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A FRAMEWORK FOR WASTE MANAGEMENT PLAN IN CITIES (CASE STUDY GREAT CAIRO REGION)

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ABSTRACT

The planning of waste management in metropolitan cities is a very critical aspect for the ongoing urban development. The process itself encompasses strategic effective allocation for both resources and infrastructure. This is essential to handle and dispose waste generated by huge population. Moreover, planning for waste management focuses on enhancing sustainable practices like recycling to minimize the negative impact of waste disposal. This Paper will study the framework for establishing a Waste Management Plan in Metropolitan Cities, which affect the planning process of cities either the new cities or the existing cities upgrading, with case study Great Cairo Region's waste management plan. The research study showes the different phases for waste management which affect the planning of cities specially the existing cities, which are waste collection, transfer station and landfill or recycling. The research expanded the different understanding for each phase for waste management which are waste collection, transfer station and landfill or recycling plan, and will focas on the main creteria and new technolgies used in each phase which affect the planning of cities and the final closure of landfill, and will developed an analysis for Great Cairo Region areas to evaluate its current situation in current waste management strategy for each phase and different areas amount of wastes. And finally will propose how to improve waste management planning for Great Cairo Region's strategy through the previous studies ways in each phase.

KEYWORDS: Waste management, Transfer satations design, Landfill design, Cairo Region waste mangement plan

إطار لخطة إدارة النفايات في المدن (دراسة حالة منطقة القاهرة الكبرى)

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الملخص

يناقش البحث التحديات التي تواجه المدن الكبرى في تخطيط ادارة النفايات لكونها جانبا هاما في التنمية العمرانية بالمدن المعاصرة. تهدف هذه الدراسة إلى تحديد إطار عمل خطة إدارة النفايات في المدن الكبرى مع دراسة حالة خطة إدارة النفايات في منطقة القاهرة الكبرى. وقام البحث بتوسيع الفهم المختلف لكل مرحلة من مراحل خطة إدارة النفايات بالاضافة إلى تحديد الاستراتيجيات الفعاله لتخطيط ادارة النفايات من حيث الوسائل و الموارد. كما

يسلط البحث الضوء على بعد الاستدامة في عمليات ادارة المخلفات مثل استراتيجيات اعادة التدوير التي تهدف إلى الحد من الأثار السلبية لعملية ادارة المخلفات في المدن الكبرى. وبناء عليه قام البحث بتطوير تحليل لمناطق منطقة القاهرة الكبرى لتقييم وضعها الحالي في استراتيجية إدارة النفايات لها. وللمضي قدمًا، قدمت الدراسة مقترحًا للتخطيط الأمثل لإدارة النفايات في منطقة القاهرة الكبرى. وسيتم التركيز على التقنيات والطرق الجديدة في كل مرحلة. وأخيراً سيتم اقتراح كيفية تحسين هذه الإستراتيجية من خلال طرق الدراسات السابقة في كل مرحلة.

الكلمات المفتاحية : إدارة المخلفات، تصميم محطات النقل، تصميم مدافن النفايات، خطة إدارة المخلفات بمنطقة القاهرة.

1. INTRODUCTION

The planning of waste management in metropolitan cities is a very critical aspect for the ongoing urban development. The process itself encompasses strategic effective allocation for both resources and infrastructure. This is essential to handle and dispose waste generated by huge population. Moreover, planning for waste management focuses on enhancing sustainable practices like recycling to minimize the negative impact of waste disposal. This research presents a brief review for waste management in metropolitan areas and its different models and principles. It reviews the different phases of waste management in metropolitans and its different elements. The research also identifies the areas of improvement and the needed principles to achieve effective waste management plan and include its elements in the land uses from the beginning. This research will apply the findings and different models of waste management on case study of Great Cairo Region and its strategic waste management plan.

2. Phases for waste management

There are three main phases for waste management; waste collection, transfer and landfill or recycling as shown in Fig. 1.

Fig. 1. Phases of the waste management process in city planning.

2.1. Phase 1 - Waste collection

The waste materials that come from various sources, such as households, businesses, and public spaces, are regularly gathered and removed in the waste collection phase[1]. Waste removal and avoiding environmental pollution are the vital roles that play in this phase [2]. Curbside pickup, placing containers, and transporting them to recycling or disposal facilities are the activities that occur in the waste collection phase [3]. Maintaining cleanliness and hygiene in communities plays a crucial role in well-organized waste collection. This phase also involves properly separating recyclable materials from non-recyclable ones at the source so that they can be processed properly [4].

2.1.1. Shooting Ducts Inside Buildings

Shooting ducts inside is an essential part of the garbage collection process. To provide effective waste management, installing interior shooting ducts requires competent specialists who can navigate the building architecture precisely. This process entails installing ductwork that will effectively move trash from various locations throughout the structure to a central collecting point using specific equipment. In order to install shooting ducts within structures, the ductwork must be precisely measured and cut to match the building's measurements. Furthermore, it's crucial to properly close the air ducts to stop any leaks or smells from entering the interior space [5, 6].

There are several phases in the indoor ducting process. The ductwork arrangement must be accurately planned and designed as the initial stage. This requires taking into consideration the building's dimensions and layout, the location of the garbage collection site, and the kind of waste that will be delivered. Then, once the layout has been designed, the technician must accurately measure and cut the ducting to match the exact measurements of the structure [1, 2, 7]. This is a detailed task that calls for certain tools and knowledge. After that, the ducting is erected using a number of techniques, including brazing, flanging, and welding. For the ducting to be securely fastened, the technician must also install the necessary hangers and supports. A test is conducted after the ducting is installed to make sure there are no leaks. In order to stop any smells from escaping, the technician will additionally seal all of the joints and seams. The ductwork is prepared for commissioning once it has been sealed and tested. This includes turning on the system and making sure everything is running well. Although installing indoor shooting ducting is a complicated procedure, safe and effective waste management depends on it. Businesses may make sure that their garbage collection system is installed and maintained correctly by following the above-mentioned process [1, 3, 7].

Fig. 2. Collection through Shooting Ducts [8].

A. Under Ground Waste Bin

An essential part of the garbage collection process is the underground waste bin. It reduces garbage's negative environmental effects and enhances general cleanliness by providing a safe and effective means of collecting and storing waste [9]. The underground garbage bin is a more sanitary waste management option since it also helps to lessen the smells and vermin that are frequently connected to conventional above-ground waste bins. Because they may be hidden from view and use less space than above-ground bins, underground garbage pins can enhance the aesthetic attractiveness of public areas [10].

The strong components used to make underground waste bins allow them to resist adverse weather, including intense heat, cold, and rain. Subterranean waste bins are adaptable enough to handle many waste kinds, including general garbage, recyclables, and biodegradables. Sorting and recycling garbage at the source may be encouraged as a result [11]. Because underground trash bins are substantially bigger than above-ground bins, they require less frequent emptying. Waste management firms may save money and time by doing this. By keeping garbage isolated below ground, underground waste bins assist to reduce smells and pests. Everyone may benefit from this by having more sanitary and enjoyable public areas [12].

All over, underground waste pins are superior to conventional above-ground waste bins in a number of ways. They are more sanitary, long-lasting, ecologically friendly, and space-efficient. Although underground garbage bins are a relatively new technology, towns, and communities all over the world are rapidly adopting them as a waste management solution.

Fig. 3. Collection through Underground Waste Collection System [13].

2.2. Phase 2 - Transfer Stations

Waste materials are moved from collection points to treatment or disposal facilities in the transfer phase of the waste management process [1]. This stage is considered a guarantee that waste will be handled correctly and transported safely. The use of various transportation methods, such as trucks, trains, or ships, depending on the type and quantity of waste being transferred, is involved in this phase [14]. The transportation methods used in the transportation phase of waste management are selected based on the specific characteristics of the waste. For example, specialized vehicles with containment

measures are required for harmful materials to ensure safe transportation. In addition to following regulations and protocols to reduce environmental impact during the transportation process [15].

2.2.1. Transfer station models for cities

Transfer stations are used to retrofit landfills that are located far from waste generation centers, but the unpleasant smells, noise, and dirt they produce annoy the neighbors. Additionally, as a transitional step between waste collection and recycling, the location of the transfer station for the separation and recycling of residential solid waste is crucial to the urban planning process, particularly in metropolitan areas with high densities of buildings and people [16]. The efficiency of waste collection and disposal is impacted by the absence of transfer station in urban centers of metropolitan areas, which has resulted in numerous issues. The necessity for urban solid waste recycling has grown significantly due to the reduction of landfill space and the rising expense of solid waste management. There are social and physical limitations to where waste can be effectively sorted before being transported to a landfill for disposal.

When planning to construct and operate a successful transfer station, location, efficiency, durability, flexibility, cost, and safety are the top six factors to take into account [19].

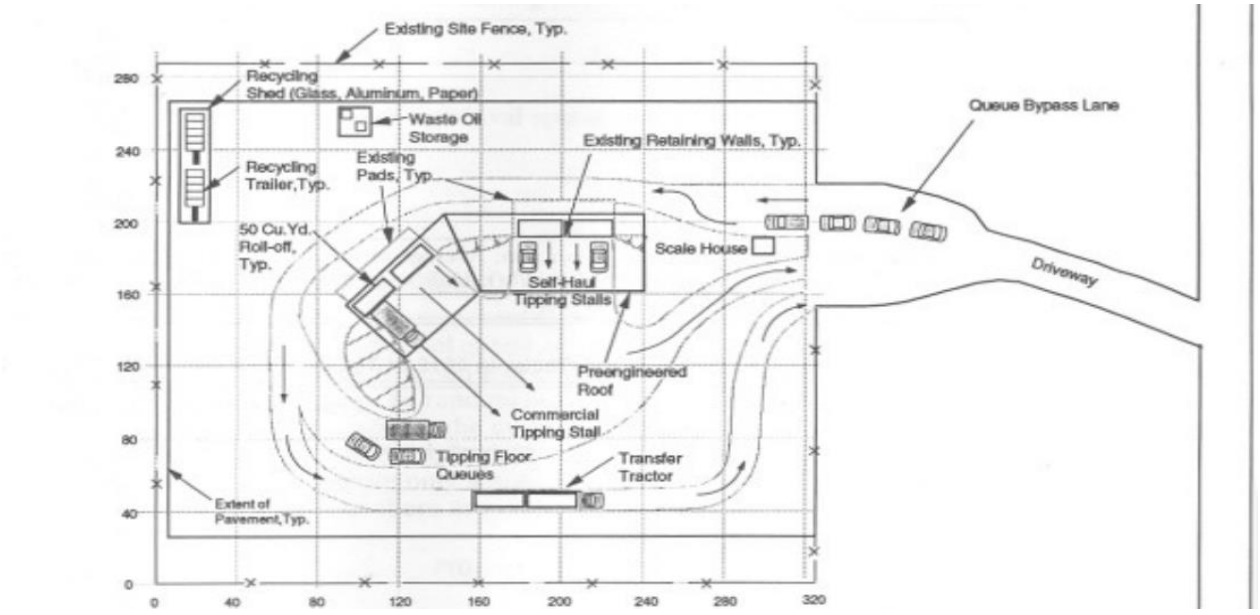

Fig. 4. Conceptual level design of Riley County Transfer Station for small site [17].

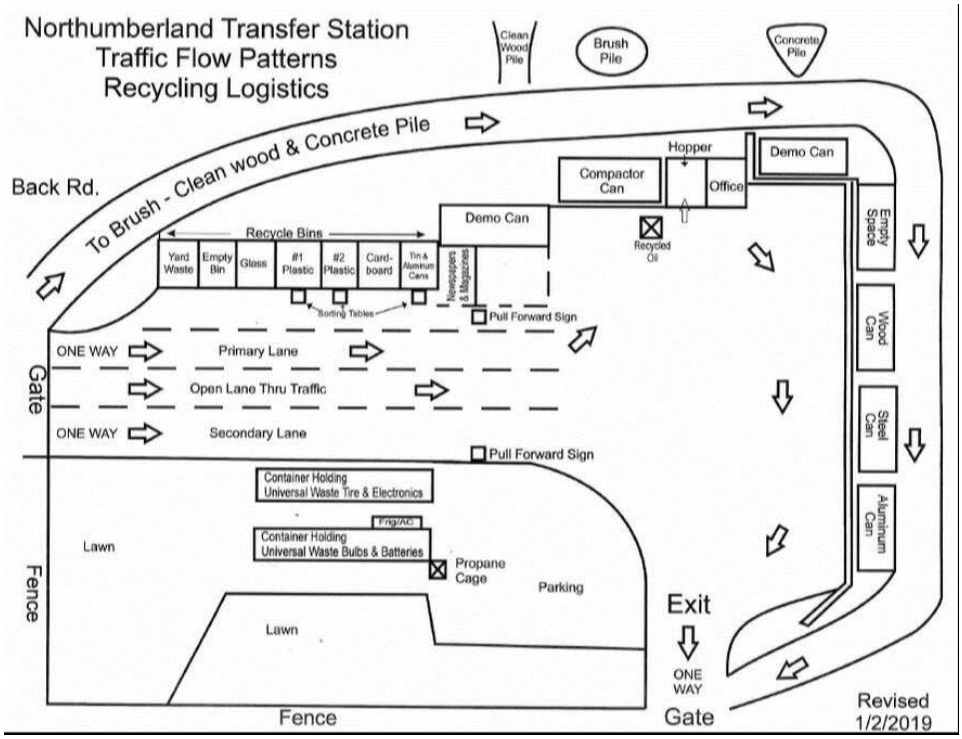

Fig. 5. Sample for transfer station traffic flow patterns [18].

A. Location

The facility's urban location must be ideal for all parties involved. The transfer station should be situated such that access roads and expressways make it simple for your trucks to get to. To optimize fuel efficiency, routes, and drive time, it must also be situated in a centrally located area of the market.

B. Efficiency

"Get them in and get them out" is all that is required. Having a site designed to allow vehicles to enter and exit in 15 minutes or less is crucial, regardless of whether the vehicles are your own, those of third parties, or trucks used for material delivery.

C. Durability

Constant shutdowns for maintenance and repairs are the last thing a transfer station operator should have to deal with.

D. Flexibility

Being flexible means having the ability to modify operations, structure, and machinery to adapt to changes in the market caused by shifting consumer demands, a growing tonnage, and a changing material stream. Future changes must be accommodated into a transfer facility's design in a way that minimizes disruption to day-to-day operations. These adjustments could include adding scales, changing the structure, or doing a lot of other things.

E. Cost

To make a transfer station a workable long-term solution, a construction budget and an operating budget must be met. There are numerous uncontrollable factors that affect construction costs, including the type of building being constructed, permit requirements, site conditions, local municipality aesthetic requirements, and your location.

F. Safety

Designing a facility that is safe to use and safe for people who pass through, should be the top priority among the aforementioned factors. Safety has to come first. This includes handling emergency situations like fires in addition to traffic patterns, signage, parking, employee walking paths, and other things of that sort.

2.3. Phase 3 - Landfill / Recycling Areas

The waste is disposed of and buried in the ground in the landfill, where designated areas are allocated for this phase, while collecting and processing materials to create new and useful products through the recycling phase [20]. Minimizing the amount of waste sent to landfills and incinerators is the main aim of the recycling phase in waste management. Recyclable materials such as paper, plastic, glass, and metal are collected, sorted, and processed to be turned into new products through this phase [21]. This process not only conserves natural resources but also reduces pollution and energy consumption associated with the manufacture of new materials. In addition, recycling plays an important role in enhancing sustainable economy and endorsing jobs. Recycling also contributes to a reduction in greenhouse gas emissions because the manufacture of new materials frequently results in large carbon dioxide emissions [22]. Recycling also lessens the need for scarce landfill space by diverting garbage from them and lowers the risk of toxic leachate and groundwater contamination. Overall, adopting recycling as a significant part of waste management is essential for a healthier world and a more environmentally friendly future [23].

A. Land Fill Location

During the recycling process, the landfill's location is vital to take into account. The landfill should be situated in a region with low groundwater levels and stable geology. This will assist in stopping leachate, a poisonous liquid that may harm water and soil resources, from leaking [24].

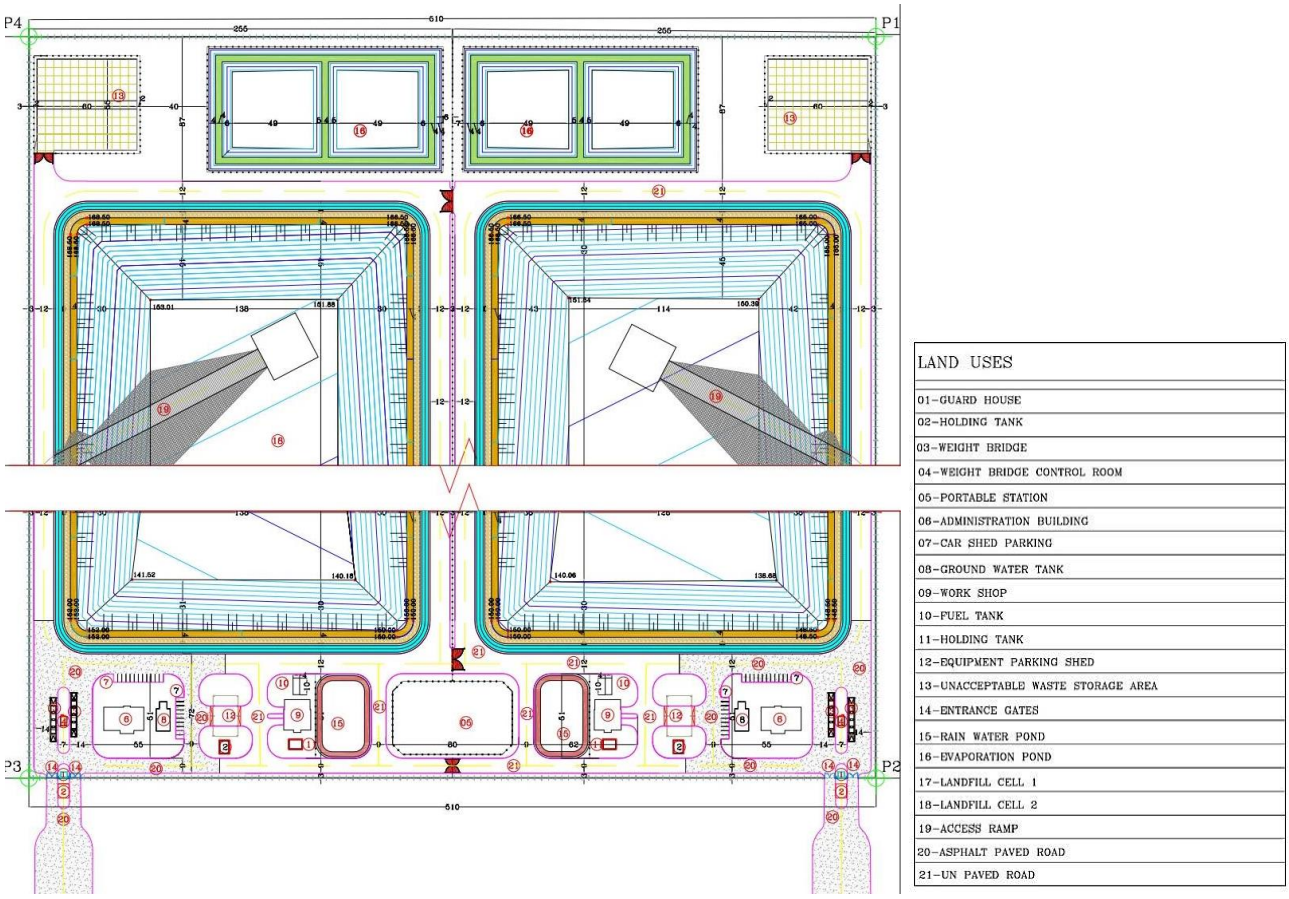

Fig. 6. Obour Landfill layout [25].

Additionally, the location needs to be situated far from delicate ecosystems like wetlands and the habitat of rare animals. Numerous adverse effects on neighboring ecosystems may be attributed to landfills, such as noise pollution, odor pollution, and infection of the air and water. Selecting a landfill location that is remote from sensitive land uses and residential areas is important. Furthermore, the landfill has to be planned and run to reduce these adverse effects [26].

The landfill should be situated close to transit hubs and recycling centers. This will reduce the expense and negative effects of transferring garbage to a landfill on the environment. It's important to take into account the landfill's social and economic effects on the neighborhood in addition to these other variables [20]. For illustration, the landfill should be situated so that it won't likely interfere with future or current land uses. Additionally, the landfill needs to give locals job chances. It is important to choose a landfill that is licensed to accept the type of waste that will be disposed of. Landfill fees vary depending on the location and the type of waste. It is important to factor in the cost of disposal when choosing a landfill [23].

- **Soil layers of landfills**

In order to minimize contamination of the surrounding groundwater, modern landfills are sealed completely. Clay is first used to line the ground. The clay layer is

covered with a thin layer of pliable plastic. This makes it possible to collect leachate, a liquid that seeps through landfills and has the potential to extract toxins from waste. The contaminated water is routed through pipes to a pool where it can undergo treatment to eliminate toxins before being re-released into the environment, collecting the leachate through a drainage system. Waste is compressed into a densely packed mound as it is added to the expanding pile. To stop rodents and smells, a layer of dirt is removed from the trash every day. As a result, the majority of the landfill is composed of soil and debris in compressed layers [27].

After a landfill is finished, it is sealed with a thin layer of plastic and clay. After that, several feet of dirt are added to allow for the growth of plants. Even though landfills are only meant to hold garbage, some of it will eventually break down. The hazardous and combustible gas methane is produced during the decomposition process. Methane in contemporary landfills is gathered in pipes so that it can be burned, vented, or even used as a source of energy.

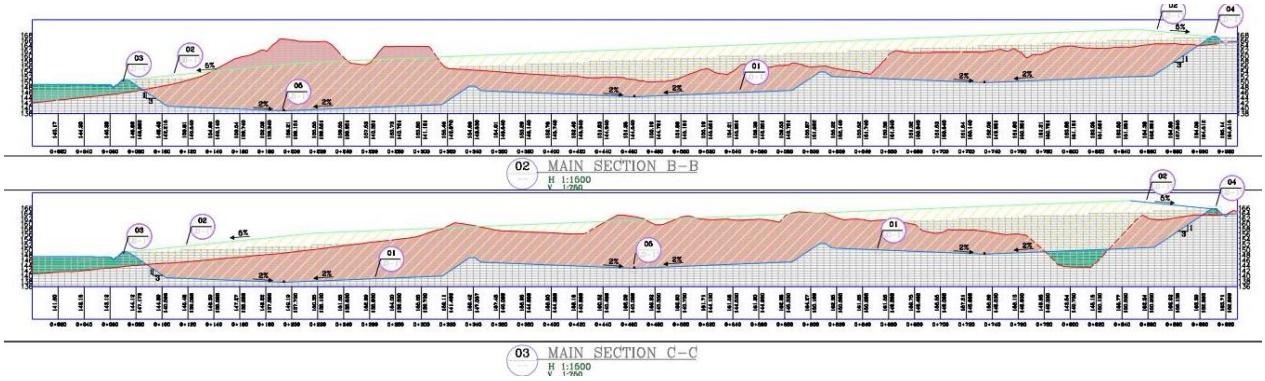

Fig. 7. Landfill soil layers [25].

- **Réhabilitation landfills into parks**

According to EPA estimates, Americans alone generate 4.3 pounds of trash every day on average. That is a significant amount of waste that ends up in the nation's landfills when multiplied by 318.9 million people. Consider how many formal and informal landfills there are worldwide, releasing methane gases and leaking a variety of harmful chemicals into ground and surface water supplies. The United States alone has about 3,500 active landfills. It's an intimidating idea; however, landfills can be transformed into something beneficial with a little creativity. Large numbers of landfills turn methane emissions into clean energy, and a large number of closed landfills have been carefully restored into flourishing public parks that conceal nothing of their former filthy status [28, 29].

Fig. 8. Freshkills Park in New York City after Réhabilitation from landfills into parks [30].

B. Recycling Factories

Recycling factories are essential to the recycling process because they create new products out of recycled resources. Numerous procedures are used to accomplish this, such as sorting, cleaning, and material separation [31]. Recycling facilities successfully complete these duties with the use of cutting-edge gear and technologies, minimizing the quantity of garbage that ends up in landfills and protecting natural resources [32 - 37].

Recyclables are gathered from curbside containers, drop-off locations, and other locations. Next, several categories of recyclables, including paper, plastic, glass, and metal, are separated. Either manual labor or automatic sorting devices can be used for this. Subsequently, the recyclable materials are cleaned to get rid of any impurities like dirt or food scraps. Separating recyclables into several classifications or grades; plastic, for instance, can be sorted by color or kind (such as PET, HDPE, and LDPE). In addition, the recyclable materials undergo processing to turn them into raw materials for fresh product creation. Glass may be crushed, plastic can be pelletized, and paper can be pulped [33 - 35].

The recyclable materials that have been processed are ultimately sold to manufacturers, who utilize them to make new goods. Recycling facilities are crucial to the circular economy, a production and consumption paradigm that tries to save resources and minimize waste. Recycling factories close the material flow loop and build a more sustainable future by converting recyclable resources into new goods [32].

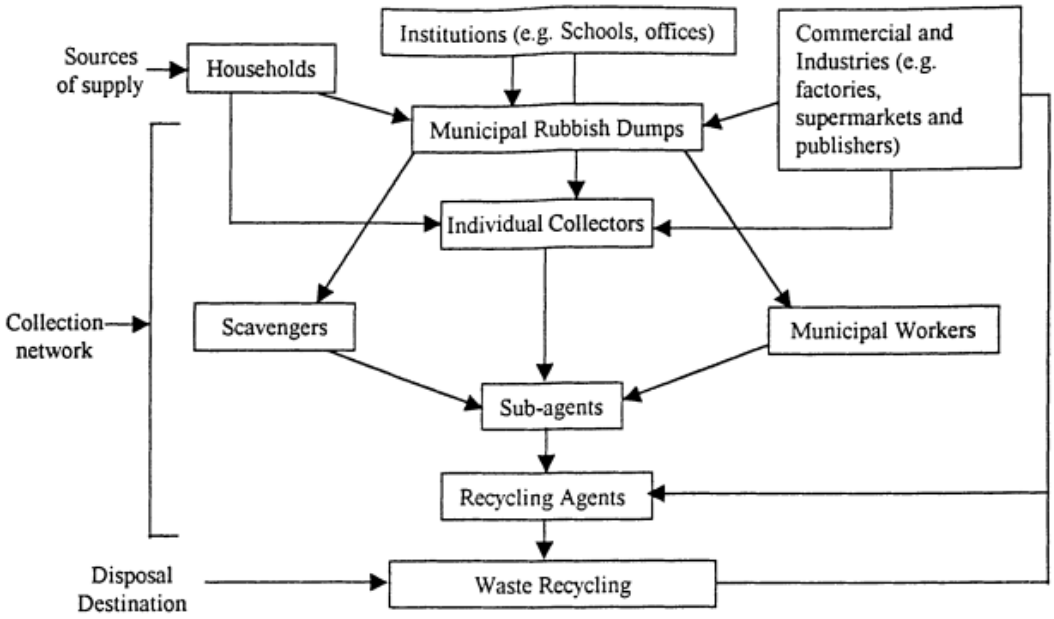

Fig. 9. Existing waste collection network system [36].

3. Great Cairo Region Strategic waste management plan

The following section shows the empirical part of the presented study on Great Cairo Region Strategic waste management plan.

3.1 Data gathering

The revised phases for waste management are applied on the strategic waste management plan for Cairo Metropolis through the folloing steps.

3.1.1. Cairo Region Master plan

Cairo Governorate is divided into 4 administrative Areas: the Eastern Area, the Western Area, the Northern Area, and the Southern Area. The amount of solid waste for each region is estimated according to the following table, which shows the relationship to the number of population in each region.

Table 1: Four zones for Great Cairo Region [25].

%	Waste Tons/day	%	Population	Area
%15.7	2345	%17.06	1544367	**Northern Area**
%33.8	5540	%41.67	3772372	**Eastern Area**
%15.4	2515	%7.77	703466	**Western Area**
%35.0	5795	%33.50	3032943	**Southern Area**
%100.0	16195	%100.00	9053148	**Total**

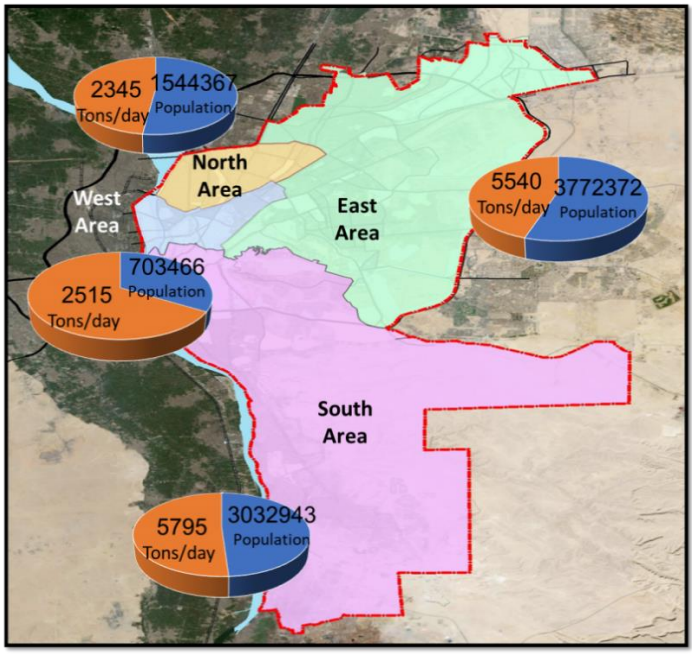

Fig. 10. Great Cairo Region Areas and waste products for each area [25].

3.1.2. Analysis of the current situation for each Area Strategy

Within the framework of the general orientation of Egypt towards the advancement of the built environment and the optimal sustainable exploitation of the historical, cultural and tourism components, governance and management centers enjoyed by Cairo Governorate and other investment elements given that it is the capital of the Republic, improving the standard of living, providing adequate shelter, supporting small and medium enterprises and economic activities, and encouraging the participation of the private sector in order to generate job opportunities and reduce unemployment and immigration rates, In order to achieve the hopes and aspirations of the residents of Cairo Governorate and its future for future generations, the vision was extracted through several procedural steps that ensured reaching a final version of the vision, which is: "Achieving a clean sustainable built environment to encourage the development of the governorate through an integrated solid waste management system within the framework of Egypt's vision for comprehensive sustainable development 2030." [25].

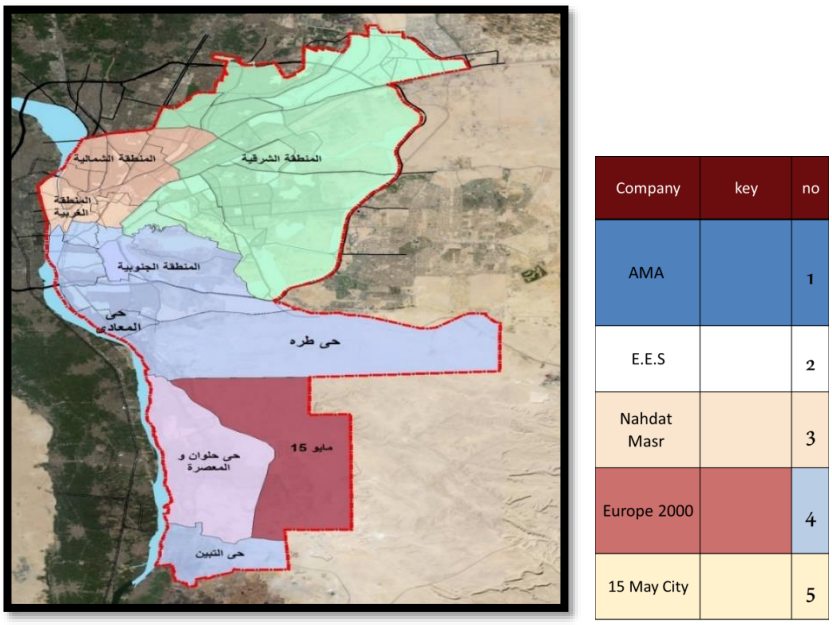

Fig. 11. Distribution of companies responsible for waste Collection for each Area of Cairo governorate [25].

3.1.2.1. Area A Strategy

Transportation from the neighborhoods in the northern region using dump trucks and residential collection contractors to handling points, then transport by cabsa trucks to 2 intermediate stations, namely (Haraki station - coast station), then transport by trucks to the final disposal site in transit or the proposed landfill in Geneva or the tenth according to the approval of the armed forces as shown in the Figure 12.

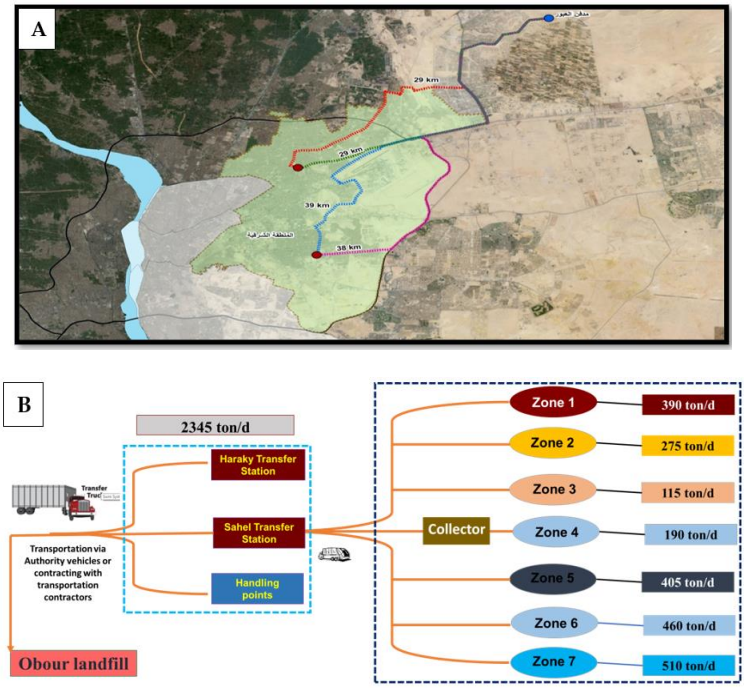

Fig. 12. (a) Waste management phases for Northen area (map) and (b) Waste management phases for Northen area [25].

3-1-2-2 Area B Strategy

Transportation from neighborhoods in the eastern region using dump trucks and residential collection contractors to handling points and then transporting directly by cabsa trucks The final disposal site in transit or the proposed landfill in Geneva or the tenth according to the approval of the armed forces, as shown in Figure 13.

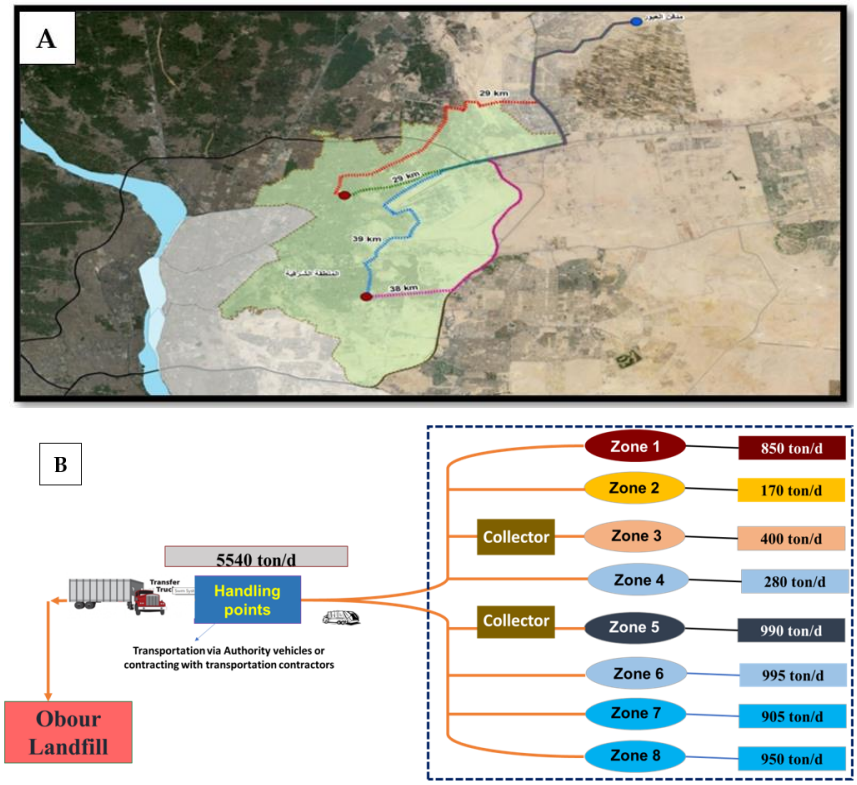

Fig. 13. (a) Waste management phases for Eastern area (map) and (b) Waste management phases for Eastern area(aerial view) [25].

3-1-2-3 Area C Strategy

Transportation from neighborhoods in the western region using dump trucks and residential collection contractors to handling points and then transporting directly by cabsa trucks The final disposal site in transit or the proposed landfill in Geneva or the tenth according to the approval of the armed forces, as shown in Figure 14.

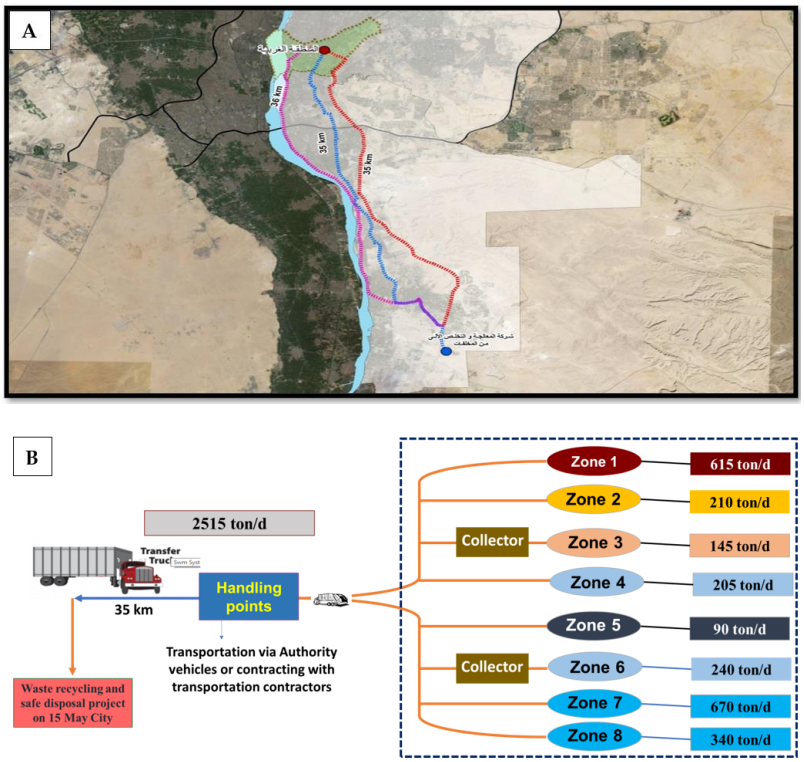

Fig. 14. (a) Waste management phases for Western area (map) and (b) Waste management phases for Western area [25].

3-1-2-4 Area D Strategy

Transportation from neighborhoods in the southern region using dump trucks and residential collection contractors to handling points and then transporting directly by cabsa trucks. The final disposal site in transit or the proposed landfill in Geneva or the tenth according to the approval of the armed forces, as shown in Figure 15.

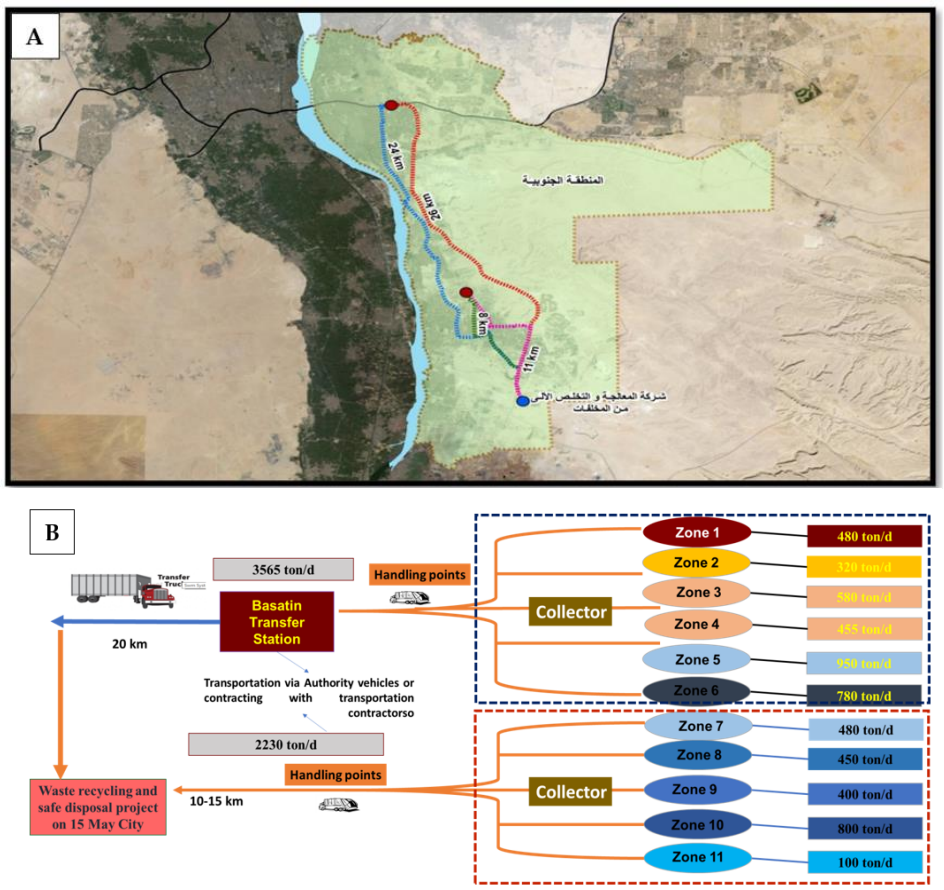

Fig. 15. (a) Waste management phases for Southern area (map) and (b) Waste management phases for Southern area [25].

4. The Proposed waste management plan to improve Great Cairo Region strategy

The proper management of solid waste requires dealing with it from the perspective of the integrated multifaceted, multi-component and interconnected system, and each phase must depends on the previous one, and at the same time represents the basis on which the aftermath is based, and in all cases, it is necessary at each stage to use appropriate and appropriate means to the prevailing conditions, available resources and existing limitations.

This means adopting the best options that meet technical standards, environmental safety, social compatibility, the lowest possible costs, the highest possible resource recovery, and compliance with legislation and regulations, while being flexible and responsive to future changes. Thus, it involves a context (or life cycle from cradle to grave) that includes successive stages, namely:

- Begin with the generation or reduction from the source, storage and collection from different sources and transport to suitable sites for phased storage or processing.
- Hence the possibility of retrieving recoverable resources that is suitable for a number of uses.

- Then final disposal in environmentally safe ways.

In addition to the technical and engineering considerations of the system, it includes many other aspects and considerations related to economics, social, planning, environmental, health, legislative and institutional factors.

The following figure represent the Proposed waste management plan to improve Great Cairo Region strategy in each phase.

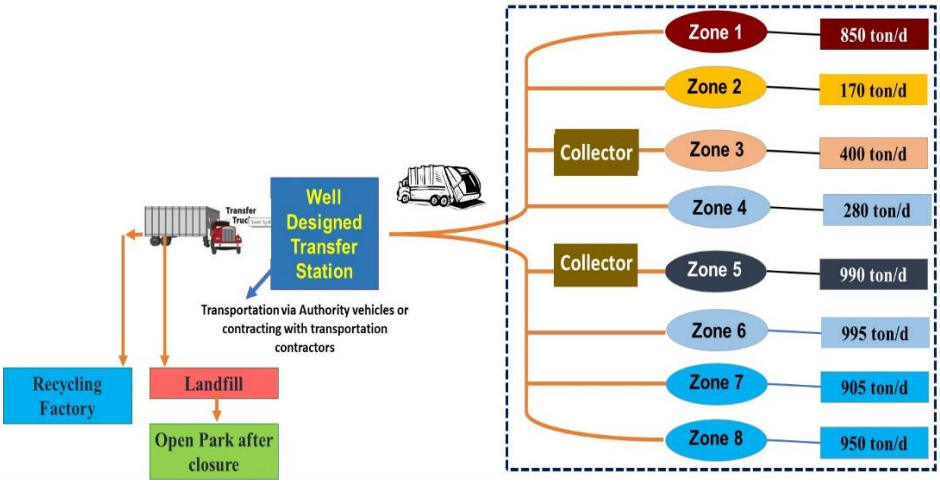

Fig. 16. Proposal for improving waste management planning for great Cairo region strategy.

SUMMARY AND CONCLUSIONS

The presented research study showed the different phases for waste management which affect the planning of cities specially the existing cities, which are waste collection, transfer station and landfill or recycling.

The research expanded the different understanding for each phase and the design creteia for each one, and developed an analysis for Great Cairo Region areas to evaluate its current situation in waste management. Moving forward the study presented a proposal for optimum waste management planning for Cairo Metropolis. The proposal would help achieving different goals like;

• Reducing the area required and required for the disposal of waste in light of the scarcity of state property and the preservation of land.

• Improving the built and aesthetic environment of Cairo Governorate.

• Optimal exploitation of the environmental and natural resources of Cairo Governorate.

• Increasing the economic return from solid waste recycling.

The research suggests directions for future research, namely; Waste management and green technologies for achieving clean and sustainable future. Pneumatic waste collection process and its contribution to new waste management technologies. New technologies that help in achieving sustainable waste management strategies.

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CONFLICT OF INTEREST

The authors have no financial interest to declare in relation to the content of this article.

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