World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

MANAGEMENT OF HOUSEHOLD SOLID WASTE USING THE RANAS APPROACH IN THE MUNICIPALITY OF ABOMEY-CALAVI, IN SOUTHWESTERN BENIN

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World Journal of Advanced Research and Reviews, 2026, 32(01), 2121–2134

Publication history: Received on 25 September 2026; revised on 27 October 2026; accepted on 30 October 2026

Article DOI: https://doi.org/10.30574/wjarr.2026.32.1.2789

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ABSTRACT

Faced with increasing urbanization and the growing volume of urban waste, household solid waste (HSW) management poses a major challenge to sustainable development in Benin. This study analyzes the issue of household solid waste management in the municipality of Abomey-Calavi in southern Benin, using the RANAS behavioral approach (Risk, Attitude, Norms, Ability, and Self-regulation). This approach is based on analyzing household behaviors to identify the psychological factors likely to influence the adoption of source separation.

The methodology is based on a quantitative survey in the municipality of Abomey-Calavi. The data were collected using KoboToolbox and analyzed using SPSS software.

The results reveal a high level of female involvement (60%), confirming that women are central to waste management in both areas. These respondents are predominantly young (18 to 45 years old) and have an average income (56.6%). They are mainly employed in salaried positions (25%) and trade (22.4%). Finally, their level of education (37.2% have a secondary education) constitutes a strategic asset for implementing the RANAS approach. Despite this favorable socio-demographic profile and their good aptitude for source separation, the practice of source separation remains marginal in both areas. Statistical analysis highlights that the Self-Regulation factor is the only statistically significant predictor of sorting behavior in the municipality of Abomey-Calavi, with a significance value (Sig. = 0.001) and $0.001 < 0.05$, unlike traditional approaches primarily based on raising awareness among households in the city. Based on these results, the study proposes intervention strategies grounded in Behavior Change Techniques (BCTs). These actions aim to promote the sustainable adoption of source separation and improve waste management practices in the studied cities.

Keywords: Household solid waste management, RANAS approach, Behavior change, Sustainable development.

1 INTRODUCTION

Humans, through their various daily activities, inevitably produce waste. Whether domestic, economic, agricultural, or industrial, every action generates waste, the quantity of which continues to increase with population growth and changing lifestyles [1]. Faced with this increasing production, waste management becomes a major issue in order to preserve human health, protect the environment and maintain a healthy living environment. This is the case for developing countries like Nigeria, due to the high cost of waste management, the lack of technical capacity, and the constantly increasing volume of waste produced, a consequence of industrialization, urbanization, and population growth [2]. By the end of the century, most of the world's population growth will be concentrated in urban areas. This dynamic, combined with increasing wealth, is leading to a significant rise in global waste production, thus threatening the sustainable development of cities. Each year, the world generates approximately 2.01 billion tons of municipal solid waste, at least 33% of which is not managed in an environmentally responsible manner. Globally, the average daily waste production per capita is 0.74 kg, although there are significant disparities ranging from 0.11 to 4.54 kg per person per day. Although they represent only about 16% of the world's population, high-income countries (78 countries with an annual GDP exceeding USD 12,000) produce nearly 34% of the world's waste, or approximately 683 million tons [3]. During the 1990s, OECD countries (i.e., the most industrialized countries) experienced a sharp increase in waste production (+19%), household consumption expenditure (+33%), and Gross Domestic Product (GDP) (+31%). This demonstrates that the more a country consumes and generates wealth, the more waste it produces. There is therefore a direct link between economic development, consumption, and waste production [4].

Furthermore, the increasing volume and diversity of this waste exacerbate the risks it poses to the environment and public health [5]. The World Health Organization (WHO) highlights the risks associated with inadequate solid waste management, including soil, water and air contamination, as well as the health impacts on nearby populations [6] [7]. Open landfills remain one of the main sources of water pollution and environmental degradation [8]. Indeed, water pollution stems primarily from the percolation of runoff water and the infiltration of contaminants through the soil at landfill sites [9]. Leachate from household waste landfills is a highly concentrated chemical mixture capable of contaminating vast aquifers even in very small quantities, rendering them unfit for human consumption..Although landfilling remains the most widespread method of waste disposal in Africa, it is one of the least effective practices for sustainable waste management. Inadequate solid waste management thus represents a major obstacle to achieving the ambitious Sustainable Development Goals (SDGs) in African cities [10]. It is in this context that source separation and recycling (SSR) emerges as an effective strategy to reduce the rapid accumulation of municipal solid waste, a phenomenon that hinders sustainable development efforts [11]. According to [12]Each 1% increase in the recycling rate is accompanied by an approximately 0.4% increase in jobs in Florida's recycling industry. Between 2001 and 2011, this same sector experienced a significant 23.8% increase in its workforce. Meanwhile,[13] highlights that, in Queensland, Australia, recycling activities are likely to create up to thirty-six times more green jobs than landfill operations.

In Benin, the Solid Waste Management and Sanitation Company (SGDS SA) indicated in November 2018 that the municipalities of Cotonou, Abomey-Calavi, Sèmè-Kpodji, Ouidah, and Porto-Novo were making significant efforts to improve their waste management. However, the effective implementation of recycling practices remained limited [14]. Despite the management of waste disposal sites by COGEDA/DST, the situation remains concerning, marked by the persistence of illegal dumping throughout the city. The establishment of the Solid Waste Management and Sanitation Company (SGDS SA) has, however, introduced several innovations that demonstrate a gradual improvement in the sanitation system. Nevertheless, some operational difficulties remain and represent major challenges to overcome in order to ensure the sustainability of the system implemented by SGDS [15]. In the municipality of Abomey-Calavi, household solid waste collection is handled by a single entity, the Solid Waste and Sanitation Management Company (SGDS SA). In 2022, a total of 23,505 tons of waste was collected upstream, representing a pre-collection rate of 80%. However, the level of recycling remains very low. An evaluation of the current system shows that the solid waste management system remains inadequate and unsustainable. It appears necessary to strengthen partnerships between public, private, and governmental stakeholders, while also consolidating household involvement. The development of a formal policy aimed at optimizing the recycling of each waste fraction is also essential [16]. It is within this framework that the SGDS (Society for the Management of Waste) piloted a pilot project in August 2024 aimed at encouraging the separation of organic waste from inorganic waste at the source in the municipality of Abomey-Calavi in southern Benin. The project's primary objectives were to reduce the volume of waste sent to landfills and to promote local job creation. Initial field observations show that, despite the implementation of a technical and organizational framework, a significant proportion of households are not following the recommendations issued by the SGDS. Given this low level of participation, it is essential to analyze not only the level of practical knowledge but also the behavioral and social factors that hinder the widespread adoption of separating organic waste from inorganic waste. To understand these factors, the RANAS approach (Risks, Attitudes, Norms, Skills/Aptitudes, and Self-Regulation) provides a proven and operational theoretical framework for diagnosing behavioral levers and designing targeted interventions. Developed around five dimensions (Risks, Attitudes, Norms, Skills, and Self-Regulation), the RANAS approach is now a recognized method for

planning and implementing behavior change strategies [17]. The proven effectiveness of the RANAS approach is widely attested by its successful deployment in large-scale international projects. This institutional recognition demonstrates its strategic relevance for understanding and sustainably transforming complex hygiene and sanitation behaviors. Therefore, basing the scientific approach on this robust conceptual model is a particularly judicious methodological choice. It offers a rigorous analytical framework for thoroughly diagnosing psychosocial barriers and mobilizing the key drivers for adopting source separation. Thus, this research provides operational insights for sustaining eco-responsible practices within the municipality of Abomey-Calavi.

2 MATERIALS AND METHODS

2.1 Study area

The Commune of Abomey-Calavi is located between 6°21' and 6°42' north latitude and between 2°13' and 2°25' east longitude. It is bordered to the north by the Commune of Zè, to the south by the Atlantic Ocean, to the west by the Communes of Tori-Bossito and Ouidah, to the east by the Commune of Sô-Ava and the Littoral department (fig 1).

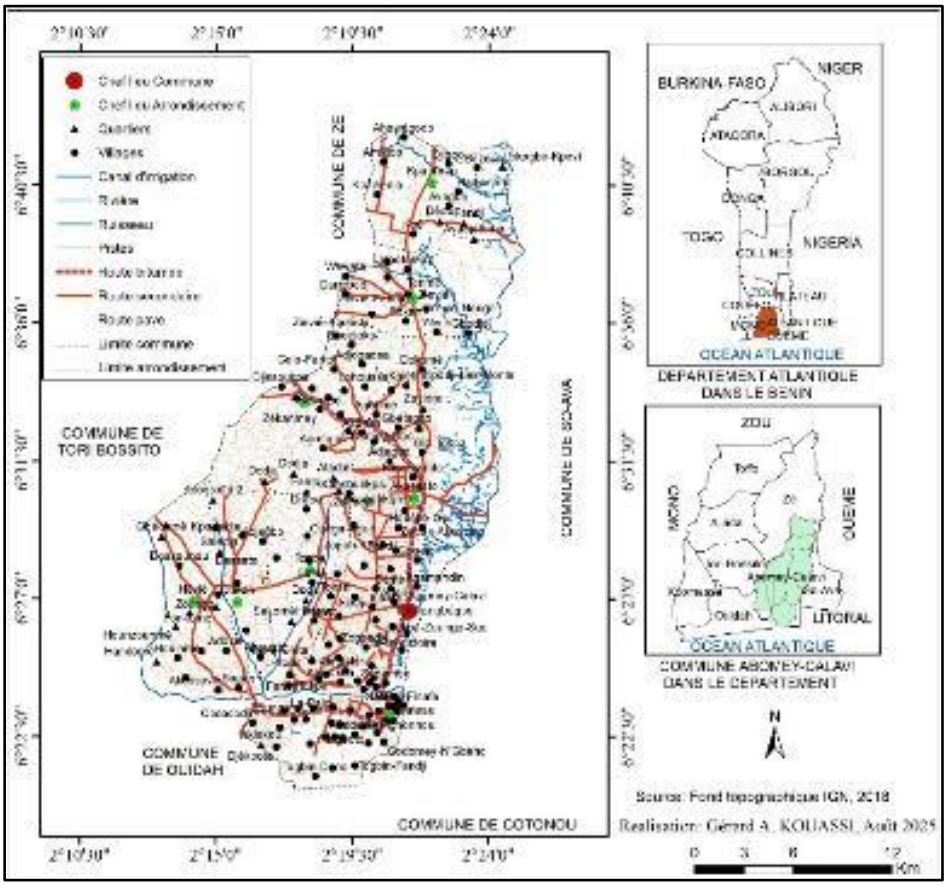


Figure 1: Geographical and administrative situation of the Commune of Abomey-Calvi

The municipality of Abomey-Calavi is divided into nine (09) districts.The Commune of Abomey-Calavi covers an area of 540 km2. The nine (9) Districts of the Commune are subdivided into sixty-four (64) villages and six (6) city districts, for a total of seventy (70) villages and city districts.

2.2 Data and methods

Within the framework of household solid waste management in the municipality of Abomey-Calavi, the methodological approach relies on an initial collection of qualitative data via questionnaire, subsequently converted into frequencies and percentages. This quantification is accompanied by the transformation of Likert scales into numerical scores, enabling a scientific analysis of the correlations between different psychosocial factors. At the heart of this application of the RANAS model to household waste management in southwestern Benin, the target behavior analyzed lies in the effective separation of organic and inorganic waste at the source. In accordance with the founding principles of the RANAS approach, the adoption of this sorting practice goes beyond mere individual will; it results from a complex interaction between perceptual, relational, and material factors. The conceptual framework is based on five independent psychological variables: Risk, Attitude, Social Norm, Aptitude, and Self-Regulation. These variables assess, respectively, awareness of health hazards, perceptions of sorting, perceived social pressure, technical capacity coupled

with the availability of equipment, and daily planning of sorting activities. These behavioral factors directly influence the intentions and actions of residents within the study area. Therefore, the central dependent variable in this research on waste management in Abomey-Calavi is the actual household sorting behavior, specifically measured during pre-collection by the separate disposal of organic and inorganic waste in two distinct containers. To support this analytical framework, the data collection process combines a literature review with empirical fieldwork. The literature review constituted the first key step, consulting specialized collections, libraries, and relevant digital resources to support the issue of waste management. To ensure the accuracy of the analyses, probabilistic sampling based on Neyman's method (1934) was applied to the reference population of 1,051 households. This approach allowed for the creation of a representative sample of 281 respondents, thus optimizing logistical and temporal resources in the field. In accordance with the requirements of the RANAS model, the survey unit specifically targets the person residing at home and responsible for daily cooking or waste disposal. Respondent participation is subject to rigorous inclusion criteria combined with the prior collection of their free and informed consent. Throughout the investigation,Adherence to ethical standards is guaranteed by the strict anonymization of collected data and the right to withdraw consent granted to each individual. All information collected remains exclusively reserved for academic use with the ultimate goal of improving public health and the local living environment. Thus,The sample size was 281 households. To collect the data, this study employed a methodological protocol combining direct observation assisted by a systematic checklist, photographs, field notes, and a questionnaire structured in six sections. Administered face-to-face to clarify sorting concepts and assess actual practice, as well as the five psychosocial factor blocks of the RANAS model, this questionnaire was digitized using the KoboToolbox application and deployed to the interviewers' smartphones. This digital approach ensured smooth interactions in the field, improved household understanding of the questions, and secure data storage on a centralized server. After data collection via KoboToolbox, the data were cleaned, coded in Excel, and then analyzed using SPSS software to create a robust database cross-referencing the sociodemographic, contextual, and psychological variables of the RANAS model. For each psychosocial pillar (Risk, Attitude, Norm, Aptitude, Self-Regulation), an average individual score on a Likert scale from 1 to 4 was calculated according to Cochran's formula (1977). Descriptive analysis then allowed for the development of the households' socioeconomic profile and the assessment of actual behavior regarding the separation of organic and inorganic waste, which was retained as the dichotomous dependent variable of the study. Finally, a binary logistic regression was used to determine the factors that significantly influenced the probability of adopting household sorting. The validity and explanatory power of this econometric analysis model were rigorously confirmed by the Hosmer-Lemeshow goodness-of-fit test and Nagelkerke's R^2 coefficient.

3 RESULTS AND DISCUSSION

3.1 Methods of managing household solid waste in the municipality of Abomey-Calavi

Since August 2024, SGDS-GN-SA has implemented an awareness campaign promoting source separation of household solid waste (HSW), aiming to reduce the landfill rate, which currently amounts to 500,000 tons of household solid waste per year. This initiative, which encourages community responsibility, is fully aligned with the 3Rs: Reduce, Reuse, and Recycle. Plate 1 illustrates the household awareness campaign in the municipality of Abomey-Calavi.



Figure 2: Household awareness campaign in Abomey-Calavi

Filming location: Aboubakar, September 2025

The awareness campaign implemented to encourage households to sort their waste at the source is as follows. The strategy deployed in the municipality of Abomey-Calavi involves a first team using loudspeakers for mass

communication, while a second team conducts door-to-door visits. Equipped with flyers, these agents provide practical information on waste separation methods directly in homes. The awareness campaign focuses on two main technical instructions: sorting inorganic waste in a green bin and organic waste in a black bin. It should be noted that the purchase of these standardized containers is the sole responsibility of the households.

Following the implementation of the source separation system by SGDS SA, field observations were conducted to assess its effectiveness among households. The findings show that, despite the provisions of this mechanism, source separation is not yet being effectively implemented by a large proportion of households. In fact, household waste continues to be largely mixed together in the same container, without distinction between different waste categories, particularly organic and non-organic waste. Furthermore, it was observed that households generally leave their mixed waste outside their homes, at gates or access points, while awaiting collection by the pre-collection agents. While this practice facilitates waste collection by the agents, it does not align with the initial requirements of the source separation system implemented by SGDS SA. Thus, these observations reveal a gap between the provisions of the waste management system and the actual practices of the population in the two cities. Plate 2 presents the current state of waste with regard to source separation.



Figure 3: Current status of waste management systems in the municipality of Abomey-Calavi regarding source separation

Filming location: Aboubakar, September 2025

There The majority of residents do not yet systematically sort their household waste at the source. However, field observations have shown that some households do indeed practice this. This situation can be explained, in some cases, by habits acquired by these households during stays or experiences abroad, where waste management systems rely heavily on source separation. These households thus comply with the guidelines established by the SGDS SA (Swiss Federal Office for Waste Management), which recommend separating waste into different categories to facilitate its management and recovery. In this context, organic waste, i.e., biodegradable materials, is separated from other types of waste. This includes, in particular, food scraps, spoiled fruit, vegetable and tuber peelings, fish viscera, and other food residues.

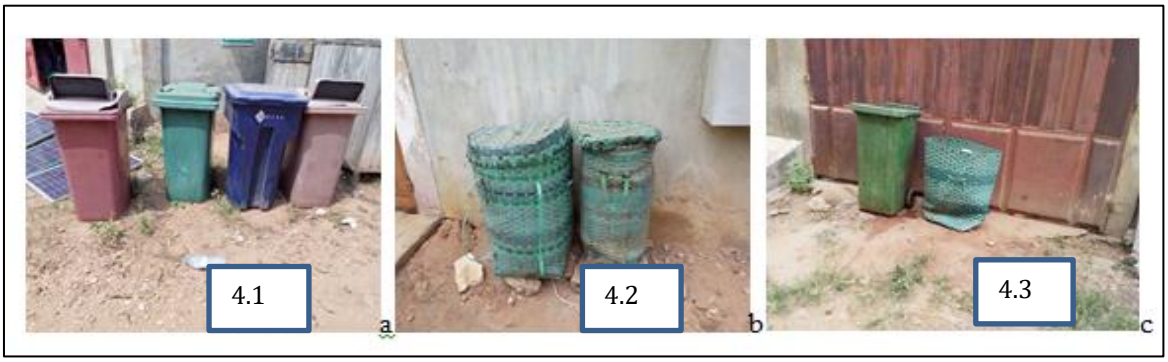


Figure 4: Partial view some cContainers available for sorting household solid waste at the source in the municipality of Abomey-Calavi

Filming location: Aboubakar, September 2025

Furthermore, inorganic waste is also identified and separated. This category includes, among other things, scrap metal, plastics, used batteries, broken electrical and electronic equipment, and other non-biodegradable items. In households that follow these guidelines, waste is generally placed in several separate containers, often two or more, depending on the requirements of the recommended sorting system. This practice allows for better organization of waste management at the household level and facilitates pre-collection and processing operations. The organization of these containers and the way waste is separated in these households are shown in Plate 3, which presents the containers available for source separation of household solid waste in Abomey-Calavi.

It has been observed that when waste is not sorted at the household level, pre-collection agents generally continue their collection practices. Indeed, despite the source separation system implemented by SGDS SA, field observations have shown that many households still deposit their waste mixed together, without distinguishing between organic and inorganic waste. Thus, during the pre-collection agents' rounds, particularly on Mondays, which are normally dedicated to the collection of organic waste, it is often found that the waste provided by households does not comply with the recommended sorting guidelines. Faced with this situation, the pre-collection agents generally collect all available waste, whether organic or inorganic. This practice, while preventing the accumulation of waste in households, nevertheless undermines the objective of source separation and complicates the differentiated management of waste. Figure 4 presents the various equipment used to process household solid waste at the pre-collection level.

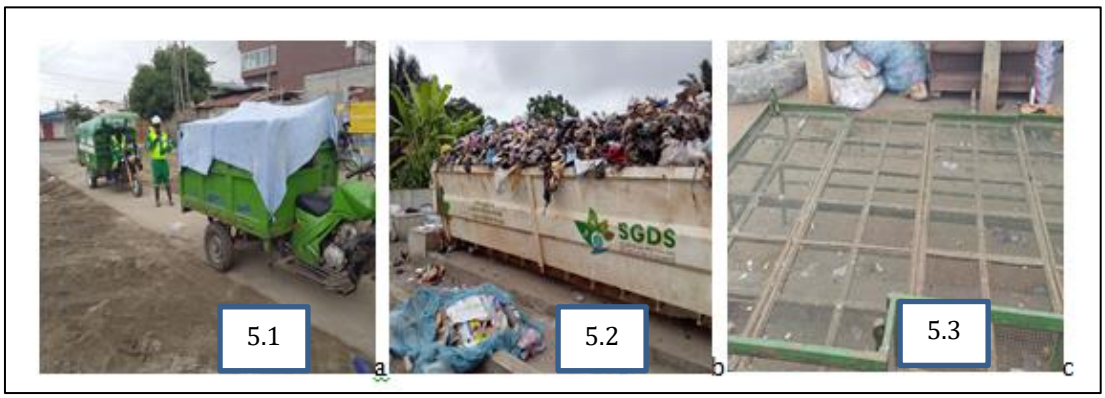


Figure 5: Partial view of the pre-collection and sorting infrastructure for household hazardous waste on the PRs

Filming location: Aboubakar, September 2025

Once collected, the waste is transported to collection points located in various areas near the city. There, the waste is emptied into metal containers with a capacity of approximately 15 m^3. These collection points serve as intermediate spaces where certain operations to recover recyclable materials are carried out before the final disposal of the waste. At each collection point, waste pickers extract recyclable materials from the waste. This activity is generally done manually and consists of identifying and removing items that can be recovered, such as certain plastics, metals, or other reusable objects. To perform this operation, the waste is handled using hand shovels and then transferred to a large sieve. Sieving separates the fine material, mainly composed of small particles resulting from the decomposition or breakdown of the waste, from the remaining larger materials. Following this initial recovery phase, the residual waste is transferred to a second container with a similar capacity of 15 m^3. These containers are then loaded and transported to transfer stations. At these stations, a second recovery phase can be carried out to extract any remaining recyclable materials that may have escaped the first sorting operation.

After these various stages of collecting, grouping, and recovering recyclable materials, the remaining waste is finally transported to its final destination: the landfill. It is at this level that the ultimate waste that is, waste that can no longer be recovered or recycled is permanently buried under controlled conditions to limit environmental and health impacts. Figure 5 shows the types of waste collected by waste pickers.



Figure 6: Partial view of the types of waste collected by waste pickers

Filming location: Aboubakar, September 2025

There are eight waste pickers operating at the CTM SME in Zone 21. These pickers are affiliated with the Ahossougbéta sorting center. Additionally, at the GIE Reed SME, there are five pickers attached to the Zoka sorting center. These operators play a vital role in recovering valuable materials from collected waste. They are organized into a recognized informal structure affiliated with SGDS SA. Their internal organization is generally based on a simple structure comprising a president, a secretary, and an accountant, responsible respectively for coordinating activities, managing administration, and monitoring the financial aspects of the recovery and sale of collected materials. In carrying out their work, the pickers collect and sort recyclable waste in a selective and organized manner. The recovered materials are carefully classified according to their type to facilitate their subsequent sale. These are primarily different types of plastics such as polypropylene (PP), polyethylene (PE), polyethylene terephthalate (PET), polystyrene (PS), polyvinyl chloride (PVC), and other hard plastics. In addition to plastics, waste pickers also collect cardboard and various types of metals found in the waste. Once collected and sorted, these materials are carefully stored in mesh bags to facilitate their preservation and transport. They are then weighed before being sold to companies specializing in waste recovery and recycling. Table 1 shows the number of garbage cans per household in the two cities.

Table 1: Number of bins available to households in the two cities studied

Number of bins per household	Frequency	Percentage %
None	17	5.9
1 bin	150	51.7
2 trash cans	106	36.6
More than 3 bins	17	5.8
Total	290	100

Source : Fieldwork, March 2026

The majority of households have only one bin. In fact, 150 households, or 51.7%, have just one bin. This means that more than half of households use a single container to store their waste. Next, 106 households, or 36.6%, have two bins. This situation can promote better waste management, as having multiple bins can facilitate the separation of certain types of waste. Furthermore, 17 households, or 5.9%, have no bins at all. This situation can lead to inappropriate waste

management practices, such as dumping waste directly in the street or in unsuitable bags. Finally, 17 households, or 5.8%, have more than three bins. This represents a small proportion of households and may indicate better organization in household waste management. While sorting requires at least two separate containers (one for organic waste, one for inorganic waste), the survey data shows that 51.7% of households still only have one bin. Consequently, the infrastructure necessary for waste separation is non-existent.

3.2 RANAS (Risk, Attitude, Norm, Capability, and Self-Regulation) Approach Integrated into Household Solid Waste Management

To overcome the failure of conventional approaches to household solid waste management, where simple awareness campaigns and the provision of infrastructure are insufficient to prevent the mixing of waste, the RANAS approach offers an innovative theoretical framework focused on the psychological drivers of behavioral change. Applied to the municipality of Abomey-Calavi, this model aims to unlock the "black box" of individual decisions by exploring the beliefs, attitudes, social norms, and self-efficacy capacities that govern source separation. The analysis is based on a rigorous comparative study between residents who "practice" and "non-practice" waste separation, allowing for a precise diagnosis of the specific psychosocial barriers and facilitators within households. By identifying these key internal factors, the research provides the empirical basis necessary to design targeted and tailored behavior change techniques. Ultimately, this approach offers operational and sustainable solutions to optimize the pre-collection and recovery of organic and inorganic waste in southwestern Benin. Figure 2 presents the RANAS behavior change model.

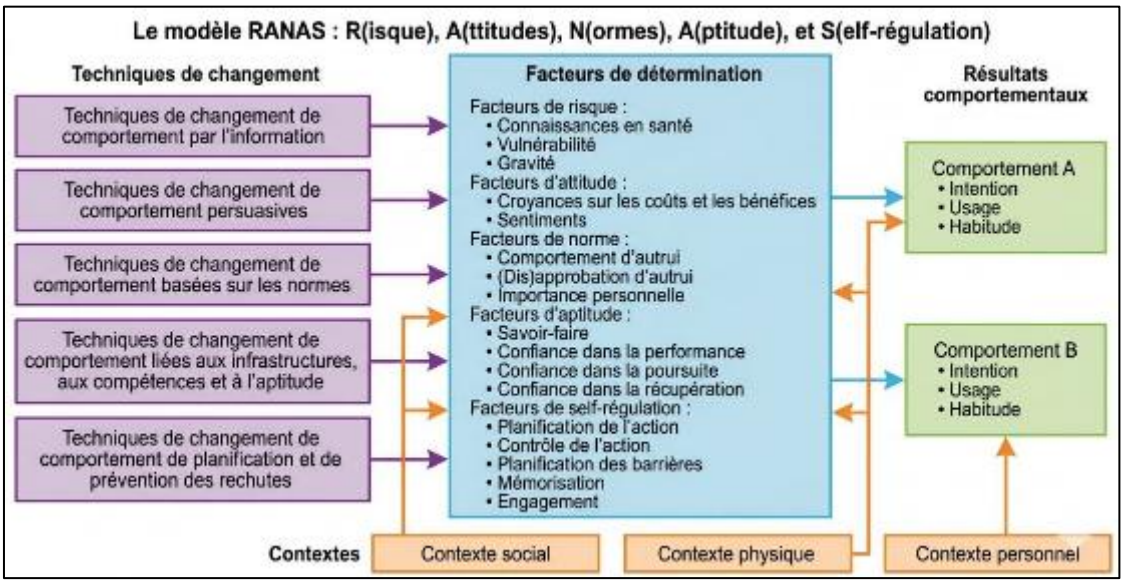


Figure 7: Model RANAS behavior change

Source: HELVETAS, 2017

In the RANAS approach, each question corresponds to a specific psychological factor. The acronym RANAS refers to five categories of factors: Risk, Attitude, Norm, Capability, and Self-Regulation. The Risk factor relates to the perception and understanding of the dangers associated with poor waste management for health and the environment. The Attitude factor concerns the positive or negative perception a person may have of the expected behavior. The Norm factor relates to the perceived social pressure and influence of other community members on individual behaviors. The Capability factor corresponds to the confidence a person has in their ability to adopt the desired behavior. Finally, Self-Regulation refers to an individual's ability to plan their behavior, overcome obstacles, and maintain a practice over time. These different factors influence individuals' beliefs and intentions, which in turn determine whether or not a given behavior is adopted. To foster lasting behavioral change, it is therefore necessary to implement interventions tailored to each of these factors. For example, to address the risk factor, information on the health and environmental consequences of poor waste management can be disseminated. To improve attitudes, initiatives to recognize or reward households that sort their waste can be implemented. Regarding social norms, community commitments or collective initiatives can encourage the adoption of waste sorting. To strengthen household capacity, practical training and the provision of appropriate infrastructure can be organized. Finally, to promote self-regulation, households can be supported in planning and organizing their waste management practices.

It is also important to emphasize that behavior change strategies must take into account the social, physical, and cultural context in which populations live. The RANAS approach thus offers a structured methodological framework for

identifying the determinants of behavior and designing appropriate interventions to improve waste management practices within communities (Table 2).

Table 2: Analysis of RANAS factors and diagnosis of waste sorting in the municipality of Abomey-Calavi

RANAS Factors and Key Indicators	Modality / Assessment	Percentage (%)
1. RISK FACTOR	*Assesses the perception of vulnerability and severity of health and environmental risks associated with mixing waste.*	
• Perceived health risk	• Very low / Low • High / Very high	71.7% 28.3%
• Observation of diseases	• Never / Rarely • Often (infections, allergies)	95.8% 4.1%
• Environmental risk	• Very low / Low • High / Very high	63.1% 36.9%
• Animal access	• No • Yes (contamination vector)	72.1% 27.9%
• Sun exposure	• Often / Sometimes / Rarely	92.1% (cumulative)
• Exposure to rain	• Frequently exposed • Completely safe	48.3% < 14.0%
• Container compliance	• Non-compliant (open bags, buckets) • Compliant (containers meet standards)	81.0% 19.0%
2. ATTITUDE FACTOR	*Measures beliefs, perceived costs (time, effort) and benefits of waste sorting.*	
• Importance of sorting	• Important / Very important • Not important at all	85.2% 14.8%
• Physical strain	• Absolutely agree (annoying) • I completely disagree	60.7% 39.3%
• Perceived loss of time	• Often / Sometimes • Rarely / Never	55.8% 44.2%
3. SOCIAL NORM FACTOR	*Analyzes perceived social pressure, the influence of the neighborhood, family, and local authorities.*	
• Complaints from those around them	• Never • Sometimes / Often	75.9% 24.1%
• Practice in the city	• Never (dominant mixture) • Rarely / Sometimes / Often	83.1% 16.9%
• Family support	• Never encouraged • Rarely / Sometimes / Often	50.3% 49.7%
• Encouraging neighbors	• Never encouraged • Rarely / Sometimes / Often	72.8% 27.2%
• Action by the authorities	• Never encouraged • Sometimes / Often / Rarely	65.2% 34.8%
4. SKILL FACTOR (CAPACITY)	*Evaluates the practical skills of households and the adequacy of the operational collection system.*	
• Separate collection *(Pre-collection)*	• Never (mixed collection) • Sometimes / Often	73.4% 26.6%

• Ability to distinguish flows	• Often • Rarely / Sometimes / Never	30.7% 69.3%
• Essential equipment	• Often (recognize the need) • Other options	42.1% 57.9%

Source : field surveys, September 2025

The cross-analysis of the factors in the RANAS model reveals a complex dynamic characterized by a paradox between households' principled support and the reality of psychosocial and logistical constraints within households. On the one hand, the Attitude factor demonstrates a very favorable environmental awareness, with 85.2% of respondents considering waste separation important to very important; however, this positive attitude clashes with a strong perception of implementation costs, with 60.7% of households equating sorting with a physical constraint and 55.8% with a waste of time that negatively impacts their domestic organization. On the other hand, the Risk factor reflects a marked underestimation of health and environmental hazards, since 71.7% of households perceive the health risk as low or very low and 95.8% do not observe any illnesses directly related to mixing, which weakens the feeling of vulnerability even though 81.0% use non-compliant containers, increasing exposure to sunlight (92.1%) and rain (48.3%). This low propensity to act is exacerbated by a largely unfavorable social norm, characterized by the absence of visible examples of sorting (83.1% believe their neighbors never sort their waste), a collective tolerance of unsanitary conditions (75.9% with no complaints from those around them), and a lack of active encouragement from family (50.3%), neighbors (72.8%), and local authorities (65.2%). Finally, at the Aptitude factor level, the transition to action is hampered by operational shortcomings: 69.3% of residents have difficulty distinguishing organic from inorganic waste streams, while a major logistical breakdown occurs during pre-collection where 73.4% of residents find that the sorted streams are systematically remixed by the collection agents, thus annihilating the motivation of households to maintain sustainable source separation in the municipality of Abomey-Calavi. These observations highlight the importance of integrating gender-sensitive approaches into public education and awareness campaigns aimed at promoting sustainable waste management practices, as emphasized by [17]. The analysis of the psychological factors of the RANAS model in the municipality of Abomey-Calavi highlights a specific behavioral dynamic that differs from several results reported in the international literature. Indeed, some studies conducted in other geographical contexts, notably in Iran and Ontario, have shown that attitude is the main predictor of selective sorting. This is particularly the case in the work of [18] and [19], which emphasizes the importance of individuals' positive perceptions of waste sorting. Although our results also confirm that attitude is a favorable factor for adopting sorting, they nevertheless show that this factor alone is not sufficient to trigger action in the Beninese context. This observation aligns with the conclusions of [20], as well as those of other authors such as [21], who highlight the complexity and multidimensional nature of the relationship between stated attitudes and actual behaviors.

3.3 Binary logistic regression analysis of the results

Household sorting behavior was assessed using the following question: "Do you separate organic waste from inorganic waste before disposing of it?" The results presented in Table 3 reveal a still very limited practice of source separation within the sample studied.

Table 3: Distribution of households according to the frequency of waste sorting in the municipality of Abomey-Calavi

Method / Frequency of practice	Percentage (%)
Always / Systematic practice	42
Often / Frequent practice	28
Sometimes / Occasional practice	20
Rarely / Exceptional practice	6
Never / Not practical	4

Source :Fieldwork, March 2026

Analysis of Table 3 shows that 42% of households surveyed report systematically sorting ("Always") their organic and inorganic waste, thus constituting the core group of "practicing" residents fully committed to the sustainable management of their waste. To this group are added 28% of households that sort frequently ("Often"), bringing the overall proportion of households demonstrating regular adherence to waste separation to 70%. However, a significant segment of the population exhibits a more fluctuating level of commitment: 20% of households sort only occasionally ("Sometimes"), their behavior remaining highly dependent on circumstantial constraints such as lack of time or the unavailability of separate containers. Finally, non-practice or marginality of the practice concerns a minority of

residents, with 6% of practitioners exceptionally ("Rarely") and only 4% of strict non-practitioners ("Never") for whom complete mixing remains the norm. These results demonstrate that environmental awareness and the willingness to sort waste are largely rooted in the study area.

3.3.1 Analysis of the determining factors of sorting

The objective of this section is to identify, among the five psychological components of the RANAS model (Risks, Attitudes, Norms, Aptitudes, and Self-Regulation), those that significantly influence the adoption of household waste sorting behavior in the municipality of Abomey-Calavi. To achieve this objective, a binary logistic regression was used. This statistical method is particularly well-suited to this case because the dependent variable, namely waste sorting practices, is dichotomous. It distinguishes households that sort waste (coded 1) from those that do not (coded 0). By incorporating the average scores calculated for each factor of the RANAS model as independent variables, this model allows us to estimate the probability that a household will adopt sorting behavior based on its perceptions and psychological dispositions. Thus, logistic regression highlights the factors that promote or hinder the adoption of source separation in the studied areas. The analysis is carried out in two main stages. The first step is to verify the overall quality of the model, that is, its ability to satisfactorily explain the relationship between the psychological variables studied and waste sorting practices. The second step is to identify the statistically significant variables, that is, the factors that actually influence the adoption of sorting behavior.

3.3.2 Evaluation of the model's performance and robustness

Before interpreting the influence of each factor, it is necessary to assess the statistical quality of the constructed logistic regression model. This step verifies whether the proposed model accurately accounts for the relationship between the psychological factors studied and household adoption of waste sorting. Table 4 presents a summary of the models.

Table 4: Summary of models

Stage	-2log-likelihood	Cox & Snell R-two	R-two of Nagelkerke
1	0.000[has]	0.661	1,000

Source :SPSS, Fieldwork, March 2026

Table 4 shows a Nagelkerke R^2 coefficient of 1.000. This result suggests that the explanatory variables included in the model, particularly the factors from the RANAS approach, have a very high explanatory power with respect to the dependent variable, namely waste sorting practices. In other words, the psychological factors considered in the analysis account for a significant portion of the observed variations in household sorting behavior. This high coefficient indicates that the model has strong explanatory power within the sample studied. To verify the goodness of fit of the model to the observed data, the Hosmer-Lemeshow test was also performed. Table 5 presents the Hosmer-Lemeshow test.

Table 5: Hosmer-Lemeshow test

Stage	Chi-Chi-two	ddl	Sign.
1	0.000	8	1,000

Source :SPSS, Fieldwork, March 2026

The results in Table 5 indicate a significance level (Sig.) of 1.000. In the interpretation of this test, a significance level greater than 0.05 means that there is no statistically significant difference between the values observed in the field and those predicted by the model. Thus, the results obtained indicate that the model provides a good fit to the empirical data, which confirms its relevance for analyzing the determinants of waste sorting behavior.

3.3.3 Analysis of the influence of RANAS factors on sorting behavior

After verifying the overall validity of the model, examination of Table 6 allows us to identify the psychological factors influencing household waste sorting behavior in the study areas. Statistical analysis shows that the Self-Regulation factor is the only statistically significant predictor of waste sorting behavior, with a significance value of 0.001. Within the RANAS model, self-regulation refers to individuals' ability to organize, plan, and maintain a behavior over time, despite daily constraints such as lack of time, forgetfulness, or difficulties with equipment. This result suggests that, in the studied cities, the adoption of waste sorting depends primarily on households' ability to integrate this practice into their daily routines. Thus, for residents of Abomey-Calavi, the decision to sort waste seems less linked to the perception of health risks or the social influence of neighbors than to the individual's ability to structure and maintain this practice over time.

Table 6 presents the variables outside the equation.

Table 6: Variables outside the equation

		Score	ddl	Sig
Variables	Average risk score	0.299	1	0.585
	Average attitude score	2,560	1	0.110
	Average standard score	0.260	1	0.610
	Average aptitude score	1,163	1	0.281
	Average self-regulation score	188,560	1	0.001
Step 0	Overall statistics	190,454	5	0.001

Source :SPSS, Fieldwork, March 2026

However, the other psychological components of the RANAS model do not show a statistically significant relationship with sorting practices in this model. Regarding the Attitude factor, the table shows that households perceive sorting as a positive action for the environment. This perception has a significance level greater than 0.005; therefore, the attitude factor alone is not necessarily sufficient to trigger a change in behavior in the municipality of Abomey-Calavi. Regarding the Aptitude factor, the table shows a significance level (p-value) greater than 0.005. Consequently, the results suggest that technical knowledge of sorting does not constitute an obstacle to triggering a change in RANAS behavior. In other words, households generally seem to know how to sort their waste but encounter difficulties in the practical organization of this activity. Similarly, for the Risk and Norm factors, the table shows a significance level (p-value) greater than 0.005. Therefore, these factors appear to have a weak influence in this model. This indicates that the perception of health risks related to waste or the influence of neighbors' behavior does not play a decisive role in the adoption of source separation in the municipality of Abomey-Calavi.

3.4 Solution approaches for sustainable waste management in the municipality of Abomey-Calavi

The implementation of sustainable waste management in the municipality of Abomey-Calavi relies on the rigorous application of the RANAS approach, particularly those related to the transition from intention to action. This process is a crucial step in linking the decision to act with the effective repetition of that action over time. At the planning and monitoring level, the main objective is to facilitate this transition through the use of precise planning techniques. To this end, the BCT26 technique allows for the clear and detailed definition of how households in these neighborhoods will implement the behavior. It is no longer simply a matter of residents expressing a willingness to sort waste, but of specifying when, where, and how the action will be carried out in practice. For example, a household might decide to sort its waste every morning and deposit it in a container specifically placed at the gate. This logistical precision reduces uncertainty and facilitates the natural integration of sorting into the residents' daily routine. Establishing these habits also requires consistent monitoring through self-observation and feedback techniques. Using simple tools like a calendar or a visual tracking system allows users to see the regularity of their practices. This personal feedback helps strengthen intrinsic motivation and highlight progress, transforming a perceived constraint into a rewarding success. Simultaneously, managing barriers becomes a strategic lever for anticipating difficulties that could hinder the adoption of the desired behavior within the concessions. This preventative step is crucial to avoid abandoning the sorting process at the first logistical or organizational obstacle.

Gap and obstacle analysis allows residents to identify the reasons why a goal has not been met, such as forgetting to put out the trash on time for collection. Based on this analysis, appropriate solutions can be considered, particularly through environmental restructuring. This technique aims to modify the physical environment of the property, for example, by placing trash cans in strategic locations or using specific colored bags for different types of waste, thus encouraging instinctive sorting. In the social context of the municipality of Abomey-Calavi, it is equally important to prepare individuals for social resistance and negotiation. These techniques strengthen households' ability to maintain their good practices despite potential criticism or a lack of neighborhood involvement, ensuring resilience in the face of negative social pressure. Maintaining long-term commitment is ensured through the judicious use of reminders and behavioral contracts. Visual reminders in the form of posters, stickers, or information panels in the common areas of housing complexes serve as constant reminders of the importance of adopting responsible behavior [22]. These initiatives can be expanded through community sorting days or cleanliness competitions between different housing blocks. To reinforce this commitment, the implementation of behavioral contracts, understood as a promise made to oneself or to the community, empowers each citizen. This contractual approach fosters perseverance and ensures that sustainable waste management is not a one-off event, but a lasting way of life in the municipality of Abomey-Calavi.

4 CONCLUSION

Since August 2024, the SGDS-GN-SA has been implementing a mass awareness and door-to-door campaign to encourage source separation of waste and reduce the annual volume of landfill by 500,000 tons. This method relies on the use of two separate bins: a green bin for inorganic waste and a black bin for organic waste. Despite these guidelines, field observations reveal a persistent discrepancy, with the majority of households continuing to mix their waste in a single container while waiting for pre-collection. More than half of households (51.7%) have only one bin, while 36.6% have two. Pre-collection agents generally maintain their mixed collection practices, which complicates the separate management of waste streams despite the involvement of informal waste pickers at collection points. To analyze these behaviors beyond traditional approaches, the RANAS psychosocial model (Risk, Attitude, Norm, Aptitude, Self-Regulation) was applied to identify the barriers and drivers of change. Although 85.2% of respondents considered sorting important (an attitudinal factor) and 70% reported doing so regularly, practical constraints and the lack of encouraging social norms hinder the widespread adoption of the practice. The robustness assessment of the binary logistic regression model yielded a Nagelkerke R^2 coefficient of 1.000 and a good overall fit validated by the Hosmer-Lemeshow test. Statistical analysis demonstrated that the self-regulation factor was the only statistically significant predictor (Sig. = 0.001) influencing the sustained adoption of sorting behavior. Therefore, the success of selective sorting in Abomey-Calavi depends mainly on the individual capacity of households to structure and maintain this organizational habit over time, well beyond simple environmental awareness.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

Acknowledgments

The author thanks the Waste Management and Sanitation Company (SGDS-SARL), the University of Abomey-Calavi, UCAO-UUC, and all participants in the survey conducted in Abomey-Calvi, southern Benin et particulièrement Messieurs MADEGNAN Armel (Chef service pré-collecte de la SGDS- SARL) et SOHOU Christel_Mahugnon pour tout son engagement.

Disclosure of conflict of interest

The author declares no conflict of interest.

Statement of informed consent

Participation was voluntary, and respondents were informed that information collected was intended solely for academic research purposes.

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