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Assessment of the Applicability of Implementing Municipal Solid Waste Separation at Source in Jordan

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Abstract

Mismanagement of municipal solid waste results in risks to human health, threats to the environment, and other socioeconomic issues. Currently, most countries have realized that they are managing their waste in a traditional way, utilizing open dumping, and this way does not achieve sustainable development goals. Therefore, these countries, including Jordan, which is the case study for this paper, decided to manage their solid waste in a more integrated way. Waste separation at the source is an effective way to reduce the amount of waste produced and is essential for Jordan to achieve environmentally friendly and integrated municipal solid waste management. This paper aims to identify citizens' attitudes and readiness to be part of a proposed MSW source separation plan by dividing solid waste into two categories: wet waste in a green bag is disposed of daily for six days of the week, and dry waste in a blue bag is disposed of on the seventh day of the week. That was done through an online questionnaire with the participation of 150 respondents. The results showed that 68.7% shared their vision and strong readiness to start separation of household waste at source, and 28.7% agreed. The study further demonstrated that there is an urgent need to focus on solid waste separation at source and make efforts by local authorities to raise the citizens' commitment towards this methodology by introducing sound public awareness campaigns.

Keywords: Solid waste management, Source Separation, Municipal Solid Waste, Jordan.
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1. Introduction

The proper disposal of municipal solid waste (MSW) is viewed as a major ecological problem. This is particularly true in developing countries like Jordan, where populations are expanding at an alarming rate. As a result of rapid, unplanned urbanization, MSW production has skyrocketed in many developing-world cities (Qdais, 2007). Accordingly, the SWM sector needs to take substantial measures and steps to manage the rising rate of solid waste (SW) creation, considering the SW's unique features (composition), as well as the most effective means of collection and disposal (Aldayyat et al., 2019). On the other hand, Jordan hosts about 1.4 million Syrian refugees, 85% of whom reside in municipal areas. This host has put a strain on a variety of sectors, including livelihoods, job opportunities, education and health services, house prices, the water shortage, municipal services, and infrastructure (Saidan et al., 2017). Refugees have increased Jordan's SW production by 340 tons per day, or 3% annually (Affairs, 2015).

In 2016, Jordan's yearly net greenhouse gas (GHG) emissions were over 29,000 Gg CO2-equivalent, and they are expected to double by 2030 (Affairs, 2015). GHG emissions can be drastically cut with the help of integrated waste management solutions including recycling, composting, and waste-to-energy. When compared to mitigation efforts in other sectors, those in waste management are comparatively straightforward(Association, 2009). In Germany, for example, waste management emissions reduced from 38 million Mg of CO2-eq in 1990 to roughly 18 million Mg of carbon dioxide equivalent (CO2-eq) in 2006, primarily due to the use of mechanical biological treatment and source separation (Dehoust et al., 2010). More than a thousand kg of CO2-eq were saved in the United States between 1974 and 1997 due to increased recycling and composting of municipal solid waste (Weitz et al., 2002).

"Green growth" (GG) is a low-carbon, climate-compatible development aimed at improving the economy while enhancing societal and ecological well-being. In pursuit of sustainable development, the Global Goals idea aims to change the global economic expansion into a greener one. After 191 United Nations (UN) member nations convened in Rio de Janeiro, Brazil, for the Rio+20 Summit in 2012, the GG concept emerged internationally (Tollefson and Gilbert, 2012). Whereas ,sustainable development (SD) was recognized as an international principle for economic growth at the Earth Summit after being defined by the World Commission on Environment and Development as development that provides for the needs of the present without compromising

the ability of future generations to do the same (Barbier, 2011). SD encourages growth by pushing public and private investments toward energy and resource efficiency, environmentally friendly, and minimal ecological footprint initiatives(Bina, 2013). Thus, since 2017, Jordan has made green growth establishment a high national goal. To further Jordan's climate and sustainable development goals, the Green Growth National Action Plan (2021–2025) was developed to integrate climate change and sustainable development targets into various industrial strategies. Jordan Vision 2025 identifies energy, transportation, water, agriculture, waste, and tourism as the top priorities for green growth (Environment, 2017, Monitor, 2017).

There is a need for a paradigm shift in how developing nations face the MSWM problem, since some of them have recently realized that the SWM policies they currently employ do not serve the goals of sustainable development (Agamuthu, 2003). Jordan has begun to develop measures to improve solid waste management. MSW management is primarily the purview of municipalities with their own resources (staff, material, and financial). As a result, it consumes 25% of municipal budgets, with cost recovery never exceeding 50% (Qdais, 2007).

In Jordan, the most common method for managing household solid waste (HSW) is the dumping of waste without sorting at landfill sites. This is the case mostly due to the availability of abundant open space and the comparatively low cost of disposal in comparison to other available choices. On the other hand, there are a multitude of negative effects on the environment, such as the persistent release of methane and the contamination of groundwater caused by the discharge of leachate(Eggleston et al., 2006). As a result, the criteria for environmentally responsible waste management in many cities have been increased. Instead of just burning or burying waste, source separation is a more effective way to enhance waste management levels and turn municipal solid waste into useful materials or goods. This can be accomplished by converting MSW into other materials or products. Source separation is the process of sorting municipal solid waste (MSW) into its component parts at the point of generation, considering the unique qualities of each type of waste before moving on to subsequent treatment (Yang et al., 2011). Waste source separation is an example of the 3R principles (reduce, reuse, recycle) in action, as it increases recycling rates and decreases overall waste disposal needs.

Solid waste is one of Jordan's primary environmental issues, which has been exacerbated over the past 20 years by a dramatic increase in waste volume and qualitative changes in its composition. Jordan faces many SWM difficulties, such as financial limits, lack of suitable equipment, and a limited qualified and skilled workforce, plus significant and unexpected population growth owing to forced migration. As it was noted, despite the wide spread of waste management studies in Jordan, there is no comprehensive study of the extent to which citizens accept sorting waste from the source. To achieve this goal, we conducted an online survey. It includes the idea of separating household waste into two parts: wet and dry waste. Finally, suggestions and recommendations for applying this idea are also provided.

2. Solid waste quantities and characteristics in Jordan

As presented in Figure 1, the MSW has increased steadily in all countries of the world, which can be mainly attributed to the increase in population, the change in living standards, and the increase in waste collection with time. According to the Ministry of Environment, the generation rate of solid waste in Jordan is 0.99 kg/cap/day in the urban areas and 0.87 kg/cap/day in the rural areas. About 2.2–3 million tons per year of solid waste are generated each year, and it is expected to reach 6 million tons per year in 2030, as illustrated in figure 2.

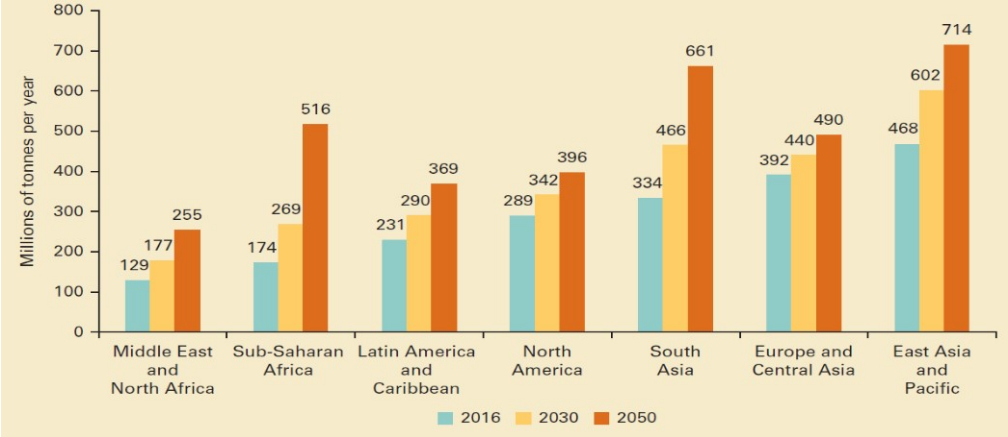

Figure 16:Projected waste generation, by region (WorldBank) .

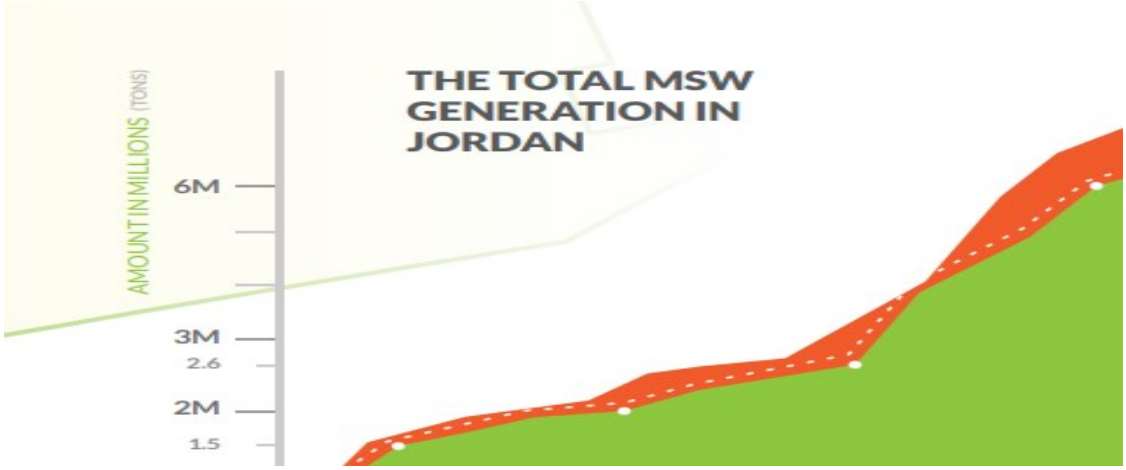

Figure 17:Average solid waste generation rate in Jordan (Saidan et al., August 2016).

Figure 3 shows the MSW in Jordan according to its physical characteristics as well as its typical distribution by percentage. Because Jordan is a developing country, most of the waste consists of organic and paper waste. It is estimated that around 80 percent of all municipal solid are biodegradable and recycled, with the remaining 20 percent consisting of inert materials (Abu-Qdais, 2000).

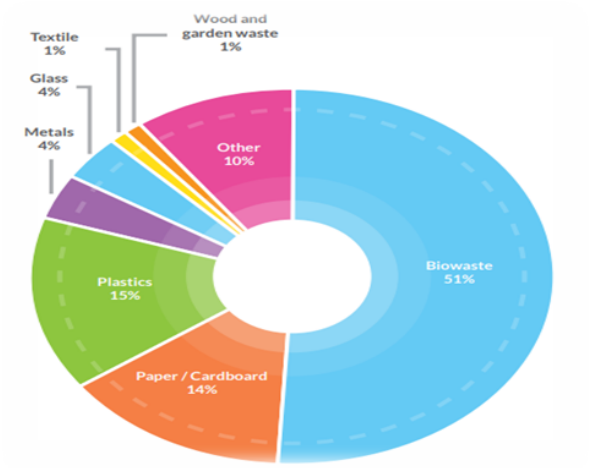

Figure 18: Municipal waste composition in Jordan (Saidan et al., August 2016) .

Biodegradable trash would degrade over time even if left alone, but aside from posing health risks, the rate of decomposition may be too slow, whereas we can reuse and recycle some of those before they end up in landfills (see Table 1). Waste management is critical due to the multifaceted nature of waste and its associated negative consequences for humans, wildlife, and the environment.

Table 3: Degradation Rate of Waste Items (Fukuda-Parr, 2013).

Type of Waste	**Time Needed to Degenerate, if left Untreated**
Organic wastes (vegetable, fruit, food, etc.)	7 – 15 days
Paper	10 – 30 days
Cotton cloth	2 – 5 months
Woolen cloth	12 months
Tin, aluminum, and other metal cans	200-500 years
Plastics	100 – 1000 + years
Glass	Not determined

3. Landfilling in Jordan

Waste disposal is one of the most significant management activities that needs to be carefully planned. Almost all solid waste generated in households is disposed of together, and there is no habit of sorting organic waste at the household level. Disposal of wastes by land filling or land spreading is the ultimate fate of all solid wastes because it is the cheapest and easiest option. In Jordan, landfilling consists of nothing more complicated than depositing trash in pits or cells, then compacting it with trash compactors to make the piles smaller and their depths shallower, and finally covering the whole thing with soil. There are twenty-one working landfill sites in Jordan, out of which seven are closed landfill sites. The location of these landfills was not based on international standards but on population density to service the most municipalities. Except Al Ghabawi, which is the only engineered sanitary landfill in the kingdom, receives more than 50% of Jordan's solid waste (Yamin, 2019). Water, soil, and air could be tainted due to a lack of linings and improper disposal techniques. The location of the Akaider dump, which lies close to the Syrian border and the Yarmouk River basin, has been a source of political concern between the two countries. The Mafraq landfill was built on top of a geological fault, which endangers the region's water supply. The dump in Russeifa can be found on the main thoroughfare connecting Jordan's two largest cities, Amman and Zarqa. Humra is situated in a bedrock region, meaning that there is no soil available for daily coverings, and the leachate created poses a hazard to human health and soil quality.

4. Recycling of waste

It is the process of converting waste into usable products to prevent the waste of restricted materials and rationalize the consumption of raw materials. Recycling is the third element in the waste hierarchy, as shown in figure 4. It is also known as collecting waste and materials, recycling them with the help of technology, and turning them into new products, which makes it easier to sell them. Recycling in Jordan is extremely low and mostly done via the informal sector. Source-separation of solid waste is not used in Jordan yet, which means that a lot of things that could be recycled end up in landfills.

Figure 19:The waste hierarchy.

Recycling is one of the most well-known methods of waste management, and it is a cost-effective procedure since it saves energy and raw resources and reduces pollution. The following items may be recycled:

1. Organic waste

2. Reusing glass and metal in new industries
3. Paper and cardboard
4. Textile materials and clothes
5. Plastic
6. Construction and demolition waste
7. Tyers.

The cost of the sorted materials, as shown in table 2, has a major impact on the waste recycling process. However, these costs could change depending on the state of the market and the cost of fuel.

Table 4**:**The prices of some sorted materials s in the local market (Saidan et al., August 2016).

Recyclable item	Price [JOD/tone]
Mixed Plastics	280
Nylon	250
Steel waste	65
Aluminum waste	600
Paper	35
Cardboard	30
Newspapers	40
Paper magazines	35

At first glance, the individual imagines that waste recycling is a complex process, but it is in fact a very simple process. After the municipality or the competent authority collects waste, it is sorted into specific categories. Each category is directed to the competent authority for equalization, recycling, melting, or reusing. Recycling is carried out in three basic processes as follows:

1. Recyclable waste is collected by public agencies or private companies.
2. The collector then transports the recyclables to a processing plant. Materials are sorted, cleaned, and loaded into transport vehicles in preparation for shipment to a mill or for manufacture.
3. Remanufacturing: is the process of turning recyclable materials into new products at a transfer station or other facility after all the necessary processing steps have been completed.

5. Municipal Solid Waste Separation at the Source

Recyclable materials are at greater danger of being polluted and have fewer potential markets when collected with general municipal waste. There is a higher rate of recycling for materials that have been cleaned up since they are more valuable to re-processors. Furthermore, non-segregation also influences climate change, which may result in drought. Therefore, sorting trash before dumping it is necessary. Humans can benefit much from practicing waste segregation, which is why it is essential. After the waste has been sorted, the recyclable materials can be turned into new materials. Considering the current societal predicament of resource scarcity, its significance is immense.

More than half of our work would be done, and the biggest challenge we confront in managing solid waste would be reduced if we segregated waste at the source itself. The aim of waste separation can be achieved only if we each take personal responsibility and act accordingly. Focusing on trash segregation, which aids in distinguishing between biodegradable and non-biodegradable waste, is essential if we want to improve recycling activities. Because it is biological matter, throwing away trash that breaks down in nature poses no threat to the environment. The inorganic components of trash are the ones that can be reused and recycled. The greatest threat is posed when inorganic waste eventually makes its way back to the Earth, where it can increase pollution levels and cause severe environmental damage. When inorganic garbage reaches the scrap market, it is further separated into its component parts, such as paper, plastic, metal, and so on. Eventually, these inputs make it to the manufacturers, who will put them to use as raw materials.

5.1 The possibility of applying waste separation at the source in Jordan

As it was noted, despite the wide spread of waste management studies in Jordan, there is no comprehensive

study of the extent to which citizens accept sorting waste from the source. To achieve this goal, we conducted an online survey. It includes the idea of separating household waste into two parts. The first one is wet waste (organic section) is placed in a green bag that contains leftovers of food, vegetables, and fruits. The other section is a dry, inorganic section that is placed in a blue bag and contains papers, nylon bags, batteries, carton boxes, fabrics, plastics, etc. The green bag containing the organic materials is disposed of every day for 6 days of the week, and the blue bag containing the dry materials on the seventh day of the week.

The questionnaire consists of three sections. The first one starts with an introductory text explaining the waste sorting process. A few types of socioeconomic data are requested (gender, education, age, work position, place of residence, etc.). The second section measured the extent of citizens' awareness about the composition of household waste and the impact of poor waste management on humans. The last section measured the possible desire of citizens to sort waste from their homes.

5.2 Results and Discussion

5.2.1 sample characteristics and respondents' behavior

Table 3 shows that 44.7 percent of survey respondents were male, and 55.3% were female. 76% of them were younger than 40, and 24% were older than 40 years old (see Table 4). 10% of them were postgraduates, 50.7% were graduates, 30.7% were Secondary School Certificate holders, and 9.3% had primary school education (see Table 5). Also, 41.3% of them worked for someone else, 6% were technicians, 19.3% were students, 11.3% worked for themselves, and 22% were housewives (see Table 6).

Table 5**:** Gender Distributions of Respondents.

Gender	Frequency	Percent
Male	67	44.7
Female	83	55.3
Total	150	100

Table 6: Age Distributions of Respondents.

Age	Frequency	Percent
10-20	15	10
20-30	60	40
30-40	39	26
Over 40	36	24
Total	150	100

Table 7:Educational Qualifications of Respondents.

Qualification	Frequency	Percent
Postgraduate	15	10
Graduate	76	50.7
Secondary Education	45	30
Primary Education	14	9.3
Total	150	100

Table 8:Occupation of Respondents.

Occupation	Frequency	Percent
Employee	62	41.3
Self-employment	17	11.3
Technician	9	6
Housewife	33	22
Student	29	19.3
Total	150	100

The data analysis showed that slightly more than half of the respondents were female, while the remaining

respondents were male. Considering that almost 90% of respondents had completed some level of secondary education, it is safe to assume that most of them could easily understand the questionnaire and provide accurate responses with little to no assistance. And we were careful to be the participants in the survey from all governorates of the Kingdom, as seen in Figure 5.

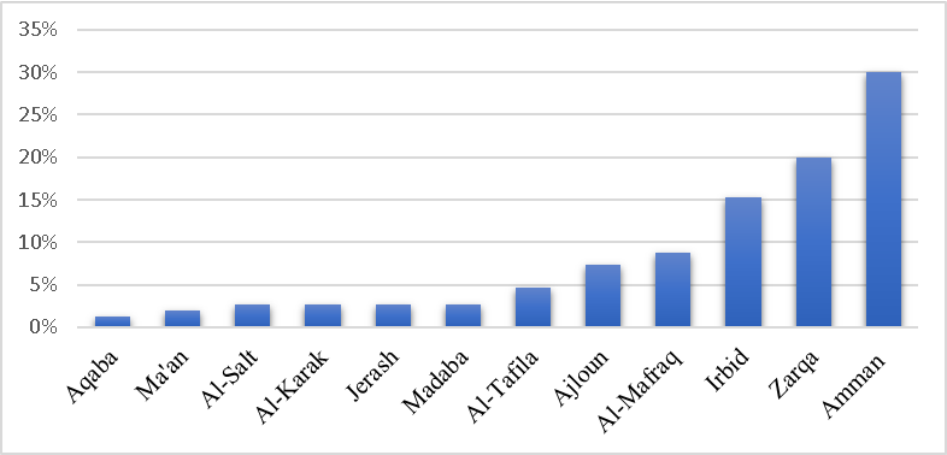

Figure 20: participants across the governates of the kingdom.

5.2.2 Discussions

In the second part of the survey, people were asked how much they knew about what was in household waste and how bad waste management affects people. 4.7% of people think that waste is natural and that there is no consequent harm to humans, whereas 2% do not know and 93.3% disagree (see Figure 6). Whereas 64.7% of the participants believe that the amount of organic matter in municipal waste is greater than the amount of inorganic matter, 12.7% believe otherwise, and 22.7% are unsure. Also, 91.3% agree that waste recycling is the process by which waste is reused in new industries; the rest 3.3% disagree and 5.3% do not know.

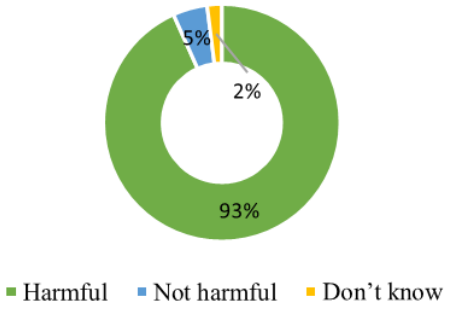

Figure 21: Effect of waste on human.

Furthermore, when we asked the participants if the waste has commercial or industrial value, the percentages for "agree," "disagree," and "don't know" were 83.3%, 3.3%, and 13.3%, respectively. Then we checked if citizens could differentiate between sorting waste at the source and recycling it. 52% of respondents stated that the separation at source is not the same as recycling, 33.3% answered that they are the same, and 14.7% said they did not know.

This means that people are very aware of the harmful effects of waste on the environment and humans. And they only need to publish more awareness-raising workshops, brochures, and short videos about the long-term impact of waste accumulation, recycling, and waste sorting at the source and their positive affect on the environment, using social media applications. In fact, public awareness initiatives, which should incorporate social marketing and behavior modification initiatives, should be seen as critical tools for increasing the social marketing of any trash recycling and sorting activity.

In the last section of the questionnaire, we measured the respondent's support for sorting waste at the source. As

shown in Figure 7, the absolute majority of respondents (68.7%) shared their vision and strong readiness to start separation of household waste into two bags: a green bag for organic materials (food scraps, fruit, and vegetable peels, etc.) And a blue bag for the rest of the inorganic dry materials (paper, nylon bags, batteries, plastic, glass, etc.), and 28.7% agreed, while a small percentage 2.7% disagreed to separate waste.

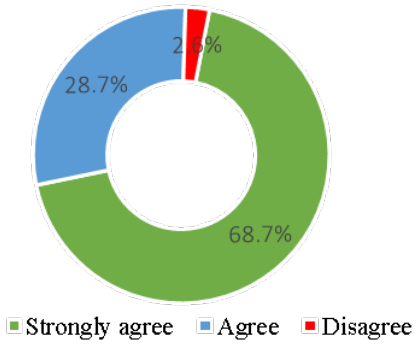

Figure 22: The respondent's support for sorting waste at the source.

According to Figure 8, 77.9% of participants accepted the idea of collecting the green bags for 6 days a week, and the seventh day will be devoted to collecting the blue bag containing inorganic materials. 12.8% did not accept that and 9.4% did not know.

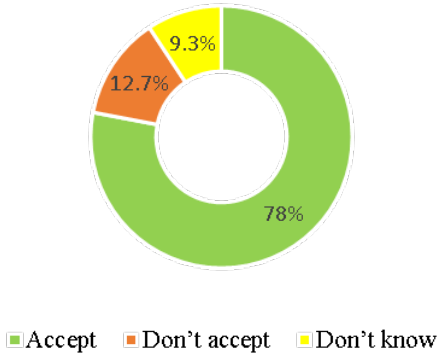

Figure 23: The results of voting on days of collecting garbage.

Figure 9 illustrates that 94% of participants see that separating the waste from the source into green and blue bags helps in solving the waste problem. 1% assume that it is not affected and 5% do not know.
The last question in the questionnaire was: "For me, reducing, reusing, and sorting waste is:

1. A national duty
2. Important for the environment
3. Very important to my family
4. Something interesting
5. Nothing.

It was found that all respondents had positive feedback for sorting waste into two parts from home, as shown in figure 10.

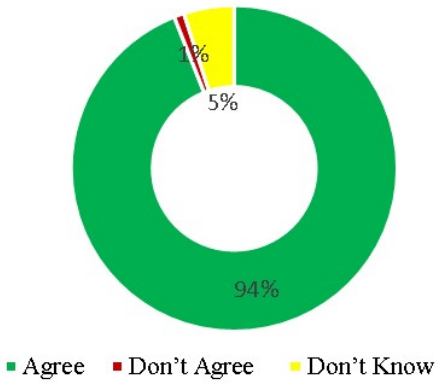

Figure 24: separation household waste in the source into green and blue bags helps in solving the waste problem.

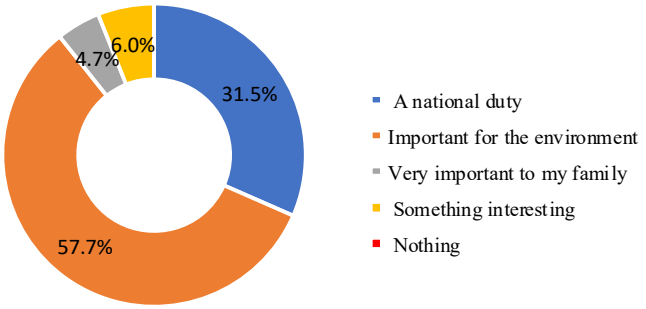

Figure 25**:** Major reasons of respondents for separation household waste.

Finally, at the end of the survey, there was a space for any comments they would like to convey. Many of them welcomed the idea and asked the competent authorities to implement it as soon as possible because it had a positive impact on the environment and to reduce the accumulation of waste on the streets, which was generally considered very bad. In general, respondents showed a positive attitude to the questions and expressed their readiness for the separation of household waste at the source. Therefore, if we separate solid trash at the site of generation, we can recycle it quite efficiently. Recycling solid waste in Jordan requires a decentralized, individual-centered approach. When we were able to separate waste at the source, we would be able to take separate actions for each type of waste.

6. Conclusion

Overall, this research successfully analyzed and provided fundamental information about the preferences and attitudes of a sample of citizens towards the source separation of MSW. Several significant findings and recommendations from the study are outlined below.

- Separating waste at the source into fundamental types like wet and dry gives it a much better chance of being recycled and reused. As well as reducing approximately 40% of costs (transportation, laborers, and raw materials).
- Segregation of recyclable materials would also lead to a reduction in the quantity of solid waste disposed in landfills by 50% at least.
- According to the results of the study, most respondents have consciously positive reactions toward the separation of MSW at source. Observe that respondents of varying education levels, genders, ages, and occupations generally hold a positive attitude. 57.7% voted that it is important for the environment and 31.5% voted that it is a national duty. 4.7% said it is important to my family and 6% said it is interesting. In contrast, and no one denies it.
- Most respondents (68.7%) shared their vision and strong readiness to start separation of household

waste into two bags: a green bag for organic materials (food scraps, fruit, and vegetable peels, etc.) And a blue bag for the rest of the inorganic dry materials (paper, nylon bags, batteries, plastic, glass, etc.). And 28.7% agreed, while a very small percentage (2.7% disagreed).

- Community participation is one of the successful techniques for developing the solid waste segregation and recycling sector.
- There is a serious need to prioritize source-separation of solid waste and increase public support for this approach.

7. Recommendations

1. Based on the study findings, it is recommended that numerous institutions, such as non-governmental organizations (NGOs), municipalities, governments, international agencies, universities, and schools, establish a real program to encourage citizens to participate in the preservation of the environment and the modification of consumer behavior by educating the public about the various aspects of solid waste and sorting it from its source. Awareness and knowledge are crucial to the success of the waste sorting at source program.
2. Apply a practical pilot in some municipalities and provide citizens with free colored bags to encourage residents to sort their waste at the source. Then assess how residents react to that before rolling out the program across Jordan.

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