prive_RespPrg	0.364**	0.130**	0.351**	0.125**
	(0.151)	(0.055)	(0.153)	(0.055)
DchMen_Sant			0.676	0.190
			(0.590)	(0.121)
D_Sto_Quart			0.387***	0.135***
			(0.112)	(0.039)
Tri	-0.275	-0.101	-0.293	-0.107
	(0.196)	(0.074)	(0.201)	(0.076)
Constant	-1.440***		-2.711***	
	(0.346)		(0.672)	
Observations	402	402	402	402
R2 pseudo	0,1865		0,2096	

% of cases correctly predicted	70,9	74, 63

We used two methods to check for lack of multicollinearity. First, we calculated correlations between pairs of variables to remove those with a coefficient above 0.45. The variables in our probit model do not show multicollinearity. We then carried out the VIF (variance inflation factor) test of multicollinearity (Cahuzac and Bontemps, 2008), the results of which are presented in Appendix 3. According to this method, there is multicollinearity in the regression if the highest VIF is over 10, which is not the case in our regression. We also carried out a test for endogeneity for the variables *Score_total* (household wealth index), *budget_utilities* (monthly budget for water, gas, and electricity), *budget_devp_hum_t* (monthly per-capity budget for food, health, and education), and *score_equip_EAE* (the household has access to drinking water, improved sanitation, and legal electricity), but their instrumentalization does not affect the model's conclusion[14].

5.2 Analysis of the evaluation of benefits to households using an informal waste collection service

In this section we present the benefits to households using an informal waste collection service as opposed to the households that do not use one (and therefore are likely to use illegal dumping methods) by calculating ATT (Average treatment effect on the treated). The results provide a clearer picture of the factors that would facilitate the implementation of the waste management service improvement project proposed by the government and the World Bank (not yet initiated at the time of the survey). Given the survey data collected, we chose to perform an econometric impact evaluation of these five variables: 1) The *amount* households would be willing to pay for each kilo of waste produced (in order to improve upon the current informal waste collection system); 2) Household *willingness to pay* a monthly fee to benefit from the improved service offered (provision of 2 rubbish bins and curb-side collection twice

---

[14] Utilizing an exogenous variation of our model's variables through instrumental variables could show the possibility of reverse causality. A good instrumental variable should be significantly correlated with the variable whose endogeneity is being tested but not correlated with the residual values from the regression. Results from our estimations from the endogeneity test are available upon request.

a week); 3) Household *monthly utility budget* (for water, gas, and electricity) (*budget_utilities*); 4) Household *monthly per-capita budget for food, health, and education* (*budget_devp_hum_t*); 5) The *score assigned for improved water, sanitation, and legal electricity facilities* (*score_equip_EAE*).

Table 2 presents the results of matching. We evaluate the effect of using an informal waste collection service on the five impact variables by comparing the average of each impact variable for the user (treatment) and non-user (control) groups, before (unmatched) and after matching (ATT). We analyze, before and after matching, the difference between these averages for each impact variable as well as the significance of this difference by using two algorithms (nearest neighbour and kernel). Finally, we use a test for good matching to ensure that we controlled sufficiently for selection bias and to justify our use of matching as our method of evaluation.

Table 2: Matching results

Impact variables	Sample	Treatment (users of informal collection service)	Control (non-users of informal collection service)	Difference	S.E.	T-stat
The *amount* households would be willing to pay for each kilo of waste produced	Nearest neighbour					
	Unmatched	153,19	96,08	57,11	36,39	1,57
	ATT	166,19	109,52	56,66	53,15	1,07
	Kernel					
	Unmatched	153,19	96,08	57,11	36.39	1,57
	ATT	153,19	110,41	42,77	44,85	0,95
Household *willingness to pay* a monthly fee to benefit from the improved service offered	Nearest neighbour					
	Unmatched	671,01	479,92	191,09	88,12	2,17
	ATT	686,46	498,49	187,96	106,8	1,76
	Kernel					
	Unmatched	671,01	479,92	191,09	88,12	2,17
	ATT	675,91	517,79	158,12	109,5	1,44
Household *monthly utility budget* (for water, gas, and electricity) (*budget_utilities*)	Nearest neighbour					
	Unmatched	17554,73	13642,08	3912,65	1317	2,97
	ATT	16849,74	14119,62	2730,12	1880	1,45
	Kernel					
	Unmatched	17554,73	13642,08	3912,65	1317	2,97
	ATT	17610,28	14548,19	3062,09	1655	1,85
Household *monthly per-capita budget for food, health, and education* (*budget_devp_hum_t*)	Nearest neighbour					
	Unmatched	35535,07	29319,78	6215,29	2511	2,47
	ATT	35549,13	28792,26	6756,87	4438	1,52
	Kernel					
	Unmatched	35535,07	29319,78	6215,29	2511	2,47
	ATT	35572,93	32280,26	3292,66	3122	1,05
The *score assigned for improved water, sanitation, and legal electricity facilities* (*score_equip_EAE*)	Nearest neighbour					
	Unmatched	0,56	0,53	0,03	0,02	1,22
	ATT	0,55	0,48	0,07	0,04	1,6
	Kernel					
	Unmatched	0,56	0,53	0,03	0,02	1.22
	ATT	0,57	0,49	0,07	0,03	2.08

Source: Author calculation

Analysis of Table 2 shows that for each of the five impact variables, there is a beneficial effect of using an informal waste collection service.

According to the matching results, the fact that a household currently uses an informal waste collection service increases the amount it would be willing to pay: while the control (non-user) group was willing to pay an average of 109.52 CFA francs, the treatment (user) group was willing to pay 166.19 CFA francs. In the contingent valuation survey, this fee was clearly presented as a source of funding for a program to improve the informal waste collection service: "The provision of two trash containers (in two different colours to encourage sorting and recycling) with twice-weekly collection". This is an incentive fee meant to encourage households to sort trash in the home. The difference between the two averages (56.66 CFA francs) is not significant, but its positive direction indicates that households that currently use an informal waste collection service are perhaps more willing to financially support an improvement project. This intuition is confirmed in that households using an informal waste collection service are willing to pay an average monthly fee of 686.46 CFA francs, as opposed to 498.49 CFA francs for non-users, for the improved service described in the scenario. This difference in averages (187.96 CFA francs) is significant and shows the strong interest in improved waste collection services that current users of an informal waste collection service have. Moreover, these estimated amounts clarify households' ability to pay and could thus help develop a fee structure for improved service. According to these two results, households in low-income settlements in Abidjan seem determined to contribute financially to the improvement of their environment and quality of life to compensate for the loss of utility due to negative externalities from extended accumulation of household waste in their communities.

The three other impact variables are aimed at analyzing the effect of using an informal waste collection service on the level of development within the household in terms of whether the

use of these informal services generates positive externalities in terms of human and socioeconomic development.

The results show first that households that use an informal waste collection service have a significantly higher utilities budget, 3,062.09 CFA francs, than non-user households. In other words, households that use an informal waste collection service find more utility (measured in terms of expenses) in satisfying their basic needs and improving their living conditions. According to the SDGs (2015), utilities are a factor of human development.

The results also show that the monthly per-capita budget allocated to food, health, and education is significantly higher, at 6,757.87 CFA francs, in the treatment group than in the control group. Households that use an informal waste collection service assign a higher utility to increased well-being than to those that do not use such services, in the sense that they spend more of their household budget to this end.

Finally, the results show that the treatment group has a significantly higher score in improved water, sanitation, and legal electricity facilities than does the control group. This significant difference reinforces the idea that households that use an informal waste collection service find more utility in having access to improved basic services. This result, which shows household interest in this type of infrastructure, is encouraging for the possibility of reaching sustainable development goals: Goal 6 of the SDGs is to "ensure availability and sustainable management of water and sanitation for all" and Goal 7 is to "ensure access to affordable, reliable, sustainable, and modern energy for all (UN, 2016)." Our econometric results show that citizens acknowledge the need for improved access to water, sanitation, energy, and electricity.

The balancing test (see Appendix 4) confirms that the matching was good and controlled for selection bias. According to the results of this test, the household characteristics of the treatment group are not significantly different from those in the control group[15]. To analyze the impact of unobserved heterogeneity on our estimates we carry out a sensitivity analysis using the bounding approach proposed by Rosenbaum (2002). The positive selection bias occurs when the people most likely to have pipe water, energy or electricity tend to have higher budget even if they had not these services (water, energy or electricity). The computation of this test is possible only for the marginal estimator PSM. Based on the assumption of positive selection bias, the tests[16] suggest that our study is insensitive to a bias that would be multiply by nineteen the odds to be have the services for all. The critical values suggest that our results are very little affected by a hidden bias.

6. Conclusion

The analysis of data from a 2014 contingent valuation survey we carried out among 402 households in low-income settlements of Abidjan allowed us to find the determinants of stated demand for an informal waste collection service and evaluate the effects of using this service on different impact variables. The results from econometric models show that households have a real interest in an improvement of the existing service and provide a clearer picture of the pricing and institutional modalities of a public policy of improved waste management service in low-income settlements of this major African city.

The first contribution of this article is to have identified the determinants of household demand for an informal waste collection service. Our study shows that material wealth and gender (female head of household) have a positive influence on the use of this type of service.

---

[15] By comparing the averages of all the x_i variables included in the propensity scores.

[16] All the results of sensitivity analysis are available from the authors.

The gender effect can be explained by the opportunity cost linked to the distance of public dumpsters (since this variable also had a positive effect on the decision to use an informal waste collection service) as well as women's greater awareness of health and sanitation issues related to exposure to waste. This intuition is confirmed in that the probability a household will use an informal waste collection service increases when the household considers disease a major issue linked to waste disposal. Our results also show a strong household sensitivity to improvement in the quality of habitat and the environment of the neighbourhood. In fact, households with a latrine and an improved drainage system for wastewater have a higher probability of using an informal waste collection service. In addition, as the average duration of household waste accumulation throughout the neighbourhood increases, the probability of using an informal waste collection service also increases. It is likely that living in a settlement abundantly endowed with trash exposes households to negative externalities (odours, insects, health risks, loss of quality of life). These negative externalities could thus lead to a household's wish to offset the loss of utility with an individual investment in an informal waste collection service. Finally, our results show a certain confidence households have in the private sector to satisfy the needs of citizens (Briand and Laré, 2013 about private water operators in Maputo, Togo). Households that use an informal waste collection service show a preference for the private sector taking charge of any waste management service improvement project. Any consideration of the institutional organization of the sector needs to take into account the potential suspicion of public actors, who may be seen as failing in their public service mission. The question remains whether informal waste collection services should be institutionalized in a public-private partnership or eliminated in favour of a proactive public policy.

This article is also novel in that it has evaluated the beneficial effects of using an informal waste collection service through five impact variables. Two of these variables relate to the contingent valuation survey. The results of matching show a positive but not significant difference of 56.66 CFA francs in the amount per kilogram of household waste the treatment and control groups were willing to pay for the current informal service. In the contingent valuation survey, this fee was clearly presented as a source of funding for a program to improve the informal waste collection service ("The provision of two trash containers [in two different colours to encourage sorting and recycling] with twice-weekly collection"). The literature shows that fees are an incentive to recycling, encouraging households to reduce the amount of waste that goes to the dump and thus the charges linked to their management (Bucciol *et al.,* 2011; Bel *et al.,* 2015). A study by Wright *et al.* (2011) used matching to evaluate the impact of a fee based on the amount of household waste disposed of in a sample of 234 towns in New Hampshire (US), 40 of which had the per-unit fee imposed. The average annual reduction of waste is estimated at 53-41%. In France, the ADEME [French environment and energy management agency] (2016) showed that unit-based pricing increased the tonnage of sorted waste by 33% (14 kg per resident for packaging, newspapers, and magazines). The opportunity to implement this kind of fee in Abidjan is supported by our results, even though some studies have shown a risk of unintended consequences like increases in illegal behaviour (trash burning and illegal dumping) (Fullerton *et al.,* 1996).

We also evaluated the use of an informal waste collection service in terms of households' willingness to pay a monthly fee for the implementation of a waste management service improvement program in the low-income settlements of Abidjan. The results of the matching show a significant and positive difference (188 CFA francs), which shows that households using an informal waste collection service are interested in the improvement proposed in the scenario. Moreover, the amounts stated (684 CFA francs for the treatment group as opposed

to 498 CFA francs for the control group) can clarify households' ability to pay and thus help develop a fee structure for improved service. Households in low-income settlements in Abidjan are determined to contribute financially to the improvement of their environment and quality of life to compensate for the loss of utility due to negative externalities from extended accumulation of household waste in their communities. Remains the question of the pricing system to be implemented taking into account the various criteria to be taken into account as universal access and cost recovery (Reynaud, 2016). For example, Nauges and Whittington (2017) analyse how alternative municipal water tariff designs affect three criteria: financial self-sufficiency for the service provider, equity among customers, and economic efficiency for society.

The results of our study also shed light on the benefits of this service in terms of socioeconomic and human development. Households that use an informal waste collection service find more utility (measured in terms of expenses) in satisfying their basic needs and improving their living conditions, as their utility budgets are 3,062 CFA francs higher than the control group, a significant difference. Moreover, households using the informal waste collection service have a higher utility from human development than the control group since their per-capita monthly expenses for food, health, and education is 6,758 CFA francs higher, a significant difference. Finally, the treatment group has a significantly higher score in improved water, sanitation, and legal electricity facilities than does the control group, showing that the treatment group finds more utility in having access to improved basic services. These three results show the positive impacts (in terms of expenses) on positions dedicated to improving quality of life and well-being.

Finally, the article sheds light on the field of development and environmental economics by showing that the SDGs match the expectation of households, which aspire to the satisfaction of their basic needs, especially in terms of utilities. Outside of pricing policies and service

subsidies, the debate on appropriate institutional organization remains open. The question remains whether informal waste collection services should be institutionalized in a public-private partnership or eliminated in favour of a proactive public policy. The question of what organizational strategy is required to ensure the SDGs are met is also still open.

7. References

ADEME (2016), « La tarification incitative de la gestion des ordures ménagères : quels impacts sur les quantités collectées ? », *Etudes et documents*, Commissariat Général au Développement Durable, Alexis Gatier, mars.

Afroz, R., Keisuke, H., and Kiyo, H. (2009), « Willingness to Pay for Waste Management Improvement in Dhaka City, Bangladesh », *Journal of Environmental Management,* 90, 492–503.

Aiga, H., Y. Arai, E. Marui, et T. Umenai. (1999), « Impact of Improvement of Water Supply on Reduction of Diarrheal Incidence in Squatter Area of Manila », *Environmental Health and Preventive Medicine*, 4, 111–116.

Banga, M., Lokina, R. B. and Mkenda, A. F. (2011), « Households'Willingness to Pay for Improved Solid Waste Collection Services in Kampala City, Uganda », *Journal of Environment & Development,* 20, 428-448.

Banque Mondiale (2016), « Moins de gâchis, plus d'économies : la gestion des déchets au cœur du développement durable », mars.

Begum, S., Ahmed, M., and Sen, B., (2013), « Impact of water and sanitation interventions on childhood diarrhea: evidence from Bangladesh », *3ie Grantee Final Report*, New Delhi: International Initiative for Impact Evaluation (3ie).

Bel G. et Gradus R., (2014), « Effects of unit-based pricing on the waste collection demand: a meta-regression analysis », Institut de Recerca en Economia Aplicada Regional i Pública, Research Institute of Applied Economics, Working Paper 20p.

Bléhaut M. et Rathelot R., (2014), « Expérimentation contrôlée contre appariement : le cas d'un dispositif d'accompagnement de jeunes diplômés demandeurs d'emploi », *Economie et prévision*, n° 204-205, p. 163-181.

Briand A., C. Nauges, M. Travers (2009), « Les déterminants du choix d'approvisionnement en eau des ménages de Dakar », *Revue d'Economie du Développement*, numéro 3, pp 83-108.

Briand, A. et A.L. Laré (2013), « La demande de raccordement des ménages auprès des Petits Opérateurs Privés d'eau potable : le cas des quartiers périphériques de Maputo », *Revue Economique*, 64, 685-719.

Briand A. et Laré-Dondarini L.A. (2017), « Impact of Improved Water Services in Informal Neighbourhoods in Ouagadougou », *Applied Economics*, 49, 1571-1583.

Bucciol A., Montinari N., Piovesan M., (2015), « Do Not Trash the Incentive! Monetary Incentives and Waste Sorting », *Scandinavian Journal of Economics*, Blackwell, 117, 1204-1229, October.

BURGEAP, (2011), « Etude stratégique pour la gestion des déchets solides dans le district d'Abidjan », Programme d'urgence d'infrastructures urbaines.

Cahuzac E., Bontemps C. (2008), « Stata par la pratique : statistiques, graphiques et éléments de programmation », *Stata Press*.

Calkins P., Larue B., Vezina M., (2002), « Willingness to pay for drinking water in the Sahara: the Case of Douentza in Mali », *Cahiers d'Économie et Sociologie Rurales,* 64 : 38-56.

Churchill A-A., (1987), « Rural Water Supply and Sanitation: Time for a Change », *World Bank Discussion Paper* 18, Washington D.C.

Dadson, A., Shaibu, I. and Godfred, S., (2013) « Urban Households' Willingness to Pay for Improved Solid Waste Disposal Services in Kumasi Metropolis, Ghana », *Urban Studies Research*, Article ID 659425.

Duflo E., Glennerster R., Kremer M., (2007), « Using Randomization in Development Economic Research: A Toolkit », Handbook of Development Economics. Elsevier-North Holland John Strauss and Paul Schultz, editors, Vol. 4.

Fullerton, D., and Kinnaman, T.C., (1996), « Household Responses to Pricing Garbage by the Bag », *American Economic Review*, 86, 971–984.

Galiani, S., P. Gertler, et E. Schargrodsky., (2005), "Water for Life: The Impact of the Privatization of Water Services on Child Mortality", *Journal of Political Economy,* 113: 1.

Gbinlo R., (2010), « Organisation et financement de la gestion des déchets ménagers dans les villes de l'Afrique Subsaharienne : le cas de la ville de Cotonou au Benin », Université d'Orléans, France.

Gubert, F., and Roubaud, F., (2005), « Analyser L'impact D'un Projet De Microfinance : l'exemple d'adéfi à Madagascar », Agence Française de Développement, Notes et Documents n°19, juin 2005, 117p.

Gertler P. J., Martinez S., Premand P., Rawlings L., B., Vermeersch C., M., J., (2011), « Impact Evaluation in Practice. The International Bank for Reconstruction and Development », The World Bank, Washington DC 20433.

Giusti L., (2009), « A Review of Waste Management Practices and their Impact on Human Health », *Waste Management,* 29, 2227–2239.

Givord P., (2014), « Méthodes Econométriques pour l'Evaluation de Politiques Publiques », Economie et Prévision, n° 204-205, p. 1-28.

Gramlich, E.M. (1977), « Intergovernmental Grants: A Review of the Empirical Literature ». W.E.Oates, The Political Economy of Fiscal Federalism : 219-239. Lexington: Lexington Books.

Gunsilius, E. (2010), « Role of informal sector in solid waste management and enabling conditions for its integration. Experiences from GTZ », Paper presented at Transwaste workshop on the Informal Sector, Geneva, 2010. http://www.transwaste.eu/file/001441.pdf

Hossain Md S. , Santhanam A., Norulaini N.A. N., A.K., Oma M., (2011), « Clinical solid waste management practices and its impact on human health and environment – A review », Waste Management, 31, 754–766.

INS-ENV (2015), « Enquête sur le Niveau de Vie des Ménages en Côte d'Ivoire », *Institut National de Statistique*, Côte d'Ivoire.

Jin, J., Wang, Z. and Ran, S. (2006), « Comparison of Contingent Valuation and Choice Experiment in Solid Waste Management Programs in Macao », *Ecological Economics* 57, 430-431.

Khandker S., R., Koolwal G., B., Samad H. A., (2010), « Handbook on Impact Evaluation. Quantitative Methods and Practices », *The International Bank for Reconstruction and Development* / The World Bank. Washington DC 20433.

Koné N., (2016), « Willingness to Pay of the Households to a Waste Management Improvement in the Precarious Districts of Abidjan (Ivory Coast) », *Economics Bulletin*, 36, 1791-1804.

Lauria D.T, Alfredo H.C, Anthony A.K, (1997), « Final Report on Willingness to Pay for Improved Water and Sanitation in Dakar », a report to the Senegal National Water Society, The Governement of Senegal and Word Bank, unpublished. Chapel Hill, North Carolina.

Milanesi J., Morel A L'Huissier A., et Contamin B., (2003), « La demande pour un assainissement amélioré à Moshi, in Gestion domestique des eaux usées et des excrétas : étude des pratiques et comportements, des fonctions de demande, de leur mesure en situation contingente et de leur opérationnalisation », Rapport final, PDM, PS-eau.

Misra V., Pandey S.D., (2005), « Hazardous waste, impact on health and environment for development of better waste management strategies in future in India », *Environment International*, 31, 417–431.

Mustafa, U., Ahmad, I. and Haq, M. U. (2014), « Capturing Willingness to Pay and Its Determinants for Improved Solid Waste Management », *Pakistan Institute of Development Economics*, Pide working papers n°110.

Nauges, C., Strand, J. (2017), «Water hauling and girls' school attendance: Some new evidence from Ghana», *Environmental and Resource Economics*, vol. 66, issue 1, pages 65-88.

Nauges, C., Whittington, D. (2017), «Evaluating the Performance of Alternative Municipal Water Tariff Designs: Quantifying the Tradeoffs between Equity, Economic Efficiency, and Cost Recovery», *World Development*, 91, 125-143.

Nkansah, E., Dafor, N.K. and Essel-Gaisey, F. (2015), «Willingness to Pay for Improved Solid Waste Disposal in Tema Metropolis» *UDS International Journal of Development* 2.

Olivier, A. (2006), « Evaluation De L'impact Sur Les Ménages De La Hausse Du Tarif De L'eau à Manaus (Brésil) », Document de travail DIAL DT/2006-10.

ONU (2015), « Objectif du Développement Durable : 17 objectifs pour transformer notre monde », sur http://www.un.org/sustainabledevelopment/fr/

Pamies-Sumner S., (2014), « Les Evaluations d'Impact dans le Domaine du Développement Etat des Lieux et Nouveaux Enjeux », Département de la Recherche, AFD.

Pariente W., (2008), « Analyse d'impact : l'apport des évaluations aléatoires », *STATECO N°103*.

Pattanayak S.K, Poulos C., Yang J-C., et Patil S., (2010), « How valuable are environmental health interventions ? Evaluation of water and sanitation programs in India », *Bulletin of the World Health Organization*, 88, 535-542.

Reynaud A. (2016), « Assessing the impact of full cost recovery of water services on European households », *Water Resources & Economics,* 14, 65-78.

Rosenbaum P., R., and Rubin D., B., (1983), « The central role of the propensity score in observational studies for causal effects », *Biometrika*, 70, 41-55.

Roushdy R., Sieverding M., et Radwan H., (2012), « The Impact of water supply and sanitation on child Health: evidence from Egypt », Population Council, Poverty, Gender and Youth Working Paper N°24.

Seraj K.F.B., (2008), « Willingness to Pay for Improved Sanitation Services and its Implication on Demand Responsive Approach of BRAC Water, Sanitation and Hygiene Programme », Working Paper No. 1 BRAC.

TERRABO (2010), Etude de caractérisation des déchets urbains du district d'Abidjan, Rapport provisoire pour le Ministère de la ville et de la salubrité urbaine, Direction générale de la salubrité et du cadre de vie.

Thonart P., Diabaté S. I., Hiligsmann S., Lardinois M., (2005), « Guide pratique sur la gestion des déchets ménagers et des sites d'enfouissement technique dans les pays du sud », Collection points de repère, Les publications de l'IEPF.

Wright, C. and Halstead J. M. (2011), « Using Matching Estimators to Evaluate the Effect of Unit-Based Pricing on Municipal Solid Waste Disposal: A Case Study of New Hampshire Towns », Selected paper for presentation at the Agricultural & Applied Economics Association's 2011 AAEA & NAREA Joint Annual Meeting, Pittsburgh, Pennsylvania, July 24-26.

Yusuf, S. A., Salimonu, K. K. and Ojo, O. T. (2007), « Determinants of Willingness to Pay for Improved Household Solid Waste Management in Oyo State, Nigeria », *Research Journal of Applied Sciences*, 2, 233-239.
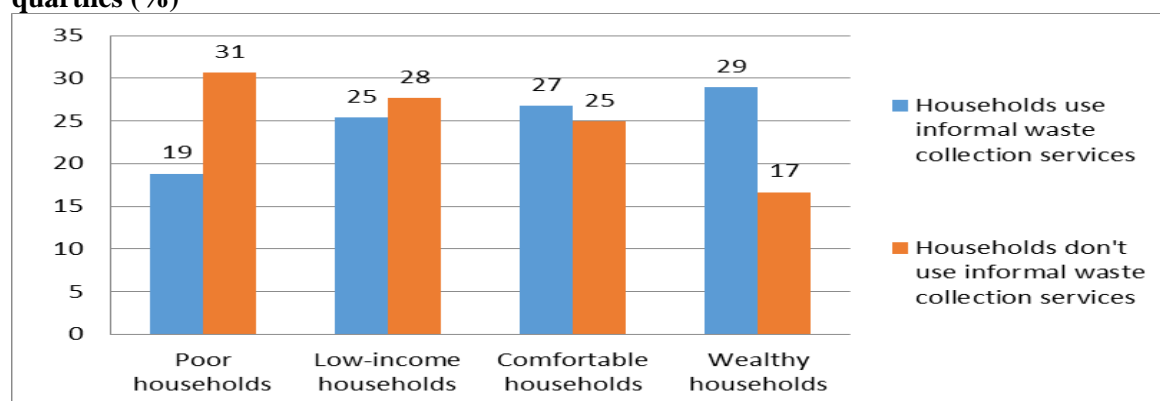
8. Appendix

Appendix 1 : Distribution of the sample (402 households in low-income settlements)

Townships	Settlements	Sample size (households)
Abobo	Agoueto	19
Adjamé	Sodeci-Filtisac	20
Attiécoubé	Lagunes	20
Cocody	Sopim Vallon, Attoban 1, Attoban 2, Danga	81
Yopougon	Gare Sud Sodeci 1, Gare Sud Sodeci 2, Gare Sud Sodeci 3, Sicogi 1, Sicogi 2, Sicogi 3, Sicogi 4, Niangon Sud 1, Niangon Sud 2, Niangon Sud 3, Niangon Sud 4, Niangon Sud 5, Port-Bouet 2	262
Total		**402**

Source : Authors

Appendix 2 : Share of households using the informal pre-collection service according to wealth quartiles (%)

Source : Authors

Appendix 3 : Multicollinearity test (VIF)

Variables	VIF	1/VIF
Score_total	1,18	0,850369
latsimples	1,16	0,865612
Prive_RespPrg	1,13	0,888778
maladie	1,11	0,903878
tri	1,10	0,912648
Ecoul_Amel	1,10	0,912898
Pas_Satisf	1,06	0,945263
CM_Femme	1,03	0,970017
Bac_Pub_Loin	1,03	0,971867
Mean VIF	1,10	

Source : Authors

Appendix 4 : *Balancing test*

Variables		Averages		% bias	% réduction in bias	T-test	
		Treatment group	Control group			T	p > T
CM_Femme	Before matching	0,21014	0,14394	17,4		1,69	0,091
	After matching	0,21168	0,20786	1,0	94,2	0,08	0,938
latsimples	Before matching	0,55072	0,46212	17,7		1,69	0,092
	After matching	0,54745	0,60142	-10,8	39,1	-0,90	0,368
Score_total	Before matching	0,626	-0,93615	43,2		4,42	0,000
	After matching	0,6078	0,03666	15,8	63,4	1,25	0,211
Ecoul_Amel	Before matching	0,7029	0,38258	67,7		6,39	0,000
	After matching	0,70073	0,72997	-6,2	90,9	-0,53	0,593
Pas_Satisf	Before matching	50725	0,63258	-25,4		-2,44	0,015
	After matching	0,51095	0,51909	-1,7	93,5	-0,13	0,893
Bac_Pub_Loin	Before matching	0,22464	0,0947	35,9		3,62	0,000
	After matching	0,21898	0,1735	12,6	65,0	0,95	0,345
maladie	Before matching	0,95652	0,86364	32,8		2,91	0,004
	After matching	0,9562	0,96783	-4,1	87,5	-0,50	0,616
Prive_RespPrg	Before matching	0,49275	0,30303	39,4		3,80	0,000
	After matching	0,48905	0,46909	4,1	89,5	0,33	0,742
tri	Before matching	0,82609	0,85227	-7,1		-0,68	0,494
	After matching	0,82482	0,77971	12,3	72,2	0,94	0,350

Source : Authors

This is a statistical test (t-test) of the hypothesis that the average value of each variable is the same in the treatment and control groups. This test is carried out before and after matching. Bias before and after matching is thus calculated for each exogenous variable. This bias is equal to the difference between the average values for the treatment and control groups, divided by the square root of the average variance of the sample in the treatment and control groups. After matching, the differences between the treatment and control groups have been reduced considerably as they are no longer statistically significant. This shows that matching helps reduce bias linked to observable characteristics (with the exception of the variable "the household sorts its trash", which in any case was not significant in the probit model used).