

Enhancing Solid Wastes Separation Behaviour at the Residential Towers,

using the Garbage Chute Systems.

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Abstract

Solid wastes separation is important for enhancing materials recycling that is good for environment and conservation of natural resources. Citizens have the central role in enhancing solid wastes separation at the household level. Inhabitants' participation in sorting wastes is a low-cost task but has great economic advantage, but it is very challenging and expensive to engage inhabitants and enhance their sorting behaviours. Despite the municipal efforts in establishing and developing the existing households' solid wastes separation schemes in Sweden, there are lots of necessary developments needs to be in place. This study is grounded on testing the garbage chute systems to induce solid wastes separation habitual changes at the residential towers. Important facts have been gathered from different studies on existing solid wastes separation schemes and behaviours on national and regional perspectives. Empirical data was gathered through directly asking inhabitants in the residential towers that has the built-in garbage chute system in how these systems can help them sorting their solid wastes. Research leaders at the field of developing the existing solid wastes separation schemes and circular economy initiatives in Sweden, were approached for understanding behavioural transformation determinants available in using garbage chute systems for solid wastes separation at the residential towers. Strategic development of the garbage chute systems to be used for sorting solid wastes at the residential towers was suggested in the work to enhance engagement level of households' solid wastes separation.

Keywords: Behavioural factors in wastes sorting, garbage chute systems, habitual wastes segregation, households' solid wastes, municipal waste management, residential towers, solid wastes separation.

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Abbreviations

HHL	Households' Level
MOAB	Motivation, Opportunity, Action & Behaviour
SW	Solid Wastes
SWS	Solid Wastes Separation
SWSB	Solid Wastes Separation Behaviour
SWSS	Solid Wastes Separation Schemes
TPB	Theory of Planned Behaviour
TPA	Theory of Planned Action

1. Introduction

People are moving toward big cities for better employment and education opportunities, and modern lifestyles. Population growth in the big cities is expected to increase in the coming 50 years. This leads to an increasing demand on the residential units in these cities. Modern concentrated residential clustering inhabitation building strategies are increasing to satisfy the increasing demand on residential units in big cities. This modern residential lifestyle contributed to product consumption patterns shifts leading to increased consumption of packaged.

More than 95% of market products needs packaging, that becomes solid wastes SW after product use. Readymade and easy to prepare food recipes and products directed to the working segments, students, and young people is increasing too. Food packaging wastes stands at least for 25% of solid wastes produced by household annually. Accordingly, urbanization contributes to products packaging wastes accumulation. Households are the second largest contributor to the total SW generated in Sweden.

Solid wastes separation SWS becomes more challenging if people cluster in residential areas. Swedish government has specified the environmental framework for building sustainable residential units, However, the mentioned framework does not clearly identify the determinants of sustainable building methods and what is the role of each of the stakeholders involved. This creates lots of gaps in identifying the requirements for solutions, applications, monitoring and controlling practices and procedures toward sustainable buildings that contribute to the government national goals in terms of enhancing resilient communities.

Increasing material recycling is important for resources conservation. Reusing the produced material for the same material use is still at very low levels compared to energy recovery. Although Sweden has reduced dumping wastes in landfill dramatically, incineration is still exceeding material recycling (Energiforsk 2019). Nationally, enhancing circular economy strategies to increase resources and materials use efficiency is a priority to the Swedish government.

To enhance material recycling, SWS needs to happen as early as possible at the wastes source generation. Considering households' SW generation, this means that inhabitants have the central role in driving the households' SWS effectively and efficiently.

1.1 Problem Definition

As urbanization increases, vertical inhabitation with built-in garbage chute systems is spreading in Sweden and in other parts of the world. Inhabitants can dispose their garbage through the garbage chute that exist in each floor in the building. To many municipalities in Sweden, these systems are a cause for mixed wastes. Many Swedish municipalities started shutting down these systems and asked inhabitants to drive their SW to separation stations and sort it there. Bring systems and curb side SW collection and separation schemes are the most prevailing in Sweden and it was determined to have high coverage rate in the country. Despite the advanced level of solid wastes separation schemes SWSS introduced to users in Sweden compared to other countries, the rate of households' SW mis-sorting is still high. This costs Swedish municipalities millions of Swedish kronor as additional wastes treatment's operational and community costs every year. Interventions investigated in scientific manner in universities' research have not been taken seriously by municipalities that have been involved in these studies for further application.

The participation of citizens is essential for any separation scheme to work effectively and efficiently. However, there is no academic research or feasibility studies conducted on the inhabitants' participation and satisfaction with the existing separation schemes. Convenient, accessible, and flexible separation schemes are necessary to strategically enhance and develop solid wastes separation behaviour SWSB at the Households level HHL. SWSS needs to offer interesting wastes separation experience and works as a tool to measure and analyse segregated households' SW.

1.2 Aim

In this work, using the built-in garbage chute system as solid wastes separation scheme at the residential towers to enhance wastes separation behaviours was investigated. Inhabitants has a central role to enhance the SWS at the HHL. Separation schemes that help initiating and sustaining inhabitants' habitual actions for actualizing behavioural changes are necessary to enhance households' SW separation. Considering the context of built-in garbage chute systems in the residential towers, this work aims to:

- 1- Understand driving factors, barriers, enablers, and disablers of the SWSB at the HHL at the residential towers.
- 2- Evidence the need to use the garbage chute schemes to enhance SWSB and reduce SW mis-sorting at the residential towers.

1.3 Research Questions

Shall inhabitants' solid wastes separation behaviour at the residential towers get developed or enhanced upon making built-in garbage chute schemes in the available for solid wastes separation?

2. Methods

Solid wastes separation behavioural factors, inhabitants' satisfaction/dissatisfaction with the existing SWSS, and political willingness to develop the existing SWSS at the HHL, were investigated through the primary data collected by questionnaires and interviews, and literature review part. The importance behind investigating these factors was to use them as a framework for evaluating using the built-in garbage chute systems as a separation scheme that enhances wastes separation behaviours at the residential towers. The major areas at which primary data got collected were as follows:

Quantitative and qualitative analysis were done as questions sent to inhabitants in residential tower that has the garbage chute systems to measure:

- 1- Inhabitants' habitual actions initiation and sustaining determinants.
- 2- Determinants of inhabitants' acceptance, satisfaction, and dissatisfaction to the existing SWSS available.

Interviews with actors involved in Research and development of the existing separation schemes or/and sustainable solutions at the residential communities in Sweden:

3- Determinants of the managerial and political reluctance that stands behind not developing the existing SWSS. These determinants can be political, economic, operational, or others.

2.1 Primary data

2.1.1 Quantitative analysis

Online survey got responded by 92 participants who lives in residential towers that has the built-in garbage chute schemes with presence of garbage chute in each floor. A questionnaire of six questions were sent to participants by email, and social media, one by one. Questions were sent to participants in different cities in Sweden. Socio demographic factors were not involved in the questionnaire because the relationship between socio demographic factors and SWSB were not established or clearly identified in theory and studies conducted in investigating necessary interventions to enhance SWSB at the HHL. All questions were obligatory to answer to go to the question after. Data were extracted on excel sheet and figured in as pie charts and histograms. ANOVA tests were done to examine the difference in SWSB upon making the garbage chute system available for SWS at the residential towers through measuring the P-Value.

2.1.2 Qualitative analysis

Different Respondents to the quantitative analysis were contacted and asked for participating in an interview for qualitative analysis purposes. One participant has accepted to go with the interview. A family who lives in a residential tower that has the built-in garbage chute system in the city of Åmål in Västra Götalands län in Sweden.

The wife in the family works as an assistant teacher in the field of kindergarten. She was asked to get the family with her to broaden the scope of understanding garbage disposal routines for both individuals and family. This will help also understanding the difference between family members attitudes and reaction to the existing SWSS. Semi structured interview has been conducted with the family that consists of the 45 years old wife, a 50-year-old husband, who studies professional educational program, and three girls of age 21, 19 and 10 respectively, who goes to gymnasium and preparatory schools. The family lives in a flat in a building of 5 floors. In each floor there is a garbage chute, where the resident use regularly to throw their garbage filled in bags.

Recently the building has formulated a new instruction of using the chute system to throw only food wastes. The family used to mix the food wastes with tissues and sometimes small plastic pieces in plastic bags before throwing them in the chute. No special bags are offered by the building "as the family said" for food wastes.

2.1.3 Interviews with professionals

Interviewees considered for this work were researchers and development professionals involved in the field of developing SW separation solutions and schemes at the HHL. They are:

Dr. Kamran Rousta, Associate professor, and senior lecturer at University of Borås, Faculty Textiles, Engineering and Business, Department of Resource Recovery and Building Technology. Dr. Kamran has overseen and conducted different academic studies on different interventions to enhance SWSB at the HHL in Sweden.

Ronny Arnberg, Key Account/project Manager at the Swedish Institute of Environmental Research. The institute is leading many projects in Sweden for sustainable transformation in different industries. Among these projects are, circular economy, Measures and strategies for increasing circularity and resource efficiency, Appealing and socially sustainable residential areas, and building sustainably in a changing climate.

An interview has been conducted with Kamran Rousta via zoom on the 26th of February 2022. Kamran has many literature reviews for several studies he conducted in the pilot area in Borås involving 208 apartments that has 447 residents. In the mentioned area the existing SWSS were bring system. Kamran said that the

building considered for the study does not have the built-in garbage chute system. Dr. Kamran Rousta were asked on the following areas:

- 1- The most important SW participation determinants to be considered upon introducing interventions to the existing separation schemes at the HHL in general, with special focus on the residential towers.
- 2- The need for examining the garbage chute schemes to satisfy the development determinants investigated in the action research studies conducted by Kamran in the municipality of Borås to increase extent and quality of inhabitants' participation in the residential towers.
- 3- Municipalities openness in terms of introducing recommended and modern interventions to enhance SW separation experience at the HHL to get higher level of engagement.
- 4- Political and administrative conservativeness and reluctance to developments and investments in the existing HHSS due to economic, administrative, social, political, resource efficiency and/or other concerns.

An interview has been conducted with Ronny Arnberg via Teams on the 5th of May 2022. Ronny is leading and/or involved in different sustainable projects run by the institution toward sustainable communities. Ronny got asked about the following areas:

- 1. The importance of inhabitants' participation in the existing separation schemes for changing the extent and quality of SW separation.
- 2. Feedback on the existing separation schemes and the main development areas to be considered for further evaluation and application.
- 3. The main obstacles in gaining the ownership of introducing smart and responsive SWSS to households.
- 4. The potential role of other stakeholders that are currently not involved in the formal scene of SWSS development strategies.
- 5. The need to use the garbage chute schemes instead of shutting them down to initiate and sustain SW separation habitual actions at HHL A step to automate sustainable behavioral conduct in terms of SW disposal at the HHL.

2.2 Secondary data

2.2.1 Theoretical Overview

Academic findings on the existing SWSS, areas for development and the required interventions for enhancing SWSB at the HHL were reviewed on national, regional, and global perspectives.

Reviewing annual reports for acting organizations in the field of SW collection and separation in Sweden. These reports present in detail the required developments areas of the established SW collection and separation schemes to enhance users' engagement and participation.

2.2.2 Literature review

Systematic review analysis for seven studies conducted in Sweden, two conducted in Europe and one conducted in China. Studies included were conducted to find out the different drivers, barriers, enablers, and disablers for households' SW separation habitual and behavioural changes on national, and international perspectives. The studies considered are listed at the appendix.

2.3 Limitations

This work is limited to SWS conducted by residents in the residential buildings that has the built-in garbage chute systems. The study does not take into considerations villas, townhouses or buildings that does not have the built-in garbage chute systems.

Although the quantitative analysis was conducted with residents in residential towers that has the same built-in garbage chute scheme, the respondents do not live in the same building or in the same residential area, or in the same city.

3. Theoretical Review

Solid waste management is one of the major challenges for sustainable lifestyle (Jamal et al. 2019). Globally, the municipal SW generated in 2016 were 2.01 billion metric tons, (Kalyanasundaram et al. 2021). On the individual level this means that everyone generates 740 g SW daily, and these figures are expected to exceed 3.4 billion in 2050, which means that it will grow by 70% (Kalyanasundaram et al. 2021). This is attributed to the rapid population growth and urbanization (Kalyanasundaram et al. 2021). China alone has reported that 242 million tons SW were collected and transported in 2019, this means that 5% growth of the wastes generated occurred in the last 10 years (Zhang et al. 2022).

The modern consumption patterns contributed massively to natural resources depletion; this makes utilization of the SW becomes a necessity that cannot be ignored for global sustainable development (Zhang et al. 2022). Pressures on landfills and alternative incinerations plants needs to be reduced through amending reuse and recycling systematic solutions (Jamal et al. 2019). Adopting valorisation techniques required to valorise household SW needs an institutional context that works on improving the SWS and recycling conditions and giving the sufficient support to reduce the involved risk in the required investments (Defeuilley & Lupton 1998).

Municipalities will carry on adapting stable, secured and economically feasible techniques provided by the well-defined market relationships as incineration and incineration induced energy markets (Defeuilley & Lupton 1998). Accordingly, municipalities will give the low cost techniques "Incineration" the largest portion of the waste management solutions mix (Defeuilley & Lupton 1998).

Despite the importance of the waste Separation behaviour on the global sustainability, rates of public exposure to the benefits of wastes separation are still at very low levels (Yusof et al. 2019). Lack of public awareness on the sustainable consumption and the importance of SW separation has contributed to the increasing quantities of households' wastes (Kamran et al. 2017). Consumers at the HH need to be educated on the problem of mixing food with non-food wastes as plastics and others, and on mixing SW in general as well (Jamal et al. 2019). Huge resources, big budgets and long-time work are required for enhancing sustainable SW management knowledge and awareness required to enhance inhabitants' participation in the separating their solid wastes (Yusof et al. 2019). Effective and

efficient collection services arranged by municipalities need to offer inhabitants convenient experiences that are regularly accessible and easy to use for actualizing habitual actions shifts (Jamal et al. 2019). Wastes separation systems needs engaging solutions that increases the level of participation by inhabitants (Jamal et al. 2019).

It is necessary to find out the motives and techniques required for enhancing SWS at the HHL (Jamal et al. 2019). The weakness of the valorisation instruments and the ineffectiveness of the incentivizing structures, gives signals to the municipalities and industries to shift toward incineration being an economically feasible technique compared to wastes separation and material recycling (Defeuilley & Lupton 1998).

3.1 Wastes Separation Political Directions

An EU directive of 1999 has recommended separation process of wastes at their generation point (Jamal et al. 2019). Despite of the implemented solutions for SWS so far, food waste separation is still a challenge in Europe (Jamal et al. 2019). European strategies states that it is necessary to find out tools and motives to enhance households' premises to increase inhabitants' involvement in SWS (Kamran et al. 2017).

There is a responsibility on building sector in finding sustainable building and social planning solutions in an economically feasible, ecological, and socially responsible frameworks (The Swedish Institute of Environmental Research 2022). Responsibilities' core is to attain development goal 11 to plan cities and human settlements that makes opportunities available to all, development goal 12 to ensure sustainable production and consumption patterns, and development goal 13 to strengthen resilience and adapt new capacities to reduce climate related hazards and disasters (The Swedish Institute of Environmental Research 2022).

In addition to the importance of reducing consumption and selecting the least packaged products or products packaged with environmentally friendly materials, separation of products packages wastes is of the mainly focused on issues in the European general strategy for waste reduction and minimization (Cichocka et al. 2020).

Municipalities are responsible for educating citizens on the importance of SWS and providing the required schemes to conduct the separation behaviours (Kamran et al. 2017). Although knowledge enhancement is necessary to actualize SWS behavioural shifts, the costs of public education is extremely high and the time needed to attain considerable developments is very long (Xua et al. 2016). Furthermore, studies have shown that enhancements in SWS behaviours were observed only in the few weeks after the study, after that it starts to fade away (Xua et al. 2016).

Despite of the advanced level of food wastes separations that has been reached in Spain and Sweden compared to other European countries, the primary actions in household's participation in waste separation at the source generation are still in need for many enhancements (Jamal et al. 2019). It is essential to create successful participation schemes that increases the engagement and participation in the SWS at the HHL (Jamal et al. 2019). This will not only reduce food wastes, plastics, and other materials sent to landfill and incineration plants; however, this will enhance material reuse and recycling figures (Jamal et al. 2019).

3.1.1 Circular Economy Strategies

European commission is working on moving from linear to circular production and consumption (The Swedish Institute of Environmental Research 2022). In Sweden 2030 vision, a minimum 65% of municipal wastes should be recycled and less than 10% to be landfilled (Kamran et al. 2017). A successful transformation of the existing waste separation systems and schemes is required to minimize costs impeded in recycling and reusing operations (Kamran et al. 2017). Sweden is concerned for increasing materials recycling targets in the coming years to compile with the Circular economic packaging agreed in the European Commission 2017 (Energiforsk 2019). According to Stockholm Resilience Center, Sweden has developed plans for increasing material recycling (Yee 2018). Wastes reduction and separation that facilitate materials recycling is extremely important and is currently under national and EU focus, to reduce plastics in the landfills (Energiforsk 2019). Systematic solutions and business leadership that are built on scientific basis should lead to an effectively and efficiently organized trash disposal systems (Yee 2018).

As per the Swedish Waste Management Association, less than 1% of household generated garbage is sent to the landfills (Energiforsk 2019). About 50% of the household wastes are incinerated in the power plants (Yee, 2018). Solid wastes generated at the HHL that undergoes material recycling in Sweden, does not exceed more than 4%, the majority goes into energy recovery (Energiforsk 2019).

Organic wastes in landfills produces methane, that is more potent than carbon dioxide by 72 times (Yee 2018). Even though trash burning reduces the emissions of methane from landfills, the burning process to the plastics and rubbers makes similar emissions like those of coal and natural gas (Yee 2018). Incineration by itself emits carbon dioxide and other toxins into the atmosphere (Energiforsk 2019). Tekniska verken in Linköping has estimated the cut down of 467,000 tons of carbon dioxide emissions in 2017 by burning trashes, this solution is reasonable but is a short-term solution as per the director of international strategy and media; Gaffney at Stockholm Resilience Center (Yee 2018).

There are many opponents against incineration, as it is dirty by itself and produces flue gases with heavy metals and toxins as per the Environmental Integrity Project in Washington (Yee 2018). This is in addition to the slags of burning the

different kinds of wastes, as per Avfall Sverige (Yee 2018). Moreover, Trash burning competes with discouraging wastes reduction and material recycling (Yee 2018). Wastes incineration is acceptable in the absence of modern waste collection systems (Yee 2018). The challenges and uncertainties the municipalities confront upon developing separate collection schemes make them divert from commitment to ambitious and large change developments of the existing separation schemes (Defeuilley & Lupton 1998). On the long run this may restrain municipalities willingness to encourage and promote valorisation, (Defeuilley & Lupton 1998).

3.2 Basics for Successful Schemes

More than 50% of world's population lives in the cities, until the year 2050 it was estimated that current city inhabitants' populations will grow by 70% (The Swedish Institute of Environmental Research 2022). Educating population on solid household wastes separation is costly and needs long time and lots of resources (Xua et al. 2016). Positive behavioural changes to educational campaigns, however, were observed only in the few weeks after the campaign directly, then it starts to decrease noticeably in the later weeks (Rousta 2018). Along with the increasing of packaging wastes generations at the HHL, this calls for self-educating and easy to understand and use wastes separation schemes at the household residential premises.

As per Arnberg, consultant in The Swedish Institute of Environmental Research; It does not matter how big the investments in these schemes and systems are, if end users do not know how to use them (Yee 2018). Studying and understanding recycling behaviours is very hard as the mentioned behaviours are complex phenomenon by itself (Rousta 2018). Behaviours need to be understood with respect to the existing wastes separation schemes contexts and social circumstances (Rousta 2018). Therefore, the required are multidisciplinary research with subjective complementary and supportive methods designed to focus on essential factors needed for developing the existing separation schemes and influencing separation and recycling behaviours (Rousta 2018).

Education, knowledge, economic incentives, and social norms are positively affecting consumers' household wastes separation behaviours (Bernstad 2014). The effect of informative and promotional mass communication campaigns on the waste separation behaviour at the HHL is still not clear and could not be identified properly (Bernstad 2014). However, the level of accessibility and efforts required to be paid by the consumers to participate in the separation process were recognized by many studies to be important enhancers (Bernstad 2014).

3.3 Food Packaging Wastes

Food packaging wastes are increasing globally due to the changing lifestyles and packaging industries (March 2007). Over 140 million tons are generated annually as municipal SW, of which 40% are products packages, (Cichocka et al. 2020). Food packaging represents 25% of the total wasted packages in the mentioned range, (Cichocka et al. 2020). This makes products packaging wastes to be one of the most increasingly growing risk on environment that causes direct and indirect destruction to the planet and to its resources (Kamran et al. 2017). The unsustainable effects get more serious if the valuable materials used in producing the wasted packages does not get reused, recovered, or recycled (Cichocka et al. 2020). The environmental effects of food packaging would have been less if the materials used in packaging gets reused or recycled (March 2007).

Food packaging is an important part of food products, food choices and purchasing processes (Cichocka et al. 2020). Food packaging has an important effect on reducing the food wastes as well as attracting customers and market food brands (March 2007). While consumers normally spend 20 minutes on average basis for buying their food, each food product takes 12 seconds to be chosen (Cichocka et al. 2020). The importance of food packaging designs and materials are getting more importance and attention (Wikström et al. 2019). Food packages was estimated to be representing 30% of the underlying purchasing drive to make a food choice (Cichocka et al. 2020). Accordingly, food packaging is getting more attention and higher budgeted investments (Bernstad 2014).

Food products are the most obvious products in market that need very special packaging criteria and techniques (Cichocka et al. 2020). Different plastics are widely used in food packaging (Cichocka et al. 2020). Plastic packages by itself are not harmful to the environment if it would have been disposed and separated in the right manner (Cichocka et al. 2020). Other materials as paper and metals are also used in food packaging are recommended to be reused and/or recycled (Wikström et al. 2019).

In a study conducted in Poland in 2015 on the importance of convenience to enhance waste separation, it was estimated that 64% of product wastes packaging was food packaging (Cichocka et al. 2020). Compared to 2009, the value of packaging market in Europe has increased by 40% in 2015 (Cichocka et al. 2020). More than 1300 respondents in Poland were surveyed on food packaging, disposing wasted packages and the determinants behind it, results showed that the mostly defined aim of the food packages is protectivity and durability (Cichocka et al. 2020). Environmental attributes of food packaging materials and the manner of disposing it came on later stage and of a less importance to the respondents (Cichocka et al. 2020).

Products packaging have an environment destroying consequences as they cause resources and energy depletion, toxic emissions and by products (Wikström et al. 2019) .Mixing different wastes causes entropy and creates disorders in the environmental systems (Cichocka et al. 2020). Mixed wastes are defined to be a reason for energy losses that has an economic value, (Kamran et al. 2018). To maintain the ecological balance, food packaging wastes needs to be carefully considered (March 2007).

3.4 Policy Review

As per the Swedish Waste Management Agency 2018, the total wastes generated in 2018 in Sweden were 139 million tonnes, of which 75% of the total wastes generated were mining wastes. The remaining generated SW came from the following main contributors, (The Swedish Waste Management Agency 2018):

Table1. Main wastes contributors in Sweden after mining sector.

Waste type	Amount In million tones
Construction industry wastes	12.4
Households' wastes	4.5
Service Industry	2.1

The total amount of SW got recycled in Sweden in 2018 were 6,8 million tonnes (The Swedish Waste Management Agency 2018). This represents only 25% of the total wastes generated in Sweden excluding mining wastes (The Swedish Waste Management Agency 2018). The total amounts got recycled to the same material through conventional recycling were 4.1 million tonnes (The Swedish Waste Management Agency 2018). The biggest portions where metal wastes (2,4 million tons), Paper wastes (1.1 million tons) and glass wastes (230 000 tons), (The Swedish Waste Management Agency 2018). There are no statistical data on what the fraction of the generated household SW got recycled, incinerated, or disposed (The Swedish Waste Management Agency 2018).

3.4.1 Current Separation Systems

In Sweden, systems available for household collection are bring/drop off stations where participants bring their SW to the residential property collection stations (Rousta et al. 2015). In the bring systems inhabitants bring their collected dried wastes for separation, these stations are located inside or outside the cities (Rousta et al. 2015). Other schemes that are close to the residential area; are bins for different waste materials (Rousta et al. 2015). Household wastes are those collected in the curb side collection schemes and drop off stations; are packaging materials, hazardous wastes, electronics, and bulky wastes (Kamran et al. 2016).

The mentioned facilities have an important role in helping municipalities in actualizing waste separation habitual and behavioural changes specially in the urban areas (Kamran et al. 2018). However, different studies have analysed the existing separation schemes in Sweden and recognized the importance of strategic developments that supports waste separation behaviour at the source of wastes generation at the HHL (Kamran et al. 2018).

Solid waste collection coverage in Sweden was estimated to be 100% (Stoeva & Alriksson 2017). In Sweden there is a legal obligation to separate household SW (Stoeva & Alriksson 2017). Separation schemes happens through curb sides collection and recycle bins for different packaging materials (Stoeva & Alriksson 2017). There are drop off stations for other bulky and hazardous materials wastes as batteries, tires, and electronics (Stoeva & Alriksson 2017). It is products producers' and materials producers' responsibility to collect and recycle product packaging wastes (Stoeva & Alriksson 2017).

In 1993, goods and packaging producers became legally responsible for collecting their products wastes because the "Polluter Pays Principle" (PPP) was introduced in Sweden at the mentioned year (Stoeva & Alriksson 2017). To carry this responsibility; goods and packaging producers have formed Packaging Recovery Organization to collect metals, plastics, glass, papers, and cardboards packaging wastes (Stoeva & Alriksson 2017). By its role, these organizations have established FTI (Förpacknings- och Tidnings Insamlingen) to carry out collection duties (Stoeva & Alriksson 2017).

Household separation schemes were introduced in Sweden in 1990 (Rousta et al. 2015). Since these systems has been implemented in Sweden until 2014, the material recycling has almost doubled increased and biological treatment was quadrupled, (Kamran et al. 2016).

SWSS in Sweden have extremely important role in making the overall national separation systems works properly, (Cichocka et al. 2020). Municipalities are responsible for collecting wastes and the citizens pays the municipality for doing this collection (Rousta et al. 2015). Fees paid by citizens for wastes collection covers the general wastes, but not the packaging wastes (Stoeva & Alriksson 2017).

3.4.2 Rules and Regulations

The Swedish environmental code entered in force in 1999 through consolidating 15 environmental acts as one act for the objective of promoting sustainable development (The Swedish Waste Management Agency 2018). The code defines the basic framework environmental protection implementation through providing procedures, control and supervision, compensations, sanctions, and evaluation of the environmental damages (The Swedish Waste Management Agency 2018). Waste management is one of these concerns under the code provisions, where the code applies on all operators and persons who commits activities that has an impact

on the code's objectives fulfilment (The Swedish Waste Management Agency 2018).

Code objectives gives guidance to actors but are legally non-binding; it provides guidance on the framework of the governmental policies for environmental protection at all levels in the society (The Swedish Waste Management Agency 2018). The agency has assigned the roles and responsibilities of the waste management different stakeholders in the country including, households, producers, and municipalities to enhance reuse, recycling, and materials management toward maintaining the natural cycles (The Swedish Waste Management Agency 2018).

Households are responsible for segregating their generated wastes and dispose them as per the existing collection systems and separation schemes regulated by municipalities (The Swedish Waste Management Agency 2018). SW defined by the code that needs to undergo in separation schemes includes Food wastes, packaging wastes of different materials, hazardous wastes as batteries, newsprints, pharmaceuticals, bulky wastes, garden wastes and tires (The Swedish Waste Management Agency 2018).

Once products reach their end-of-life cycle, it becomes producers' responsibility to collect their products and attain the recovery targets (The Swedish Waste Management Agency 2018). Municipalities are responsible for wastes collections, transportation, and treatment as well as to educate households on the existing separation schemes and encouraging them to deliver SWS (The Swedish Waste Management Agency 2018). This can be done directly by municipalities or by private contractors (The Swedish Waste Management Agency 2018). Politicians in the municipality local council sets the local waste regulations, municipal waste management plans and the local waste management fees (The Swedish Waste Management Agency 2018). Furthermore, the municipal office for environmental protection is responsible for inspecting and supervising local wastes issues (The Swedish Waste Management Agency 2018).

3.5 Waste Separation Behaviour

Inhabitants waste separation habits greatly influences their behavioural conduct toward different environmental and sources consumption issues (Kamran et al. 2018). Although people involvement is never easy, but their contribution toward successful SWSS is widely recognized to be extremely important (Kamran et al. 2018). Stakeholders as municipalities' professionals, properties' owners, waste managers and policy makers should work together to make the required interventions that enhances SWS habits at the source generation at the HHL (Kamran et al. 2018).

Many studies and research were conducted to understand waste separation behaviours in environmental, psychological, and sociological disciplines (Rousta 2018). Majority of these studies recognized the importance of; convenience, accessibility, and closeness of the separation infrastructure to inhabitants for encouraging the habitual changes regardless of socioeconomic and geographical factors (Rousta 2018).

Information communication channels that promote SWS and further communicates the ways to sort correctly are important (Rousta 2018). These communications should further give feedback on the results of sorting wastes to the inhabitants that are "waste sorters" (Rousta 2018). Waste separation infrastructures at the HHL should not only enable inhabitants to sort wastes, but rather be used as a tool for waste quantification, composition analysis, and source understanding (Rousta 2018). This helps in designing the required interventions toward reduction of waste generation at the source and enhancement of garbage dispensing behaviours (Rousta 2018).

There are different factors considered in the wastes separation behaviour that are internal, external, and sociodemographic (Rousta 2018). Internal factors are intentions, feel of responsibility and attitudes toward recycling and other environmental concerns (Rousta 2018). External factors are the tools available to dispose wastes, accessibility, closeness, available spaces at flats/apartments and educational and/or rewarding campaigns (Rousta 2018). Despite the different studies on the gender, income, and age relations to recycling behaviour, the relation between these socio-economic factors and waste separation behaviour at the HHL is still unclear and not yet established (Rousta et al. 2015).

Feeling good toward recycling creates intention factors to separate SW, this attitude may lead to behavioural actions if the separation tools were available, accessible, and easy to understand and use (Rousta 2018). This consequence is explained by Theory of Reasoned Action (Rousta 2018). In addition to attitudes, there are important determinants that has direct influence on the intention to separate wastes as subjective norms and perceived behavioural control that can be positive or negative (Zhang et al. 2022). The perceived lack of convenient separation schemes and/or satisfaction with the existing schemes predicts the intention to not separate SW for recycling skull (Stoeva & Alriksson 2017). This reduces the power of inhabitants perceived behavioural control toward SWS (Stoeva & Alriksson 2017). Moreover, the trust in the existing separation schemes has s significant positive effect on inhabitants perceived behavioural control toward waste separation behaviour (Stoeva & Alriksson 2017).

This shows that the efficiency of separation schemes and waste management systems in each municipality is an important determinant of the degree of citizen participation (Stoeva & Alriksson 2017). The difficulty in delivering waste separation actions may negatively affect the performed behaviour even in the

presence of positive attitudes and supporting subjective norms (Stoeva & Alriksson 2017). This explains the importance of facilitating SWS and recycling actions to actualize behavioural changes according to the Theory of Planned Behaviours (TPB) (Rousta 2018).

Many scholars have explored waste separation determinants using the Theory of Planned Behaviour framework (Zhang et al. 2022). Although the TPB became frequently used to predict individuals' behaviour, many scholars argues that the individual behaviour does not only rely on the intrinsic factors as intention, norms, and perceived behavioural control (Zhang et al. 2022). Many recent studies have given solid evidence that wastes separation behaviour at HHL is affected by a combined factors that are internal, external, and contextual factors (Zhang et al. 2022). The newly added factors as separation schemes infrastructures, economic incentives, supervision, and assistance, were evidenced to positively bridge the intention to separate with actual separation habitual and behavioural changes (Stoeva & Alriksson 2017).

These added factors have helped in getting deeper and more comprehensive understanding of the residents' waste separation behaviour at the HHL (Stoeva & Alriksson 2017). In the presence of the intention to separate households' SW, the actions to separate wastes will not proceed in the absence of the contextual and external enablers to translate the intention into actions and actualized behaviours (Zhang et al. 2022). To narrow the gap between intention to behaviour a set of external factors and contexts as convenient separation schemes, incentive methods and governmental policies should be in place (Zhang et al. 2022).

3.5.1 Behavioural Models

Different behavioural models have been developed after different European investigations and studies to explain recycling behaviours at HHL in different regions, situations, conditions, and social contexts as follows:

- 1- MOAB (Motivation and Opportunities to Actioned Behaviour) model: In 1995 (Ölander & Thøgersen 1995). Attitudes towards recycling is created through social norms, values, beliefs, understanding and evaluation of the end results and outcomes (Rousta 2018). These mentioned factors collectively form the Motivation to act (Rousta 2018). Getting motivated is essential to conduct habitual actions and accordingly, actualizes new behaviours (Rousta 2018). Opportunities and abilities of individuals to perform the actions are the meditators to convert the positive attitudes into actions and behaviours (Rousta 2018).
- 2- In environmental behaviour conceptual framework, developed by Barr (Rousta 2018) the environmental values, as well as psychological and situational variables plays a big role in individual's behavioural intentions (Rousta 2018). Psychological variables work as motivators or barriers while the situational variables are the enablers or disablers of the intentional

behaviour (Rousta 2018). The psychological variables such as social norms and different intrinsic factors as enjoying participating in the waste separation to receive a reward or a targeted income (Rousta 2018). Enablers and disablers affect the cognitive learning, metacognitive learning and affective learning of the different learners and participants (Lagwankar et al. 2013).

3- Tucker has developed the **Model of recycling participation**; in which social norms and attitudes are antecedents to the intension to recycle, however, how the intention influences the behaviour depends on the system and personal difficulties (Rousta 2018).

There are different factors promoting recycling behaviour and it is very complex and hard to construct all these factors in one model (Kamran et al. 2018). The three mentioned models cross at the point that inadequate systems prevent recycling behaviour even if the intention exists. Developing successful recycling schemes needs deep and comprehensive understanding of the different factors affecting recycling behaviour using the right methods in each context. It is important to consider the differences between contexts in terms of social, situational, and environmental performance factors.

Despite of the different quantitative and qualitative methods used to measure the different interventions amended in the existing recycling schemes, none of them has introduced or have aimed to introduce a common evaluation tool for the existing waste sorting schemes (Rousta 2018). Furthermore, the different studies that have used waste composition analysis, direct observations, self-reported and attitude-behaviour surveys approaches separately or in a combined manner, has not defined the interventions required in the existing recycling schemes (Kamran et al. 2018). These interventions are required to enable wasted material separation at the HHL, recovery, and further quantitative and qualitative measurements (Rousta 2018).

3.5.2 Behavioural Factors

Environmental performance improvements involve lots of complexities due to different underling linkages and mechanisms that needs deep and comprehensive understanding (Young et al. 2013). Existing separation schemes interventions should not ignore integrating consumer behaviour models as MOAB and Theory of Planned Behaviour to bridge the gap between intentions and actions to influence waste separation behaviours (Kalyanasundaram et al. 2021). It is also necessary to consider the different behavioural factors at the three different levels of; individual, group, organizational and community factors, that affects the individual, group, and community behaviours (Young et al. 2013).

Individual factors: As per Young et al. (2013), these factors that are important to be considered in the separation schemes for creating the trust of individuals in these schemes and get them motivated to participate. Further consideration of simplicity, convenience, practicality is important for individuals to perform day to day routine actions (Rousta 2018). Examples of these factors are:

- *Psychological and cognitive factors*
- Beliefs and Environmental Attitudes
- Environmental Awareness
- Individual-Level Feedback
- Changing Behaviour
- Individual-Level Financial Incentives

Group factors; influence day-to-day individuals' behaviour within a group (Young et al. 2013), as:

- *Team Level feedback*: giving feedback on consumption influences consumers and lead and/or encourage them toward resources conservation behavioural patterns (Young et al. 2013). Information and feedback need to be communicated on continual basis as the habitual and behavioural change start fading out after the communication campaigns ends (Young et al. 2013). Moreover, communication should be done in a simplified language to establish the link between consumption behaviour and environmental wellbeing (Young et al. 2013).
- *Financial incentive:* Establishing separation schemes that financially incentivize the separators helps increasing the participation of the end users in the mentioned schemes (Young et al. 2013). In the annual report of the Pantamera in Sweden; a subsidiary company for Returpack, it was mentioned that the most important step for enhancing the material recycling end results delivered by the company group is to get people participate more in the Pantamera system (Returpack Svenska AB 2020). This system has been established in Sweden to collect the bottles made of metals and plastics (Returpack Svenska AB 2020). However, they came to know from their ongoing research that it is never enough to remind people to collect their bottles and dispense them in the machines, there are lots of other important participation drivers as paying back for their efforts in taking the hassle upon collecting and sorting their SW (Returpack Svenska AB 2020).

Organizational factors: work on an organizational scale or group of people in an organized group, examples of these factors are (Young et al. 2013):

6. *Environmental Infrastructure:* Accessibility of schemes or equipment and tools that are physically laid out in a convenient manner; support the environmental practices, habitual development, and consequently behavioural change (Young et al. 2013). Conscious behavioural planning that is induced and introduced to the end users through proper facilities have helped observably in improving recycling habits in terms of SWS by the end users on a consistent and manner (Young et al. 2013).

- 7. *Management Support:* Through amending green leadership concepts and visions (Young et al. 2013).
- 8. Organizational Culture: Due to the intangibility of the organizational culture, it is hard to define the relationship between this culture and the sustainability behaviours of those involved in or within the organization (Young et al. 2013). However, the organizational culture may have a great influence on the way people perceives norms and accepting it from social perspective (Young et al. 2013). Frequency, quality and means of environmental communications in the organization may develop the environmental culture across people and enhance visibility of the available environmental infrastructures that creates potential motivation toward sustainability (Young et al. 2013).

3.6 Economic Attributes

More than 60% of households' packaging wastes are food packaging wastes, these wastes can be recycled (Avfall Sverige 2021). Source waste separation at the HHL in the Swedish waste management system has a national economic perspective (Rousta 2018). The Action Research analysis study conducted in Borås University to evaluate the sorting behaviour in Pilot area in Borås municipality showed that the miss-sorted fractions of the combustible wastes and food wastes were 70% and 30% respectively (Rousta 2018). The average total miss-sorting in the mentioned study was 30% (Rousta 2018).

Incorrect SWS at the HHL done by inhabitants bears a significant different type of costs to the society as wastes treatment operational costs, economic costs, and community costs (Ekström & Kamran 2013). In the mentioned study, combustible SW miss-sorting costs the community 13 million SEK for the study size of 105,000 inhabitants (Rousta 2018), 28% of the mentioned cost gets paid to the collection companies (Rousta 2018). Although there is an obligation on the producers toward product packaging recycling based on (SFS1994a; SFS1994b), producers simply cannot collect and recycle packages when it becomes mis-sorted (Rousta 2018). Household SWSB were estimated to reduce the community costs by 40% (Rousta 2018). The rate of household participation in the SWSS in Sweden was estimated to be 86% (Stoeva & Alriksson 2017). Personal moral norms were estimated to be an important engagement factor behind this participation (Stoeva & Alriksson 2017). However, 68% of non-food SW and 29% of food wastes were sorted improperly, this causes Swedish community additional costs of millions of Swedish kronor every year (Stoeva & Alriksson 2017).

Economic losses due to waste mis-sorting behaviour should be accordingly put under focus by politicians and policy makers (Rousta 2018). Households' hazardous wastes, as wastes from electrical equipment and batteries are only 0.5% of total households' contents, the same need special treatment in the different separation entities and separating the mentioned wastes saves Swedish municipalities a lot of money (Avfall Sverige 2021).

Products Life Cycle Assessments combined with economic evaluation shows that profits generated upon source separations of recyclables and biodegradables are more than profits defined upon gas collection in landfilling (Kamran et al. 2018). The economic incentives for companies will be even more feasible upon applying taxes on wastes disposing and even incinerating these disposed wastes (Kamran et al. 2018), or upon selling these collected wastes to materials producers at profitable prices (Defeuilley & Lupton 1998). Waste sorting task at the HHL in the long waste management supply chain is relatively low-cost task that has great economic value; however, it is very challenging to be endorsed (Rousta 2018). The social impact of endorsing this task is very important and should be highly considered (Kamran et al. 2018).

3.7 Municipal Wastes Management Mix

Municipalities consider different waste management technical combinations as energy recovery, material recycling, composting, and anaerobic digestion to minimize the valorisation costs (Asnoune et al. 2016). Through bidding process, the municipalities get the best price versus benefits offered by commercial operators in waste management work activities, which by its role look at the most profitable combinations (Defeuilley & Lupton 1998). Municipalities and companies subsidized will both look at the combination of the lowest costs (Defeuilley & Lupton 1998).

The weaker the instruments amended in place for recycling are, the more leading position incineration goes to in terms of energy recovery (Defeuilley & Lupton 1998). This bias is caused by institutional reasons (Defeuilley & Lupton 1998). Decentralized agents do not want to get committed to other valorisation techniques as packaging waste recycling because this solution is too expensive and risky compared to incineration adoptions (Defeuilley & Lupton 1998).

Despite all efforts done by municipalities to promote valorisation techniques, waste management mix still goes in the direction of incineration (Asnoune et al. 2016). Policy makers needs to work in an institutional framework and needs to establish wastes separation and recycling schemes and instruments that has economic basis to reduce the economic and operational costs, minimize investment risks and increase income through selling collected materials to materials producers (Defeuilley & Lupton 1998). Selling SW for good price will enhance municipalities to increase the share of the material recycling in the waste management mix (Asnoune et al. 2016).

3.8 Political Hesitation

National waste management and prevention strategies should be developed and implemented by the governments (Stoeva & Alriksson 2017). This means that rules and instruments used toward valorisation should be taken on national level to lead the local decision making on technological adoption on the municipalities levels, (Defeuilley & Lupton 1998), however, municipalities are solely responsible for budget control, spendings and fees design and collection (Rai et al. 2019), in other words; municipalities are responsible for their waste management and can take actions within their own budgets (Kamran 2018). National authorities do not specify the valorisation mixes, techniques, and targets (Defeuilley & Lupton1998).

Municipalities are responsible for facilitating waste collection and treatment only for their own wastes (Stoeva & Alriksson 2017). Local municipalities are the bodies responsible for delivering these general waste management orientations into technical directions and trajectories (Defeuilley & Lupton 1998). Fees allocated on the households with respect to the collection and separation schemes provided by the municipality needs to be designed based on the profitability of the different waste management mixes' components (Yukalang et al. 2017). Decisions taken by municipalities on valorisation techniques adoptions; for example the percentage of generated households SW to valorise and the techniques to be used are the keys toward achieving the national objectives (Defeuilley & Lupton 1998).

Municipalities consider different waste management technical combinations as energy recovery, material recycling, composting, and anaerobic digestion to minimize the valorisation (Asnoune et al. 2016). The wastes management technical combinations considered gets heavily affected of the municipalities' expertise, resources, capabilities, and budgets (Lindqvist 2013). Valorisation costs of the different waste management solutions have a great role on the municipalities strategic decisions for their own municipal waste management (Defeuilley & Lupton 1998).

To enhance economic feasibility of material recovery adoptions, material production industries need to offer a guaranteed return price on collected materials if the sorted wasted materials get accepted by materials producers as per the minimum technical prescriptions of materials density and purity (Asnoune et al. 2016). Guaranteed return prices and direct payments may have a considerable role in mitigating the risks and ambiguities imbedded in material recycling adoptions (Defeuilley & Lupton 1998).

Incineration is accused of emitting different atmospheric pollutants as hydrochloric acid, dioxins, and heavy metals (Yee 2018). Many local authorities becomes hesitant to get engaged in a national initiatives that promote incineration adoptions instead of promoting recycling and composting (Defeuilley & Lupton 1998). On the other side many politicians get reluctant to enforce SWS policies or ask for a premium on the waste management fees for election purposes (Yukalang et al.

2017). Oppositions and criticism to incinerations gets increasing on both the international and national levels, (Yee 2018), this places national authorities at odds with their environmentally and socially active citizens (Defeuilley & Lupton 1998). However, financial constraints, administrative difficulties, and public acceptance, creates a big conflict between the ability of the municipalities to play their role in the environmental national objectives and the municipalities challenges to change their citizens SWSB (Yukalang et al. 2017).

3.9 Public Acceptance

Public acceptability should become one of the basic criterions for evaluating existing and new policies to protect the environment (Anthony 2021). Convenience is an important measure in public acceptance to the SWSS (Rousta 2018). Citizens' support and participation are essential for the success of interventions that requires environmental collective action (Anthony 2021). Interventions meant to transitioning toward sustainable lifestyles requires understanding and assessing of populations' general willingness to contribute (Anthony 2021). Majority of households inhabitants shows favourable attitudes toward the more convenient door to door SW collection than curb side solutions (Safitri & Chambri 2015).

For the environmental policies to work as planned, it is necessary to consider the gain goals, personal hedonic goals, normative goals, and social goals (Anthony 2021). It is important to consider the gain goals for SW materials buyers and sellers, this is important to provide a value for the collected wastes for both parties (Asnoune et al. 2016). Monetary incentives used by some itinerants and door to door wastes collectors in the developing countries has enhanced inhabitants' participation in SWS (Safitri & Chambri 2015). It is recommended to provide the SW collectors with an incentive to pay off the efforts they made to collect and/or transport their wastes (Defeuilley & Lupton 1998). Itinerant SW collectors have contributed obviously to increase households' participation in SWS and collection via providing convenient door to door collection solution (Safitri & Chambri 2015). Individual gain goals in terms of sensitivity to status, money, and other personal resources needs to be used to perform actions in response to existing or new environmental policies, are important to consider (Anthony 2021).

Efforts done by citizens to contribute to existing sustainable environmental policies and schemes, as well as the appropriateness of the required actions in respect to their abilities to contribute to clean environment is very important examples of individuals normative goals (Anthony 2021). Identifying households' inhabitants' acceptance, support, and requirements to act toward the existing SWSS are important to avoid misjudgement, poor schemes and facilities design and performance (Safitri & Chambri 2015). Personal hedonic goals that provide households inhabitants the experience excitement, pleasure, and less efforts to

conduct an action and get motivated to do it repeatedly (Anthony 2021). Approaching consumers preferences in terms of SWSS features along with their willingness to pay money, efforts, and time are emerging necessities to make the separation schemes working their goals (Safitri & Chambri 2015). Nordic regions citizens especially in Sweden, showed willingness and positive association to support policies for environmental benefits (Anthony 2021). However, it is necessary to understand the limits of this willingness to respond to political interventions to solve transboundary problems for the long-time scale challenges as climate change (Anthony 2021).

Although Nordic regions citizens are willing to pay for keeping the environment clean, for sustainability innovations to be durable as well as attractive to citizens at both local and global level, it should not ask citizens to go beyond their economic abilities (Anthony 2021). Despite of the government's commitment to increase the quality of SWS and their serious efforts to facilitate the same at the public level, further studies should be conducted to identify and understand households' responses to the existing schemes (Safitri & Chambri 2015). Respecting citizens economic sensitivities is important to consider upon formulating any political interventions for environmental protection (Anthony 2021).

Citizens are unevenly concerned with environmental problems and varies much in their preferences, willingness to change their behaviour and pay efforts and money for environmental protections (Anthony 2021). Accordingly, instruments used ask inhabitants for supportive participation to reduce the environmental destruction should be carefully (Safitri & Chambri 2015). Environmental policy choice architectures to drive behavioural change needs to consider other nonpecuniary policy interventions (Anthony 2021). Identifying the way households' inhabitants perceive adoption of new interventions and developments to the existing SWSS at the HHL needs to be carried out before conducting them (Safitri & Chambri,\ 2015). For these policies to work successfully it should be engaging to citizens and should not ask for much economic and lifestyle sacrifices and changes.

4. Literature Review

Citizen's participation in the waste sorting schemes is essential for the SWSS to work successfully (Ekström & Kamran 2013). Creating engaging schemes for SWS at the HHL may lead to "normalization" of SWSB (Bernstad 2014). This means that all are involved and questioned to perform a specific behaviour and not only the environmentally aware users (Bernstad 2014). Creating and enforcing behavioural conduct with convenience, accessibility and availability focus is essential for actualizing a change in the habitual behaviour (Bernstad 2014). This may get accompanied with intentional or non-intentional acts for SWS at the households (Bernstad 2014).

A study for assessing separate collection schemes had been conducted in 28 capitals in the European Union in 2015 (European Commission 2015). In this study interviews were conducted with stakeholders and experts on governmental levels, as waste management operators (European Commission 2015). Capital administration, and different associations as public statistics, reports and websites were also considered in the study (European Commission 2015). In the "Capital Fact Sheet" for Stockholm generated by this study stated that for the different collection system implemented in the capital, one common barrier was defined, that is the participation registered in the "voluntary system" (European Commission 2015). Even though citizens and inhabitants showed positive attitude toward SWS, and good understanding of the benefits behinds it, they did not know how to participate (European Commission 2015).

In the Action Research Study conducted by Borås University on understanding why inhabitants does not participate in the existing sorting schemes in the Pilot area in Borås, inhabitants' behaviours were observed and questioned directly through semi structured and structured interviews (Rousta 2018). There were different factors affected the behaviours of the surveyed inhabitants who cares about sorting but do not do it, as follows (Rousta 2018):

- 1- Do not know how to sort SW.
- 2- Distance between residence and sorting station, that was 2 km. Majority of the inhabitants do not have cars.
- 3- Lack of clear and available communication tools to distribute the right information on how to sort.
- 4- Inconvenience and poor personal situations.

5- Weak "first impression" on the existing sorting schemes and recycling systems.

Many studies have been conducted so far on the recycling and participation behaviours both locally and internationally. Majority of these studies has focused on understanding the behavioural interaction of schemes' users with the existing separation schemes and/or to interventions in each social context. For example, conducting the behavioural observations, inhabitants' questionnaires and disposed garbage measurement and composition analysis were done in residential area approved by the municipalities, there studies have been conducted.

The areas to be chosen should exercise specific socio demographic, population size, residence structure and socio-economic criteria. For the study to gain credibility, the municipality where the study will be conducted should approve these mentioned criteria. Different major drivers, barriers, enablers, and disablers; have been investigated in these studies using different consumer behaviour al theories and behavioural models' frameworks. We mention here the most common of these factors; most of the studies has agreed on.

Existing separation schemes and infrastructures should be investigated for potential improvements to make these schemes gets more convenient and friendly to use (Ekström & Kamran 2013). In the study conducted by Borås University in the pilot area in the city of Borås; two interventions have been introduced to the existing waste sorting system (Rousta 2018). These two interventions are by making sorting station becomes closer to the residence area and through spreading guiding information to the inhabitants on how to do sorting at the right manner (Rousta 2018).

It was found in the study that getting sorting stations closer to inhabitants' residents had shown much more significant effect on the waste sorting actions compared to spreading information to the inhabitants on the importance of waste separations behaviour (Rousta 2018). This draws the attention to the necessity of convenience elements in the sorting systems, to enhance SWSB (Rousta 2018).

In this work 10 studies have been considered of which seven studies were conducted in Sweden, 2 in Europe and one in China. These studies have investigated the drivers, barriers, enablers, and disablers in different contexts. Although the variety among the contexts in which the studies has investigated the SWS, interventions required for enhancing behavioural change were very similar. Studies has crossed in the most important areas of development that enhances the engagement of the participants in the existing SWSS. However, in the following section on areas of development, findings related to Sweden will be presented.

4.1 Developments Areas

4.1.1 Continuous and Informative Communication

It is costly and time consuming to educate thousands and millions of inhabitants on the importance of SWS, especially in the absence of the intention to do so (Bernstad 2014). However, it is an important step toward enhancing SWS participation (Rousta 2015). For Educational communications to give effect, it should be consistent and continuous (Jamal et al. 2019).

In a study conducted in Ireland by visiting 1362 households located in different regions in the country, 29% of the households were visited, while the remaining were given learning materials on the importance of food waste separation (Jamal et al. 2019). It was observed that 50% increase in household participation happens in the first 6 weeks after the conducted interviews and campaign, then participation started to decrease afterward (Jamal et al. 2019).

Typical questions received from the household on what to throw in the used bins, and what not to throw, storage spaces for wastes before segregating them, and hygienic treatment of the bins, gives very important guidance and tips for the required interventions (Jamal et al. 2019). Both convenient waste separation schemes and accessibility to "how to sort" information through proper communication channels are the key elements toward improved sorting habits that lead by its role to behavioural changes (Rousta 2018).

4.1.2 Accessibility and Availability

Regardless of the environmental awareness, participation rates increase with the higher accessibility (Bernstad 2014). Empirical studies shows that low levels of separation performance are not related to negative attitudes or low awareness, but to absence of structural constraints, convenient and accessible schemes (Bernstad 2014). The more often the household has access on the waste collection devices, the more will be the participation of inhabitants in segregating their SW (Jamal et al. 2019).

4.1.3 Space and Collection Equipment

Curb side collection availability and adequate space for storing wastes before disposing them has shown in several studies to be an encouraging factor toward solid wastes separation at the HHL (Bernstad 2014). Simultaneously the absence of temporary storage spaces for recyclable materials in flats and apartments has reduced inhabitants' tendencies to segregate their SW compared to villas, detached and semi-detached residential units (Bernstad 2014).

In the study conducted on food waste separation behaviour in a residential area in Malmö including 1632 households with 2800 inhabitants (Bernstad 2014), the effect of knowledge awareness campaign and installation of equipment for sorting food wastes in kitchens were examined for the effect on the tendency of food waste separation behaviour among inhabitants in the selected residential area (Bernstad 2014). Establishing separation equipment at the kitchen level has encouraged inhabitants to conduct responsible attitudes toward waste separation within the residential area examined in the study more than informational distribution conducted in the same study (Bernstad 2014).

Upon measuring food wastes after the informational campaign, no significant increases in the amount of food wastes collected separately or in the ratio of source separation has been lasted for long time, (Ekström & Kamran 2013), however getting the sorting systems and facilities closer to the inhabitants showed an enhanced wastes separation behaviour (Rousta 2018). Behavioural enforcement becomes necessary in communities where the SWS is not part of priorities or prevailing norms (Jamal et al. 2019). Food waste collection equipment has led to long-lasting habitual change that may lead to actualize a behavioural development (Bernstad 2014). The results of the study have recognized the necessity of establishing convenient and accessible solutions at the HHL for enhancing SWSB.

4.1.4 Convenience

Convenience is the most effective sorting scheme's success factor (Rousta 2018). Majority of the citizens are not willing to pay extra efforts toward sustainable waste separation, and do not really understand their significant role in making any collection scheme and waste management system works properly (Hawlitschek 2020). Most of the time, inhabitants choose the comfortable and easy ways to dispose their daily generated SW (Hawlitschek 2020).

Waste separation behaviour is very complex, furthermore, the different studies results are applied only within the context of the study and cannot simply be applied on other contexts (Kamran et al. 2018). However, most studies cross at the point of the importance of convenient infrastructures in enhancing wastes separation habitual shift at the HHL (Kamran et al. 2018).

Physical infrastructure and convenient tools for waste separation at the HHL has been inadequately and poorly considered in academic literature, and no studies have been conducted focusing on the food waste separation and collection at the mentioned level (Bernstad 2014). The absence of SWS infrastructure and tools in the residential areas contributes obviously to that inhabitant shows reluctant behaviour toward SWSS at the HHL (Bernstad 2014).

Space for storage, accessibility to curb side collection schemes, and the distance to the sorting stations/facilities are also important success factors, as it makes sorting easier (Rousta et al. 2015). In a questionnaire for a wide study on participants sorting behaviour in Sweden, results shows that the recycling rate was increased by 66% upon applying doorstep collection instead of dropping off stations (Rousta et al. 2015). Well-functioning solutions and systems that provide convenience in performing wastes separation at the household should be in place (Bernstad 2014).

This is important to enable and sustain a habitual change required for environmentally responsible behavioural shifts in terms of SWS at the households (Bernstad 2014). This is by it is role is essential for enhancing material recycling and reusing both locally and globally, as part of the accumulative social responsibilities toward resilient local, national, and global communities (Bernstad 2014).

Majority of the participating households said that to encourage food waste separation, convenient and appropriate waste collection practices that can be used on regular basis are required (Jamal et al. 2019). When it comes to SWSB encouragement at the HHL, convenience is important (Bernstad 2014). Upon conducting interventions to enhance recycling behaviour in the Pilot area in Borås, it was found that getting the recycling station closer to the residential area from being 2 km to be 50 m instead has reduced the mis sorting of households wastes by 30%, which considered to be a significant change (Rousta et al. 2015). The shorter the distance is to the sorting station, the more motivated the inhabitants become toward their SWS (Rousta et al. 2015).

4.1.5 Simple & Clear Schemes

In the annual report issued by Returpack Svenska AB in 2020, the simplicity and easy to use elements have always been in the core of metal and plastics bottles collection schemes developed by the company (Returpack Svenska AB 2020). Simplicity in using the schemes is essential for getting participation in the separation schemes level increases; an element that cannot be ignored in the direction of increasing material recycling in Sweden (Returpack Svenska AB 2020).

Near, accessible, and easy to understand and use SWSS, that makes it easier for household inhabitants to sort their SW correctly, are essential for developing habitual shifts toward wastes separation (Rousta et al. 2015). The shorter distance intervention study conducted in Borås University was combined with using stickers on the recycling bins to enhance inhabitants' knowledge on how to use the recycling facilities (Rousta et al. 2015), this led to reduction of material waste mis sorting by 70% (Rousta et al. 2015).

4.2 Modernity of Existing Schemes

Benjamin Scheffler, the managing director of Frankfurter Entsorgungs- und Service GmbH (FES) stated that waste management industry is not innovative, is not ready to examine on the large-scale processes thoroughly and further very conservative toward significant changes (Hawlitschek 2020). He sees a potential in automated sorting and separation schemes (Hawlitschek 2020). Scheffler considers the work within digitalization of the existing separation schemes is a great investment opportunity (Hawlitschek 2020). He saw a great potential in the digitalization role in building successful and strong customers relations in both private and public sectors (Hawlitschek 2020).

Different digital detection systems as radiofrequency Identification devices and different electrical based identification solutions are used for waste separation after collection stage in the material flow (Daud & Razali 2016). However, there are no digital based waste separation schemes are applied so far at the HHL (Daud & Razali 2016).

Digitalization is highly required and may lead by its role to disrupting the existing waste management industry (Hawlitschek 2020). Smart waste management systems were determined to be efficient and effective in executing the separation of the dry wastes at HHL into metallic, dry, and wet wastes (Sasikanth et al. 2021). Existing household collection schemes to be inflexible and insufficient despite of their productivity, compared to the situation if they were not existing (Hawlitschek, 2020). Social sustainability measures are important to be considered and built in the residential areas for the benefits of the community and society in the shape of sustainable renovations that has socio economic values and responsibilities (Mjörnell et al. 2019).

A proposed system to segregate wastes disposed by households at the generation source, was recommended to reduce the costs of separation at later times of SW treatment (Sasikanth et al. 2021). System modelling was done by the Department of electronics and electrical engineering at Amrita schools of Engineering in Bengaluru in India (Sasikanth et al. 2021). Household wastes gets disposed by users without prior separation, SW to be separated in the step after in the modelled system (Sasikanth et al. 2021). Disposed wastes gets circulated on a conveyor belt that passes through wastes material detection system used to segregate hard wastes into metallic, dry, and wet wastes at the first stage of the system (Sasikanth et al. 2021). At the second stage, the dry wastes get segregated into glass, paper, and plastics (Sasikanth et al. 2021). Detection of objects is done on a Tensor Flow Platform using SSD and RCNN algorithms (Sasikanth et al. 2021). Data exported from the systems are used for further development as well as communicating the volume and the composition of the wastes disposed to the end users, that are households in this case (Sasikanth et al. 2021).

5. Empirical Data

5.1 Inputs from Interviews with research professionals

Kamran¹ sees that, despite the advanced level of wastes separation schemes in Sweden compared to other countries, and the higher sense of environmental responsibility among citizens, mis sorting household garbage is still happening and causing the government to pay high costs for that every year.

Kamran¹ were approached to define these costs he mentioned in his research. He gave the feedback that, about the induced economic losses due to mis storing, these economic losses are invisible costs. He referred to these costs as part of the entire waste management chain.

Although, these costs are not detectable directly, or cannot be defined as direct costs, Kamran¹ clarified that these costs would have been saved from the total operational costs involved in the waste treatment operation's chain, if participants had sorted their household SW properly.

Upon asking Kamran Rousta¹ on the application of his study results in developing the existing waste separation schemes in the Pilot area in the city of Borås, where the study had been delivered, or in other residential areas in Borås city, he said that a few similar interventions have been introduced to the existing separation schemes.

In the discussion Kamran Rousta¹ has pointed out the conservativeness of the Swedish municipalities on developing and innovating the existing waste separation schemes and waste management systems in the whole country.

¹Kamran Rousta, professor, The University of Borås, Interview 2022-02-23

Ronny Arnberg² has mentioned the stages of development for wastes separation strategic act in Sweden since the last twenty years. He pointed out that the separation schemes have developed in terms of spreading, especially near to the food outlets. However, he sees a potential in using the garbage chute schemes in the residential towers to initiate and sustain habitual changes toward SWS. Inhabitants has an important role and needs to get engaged in SWSS and other sustainable practices. Arnberg² agreed on the important social factor in offering inhabitants convenient waste separation schemes that makes a difference in the extent and quality of participation in SWS at the HHL. Using the garbage chute systems to offer the same for the inhabitants in the residential towers is a good idea and worth's to be considered for further investigation, evaluations, and application.

5.2 Qualitative Results

The interview has shown that the family are partly sorting their SW regularly based on the want of the father to adhere to the garbage disposing instructions in the building that says only food wastes are allowed to be disposed in the garbage chute, however, the following important findings were identified in the interview as follows:

- 1- Unintended mis-sorting of the disciplined inhabitants due to shortage of educational communications and support with the required tools to deliver soldi wastes separation at the right manner. There are no paper bags given by the building for collecting food wastes, the family collects the food wastes in plastic bags and throw it in the garbage chute.
- 2- Obvious SW mis-sorting in the building despite procedures formulation due to lack of informative communications. Although garbage chute is allowed only for food wastes, the family has collected the food wastes in plastic bags with tissues, and other small pieces of plastic packaging or plastic bags, because it is hard to collect them and take them to the sorting station.
- 3- Dissatisfaction with the existing SWSS due to different inconvenience determinants identified in the qualitative analysis, that are very similar to findings in the systematic analysis. Metallic, plastic and glass bottles, and paper packaging gets sorted in the nearest sorting station. The nearest wastes sorting station is about one km far. Car is needed to pack and transport the collected wastes. Sometimes due to the very small storage place under the sink, they store some garbage in the car until finding the time to go for sorting.

²Ronny Arnberg, Key Account Manager/Project manager, The Swedish Institute of Environmental Sciences. Interview 2022-04-24

4- Uneven engagements level among inhabitants. Those who does not have the environmental awareness, or the disciplinary behavior needs convenient SWS experience to participate in sorting wastes. Their neighbors do not waste, there is no control on that. They do not have car; it is very inconvenient and hard for them to carry the SW to the sorting station.

Even though the environmental awareness and disciplinary behavior is higher in Sweden compared to other countries, the participation schemes do not help participants to understand how to sort their SW in the right manner. SWS was extremely challenging and inconvenient to the family members due to the following pointed out determinants:

- Does not have enough space.
- Packing wastes and carrying them to the car.
- Taking wastes to sorting station after work needs energy and sacrifices.
- Cost of transport, and now it is getting even higher.
- Time issues.
- Other transport issues: the working wife is the only family member who has driving license, it makes things even harder. In Sweden it is very expensive to go for car driving school.
- Despite the education in schools on the behavioural needs for different sustainable needs, the inconvenient old fashion systems are not engaging to younger generations who get inspired of the artificial intelligence. Girls do not participate or help with sorting at all, for them it is hard, frustrating, and not interesting at all.

Upon sharing the concept of using the garbage chute for sorting the SW, family members regardless of their age gets very engaged with it for the following reasons:

- More convenient, especially in winter times.
- Transport takes time and costs money for the petrol.
- Space
- Responsibility will be shared among family members; everyone can participate even kids above 10 years old.
- Helps kids gets educated on the sorting, gets engaged and start participating in SWS.
- Getting information and feedback will help in increasing the sorting, but convenience is the most important.

5.3 Qualitative Results

Results helped in exploring the role of the garbage chute systems in initiating and sustaining SWS habitual actions among respondents. The new experience expected to provide convenient waste separation in terms of accessibility, transport, space, frequency, and easy to understand and to use SWSS. This intervention most importantly; does not ask inhabitants in the residential towers for any economic sacrifices or much lifestyle and behavioral changes. Total responses were 104, however, duplicate responses were deleted from the data. The total responses considered were 92.

Characteristics	Distribution in sample		
Gender	Male: 35 (38%). Female: 57 (62%)		
Sorting behaviours	Do not sort: 52 (58%). Once a week: 35 (35.3%). Once in a		
	month: 2 (2 %), Once every three months: 2 (2%)		
Space to store wastes	Have space: 62 (67%). Do not have space: 30 (33%)		
Wastes separation	Do not sort wastes: 48 (52%), In the building: 30 (33%). Nearest		
scheme used by	sorting stations: 14 (15%)		
respondents			

Table 1. Sample Properties for quantitative analysis

In the questionnaire, the intervention of using the garbage chute system for SWS at the residential towers was introduced to respondents to get their feedback in terms of convenient SWS experience and proper informative communications approach.

The responses showed that; using garbage chute to sort wastes has will help increasing inhabitants' participation in SWS. The pie chart of the collected responses majority agrees on the fact that using garbage chute systems is a reason for the respondents to start participating or increase their participation in SWS.



Figure 1. Respondents feedback on their Waste separation actions upon using garbage chute systems for solid wastes separation.

Respondents were asked on the benefits of adding an informative communication element to the garbage chute in each floor, if that would help them understand how to sort their SW. The element was an informative poster used in the questionnaire as an example to help respondents understand the question properly. Responses showed that communicating to respondents properly on how to sort their wastes will help more than 92% of the respondents upon sorting their SW.



Figure 2. Respondents feedback on their Waste separation actions upon communicating on how to sort as informative posters.

Suggesting using the garbage chute system showed enhancement to the respondents' intention to initiate or increase participation to sort their SW, due to different behavioral drivers listed to choose from in the questionnaire, as convenience, space, and information on sorting upon sorting wastes. Summary looks as follows:





To understand the relationship between making the built-in garbage chute systems available for SWS at the HHL and the separation behavior at the residential towers. regression analysis was used. Regression analyses were conducted to the 92 responses to see if there is a significant difference in the SWSB among those who does not sort wastes at all, and those who does weekly upon using the garbage chute systems to sort their SW.

The following summary output shows that there is a significant difference between participation in SWS among these two groups upon making garbage chute system available for SWS. The coefficients shows that there is positive relationship between using garbage chute systems for SWS and respondents' participation in the SWS

P value was found to be <0.00. This shows that there is a significant difference between current sorting behavior and intended behavior upon using the garbage chute system for sorting SW among the respondents targeted in the quantitative analysis.

6. Results and Analysis

6.1 Stakeholders' roles and responsibilities

Although municipalities are solely responsible for waste management's strategies, actions and developments, there are other actors that has extremely important role in wastes separation but still not well identified or/and involved properly. After the theoretical overview conducted in this work, more stakeholders became identified. There are important links to understand, evaluate and approach between these stakeholders and between their roles and responsibilities. Below are the main findings:

- 1- Inhabitants has the central role in the success of the established wastes separation schemes, no matter how big investments are in these schemes, if it really does not offer easy to follow and practice daily experience of SWS at the HHL, especially at the concentrated residential areas. Inhabitants' participation has very low costs, but great economic advantages. It offers segregated materials of high quality that can be sold for materials producers at guaranteed prices at later stages of the long waste management chain.
- 2- Despite the environmental framework set by the government to all industries on governmental, federal, and private levels, the exact definition of roles and responsibilities in details is still missing.
- 3- Municipalities are relying on different contractors to conduct the annually approved strategic plan for waste management mix, due to missing the required expertise and resources. Municipalities accordingly decide and plan their annual waste management mix according to the existing expertise, not as per the required sustainable changes to reach the national goals. Since selling energy is more secure for contractors to gain an economic advantage compared to sell garbage as raw materials, contractors exercise power in indirectly driving municipalities decision engine toward energy recovery than to material recovery as the first market is more well established and attractive compared to material recovery.
- 4- According to the environmental framework assigned by the government, building professionals and decision makers are concerned with delivering sustainable properties and building methods. However, these frameworks do not specify and give important details on the strategic plans, directions, and priorities for the actions to be taken.

Materials producers are currently not part of the scene at all, although they may play the second largest role after the inhabitants' participation. Materials producers has an important role in defining the main determinants of the economic advantage upon investing in developing wastes separations schemes. Offering a guaranteed prices for a pre-approved segregated materials quality and quantity that pays back for the investments required to develop the existing wastes separation schemes, is an important driver to change municipalities' waste management mixes.



Figure 4. Households' solid wastes collection systems.

Established relationships

Non established relationships

6.2 Development of Existing Schemes

Academic studies showed that inhabitants are still resistant to change their habitual actions toward SWS in the existing separation schemes contexts, and consequently change their behaviours (Rousta et al. 2015). There is dissatisfaction with the existing separation schemes, that can be well addressed if the inhabitants would have been given the chance to declare it. Quantitative and qualitative analysis conducted in this work has shown similar results to what has been found

in other research and studies on households' solid wastes participation. There are many factors that hinder inhabitants habitual change toward waste separation such as follows:

- 1. Limited space to store recyclable materials at apartments and houses is a challenge to participation in SWS.
- 2. The limitation in SW storage space increases the need for frequency of wastes sorting, and accordingly increases the sense of inconvenience with the existing wastes separation schemes.
- 3. Participants may not always be able to participate in the waste separation due to time limitations.
- 4. Extra costs to perform waste separation as transportation costs and collection bags.
- 5. Distance for transporting the SW for separation, traffic congestions and parking issues.
- 6. Lack of effective communication channels in the existing SWSS.
- 7. Inhabitants eventual low level of trust in the old fashion existing separation schemes demotivate them to use these schemes and pay efforts for separating wastes in the time of technology advancements.
- 8. The existing schemes does not stress on the roles and responsibilities of residents to make the SWSS works successfully.
- 9. Old fashion separation systems that are way far from artificial intelligence.

The most important features required for the SWSS to engage inhabitants in starting to participate, or to increase their level of participation were:

- 1. Convenient.
- 2. Does not need space to store wastes.
- 3. Offers higher frequency for sorting.
- 4. Self-explanatory.
- 5. Informative and continuous communication on how to sort.
- 6. Gain trust of inhabitants.
- 7. Giving feedback.
- 8. Cost effective.
- 9. Does not need huge investments.
- 10. Does not to need to change behaviors.
- 11. Does not ask inhabitants for economic sacrifices.
- 12. Provide high quality of separated materials.
- 13. Provide opportunity to gain higher material prices upon selling collected SW.
- 14. Provide measurement tool.
- 15. Add control functions, codes.

7. Discussion

Developing successful SWSS requires deep and comprehensive understanding of the existing collection and separation systems, rules and regulations and consumer's needs, expectations, and behaviors. These schemes should first engage inhabitants through offering a convenient separation experience. This is necessary to increase inhabitants' participation in separating their SW. Successful separation schemes should not require big behavioral changes and should not ask inhabitants to go beyond their abilities and willingness to sacrifice their money, time, and energy to take responsibilities toward the environmental wellbeing.

Furthermore, these schemes should do not require big investment budgets and should offer sustainable economic advantages to all stakeholders involved in the waste management chain, and more importantly have a social sustainability element in educating users sustainable waste reduction and management patterns and practices.

7.1 Participation Behavioural Factors

Convenience is the most important external factor in initiating and sustaining waste separation behavior at the HHL. Factors linked to convenience upon disposing garbage are many and interrelated. The different socio economic and demographic structure of the residents in these towers play an important role in defining "Convenience" when it comes to daily or weekly use of garbage disposal and separation schemes. Space required to store wastes, time and efforts needed to package wastes, transport to sorting stations are disablers that should be evaluated for better alternatives.

These disablers will make residents perceive inability to conduct sorting actions if they do not have the means to, and accordingly develop an internal barrier to sorting actions. Working for long hours on daily basis increases the sense of inability and loss of perceived of behavioral control. Many residents do not own cars and uses collective transport to save money, though transporting SW to sorting station will be extremely inconvenient and disabling.

Space for storing wastes is connected to the frequency of sorting wastes needed. The smaller is the space for storing wastes, the higher is the frequency required for conducting wastes separation. If this was accompanied with hard and inconvenient schemes to separate wastes that requires energy, time, and transport, inhabitants will more likely feel that they do not own the control over their attitudes toward wastes separation even if it exists on a positive manner. Consequently, there will be a gap between intentions, attitudes, and waste sorting actions conducted by inhabitants.

Waste separation behavior drivers, barriers, enablers, and disablers found out and mentioned in the different literature studies considered in this work were collected and matched in together in one chart. Although, complexity of SWSB is very high, the most important factors in bridging the gap between positive intentions and attitudes toward actual SWS actions are the external factors. These external factors are convenient, accessible, close, and easy to use schemes that does not ask inhabitants for many economic or lifestyles sacrifices and/or changes.



Figure.5: Behavioral factors effects on inhabitants' participation actions. Graphic: K. Chehab.

7.2 Separation Schemes' Competitiveness

The schemes that do not ask for big behavioral changes, lifestyle, and financial sacrifices, will be more engaging. Even if intentions, feel of responsibility and positive attitudes to wastes separation exists, these will not be converted into actions without the presence of convenient separation schemes. By looking at the factors suggested by the different SWS behavioral theories and models, it is obvious that external and situational factors in terms of separation schemes that offers convenient sorting experience, are the most important among other factors.

Garbage chute systems are constructed structures in the residential towers that can be used to offer convenient SWS experience within the situational context it exists in in the residential towers. It unignorable that the existing separation schemes are not operated on intelligent platforms, and subsequently are not perceived as credible schemes by adults or as attractive experiences for younger inhabitants who are inspired by new artificial intelligent advancements. AI can be used to organize the use of the existing chute systems to provide different times slots for different categories of SW disposal. In this way inhabitants will not be asked to change their behavior, but just use the same built-in garbage chute system they used to us for throwing their daily garbage as separation facility. In which they will throw the right SW at the right time and do the sorting work easily through the garbage chute.

Easiness in using the garbage chute systems, will help in automating and routinize inhabitants' actions in throwing the right SW category at the right time in the right place. Accordingly, habitual actions are more likely to happen in routinized manner and make SWS using the chute systems is part of inhabitants' daily life. Garbage chute systems would offer residential towers inhabitants convenient garbage sorting experience because of the following determinants:

- 1- The garbage chute is very close to inhabitants, almost at the door of the apartment.
- 2- No cars required for transporting SW.
- 3- Time saving.
- 4- Can sort SW instantly as required.
- 5- No need for storing space, as sorting can be done daily.
- 6- All family members can participate.
- 7- Easy to educate the kids on sorting of the SW.
- 8- Have higher hygienic standards and satisfaction.
- 9- Gives a tool for measuring SW generated regularly.
- 10- Understand SW composition through providing a tool for garbage analysis.

7.3 Actors Involvement

In the current scene of waste management ownership, municipalities hold the biggest share of responsibility in wastes management and material recycling. Then comes the producer's responsibility in terms of collection and separation in sharing the responsibility of collecting and separating food and other products packaging wastes. Although the importance of the inhabitants' participation in wastes separation schemes and the centrality of their role in making these separations schemes work successfully, their satisfaction with the existing schemes is not well investigated and defined by the service providers and designers. Participants should not be asked for huge sacrifices to do the tasks expected from them, as separation schemes should work as enablers and the experience of SWS should be a motivator for inhabitants to actualize and sustain the actions conduct. They need to be provided by convenient wastes separation schemes that helps them in sustaining a habitual action to create automated separation behaviors.

Garbage chute systems will provide a tool for materials separation at the very early stage of wastes' generation, this will provide separated wastes of high quality, that can be reused and recycled with lower treatment costs. These separated SW at the generation stage and before entering the garbage flow will provide high quality separated materials. Materials producers will find the quality and purity standards in the separated materials attractive enough to pay good prices. Pre-approved prices to be paid by the materials producers have an important role for motivating the municipalities to invest in SWSS that facilitates SWS so early in the waste collection process. Materials' producers may play an important role in shifting the annual wastes management mix toward material recycling than incineration. Building and properties management sectors have important roles in building and integrating wastes separation facilities and solutions at the residential towers that facilitate the SWS to happen at the generation stage in the residential towers.

8. Conclusions

Further research and investigation are required to assess residential towers inhabitants' satisfaction with the existing solid wastes separation schemes. These investigations are essential to do the needful interventions to enhance solid wastes separation experience and make it more convenient to inhabitants. Solid wastes separation at the household level is essential for enhancing the material recycling. Well-designed interventions that transform the garbage chute systems from being a reason for mixed wastes into a tool that provide convenient and engaging solid wastes separation experience must be considered. This transformation is important to bridge the gap between intentions and attitudes to actions and behaviours. Separations schemes should act as a smart link between governmental national objectives, municipal rules and regulations, and inhabitants' participations behaviours. These separation schemes should act as a platform for conducting automatized and routinized habitual patterns, that leads to behavioural shifts at the long run. High quality sorted wastes should be strategically approached as valuable raw materials. These raw materials are sellable commodities to materials producers at preapproved prices for preapproved quality. In the long-term profitable deals of selling separated materials for material producers will create an economic advantage that will make materials recycling become an attractive market to investors.

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Popular science summary

Imagine! The whole sorting station is just at your door! This will make you sort your garbage in Style. All you need is to press a bottom beside the elevator instead of driving to the sorting stations.

When you throw your water plastic bottle, drinks cans and glass bottle in the right manner you help in reducing the global warming. Plastics bottles are not harmful to environment if they will be disposed in the right manner.

Your participation is very important! Just by sorting your daily garbage correctly, you are going to help your home municipality to save millions every year. These millions will be spent on something else of great value to your kids and your family.

Wastes reduction and recycling is necessary for global sustainable development, but it is very challenging to happen properly. No matter how big the investments are in the solid wastes' infrastructures, these will never work without inhabitants' participation.

We all gets inspired with technology. The garbage window at your floor will be operated by artificial intelligence. The garbage window will give you the chance to sort your garbage in convenient manner, because you:

- 1- Will not need to store your garbage before sorting.
- 2- Will not need to drive your garbage to the sorting stations.
- 3- Will save time, energy and petrol.
- 4- Can sort your garbage instantly.
- 5- All your family members can sort the garbage.
- 6- Easy to engage your kids and teach how to sort.
- 7- Sort you wastes in moder and style.
- 8- Higher hygienic standards.

Garbage thrown today are futures resources and raw materials. We need to work together to sort garbage on daily basis. By having the garbage chute systems work as sorting station, we are helping you to sort every day in convenient manner. We know that you have a lot to do every day, however your participation makes a great difference. We are here to provide the tools you need to make you able to sort your garbage in seconds.

The idea is simply by using the garbage chute systems in the building you live in as a sorting scheme. This means that you will have times where you can throw plastics, glass, metals, paper packaging separately, in the garbage window at your floor. You do not think how you will get to throw and when, because there will be simple screens at above the garbage window that would tell what to throw in a timelapse and what to not to throw.

Is not that easier than driving to sorting stations?

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Appendix 1

List of studies used in the literature review

Author	Article title	Area and inhabitants	Methods of analysis	Main aim of the study
Rousta.	Thesis for the Degree	Pilot area in Borås	Pick analysis was	Understanding inhabitants'
2018	of Doctor of Philosophy.	208 flats	performed choosing the sample	needs to participate in the waste
	HOUSEHOLD WASTE	Income level $\leq 15,000$	according to the Swedish	segregation system.
	SORTING AT THE	Car availability: 1/3 of	Management Waste	
	SOURCE. A procedure	inhabitants does not have	Association manual for pick	
	for improvement	cars.	analysis for municipalities.	
		Existing sorting system:	Data got analyzed by	
		Bring system.	comparing the two sets of data	
		Nearest recycling	of the two group in a t-test,	
		station: 2 km	using statistical software:	
		Reference area:	Minitab.	
		299 apartments	Interviews were done in	
		Two recycling station:	structured for 9 interviewees	
		400 m each.	each long was 50 to 65 minutes.	
			And short-term interviews in	
			front of the building.	
			Pick analysis, qualitative	
			and quantitative analysis were	
			done as part of Action	
			Research Methodology that	
			aimed at Recycling Behavior	
			Transition solutions.	
Kim, et al.	Quantitative	208 Apartments	Sampling and manual	Investigating the effect of
2015	assessment of distance to	447 inhabitants of	sorting in a pick analysis	the distance between sorting
	collection point and	diversified socio-economic	conducted before and after	station and residential entities
	improved sorting	backgrounds.	convenience enhancing	on the sorting and mis sorting
	information on source	Around 37% had	interventions, as creating close	behavior.
	separation of household	medium or high income.	collection in the property and	
	waste	Around 58% had higher	environmental rooms.	
		secondary education and	Second intervention was	
		higher education.	putting new stickers on the	

		Approximately 33% of the householders owned a car.	food waste bins that has less texts and figures full.	
Karin & Kamran. 2013	Assessing Incorrect Household Waste Sorting in a Medium-Sized Swedish City.	Pick analysis where both qualitative and quantitative analysis were conducted. 447 inhabitants living in 208 flats in 9 apartments block of 8 floors each	Pickanalysiswasperformed choosing the sampleaccordingtotheswedishManagementWasteAssociation manual for pickanalysis for municipalities.Datagotanalyzedbycomparing the two sets of dataof the two group in a t-test,usingstatisticalsoftware:Minitab.Interviews were done instructured for 9 intervieweeseach long was 50 to 65 minutes.And short-term interviews infront of the building.Pickanalysis,quantitativeandquantitativeand spartofActionResearchMethodologythataimed atRecyclingBehaviorTransition solutions.	Understanding inhabitants' mis sorting behavior that implicit significant costs to the society.
Kamran et al. 2016	A Procedure to Transform Recycling Behavior for Source Separation of Household Waste.	Pick analysis where both qualitative and quantitative analysis were conducted. Qualitative analysis was conducted in structured and semi structured interviews. 447 inhabitants living in 208 flats in 9 apartments block of 8 floors each 67% of inhabitants were born outside Sweden and has moved to Sweden recently (Less than three years),	Pickanalysiswasperformed choosing the sampleaccordingtotheaccordingtotheSwedishManagementWasteAssociation manual for pickanalysis for municipalities.Datagotanalyzedbycomparing the two sets of dataof the two group in a t-test,usingstatisticalsoftware:Minitab.Interviewsmanner.Pickanalysis,quantitativeandquantitativeanalysis,were	Action Research methods to observe, analyze and theorize an existing waste sorting behavior is recommended method to suggest appropriate interventions and assess the outcomes of the interventions further.

		before system	done as part of Action	
		implementation.	Research Methodology that	
		31% of inhabitants aged	aimed at Recycling Behavior	
		from 25 to 44 years.	Transition solutions.	
		20% aged 45 to 64.		
		63% of inhabitants had		
		less than 15,600-euro annual		
		income.		
		58% had higher		
		secondary school/education.		
		Only 33% of the		
		residents owned a car.		
Henrikson	Uncertainty	20 subjects living in	Interviewing and	Causes of uncertainty in
et al, 2010.	Regarding Waste	Augustenborg in Malmö,	observing 20 subjects in the	everyday life waste sorting and
	Handling in Everyday	had been observed and	mentioned area and population.	the effects of system uncertainty
	Life.	interviewed.	Surveying 1000	on inhabitants' behaviors.
		3,000 residents living in	inhabitants were randomly	
		1,800 small one, two or	chosen in Sweden.	
		three rooms apartments.	Surveys has questioned the	
		Age range 18 to 40.	uncertainty of waste separation	
		48% of residents were	schemes available in surveyed	
		born outside Sweden,	participants.	
		Romania, Poland, Iraq,		
		Bosnian-Herzegovina, &		
		Yugoslavia.		
Bernstad,	Household food	1632 households of 2 to	Evaluation of food wastes	The study aimed at testing
A. 2014.	waste separation behavior	3 room rental apartments in	collected and the composition	importance of convenience and
	and the importance of	Malmö; were involved in the	of the waste after giving two	knowledge on the waste
	convenience.	study with around 2800	separate interventions that are	separation behavior at the
		habitants. Households are	kitchen equipment and	household level. The effects of
		largely diversified in terms	distributing information on	the two interventions of
		of age and gender, where 28	waste separation requirements.	inserting kitchen equipment and
		% of them whom aged	Wastes were collected at	distributing information were
		between 20 to 60 years old	different frequencies.	investigated separately.
		have passed the higher	Inhabitants did not know about	
		education and have limited	he waste composition analysis	
		socio economic status where	performed on the wastes they	
		15 % rely on the social	collected under the study time.	
		security system.		

		49% of population in		
		the mentioned area were		
		born outside Sweden.		
		14% have at least one		
		parent of non-Swedish		
		background.		
Stoeva &	Influence of recycling	412 Swedish student of	Questionnaire that are	The study aim was to study
Alriksson.	programmes on waste	environmental sciences in	Self-administered in both	was to shows the effect of the
2017.	separation behaviour	Linnaeus University in	Swedish and Bulgarian	separation and recycling
		Kalmar, and 179 students	languages were used.	schemes and programs on the
		from Bulgaria (Paisii	Separation schemes	solid waste separation behavior
		Hilendarski University in	satisfaction factors were	within the framework of the
		Plovdiv), mainly have	questioned in a 5-scale measure	theory of the planned behavior.
		natural sciences	from strongly agree to	
		background.	disagree. Neither agree nor	
			disagree were also included.	
Anthony,	How Different Are	Population from the	Data from the survey done	Investigate citizens'
J. 2021.	the Nordics? Unravelling	following countries:	to populations in the Nordic	positions in terms of willingness
	the Willingness to Make	Denmark (1305)	region countries in the	to make pecuniary and non-
	Economic Sacrifices for	Finland (1211)	ISSP Environment III	pecuniary sacrifices for
	the Environment.	Iceland (798)	module.	following environmental
		Norway (1382)		protection policies.
		Sweden (1181)		
Cichocka,	The consumer	Questionnaires got	1,310 questionnaire	The study aims at
et al, 2020.	awareness and behavior	distributed to consumers in	surveys conducted with 1239	investigating the opinion of
	towards food packaging in	different places as	respondents.	more than 1,300 respondents
	Poland	-Podkarpackie		about the functions and
		Voivodeship.		properties of the food packaging
		-Lesser Poland		and the way end users are
		Voivodeship.		disposing it, and the
		-KuyavianPomeranian		determinants involved in the
		Voivodeship.		assessments. The study in one of
		-Greater Poland		the questionnaires aimed at
		Voivodeship.		demonstrating respondents'
		-Voivodeships of;		knowledge on the scale of the
		Mazovian, Lubiln, West		problems belonging to the food
		Pomeranian, and Silesian.		packaging.
Jamal et	Commercial and	The study was	After applying the brown	The study aims to
al, 2019.	household food waste	conducted in the largest city	bin advisor scheme, 568	investigate the local authority's

	separation behaviour and	by area in the southwest of	commercial premises located	role in implementing and
	the role of Local	Ireland, in Cork County.	in 22 towns for 1362 houses	increasing the food waste
	Authority: a case study.		that located in 5 major towns	separation at the source in both
			Brown bin advisor schemes	households and commercial
			was tested.	premises, and further identify
			Questionnaires were	potential gaps in the public
			directed to 6 % of the town's	awareness.
			population that were 10,000	
			and above.	
			Questionnaires sent to the	
			collectors as well for getting	
			feedback after the mentioned	
			scheme.	
Zhang et	What determines	Urban areas with dense	Male till female ratio of	The study aimed to focus
al, 2022.	urban household intention	population and huge flow of	interviewed population in	on the determinants that bring
	and behavior of solid	solid wastes in Shenzhen	Shenzhen and Tianjin was	and encourage both the
	waste separation? A case	and Tianjin cities in China.	almost 1:1.13. The same is	intention and behavior for solid
	study in China.		consistent with the actual	waste separation actions among
			overall sex ratio in the	residents in different urban
			mentioned cities as per the	areas in China.
			NBSC, 2020.	
			Age wise, in Shenzhen;	
			most of the respondents were in	
			the range of 18 to 45 years,	
			while in Tianjin majority of	
			interviewees were between 31	
			and 61 years.	

Appendix 2

Questionnaire used for the quantitative analysis Solid waste Sorting in the towers.

Dear participant!

I am currently doing my master's degree in Sustainable food systems in the Swedish University of Agricultural Sciences. The purpose of this survey is to understand how convenient it is for residents in towers to use the garbage chute in each floor to sort households wastes as plastic, metal, glass flasks, paper packaging and other kinds of generated wastes.

Question number 1:

How many times you sort your household garbage?

- Once in a week
- Once in a month
- Once every three months
- I do not sort wastes

Question number 2:

Do you have space to store garbage at your flat before sorting them?

- Yes
- No

Question number 3:

Where do you sort your garbage?

- In the building I live in; there is sorting room in the bottom floor.
- I drive to the nearest wastes sorting station.
- I do not sort wastes

Question number 4:

If you would be able to use the garbage chute at your floor to sort garbage, shall this be easier for you?

- Yes, this will help me sorting more
- If this is available, I will start sorting my wastes
- No, this will make no difference

Question number 5:

Does information on the garbage chute helps you to know how to sort your household garbage? this poster is used as an example; information can be presented in different ways.

- Yes
- No

Question number 6:

Why does garbage chute help you sort more? you can choose more than one answer.

- More convenient
- I have no space to store wastes before sorting
- I do not have car to drive to sorting stations
- I can sort more frequently
- I do not want to carry wastes to wastes stations
- Easy to show my kids and other family members how to sort wastes
- More hygienic to waste like this than to waste to the garbage stations

Qualitative analysis interview, 29 April 2022.

1. How many family members are you at home?

5 persons

2. How old are your family members?

Mother 45 years old and father is 50 years old. Girls were: 20, 19 and 10 years old 3. Do your kids go to school?

Yes

4. Where do you live?

In the city of Åmål in Västragötalandslän. In four floor building in the fourth floor in a three room apartment.

5. Do you have garbage chute at your floor?

Yes, we have.

6. How many times you through garbage?

1-2 times daily.

7. How do you throw your garbage?

Sort big paper packaging, plastics, glass, metals, twice a week in the sorting stations

Food, tissues and sometimes paper in the garbage chute.

It is not allowed to throw in the chute except food and tissues, but there are inhabitants who do not sort and throw bags of mixed wastes in the chute.

8. Do you completely or partly sort your garbage? Can choose that you do not sort at all!

I sort partly, as I mix food and tissues together and through in the garbage chute. Sometimes I throw the small plastic things and bags in the garbage bags I dispose in the garbage chute.

9. Do the building management make control and how?

I do not, but I know some of my neighbours, who does not sort, or does not sort properly.

10. What do you sort?

Paper packages, metal, plastics, glass flasks, and electrical materials. 11. Why do you sort?

In the building it is compulsory to sort; however, there are people in the building who do not sort.

In the garbage chute it is allowed only to throw food wastes.

My husband is much discipline and does not allow us not to sort, If he would not ask us to sort, I will never do that.

12. What do you not sort?

Small plastic bags, tissues, small plastic, and metallic pieces that are difficult to take to sorting stations, I just throw I in the garbage bag to be disposed in the garbage chute.

13. Why do you not sort sometimes, or mis sort sometimes?

- Being very inconvenient, it is the worst.
- I do not have enough Space.
- Packing them and getting them to my car.
- Need to take them after work.
- Cost of transport, and now it is getting even higher.
- Time consuming.
- It takes a lot of my energy and I work for more than 8 hours a day.
- I am the only family member who has driving license, and I work, it is very difficult, I do not like it.
- 14. Are there times where you can sort or like to sort more than other times?

No, I take them only If I must go anyway and buy something else, I do not want to leave my home in the weekends to pack garbage to the sorting stations, I need to rest under weekends.

The girls hate to go to the sorting station, especially in the wintertime. They do not participate at all, for them it is very non interesting.

The girls said that no one of their friends goes to the sorting stations, to them this is not interesting and frustrating to go there, especially that majority does not have cars.

15. Do you have the time to sort?

No, it is very challenging, much time consuming and takes energy. On the long run it becomes very frustrating.

16. Do you have the space to sort your garbage before sorting?

No space, so I am forced due to space limitations to sort at least twice a week, sometimes more, oh my god it is very frustrating.

17. Do you find it difficult to transport your wastes to sorting station, and why?

It is very difficult, and cost me a lot of money and efforts, especially in the winter.

18. Do you think that if you would use the garbage chute to sort your wastes, it will become easier to waste?

Yes, sure. Please do it.

19. Do you think that garbage chute will help you engaging your kids and other family members to start sorting their wastes, or waste more if they do?

Yes, sure. This will also make them help me in doing this. Oh I wish we can use the garbage room to do that, this will definitely make our life easier.

20. Do you recommend it and why?

Yes,

- More convenient, especially in the winter.
- Transport takes time and costs money for the petrol.
- Space
- Responsibility will be shared among family members.
- Helps kids gets educated on the sorting, gets engaged and start participating, participate more.
- 21. Does information left on the garbage chute may help in sorting better "for example, what to throw now and what not to throw now", would help you know how to sort your wastes?

Yes, sure.

22. Is getting feedback on the participation benefits of the sorting actions, like for example to get a message at the left on the garbage chute, "on this month, because of your sorting efforts, we were able to sort 30 kilos glass, 20 kilos metals, 10 kilos plastics, etc.?

Yes, this will help, especially for younger age people. But for me and my husband, using the garbage chute is the most important.

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