

# Integration of Digital and New Technologies for a Renewed Management of Household Waste: Current State and Prospects, Case of the New City Ali Mendjeli

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## Abstract

With the rapid growth of new technologies and various environmental issues, modernizing waste management has become one of the key priorities for today's cities.

In a specific context, cities in developing countries are currently facing difficulties in managing the growing quantities of waste they generate intelligently and rationally.

Tendentiously, the development of the sector requires the optimization of processes both technologically and methodologically, and organizationally.

Using the example of neighborhood unit 5 - New City "Ali Mendjeli", our study aims to define the inhabitant profile in order to integrate and implement new technologies in the waste management process in this city. Moreover, our investigations have revealed the lack of cooperation of citizens. The results obtained showed the limitations of the information and communication methods adopted, as well as the inadequacy of the proposed service in terms of specific standards and needs for the use of innovative devices.

Through the established survey, guidelines for innovative management of household waste are developed in order to rethink the issues in the future. The proposals for actions recommended in this article focus on the adoption of ICTs and technological innovations in favor of waste reduction at the source, selective sorting, and intelligent collection of flows for better recovery.

**Key words:** Cooperation, household waste, inhabitant profile, innovative management, new technologies, New City Ali Mendjeli.

## INTRODUCTION

In today's urban world, the issue of waste is one of the major concerns. Their output is exacerbated by demographic changes and economic growth. As a result, the quantities generated reflect the general upward trend observed so far in cities.

Depending on factors such as accelerated urbanization and improved living standards, the volume of waste is expected to increase to 2.2 billion tonnes by 2025 (i.e. 1.42 kg/capita/day) coming mainly from large conurbations in developing countries. However, only 13.5% of waste is recycled and 5.5% is composted (World Bank, 2018).

The consequences will be more pronounced in the sharp rise in the costs of waste treatment and disposal for low-income countries (Le Bozec, 1994). In the majority of cities and residential agglomerations in these countries, upgrading is still at an abbreviated stage and sorting is almost unknown, despite the importance of significantly recyclable waste deposits.

This state of affairs has highlighted the challenges that local collectivity in developing countries must face (Cirelli & Florin, 2018). The main priorities and current solutions converge on the need to reduce waste at the source and efficient and environmentally friendly collection and disposal (Aspe & Jacqu , 2019).

In this regard, (Stiglitz, 2015) emphatically states, "*the linear economy model of producing, consuming, throwing away has reached its limits. Faced with the need to optimize resources and limit waste, a new model is needed, that of the circular economy*".

Thereupon, varieties of treatment and valuation methods have developed. However, it is obvious that it is not just a matter of mobilizing the various human and technical resources, success depends more on the choice of the management system adopted (Marcoux et al., 2016).

In the same respect, new technologies and improved techniques are a factor of modernization, and a mark of attractiveness that can be used in future waste management processes in cities (Forest, 2015). They would improve coordination, cohesion, and the cost-effectiveness of the various actors. Certainly, more cost-effective stewardship, more efficient services, a lower environmental footprint, and integrated and improved management.

Although, with regard to the characteristics of cities at the same time physical, geographical, and social, each space has its modalities of management of the generated waste. Indeed, diversified solutions, depending on local configurations, must be sought (Bertolini & Brakez, 2008).

It is therefore important to determine a typology of spaces in order to engage the most appropriate innovative solutions. Nevertheless, it is necessary to involve citizens in change. Measures must be taken to increase their cooperation and sense of responsibility.

Thus, the acceptability of social practices and techniques requires methods of prevention and communication to mobilize all stakeholders (Durand, 2015).

### **Innovation in the Field of Household Waste Management in Algeria: State of Progress and Elements of Appreciation.**

At the national level, the obstacles related to the innovation activities of the waste sector in Algeria are to date perceived. Despite capacity building and the use of new forms of organization, local authorities are still struggling to implement the reforms needed to achieve the goals set out in the national environmental action plan.

The observation made on the ground according to the different methods of management of households and similar waste used reveals that “*direct management*” is the mode of management most answered at the national level. This practice is characterized by a limited organizational chart. The involvement of multiple actors poses enormous difficulties in terms of monitoring and control on the ground (AND, 2020).

In the field of information and communication techniques, the National Waste Agency has set up a National Waste Information System (SNID) for the benefit of local collectivities, project promoters, administrations, and institutions.

This information system corresponds to both an analysis tool and decision-making support (*maps, indicators, etc.*) and an alert system; toll-free number, requests on the Website, and connection through a Virtual Private Network (VPN) with the local environment directorates.

The system makes it possible, on the one hand, to facilitate the exchange of data between the various actors involved in the field of waste management, and, on the other hand, to establish indicators that form a dashboard for decision-makers (AND, 2020). Thus, SNID represents a digital link between organizations and operators that are geographically remote.

The following figure(Cf. fig.1) shows the architecture of the system and the functioning of the platform.



**Figure1.**The architecture of the National Waste Information System (operation of the platform) **Source:**Authors, 2022.

However, despite the importance of the data that be collected through the system, the differential characteristics of the urban agglomerations of the country condition the implementation of distinctive indicators enabling the improvement of performance at the local level. To this is added, changing social practices from one region to another.

At the local level, the feedback is not convincing enough. The operational and organizational performance of local waste utilities is still not improved. It is therefore also a question of having indicators of impact on the local territory in view of the existing means and the funding allocated.

In this same context of innovation, the National Waste Agency has also made available to citizens a mobile application “NDIF” in order to mobilize them on better management of waste. This mobile application allows the reporting of random dumps, blackheads, slowness in the waste collection and elevation process, or lack of containers.

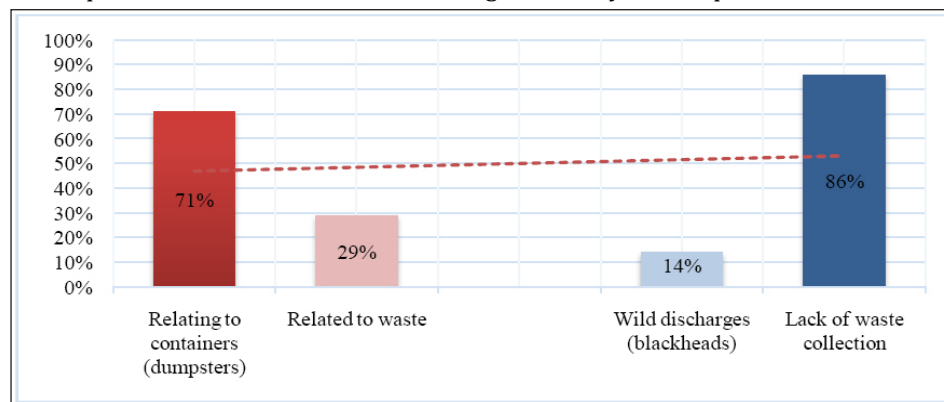
According to the agency, 8500 requests were registered in 2019 and 2020 (AND, 2020). Although considering the estimated total population of 43.85 million (ONS, 2020) and 13.5 million tonnes of household waste and similar waste generated, the number of requests remains significantly low in proportion to the objectives sought and the number of the target population.

The reports recorded by the application “NDIF” across the national territory show that the majority of citizens claim the inadequacy of garbage containers as well as the defect in waste collection.

The Feedback from users of the mobile application “NDIF” includes the lack of handling of claims related to wild deposits by local services and requests take a lot of processing time(*Cf. fig.2*).

The collaboration of the National Waste Agency and local officials is therefore necessary for concrete handling of citizens’ complaints.

Locally, deficiencies are still noted. The state of affairs reveals the lack of coordination between the agency and local collectivities. The inadequacies thus show the need to strengthen the system implemented.



**Figure2.**Typology of reclamations sent by citizens through the mobile application (NDIF) at the national level. **Source:** National Waste Agency, 2020,Treatment Authors, 2022.

Overall, the general observation in Algeria is that despite the efforts made, there are still difficulties in integrating information and communication systems in the waste sector.

More precisely, and in a one-way fashion, the authorities take on the role of informant while citizens, being receivers, are far from being involved in decision-making.

To the various recurring constraints, the progress made to date has not solved the problem of the absence of a communication framework at the level of the municipalities.

In this specific case, the “NDIF” mobile application, implemented as part of the digital communication strategy, allows citizens to report failures in waste management. However, it does not offer the possibility of two-way communication.

### **Household Waste Management in the New City“Ali Mendjeli”: Difficulties Still to be Overcome**

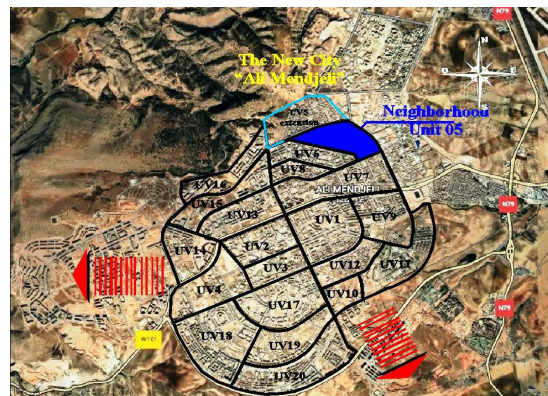
Product of proactive urbanism, the New City “Ali Mendjeli” was created to absorb the strong demographic growth and regulate the urban sprawl of the agglomeration of Constantine.

Decidedly, the ambition was to design an urban center offering an attractive living environment promoting social diversity.

Thus, the New City “Ali Mendjeli” was implanted on a vast virgin site on the plateau of Ain El Bey at an average altitude of 800 m. It is located about 15 kilometers south of the city of Constantine, about 12 kilometers west of the city of El Khroub, and about 10 kilometers east of Ain Smara.

In the master plan, the territory of the new city was divided into five major districts, including the main center and four secondary districts for better control of the urbanizable space and future urbanization. Each neighborhood is divided into neighborhood units.

Currently, the city continues to spread south and west to include in its extension two new neighborhood units (*Cf. fig.3*). As a result, the total area increased from 1500 hectares to 2280 hectares (URBACO, 2014).



**Figure3.** Spatial structure of the New City “Ali Mendjeli”. **Source:**Satellite view (Google Earth), Treatment Authors, 2022.

Concerning waste, the situation in the New City “Ali Mendjeli” is no better than in other cities. In fact, despite the development in the economic and social field, and even more in the environmental field, the systems for managing household waste have remained relatively unchanged. A modest management that is limited to a simple urban cleanliness. In particular, linear management, with landfilling being the main means of waste disposal, mostly without any technical support or recovery.

From a substantialist organizational point of view, innovation had to play a decisive role in the strategy of forward-looking management. However, the reality is very different, household waste is deposited by citizens in pre-collection devices consisting of ordinary garbage cans (*Cf. fig.4*), either plastic or metal, at collection points sometimes unidentified, without any sorting beforehand.



**Figure 4.** State of pre-collection devices in the districts of the new city “Ali Mendjeli”  
**Source:** Field Survey, Authors, May 2022.

The mechanized collection, which remains on its non-selective side, is carried out by the operators with the help of trucks (packing bins) without the use of technological tools (*Cf. fig.5*), as an example, it is indicated; the ID receiver, tablet, Global Positioning System (GPS), or other.





**Figure 5.** Model of a dumpster in use (Lack of computerized truck fleet management)  
Source: Field Survey, Authors, 2022.

Almost all the collected and mixed quantities of waste are sent to the Technical Landfill Centre for household or similar waste. In addition to the environmental risks and inconvenience caused by the storage of the final waste in this technical landfill, special difficulties have arisen for the public authorities. The saturation of the locker and the realization of a new locker prompted the inhabitants to undertake a protest action. Equally important are the operating costs and the relocation of the landfill. Several challenges must be noted, including the organization of areas for the treatment or burial of ultimate waste, which is an inescapable element.

Furthermore, information and communication technologies (ICT) contribute a priori to a real relationship in terms of the participation of all actors in the different stages of management.

In this respect, citizens must have access to information held by public authorities on the management of their waste. It is a matter of facilitating and encouraging the awareness and participation of the inhabitants.

In contrast, digital technology is almost nonexistent in the waste management process in the New City “Ali Mendjeli”. The current situation seems to be characterized by a lack of active communication and real-time dissemination of information between local officials, waste management operators, and citizens. This shift certainly impacts the performance and effectiveness of the actions implemented.

Adding to the non-involvement of the inhabitants, the information-communication practices adopted by the public management services are breaking with the urban context, the models, and the possibilities offered by the new information and communication technologies.

## **ISSUES AND OBJECTIVES**

This state of affairs, which we have outlined, fully expressed our main concern. Thus, our study was based on the following central question: *In the process of change and innovation, will new technologies be the key tool to adapt to make the inhabitants of the New City “Ali Mendjeli” interact with local services in the management of their household waste?*

Our objectives are to highlight the barriers to innovation activities in the local waste management strategy. To perceive the behavior and practices of the citizens of the New City “Ali Mendjeli” through the example of neighborhood unit 5, for a clear definition of an inhabitant profile allowing a conclusive identification for a real implementation of innovative solutions. Firstly, the adoption of new information and communication technologies (ICTs), and secondly, the use of intelligent devices in the waste management process.

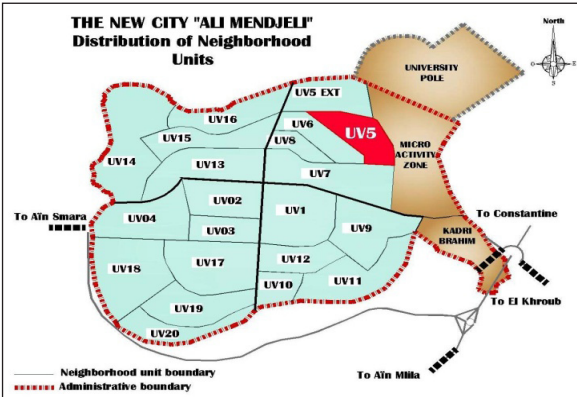
In this way, we will try to provide recommendations that will help to optimize management by effectively integrating digital and new technologies as a vector of opportunities for a renewed management.

## **PRESENTATION OF THE CASE STUDY**

As presented in the previous sections, the New City “Ali Mendjeli” was created from a composition of a set of neighborhoods bringing together neighborhood units (Cf. fig.6).

Progressively, the city has developed, in the sense of Clarence Perry’s model, with the aim of organizing residential communities in a way that encourages social interaction and cohesion among the residents of defined neighborhoods (Hall, 1992).

In this context, and in order to read the behavior of citizens and to measure the degree of acceptability of new technologies in the waste sector, our study adopted Neighborhood Unit 5 as a model for analysis(Cf. fig.7).



**Figure 6.** Location of UV5 in the administrative division of the New City «Ali Mendjeli». Source: Treatment Authors, 2022.



**Figure 7.** The Neighborhood Unit 5 District. Source: Satellite view (Google Earth), Treatment Authors, 2022.

The choice of this case study was made in view of the socio-urban heterogeneity perceived in the site. Covering an area of 47 hectares, Neighborhood Unit 5 is home to several social classes and is characterized by a diverse typology of buildings. In addition to the various existing public buildings, the study area includes a variety of constructions that combine various programs and types of housing: collective and individual housing(Cf.Tab.1).

Concerning the collective dwelling, being the most answered (83% of the total number of affected dwellings), we emphasize that the realization was made in the form of several types of programs for the benefit of all social categories; co-op housing, participatory social housing, public and assisted promotional housing, and housing from the national social work equalization fund. The gross density recorded is 69 dwellings per hectare.

**Table.1** Distribution of housing stock assigned to the Neirhood Unit 5. (New City “Ali Mendjeli”)

Typology	Types Program	Completed	Total housing units completed	Total housing units under construction
Collective housing	Housing cooperative	714	2 407	230
	Participatory social housing (LSP)	895		
	Promotional housing	344		
	Public and assisted promotional housing	174		
	Housing from the national equalization fund for social works	280		
Individual housing	Individual housing	500		84
Total housing units completed and under construction		2907		314
Total number of dwellings		3221		

**Source:** Development Establishment of the Cities of Ain Nehas and Ali Mendjeli (EAVANAM,2020) & Treatment Authors, 2022.

Thus, the urban composition exposes a high density of population. Taking into account the number of inhabitants estimated at 15 240 inhabitants in 2020, our study area has a high population density of 324 people per hectare.

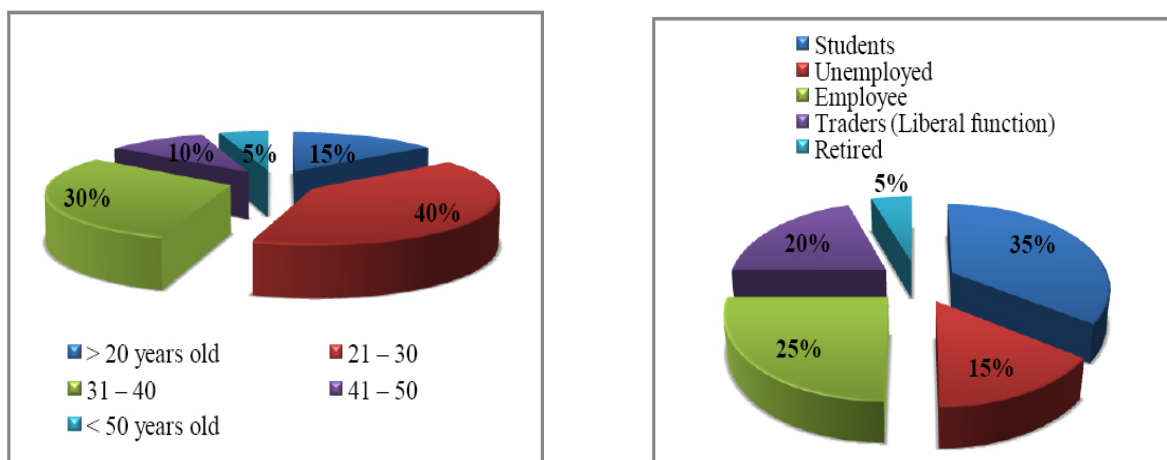
This considerable rate of occupancy of residential space significantly indicates the importance of the daily quantities of household waste generated by citizens.

Based on a national average of 0.80 kg/inhabitant/day of household waste and similar waste produced (AND, 2020), Neighborhood Unit 5 residents generate an average of 12.19 tonnes of household waste daily. This quantity appears to be characteristic in view of the high concentration of the population in the residential complex.

## MATERIALS AND METHODS

In order to achieve our objectives and establish indicators that make it possible to evaluate the incorporation of digital and ICTs in the waste management system in the new city “Ali Mendjeli”, we used the SWOT analysis method (Strengths, Weaknesses, Opportunities, and Threats) as a planning tool. The advantage is to reveal the positive and negative elements (the external environment and the internal context) as well as the determination of the actions to be carried out in priority for an effective strengthening of the communication between the different actors of the management.

The methodology was supported by a qualitative survey (Guelfand, 2013). Based on interviews and direct observation, we conducted a field survey of 60 sample units (persons) representing 324 population units (households). Thus, a questionnaire was submitted directly to each inhabitant as head or representative of the household. The selected sample shows a slight male superiority, which represents 55% in exchange for 45% of women. The subset of individuals includes the different age groups(*Cf. fig.8*), as well as the various occupations and socio-professional categories(*Cf. fig.9*). The following sections summarize the survey results.



**Figure 8.** Distribution of respondents by age group Source: **Figure 9.** The socio-professional situation of respondents  
Field survey, May 2022. Source:Field survey, May 2022

## RESULTS AND DISCUSSION

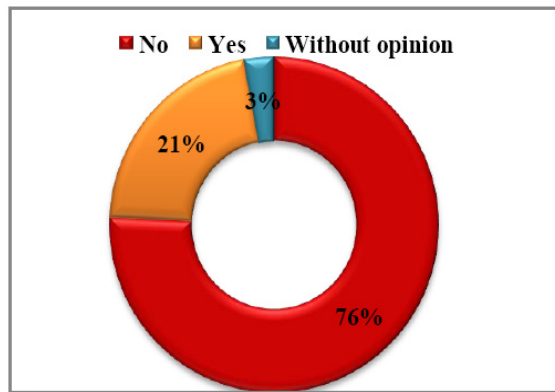
The results indicated by the completed survey reflect a state of the opinion of a sample of the inhabitants of Neighborhood Unit 5 at the time of its elaboration. A total of 60 questionnaires were distributed at the neighborhood level and the entire interviewed population responded favorably to the survey. Thus, all the questionnaires could be used and the results were structured in proportion to the priority objectives initially pursued:

- Evaluate citizens' behavior and practices in waste management in order to reflect on future actions.
- To measure the perception and satisfaction of residents in proportion to the management of household waste with regard to technical and communication criteria.
- Identify the needs and expectations of the inhabitants and assess the acceptability of the adoption of new technologies and proposals for change in favor of an innovative and optimized management.

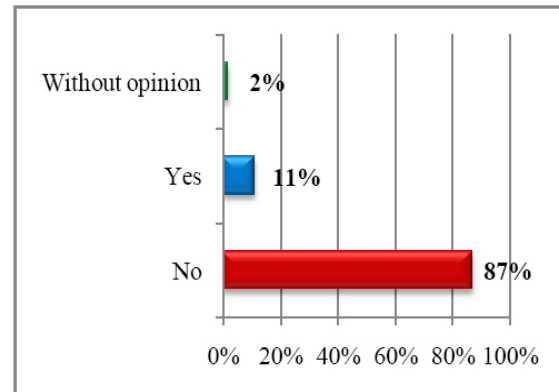
## Perception of Current Practices: Lack of Cooperation and Identified Obstacles to Technical and Organizational Actions

The survey results show that the majority of households do not sort their waste. According to the questionnaire, 76% of the inhabitants dispose of their waste in plastic bags without any sorting beforehand (Cf. fig.10). The 21% who gave a favorable response revealed that the sorting they carry out concerns only packaging waste (plastic bottles, cardboard boxes, etc.). This amounts to the lack of information and communication about the modalities and conditions for implementing ecological management. On this point, no awareness raising or support action has been recorded for the inhabitants of the neighborhood.

Moreover, Figure 11 shows that 87% of respondents do not know the public service or operators in charge of the management mission. The minority (11% of respondents) say that they have relatively limited knowledge.



**Figure10.** Household-level waste sorting practices

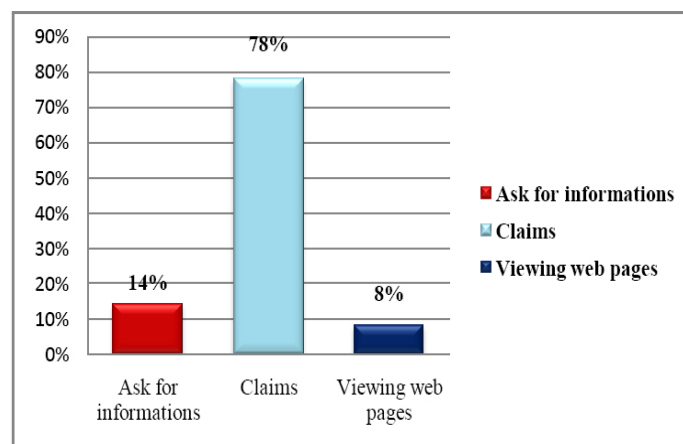


**Figure11.** Resident relationship and waste management department

In order to know the existing means of communication and information, it was discussed to rely on the tools and the reasons why the inhabitants use the establishment in charge of the urban management of the city.

According to the results (Cf. fig.12), 78% of people report that they travel to the establishment's headquarters for complaints, while 14% do so by mobile phone as a means of telecommunication to acquire information. A small percentage of respondents (8%) view web pages for personal information only.

Similarly, most residents raise the problem of the slow processing of their claims. Of a common opinion, for the citizens, the reactivity of the requests answers more to the stakes of image, of improvement of the quality of the service.



**Figure12.** Type and means of communication and information

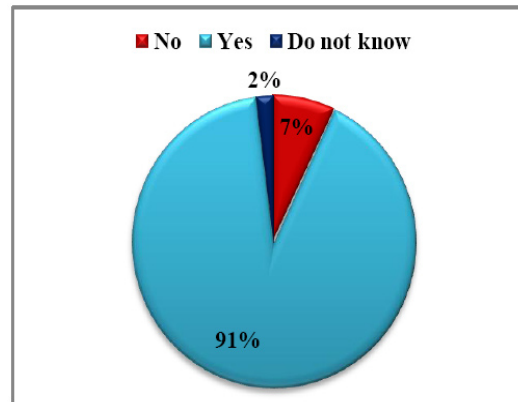
The acceptability of the adoption of new technologies and proposals for change of current methods: Motivated citizens for the implementation of participatory practices.

The following figure (Cf. fig.13) indicates that most of the inhabitants of neighborhood unit 5 (91%) were motivated by continuous improvement and concrete innovation in the current system of managing their household waste.



While a minority (7% of respondents) stated that this is an administrative responsibility for the departments concerned and local authorities. Moreover, the oldest (retired) are the most involved and the most cooperative although they show themselves less demanding of change.

This resulting fact finds its causes in the lack of information and awareness as well as the less frequent use of the Internet and digital technologies by these people compared to other age groups.

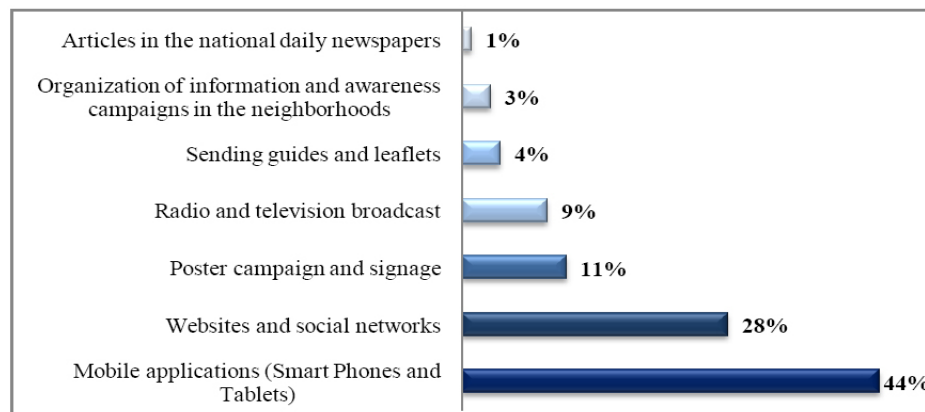


**Figure13.** Appreciation of the degree of reception and participation of the inhabitants regarding the innovation of waste management

In terms of the information and awareness-raising actions expected by the inhabitants, the results of the investigation revealed that almost half of the inhabitants interviewed (44%) suggest that the best way is the use of mobile applications. The reason respondents favored this choice is that the information is transmitted in real-time. Even more, the ease of access and the availability of use media: smartphones, tablets, microcomputers, etc.

However, 28% of residents believe that the use of Websites and social networks contributes effectively to information and awareness actions. While the participants (successively 11% and 9%) recommend almost equally the implementation of actions through signage and signage, as well as radio and television broadcasts (Cf. fig.14).

A low proportion of respondents (which varies between 1% and 4%) opt for the usual actions; the sending of guides and leaflets, the organization of information and awareness campaigns in the neighborhoods, and the publication of articles in the national daily newspapers.



**Figure14.** Information and awareness-raising actions to be implemented with citizens. (Needs and expectations)

In the last part of the questionnaire, short- and medium-term perspectives for change were discussed in the context of innovative waste management at the neighborhood level. Thus, several practices could be implemented in the field (Cf. fig.15).

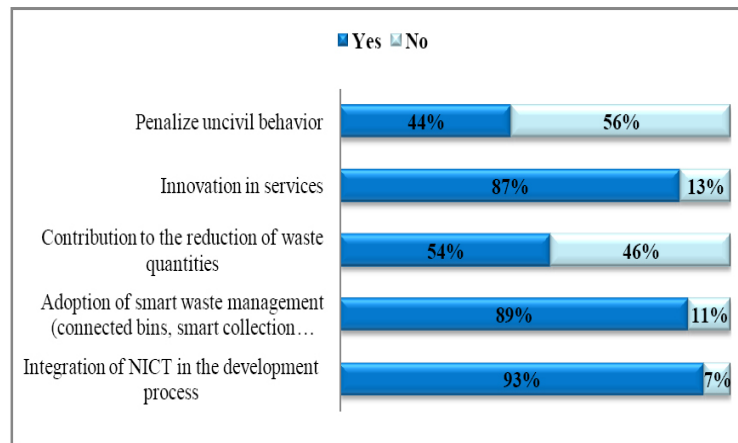
For the inhabitants (93%), the integration of new information and communication technologies (ICTs) represents the most priority proposal and practice. The information and support of citizens will allow the reduction of the production of waste and advantageously the development of treatment and recovery systems.

At the same level of priority, most respondents support the service innovation proposal and the acquisition of innovative devices for intelligent waste management, thus offering a better quality of life to residents, for example; sensors connected directly to the voluntary supply points, high-tech trucks for an environmentally friendly and intelligent collection.

In contrast, a minority of respondents felt that the transition should first be ensured through implementation studies.

In addition, the opinions of the inhabitants are almost equally divided in terms of contributions and sanctions. Just over half have shown their willingness to contribute and approve sanctions for uncivil behavior.

Although they are motivated to cooperate, 46% of respondents believe that the proposed fees should be related to the financial capacities and incomes of households.



**Figure15.** Degree of admissibility and acceptability of proposals for the renovation of household waste management

At the same time as the land survey, we were able to shed light on the profile of the inhabitants of the New City“Ali Mendjeli” in general and the Neighborhood 5 Unit in particular. To confirm the ineffectiveness of the management system adopted, also the lack of cooperation and collaboration between citizens and local officials in the management of household waste within neighborhoods. The SWOT matrix analysis tool allowed us to collect an informative data set. The same goes for defining the prospects for development, the positive points, and the points to be considered for the integration of ICTs, in particular the development and use of mobile applications. Using the SWOT method, the main strengths, weaknesses, opportunities, and threats identified are presented in the matrix below.

## The SWOT Matrix

### Strengths

- High level of education of the inhabitants implies an easy implementation of new information and communication technologies (ICTs), especially through mobile applications.
- Juvenile digital practice: young population who master technological and interactive tools.
- Trend of mobile applications not common at the local level (existence of only one national treatment application).
- Advanced technology and immediate data and information transfer; geo-location of complaint locations (wild dumps, bulky waste, etc.), the possibility of instantly adding photos, receiving notifications, etc.
- Social acceptability for a concrete improvement of waste collection at the neighborhood unit level through the integration of digital devices.
- Lack of innovative devices, such as connected bins.
- Access to information.

### Weaknesses

- Lack of cooperation and coordination between citizens and waste management officials (reciprocal responsibility).
- Absence of information a priori and a posteriori.
- Lack of funding.

## **Organizational Environment: Identification of opportunities and threats**

### **Opportunities**

- Very high usage rate of smartphones and mobile connection.
- Motivated population for the use of new technologies and the implementation of innovative equipment.
- Acceptance of inhabitants to pay to renovate their household waste management services.
- Consent of the inhabitants to cooperate with the public authorities for the modernization of the sector.

Overall, the management of household waste in the new City "Ali Mendjeli" encounters many difficulties. At the end of the investigation, many failures were identified in the neighborhood unit5. Collection points are constantly overflowing with unsorted waste. In addition, there is no cooperative practice between local citizens and managers. However, in return, several positive points are counted. Among other things, inhabitants were motivated to improve and innovate the mechanism for managing household waste in their neighborhood.

To ensure the efficiency of the public service, the use of new technologies is the most appropriate solution. It is a matter of rethinking the methods adopted and the way urban spaces are used.

To bring together also all the actors; local administration, management companies, and citizens around an innovative model. Starting with the integration of digital and new information and communication technologies, especially mobile applications, into the process.

Thus, the proposed approach will allow for the reduction at the source of the waste, therefore, the control of the flows. It will also enable citizens and services to be held accountable for the successful exploitation of detritus and a visible reduction of nuisances.

## **CONCLUSION**

In more recent times, information and communication technologies have become imperative in the daily life of individuals and play a main role in the evolution of various fields including that waste. These technologies and digital tools have not only facilitated exchange by involving all the stakeholders, but also the organization and optimization of the various waste collection and treatment operations.

In the New City "Ali Mendjeli", local waste management services are now unable to bear the burden of the colossal quantities produced in neighborhoods that are experiencing the same disarray. The results of the investigations have shown the weaknesses of the methods adopted which interpret the shortcomings that are mainly due to old management practices, and poor organization, but especially the lack of information, communication, and cooperation between citizens and local authorities.

The aim is to involve the inhabitants, provide them with all the necessary information and encourage them to collaborate. With regard to the communication, informational, and accessibility dimensions, digital technology, and new information and communication technologies (ICTs) are undoubtedly the key management support tool.

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**Citation:** Dr. REDJAL Omar, Dr. Bouarroudj Radia. *Integration of Digital and New Technologies for a Renewed Management of Household Waste: Current State and Prospects, Case of the New City Ali Mendjeli. Int J Innov Stud Sociol Humanities. 2022;7(7):97-108. DOI: <https://doi.org/10.20431/2456-4931.070709>.*

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