Using Drone Technology Smart Waste Management in Reducing Municipal Solid Waste and Enhancing Society Recycling Rate

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Abstract- Fast industrial development and expansion in several portions of the earth have controlled to a rush in waste production. Presently, over 50 percent of the world's population has established into smart cities. Near 2030, an expected 60 percent of the population will move from rural to urban zones, on behalf of up to 1.5 billion populations. The town population is established to rise considerably by 2045 to 6 billion; by 2050, it is predictable that seven out of 10 populations will be living within town zones.

Last 30 years, the Kingdom of Saudi Arabia has verified financial growth and expansion rates corresponding by consistent directs of intake. It has indicated to an exponential raise in the capacity of municipal solid waste. Constant if the mass segment of this waste is recyclable, the inclination of residential to retain in the recycling of waste has so far constructed a minor influence.

The objective of paper, smart waste management is a new frontier for local authorities assisting in reducing municipal solid waste and improving community recycling rate. We must solve this problem by driving Drone Technology, manufacturing and their established approaches are redefined. Unmanned Aerial Vehicles (UAVs) have released their capacity in the Smart Waste Management industry still again and have confirmed to be the most efficient, virtual tool.

We have driven a drone program smart waste management to provide exact and real-time data of your smart waste's progression and throughput. Drones are not only seeking your waste management, but also save the environment. The objective of zero waste is to decrease and finally destroy smart waste and smart waste management.

Keywords- Drone Technology, Smart Waste Management, Municipal Solid Waste, Recycling Rate and Unmanned Aerial Vehicles.

1. INTRODUCTION

The Kingdom of Saudi Arabia (KSA) is occupied concerning executing Vision 2030. Opened in 2016 [1], Vision 2030 denotes a roadmap of community, commercial, and constitutional renovation for KSA. Imagined by the Crown Prince of Saudi Arabia, Mohammed bin Salman, at the focal point of Vision 2030 keeps the goal of sustainability, which involves, between others, the motivation regarding waste management and recycling. Recognition of the value of recycling is general throughout the Saudi culture. Appropriately, a vast amount of extremely actual profitable/official regions waste recycling procedures have been executed around KSA over the last few years. Nevertheless, the waste management of homes, containing recycling, is still yet to be adopted in a planned approach. Distinctly, seeing the limit of socio-economic progress and development that KSA has verified over the last 30 years, the basic of installing either a republic or urban direct domestic waste recycling procedures and strategies is certain. KSA delivers around 15 million tons of municipal solid waste per annum at an everyday rate of 1.4 kg per individual [2]. Through the raise in the population of KSA, it is probable that this amount will be dual to 30 million tons yearly by 2033 [2]. Families are the primary supply of solid waste generated by people. However, tied if the mass portion of this solid waste is recyclable, in commonly, families do not connect in gathering and separating that waste. In the situation of the wide discussion on helping domestic waste management, the impartial of this research paper is to classify and observe the constraining and smoothing issues that control whether and how families involve in the assortment and isolation of recyclable solid waste, despite the nonappearance of a top-down city equal domestic solid and recyclable waste management strategy. To report this composite request, in link with the study model included in Figure 1, the plan intellectual method [3] was working to classify the factors of the equal of visit in solid recyclable waste assortment, isolation, and logical

disposal between families. The observed emphasis of the analysis was pointed at the town of Abha, KSA, which is presently facing instant socio-economic progress and improvement [4]. In Abha, no domestic recyclable waste gathering management has been in place. In its site, there is only a routine waste isolation procedure supervised at the municipal landfill. The outcomes of this research paper advise the succeeding: Primary, there is huge capacity in retaining people in waste isolation and removal. Next, the hypothetical commercial benefits from isolating, gathering, and recycling solid waste can balance the price of its gathering and systematic clearance [5]. Here showing the study model:

1.1. The Study Model

1.1.1. The Problem

Smart waste management is an original limit for community authorities support in reducing municipal solid waste and developing municipal recycling rate. Development models to growth in waste production suggestion at the necessary of recycling. Yet if the mass of sold domestic waste is recyclable, regularly, removal of top-down controls directing these results, undermines the prospect of recycling exist to progress domestic waste separate & recycle.

1.1.2. The Question

What is the possibility and the methods of improving family's involvement in recyclable waste gathering, separation, and throwing away in a circumstance empty of a top-down city level smart waste management plan?

1.1.3. The Method and Materials

Desk-research Literature review, association, and analysis (Abha, KSA) Purpose intellectual and ideation methods Landfill regions, Work spots for UAV in WDS management, linear material Economy, Circular Economy, Design Imagining problem solving process Describe and Ideation Methods and Materials.

1.1.4. The Outcomes

The bulk of families are ready to separate recyclable waste, delivered that either a recycling bin is existing in their locality, or a planned gate to gate recyclable waste gathering pick up are choice: Drone, Linear) economy, Circular economy, Describe, Ideation stage and Zero Waste Network Model Findings.

Unmanned aerial vehicles (UAV) have developed general devices for achieving crucial investigative information in numerous areas. Corresponding to universal developments, the number of unmanned aerial picture imaging information is raising highest significantly in the building and drilling productions, as well as in farming and solid waste detection (Smart Drones, 2018) [6].
At the similar programme, UAV are broadly applied in waste management, specifically for gathering information on solid waste domestic and landfills. Still, in times of UAV product, the waste management production is yet distant after, when evaluated to building and dig scanning. In Abha, KSA, instances of the assistance of drones for seeking deposits and solid waste landfills stay rare and remote among. So, we have doing work in this research.

It is significant to recognise that there is a substantial break among the manufacturing training of retaining UAV to crack waste management difficulties (which we today have extensive real-world knowledge doing) and the presence of identifications on unmanned aerial picture imaging in technical journals [7]. Despite, the statistic that the increasing numeral of accounts on the practice of UAV for resolving waste management problems displays a cumulative drive in the technical works, there is a confident stay between the technical municipal in investigating the extensive apply UAV in the ground of waste management [8]. The aims for this gap involve isolated standalone research by authorities in the viewpoint of discipline. The fast growth of remote sensing machineries at the try of the 20th and 21st eras set the technical municipal of authorities in the ground of waste management in front of very problematic duties of adapting important volumes of information got by approaches that are very diverse from standard single – the detail, with which it cannot entirely survive active to now. So, a solution, clients only find a restricted response to the real tasks and requirements of manufacturing procedure [9,10,11].

In this paper, we have discussion about five sections. **First** section has introduction of waste recycling procedures have been executed around KSA over the last few years. **Second** section covers a literature review of the exactly run in the current discussion on the varied features of waste management and components manipulating contribution in recyclable waste gathering between families, founding the environment of this findings. **Third** section proposals a vision into the methods and methodology underlying the analysis. **Fourth** section specifies of the examined division of the outcomes are acquired. In **final** section displays the results of the analyse. Other details display result discussion and conclusion.

2. LITERATURE REVIEW

Study on Smart waste management, containing recycling, maintains to increase. Numerous ways and scope in the developing discussion can be detected. These involve, respectively, like industrial results and requests connected to domestic, municipality, hospital, and manufacturing waste management [12–14]. A material separates of the associated literature arrangements with the matter of individual categories of waste, i.e., plastics, solid and non-solid waste, [15,16], bio- and food waste, paper, metal, [17–19], medical waste [20], e-waste [21], etc., and the important associated to their separation and removal. Now, due to the features of a waste classification, different concerns are presented. These involve, for example, the ecological and municipal strength effect of the unsuitable loading of plastic waste [22]. In a related element, e-waste, i.e., waste containing of electronic machines [20] stimuli issues of, on the one hand, ecological influence, and on the other hand, of moral and publicly sensible matters associated to e-waste separation.

A special objective, study focusing the challenge of smart waste management approaches loaded and allocated visions into the specificities of smart waste management in decide on countries, zones, towns, municipalities, and rural regions [23,24]. These, commonly observe determined publications approach attracting visions into the behaviours we should achieve alter around smart waste management in the creating and in the progressed humanity [25,26]. The otherwise exact impactful argument on smart cities [27,28] has also generated subjects of smart waste management in urban and rural areas [29,30]. The dimensions of municipal agencies to assemble supplies, protected logistics, and organize peoples shows an essential part in this procedure [31–33].

To be further individual, observing the demand of participation, a solid volume of study observing the industry area's/manufacturing's task in waste production, or the waste establish exited by domestics [34,35] occurs. Particularly, the view of require (production) look after to abstracted and analysed through the main function of municipalities in the gathering and removal of waste [36]. Certainly, a valuable portion of study on smart waste management worries the peoples and families' activities. Now, the issue of influences changing (delaying/helping) the tendency of families to connect in ecologically balanced systems linked to family waste isolation and removal [37] is fundamental. Concerning the Arabian Point, the literature on smart waste management is closely filled by papers detailing about Saudi Arabia [38]. The further assess of this component of the literature is that it describes the socio-cultural specificity of KSA and approaches greatly appreciated visions into an open diversity of matters relevant to smart waste management in KSA. Conversely, we are direct primarily on the task of solid waste, food waste and plastic waste in Saudi Arabia [39].

Even though apply of drones at waste disposal sites (WDS) has an extra than 10 years history, the involved product of these technologies has grown in the preceding 4-5 years. Numerous foodstuffs and products are tough or incredible – or even risky – to recycle or fertilizer, production them tough and expensive for municipalities to succeed securely. Plastics have particularly extreme environmental expenses, due to the pollution from generating oil and gas and managing petrochemical feedstocks [40].

Some countries developed gradually worried about the environmental influences of this preparation. Fronting extensive pollution and an excess of 60-70 billion tons of waste, China broadcasted that it would no longer agree most introduced round and recyclable resources opening in 2018. China's declaration was followed by similar policies in Malaysia, Vietnam, and Thailand.[41]

Since some countries started applying their waste import limitations, U.S.A. recyclers have been gone to contract with vast amounts of resources that are deficient domestic end-marketplaces or for which product standards have

dropped. As an outcome, numerous recyclers have knowingly improved how much they control municipalities to revenue their recycling. This has caused numerous municipalities across the country to jump to bound their recycling plans or to close them overall.[42] The COVID-19 pandemic makes worse this movement, unstable forms of smart waste production from the marketable to domestical area while further damaging municipal funds. Since March to April of 2020, waste, and recycling together in U.S.A. municipalities was active an average of 20 percent even as closely 90 control cross recycling plans were closed.[43]

3. THE METHODS AND MATERIALS

In this paper, a regular evaluate of periodicals applied to the behave of UAV for monitor and management of Waste Disposal Solid (WDS) was controlled. Additional purposes for UAV in extra waste management areas (containing dynamically initial areas such as observing sea disorder, shore waste or tracing sea toxic waste) are not studied in this article.

WDS were classified as controlled waste landfills (healthy landfills), measured and wild open throws, waste bundles, as well as other specific waste.

3.1. Work spots for UAV in WDS Management

Founded on analysis of the mechanism, collections of related jobs that can be proficient consuming unofficial aerial picture tomography were recognised (though in one effort, jobs of changed collections could be measured, so some journals were occupied into version recurrently and the quantity of ratios for all collections twisted).

3.2. Recent drawbacks and chances

The problems to wide run of UAV in the preparation of landfill organisation are well recognised to be deficient governmental rules, working restrictions of sunny and ultralight UAV in relations of aeronautical period and shipment, and finally, the comparative extreme charge of highest-quality involved sensors [44]. At the identical point, it can be expected with certainty that all these restricting components will reduce every time as latest governmental standards and technological.

Put off out huge volumes of material – almost 1.5 million mashes each period. Mainly material is landfilled or destroyed. To supply the nonstop requirement for fresh wasteful produce, manufacturing obtain more and more environmental supplies. Isolate, supply, destroy, landfill, domestic or destroy, and restate. This scheme is called a “direct raw material reduction” and is broadly a one-scheme method road that transforms ecological supplies into waste and pollution.

3.3. The linear material Economy is at the source of ecological opposes.

The direct intake and wasteful approach provide to several of the domain’s most valuable ecological effort. The actions it enables – obtaining properties, manufacturing products, arranging of smart waste management, and moving resources at each phase of the procedure – together create some percent of greenhouse gas productions, causing extensively to the atmosphere disaster. It is shown in below figure 1.

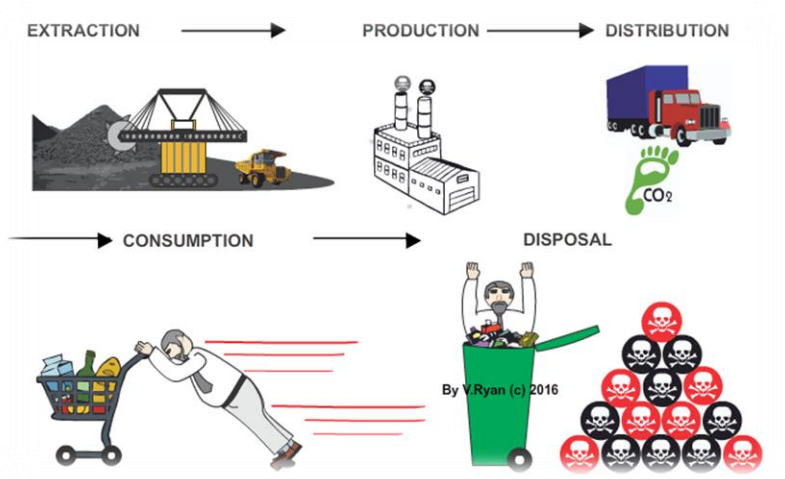

Figure 1: In a linear materials economy, resources are extracted and ultimately landfilled or destroyed.

Our direct reduced also generates air, sea, and ocean effluence, underwrites to the harm of natural fields and environments, and reduces natural properties. Numerous goods and resources are tough or incredible – or even risky – to recycle or fertilizer, production them tough and expensive for (MSW) Municipal Solid Waste towns to succeed securely. Plastics have particularly extreme ecological costly, due to the pollution from manufacturing oil and gas and handling petrochemical feedstocks.

Since this scheme is so injurious to our health, atmosphere and upcoming – why does the Abha city yield, consume and put out more and more resources in this way each time? The main purpose is that the creators and clients that initiative this scheme do not accept the complete cost or concern for the influences of the goods they create or accept, so they have no straight, economic incentives to save or to move to fewer injurious observes.

3.4. Producer concern systems incentivize a change to a Circular Economy

Plans have occurred for years in the Abha in KSA and in a different place that obtain to create producers accountable for waste management. These manufacturer accountability plans change concern for removal of waste materials from MSW municipalities to manufacturers, either by needing manufacturers to gather their goods at the last of their time, needful them to compensation for the assembly and removal procedure over dues compensated to a producer accountability society that gathers and procedures resources on the producers' behalf, or a grouping of mutually. It is shown in below figure 2.

Figure 2: In a circular economy all materials are reduced, reused, repaired, recycled.

Requiring producers accountable for the maximum rates and effects of their materials – from removal to disposal – be incentivize them to remove to fewer risky and valuable methods. Organizing so can support make a "circular" or "locked loop" economy. In a circular economy, zero smart waste is landfilled or destroyed – all resources are recycled, changing the take for removal actions.

The findings manufacturers create in suggesting materials decide the level to which those waste materials can be recycled or used and support model the influence on the environment when those materials are prepared of.

Presently, MSW municipalities – consuming duty charge – accept most of the expenses of smart waste gathering and removal [45]. Manufacture creators responsible for the complete environmental and community health prices of their smart waste materials – from removal to manufacture to deletion – being incentivize them to reformat their waste materials. We will be more probable to apply recycled in its place virgin waste materials and to construct less uneconomical and less dangerous effects. This change would transfer Abha KSA toward a rotary economy that preserves natural supplies and natural regions; reduces air, water, and global warming toxic waste; and generates zero smart waste materials.

3.5. Design Imagining problem solving process for Smart Waste Management: Describe-

It gives a transparent knowledge of the problems, tasks, requirements, favourites clients and prospects to reside on these. The aim of this segment is to describe illegal problem statements and establish the happening faces and those that will require to be selected into issue. In this paper iterative assessments and planning were operated among group members. To this finish, the idea chart [46] and the corporation process model were established. For the idea chart, was used to draft the smart waste gathering procedure; the major ideas associated to the modern environment are illustrated in figure 3.

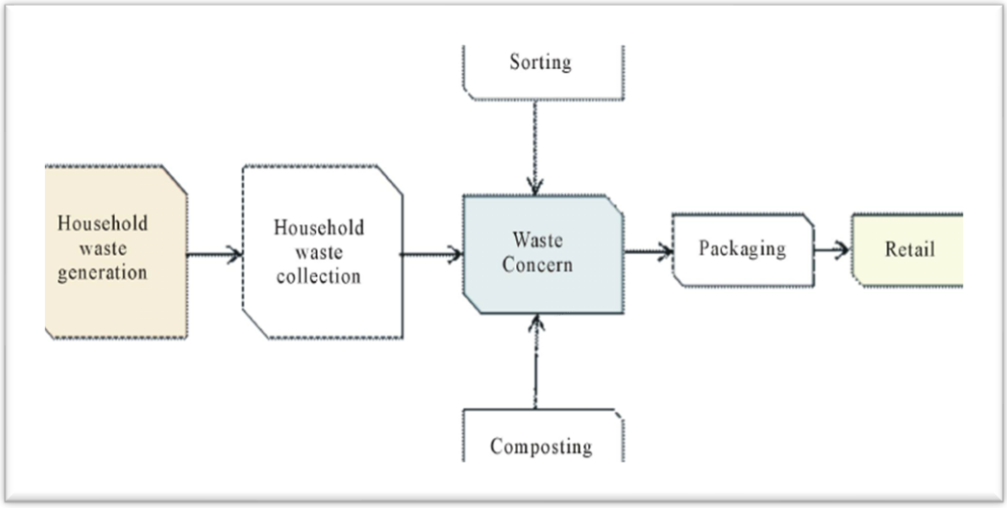

Figure 3: Idea chart of the recyclable smart waste management framework

The primary key issues involved the challenges that require to be adopted, logistics, and action taken. In this model, was used to imagine the recyclable smart waste management, which enables the extra scoping of the challenge in the modern framework. Figure 4 shows the order of actions in the recycled smart waste management from families in Abha. The procedure began by gathering recyclable smart waste from the locality's tank via municipal transportation vehicles. Afterwards, the smart waste is cleared and reduced into twenty times fewer amount, which is the initial phase of the procedure. Successively, it is released to the landfill by heavier vehicles, and the reduced smart waste dump is counted the second phase of the procedure. In the last phase, smart waste is separated through being automatically ordered into two pieces. In the method of automated ordering, smart waste is placed on a conveyor ring that passes through several steps. The first step includes paper puffing (for gathering paper), tracked by magnetization (for gathering minerals), and the smart waste that influences the last of the ring contains of materials that have no charge and are changed to backfill—first as spoiled stays that are occupied in, and next, as materials compressed into blocks that can be traded.

3.6. Design Imagining problem solving process for Smart Waste Management: Ideation-

When the problem is distinct—this involves not only the list of troubles but also a list of possible explanations—under well cases and in a competently set-out research environment, perceptions on how to steer the problem at hand is begin. All initiatives from all respondents are accept and involved in the ideation group. To design the explanation, the design intellectual does not choose one idea and reject another; in its place, all ideas are appreciated in observation of solving other qualities of the problem. This stage is an iterative aspect procedure, where certain proposals require to be tested with and reformed corresponding to prompt response until a sufficient and natural solution is identified [47]. During this stage, the group recognized the problem of emerging an explanation without the authority of an approved organisation to gather the recyclable smart waste. Here engage an approved group, in the second iteration of the design imagining process, two discussions (Linear and Circular Economic) were directed with the agents of two not-for-profit corporations that gather recyclable objects and reusable materials. There are two organization handle it, first one is the KAU Endowment organization. This organization functions are recycling, enterprise controller, recycling implementer (Approved group to gather and trade non-commercial recyclable smart waste for social properties), and the second organization is Mawakeb Alajer that's a charity organization) functions are receive recyclable smart waste as contribution to sell again to persons or recycling corporation to help resident foundlings. Afterwards, the KAU Endowment agent was requested to be a sponsor. This caused in an instant returning of both the describe and ideation stage. Figure 4 demonstrates this modification to the plan by drone technology.

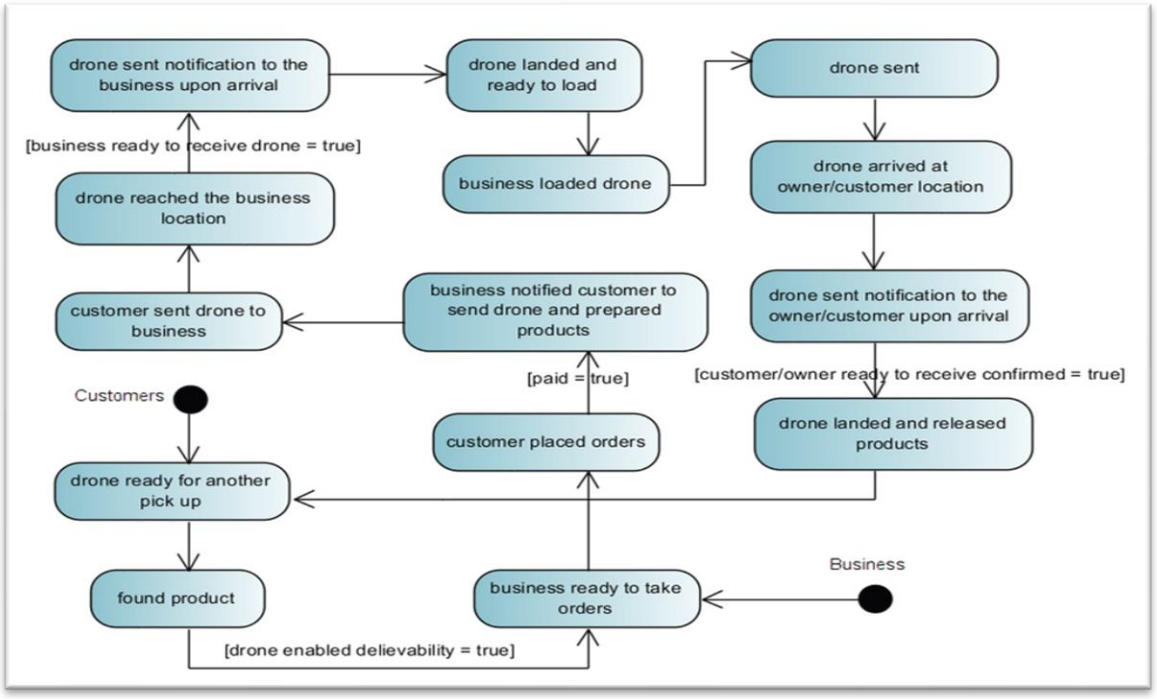

Figure 4. New Business Process Model for Municipal Solid Waste Management Collection with Drone Technology in Abha

4. THE OUTCOMES

4.1 Drone Observing

Even though the first involvement using UAV at WDS was allocated with the scientific society more than a period back, operating findings of the abilities of UAV in organisation WDS have initiated only in the last 4–5 years. This technology's application in manufacturing for an extended period was meaningfully fast of its use in science, but a few years back this condition ongoing emerging, and in the close upcoming we can suppose a stable growth in the number of scientific mechanisms dedicated to the use of UAV.

4.2. Direct (Linear) Economy Decision

In a direct market, after a product's cost has been separated, the expenditures of its removal are normally distributed. Until a few years back, America recyclers would arrange out the most precious materials from the recycling flow and transport the remaining mixed, lower-value bundles of recyclables to other countries. Approximately one third of composed America recyclables were distributed, with half of that material going to other country – 800,000 tons of plastic in 2017 only. The America considered this distributed material as recycled, but in certainty, other countries were removing the materials that they could economically recycle and landfilling and destroying the rest.

4.3. Circular economy Decision

Creation manufacturers sensible for smart waste is a vital phase toward a rotary economy. Applicable strategies can incentivize manufacturers to reduce their use of covering and construct products that are less dangerous, developed to last, and are simple to restore, recycle or compost. The Federal authority and individual states should apply rules that create manufacturers accountable for the smart waste produced by their products. Such plans are specifically main for products that are dangerous, challenging to recycle or compost, or that produce a lot of smart waste. These consist of batteries, mercury thermostats, mattresses, carpet, insecticides, drains, pharmaceuticals, paint, electronics, packaging, and fabrics.

4.4. Describe Retrieving

It is decisions restrictions for scoping the problem:

Decision 1: The two primary aspects that support domestic involvement in recyclable smart waste gathering are a recognition of the performs recycling has on the environment and the procedure of a regular recyclable smart waste gathering facility.

Decision 2: The expense of moving recyclable smart waste is a difficulty for specific individuals. Thus, studying the cost distance for recyclable smart waste transportation and producing feasible solutions to include this price could assist solve this problem.

Decision 3: Roughly charities are producing sponsors from offering recyclable smart waste in smart cities. Moreover, various charities are offering motor vehicle and containers to transport recyclable smart waste. While concluding the accurate number of these enterprises is not feasible, the range of these enterprises implies that there is a capability for economic revenue.

4.5. Ideation stage Decision

The corporate procedure model summarized in Figure 5 directs the legal condition for cooperation with the KAU endowment, as legal approval is needed from the Abha Municipality to selectively offer domestic recyclable smart waste. The KAU endowment is supporting in controlling the transportation route too. In conditions of domestic involvement, the authority of the procedure was displayed by figures.

5. RESULT DISCUSSION

To begin applicable plans that make manufacturers accountable for smart waste, representatives should follow these appropriate methods:

1. To begin a smart waste pyramid and manage effective that rules arrange the more-desired results over the less-desired. Initially and primary, to decrease the amount of smart waste produced. To recycle, restore and renew products whenever probable. To recycle or fertilize all staying materials. To landfill and destroy as little as feasible.

2. To involve producers to start active gathering, recycling and composting systems for products that do not presently have them. To set growing supplies for the percentage of allocated products that must be gathered.

3. To involve producers to give fees that include all their products' end-of-life expenses, involving smart waste gathering, transport, recycling, composting, landfilling, burning and waste cleanup expenses. The fees have also covered the directing prices of the entity that sets, gathers, and issues these fees and the inclusive prices of the supervising agencies.

4. To involve producers to use recycled matter in their results to make sure that recycled materials are reused in the direct market. Adding the gathering and recycling of materials only decreases smart waste if the recycled materials are used. Applying recycled materials decreases the require removing new materials and closes the ring in the rotary economy.

5. Ideation Stage Decisions to Design the Solution

It has illustrated the procedure model for moving recyclable smart waste. This model has formed following a thinking and selection step in the ideation stage. The result of this stage arrived in the form of a model procedure that can be used to handle smart waste moving via mobile application.

6. Waste Network Model

Zero Waste processes have organisation and supervising outcomes and systems to systematically check and remove the largest and poisonousness of smart waste and materials, reserve, and retrieve all assets, and not smart or cover them. Zero Waste Network Model process shown in below figure 5.

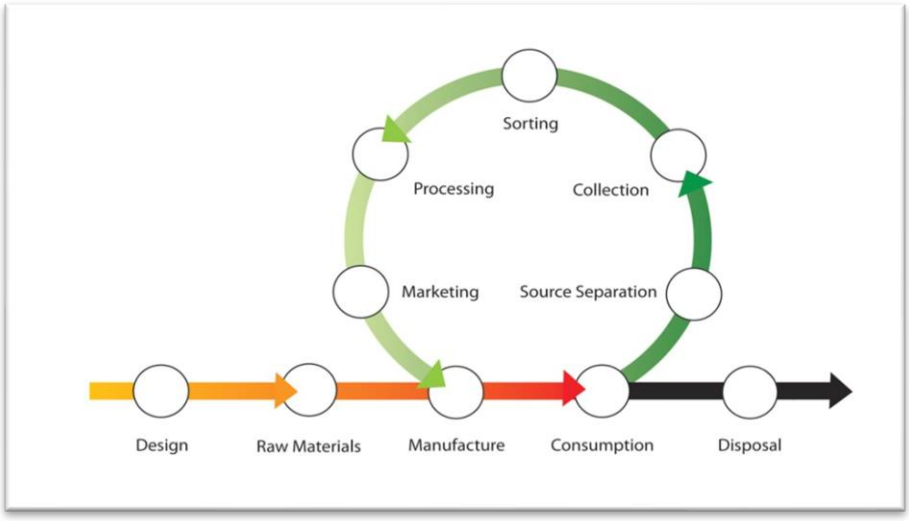

Figure 5: Zero Waste Network Model (linear economy and circular economy)

At last, all outcomes, result analysis and models are concluded in zero waste framework model. A zero-waste ecosphere is one where properties are assessed, and nothing is smart wasted. The objective of zero waste is to decrease and finally destroy smart waste and smart waste management. Like Zero Waste has minimises waste, reduces consumption, maximises recycling and ensures that products are made to be reused, repaired, recycled, or composted.

Table 1: Area analysis of different Landfill regions and different very extreme for Smart Sloid Waste Management

MSW appropriateness Regions	Pixel total	Regions (Km')	Percentage of Regions
Very Less	78145	71.33	8.25
Less	171056	154.95	18.13
Moderate	263411	238.07	27.96
Extreme	273839	247.46	29.06
Very Extreme	203661	184.2	23.4
Very Extreme-1	33534	30.28	16.8
Very Extreme-2	35879	32.39	18.01
Very Extreme-3	30955	27.96	15.47
Very Extreme-4	26895	24.31	13.37
Very Extreme-5	20001	18.1	9.81
Very Extreme-6	16421	14.88	7.96
Very Extreme-7	15237	13.81	7.35
Very Extreme-8	10228	9.31	4.78
Very Extreme-9	8519	7.76	3.86
Very Extreme-10	5992	5.4	2.59
Total Very Extreme		184.20	100

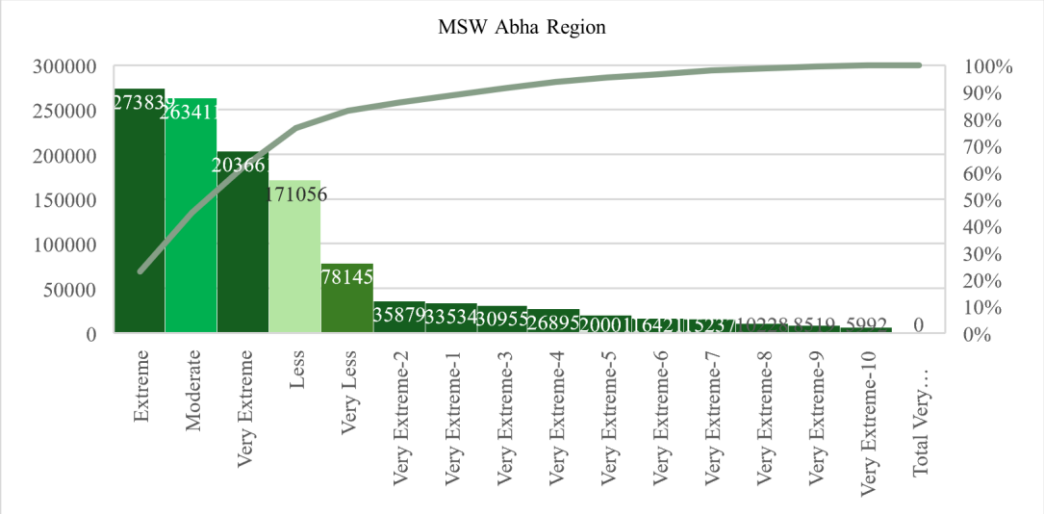

Figure 6: Area analysis of different Landfill regions and different very extreme for Smart Solid Waste Management

Table 1 and figure 6 show the comprehensive outcomes of this grouping, delivering detailed statistics on the Municipal Solid Waste (MSW) appropriateness regions, containing pixel count, area in square kilometres, and the percentage of total areas protected by individually region. The very less region involves a range of 71.33 square kilometres, indicating 8.25% of the total region. The less region appearances 154.95 square kilometres (18.13%), tracked by the moderate region with 238.07 square kilometres (27.96%). The extreme appropriateness region covers 247.46 square kilometres (29.06%), while the very extreme appropriateness region incorporates 184.2 square kilometres (23.40%).

Further assessment aims on the sub-regions within the very extreme appropriateness region, presenting extra visions into the magnitude alternatives. Each sub-region, from very extreme-1 to very extreme-10, has been indicated by its pixel count, area in square kilometres, and the percentage of the total very extreme appropriateness region it characterizes. For example, the very extreme-1 sub-region involves of 33,534 pixels, containing a region of 30.28 square kilometres, which descriptions for 16.80% of the total very extreme appropriateness region. As we improvement through the very extreme-2 to very extreme-10 sub-regions, the pixel count and region regularly reduce, directing an improving magnitude of appropriateness. Likewise, the classification of these sub-regions within the very extreme class accepts for a more enhanced evaluation. The best magnitude sub-regions, such as very extreme-10, indicate areas highly appropriate for landfill organization. Equally, areas dropping within the reduce magnitude sub-regions, from very extreme-1 to very extreme-6, involve affected management procedures to improve their appropriateness. By controlling consideration to these individual regions, participants can implement approaches adapted to improve their appropriateness, possibly carrying them into the highest region for landfill region. General, the comprehensive assessment of the MSW appropriateness regions requires a systematic identifying of their longitudinal allocation, scale alterations, and listing for landfill regions. The visions added from this assessment provide as valuable direction for decision-makers and participants interested in Smart waste management and city planning. They allow advised decision-making based on the appropriateness of various regions within the finding's region, assisting the concern of active Smart waste management approaches.

6. CONCLUSION

Drone Technology has extended a new level to the involved manufacturing of Smart Waste Management. Drones have redesigned established finding and assessment approaches to initiate a more effective and on-economical strategy to control day-to-day movements. Smart Waste management groups no longer demand someone with far-incredible expertise and drone instruction. A modest drone driving lessons with detailed apply to help you in getting a licence too! can be capture real-time and exact data to produce this method more capable and environmentally well disposed. It's never too delay!

Set enhancing conditions for the percentage of gathered smart waste management materials that must be recycled, restored, renewed, reprocessed, or composted.

Alternative method of thinking about it is in relations of a circular economy, where resources are applied again and again, as opposed to the linear economy where resources are removed, used, and finally end up being disposed of in landfill (also used this method other countries, being burned).

Area analysis of different Landfill regions and different very extreme for smart solid waste management, which recover the identifying of features affecting the regions appropriate for municipal solid waste. This combined method enabled tough, transparent decision-making procedures, to detect into describe doubts and imperfect statistics. Our results determine the efficiency of these approaches, with the Landfill regions characterised into five appropriateness regions, ranging from very small to very extreme appropriateness. The high correctness of the model very less 71.33 square kilometres, indicating (8.25%) of the total range to very extreme appropriateness region incorporates 184.2 square kilometres (23.40%), and the complete region organisation represent an innovation in terms of exactness and consistency in the selection of landfill regions assortment.

Forthcoming research can attention on developing a mobile application by allowing social economy and assistance supply online. For allowing contribution with a reliability procedure, the investigate to identify a visible variance in the amount of smart waste gathered daily. A huge number of statistics is depicted through the plan imagining procedure, and it would be interesting to accept approaches from social study to examine statistics, conducting to further gaps and co-designing feasible results.

Conflict of Interest

"We declared no conflict of interest".

Data Availability Statement

Not applicable.

Author Contributions

Please state each author's contribution to this work, it can be up to several sentences long and should briefly describe the tasks of individual authors. e.g., Fatma Dafallah Mohamed Alhasan abstract and Introduction section, Nirmla Sharma, Olfa Ben Said and Ashwaq Aldhawi conducted the research, analyzed the data, and wrote the paper; all authors had approved the final version.

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REFERENCE

[1] “Saudi Vision 2030,” The Honor to Serve the Increasing Number of Umrah Visitors in the Best Way Possible, 2019. Available online: https://vision2030.gov.sa/en/node/11 (accessed on 2 January 2023).

[2] Ossama, L.; Manaf, L.A.; Sharaai, A.H.B.; Zaid, S.S.B.M. A Review of Municipal Solid Waste Management Practices in Saudi Arabia. J. Waste Manag. Dispos. 2020, 3, 209–215.

[3] Buhl, A.; Schmidt-Keilich, M.; Muster, V.; Blazejewski, S.; Schrader, U.; Harrach, C.; Schäfer, M.; Süßbauer, E. Design thinking for sustainability: Why and how design thinking can foster sustainability-oriented innovation development. J. Clean. Prod. 2019, 231, 1248–1257. [CrossRef]

[4] Municipality, J. About Jeddah City. Available online: https://www.jeddah.gov.sa/english/jeddahcity/about/index.php (accessed on 10 October 2022).

[5] Kawther Saeedi, Anna Visvizi, Dimah Alahmadi and Amal Babour, “Smart Cities and Households’ RecyclableWaste Management:The Case of Jeddah”, Sustainability 2023, 15, 6776.
https://www.mdpi.com/journal/sustainability

[6] Carrillo-Larco, R.M.; Moscoso-Porras, M.; Taype-Rondan, A.; Ruiz-Alejos, A.; Bernabe-Ortiz, A., "The use of unmanned aerial vehicles for health purposes: A systematic review of experimental studies", Glob. Health Epidemiol. Genom. 2018, 3, e13. Available online: https://www.cambridge.org/core/product/identifier/

S2054420018000118/type/journal_article (accessed on 14 February 2020). [CrossRef] [PubMed].

[7] G. Allen et al. "The development and trial of an unmanned aerial system for the measurement of methane flux from landfill and greenhouse gas emission hotspots Waste Manag", (2019).

[8] L. Fjelsted et al., "Assessment of a landfill methane emission screening method using an unmanned aerial vehicle mounted thermal infrared camera – a field study Waste Manag", (2019).

[9] Y.M. Kim et al., "Evaluation of error inducing factors in unmanned aerial vehicle mounted detector to measure fugitive methane from solid waste landfill Waste Manag", (2021).

[10] M. Messinger et al.," Unmanned aerial vehicles for the assessment and monitoring of environmental contamination: an example from coal ash spills Environ. Pollution" (2016).

[11] V. Nikulishyn et al. "Applying of geodetic methods for monitoring the effects of waste-slide at Lviv municipal solid waste landfill Environ. Nanotechnol. Monit. Manage", (2020).

[12] Cano, N.S.d.S.L.; Iacovidou, E.; Rutkowski, E.W. Typology of municipal solid waste recycling value chains: A global perspective. J. Clean. Prod. 2022, 336, 130386. [CrossRef]

[13] Van Fan, Y.; Jiang, P.; Hemzal, M.; Klemeš, J.J. An update of COVID-19 influence on waste management. Sci. Total Environ. 2021, 754, 142014. [CrossRef] [PubMed]

[14] Tulebayeva, N.; Yergobek, D.; Pestunova, G.; Mottaeva, A.; Sapakova, Z. Green economy: Waste management and recycling methods. E3S Web Conf. 2020, 159, 01012. [CrossRef]

[15] AlHumid, H.A.; Haider, H.; AlSaleem, S.S.; Alinizzi, M.; Shafiquzaman; Sadiq, R. Performance Assessment Model for Municipal Solid Waste Management Systems: Development and Implementation. Environments 2019, 6, 19. [CrossRef]

[16] Dilkes-Hoffman, L.S.; Pratt, S.; Laycock, B.; Ashworth, P.; Lant, P.A. Public attitudes towards plastics. Resour. Conserv. Recycl. 2019, 147, 227–235. [CrossRef]

[17] OECD. Improving Plastics Management: Trends, policy responses, and the role of international co-operation and trade. OECD Environ. Policy Pap. 2018, 12, 21. [CrossRef]

[18] Almasi, A.; Mohammadi, M.; Azizi, A.; Berizi, Z.; Shamsi, K.; Shahbazi, A.; Mosavi, S.A. Assessing the knowledge, attitude and practice of the kermanshahi women towards reducing, recycling and reusing of municipal solid waste. Resour. Conserv. Recycl. 2019, 141, 329–338. [CrossRef]

[19] Dronia, W.; Połomka, J.; J˛edrczak, A. Morphological composition of bio-waste collected selectively in towns and villages during autumn and winter. J. Air Waste Manag. Assoc. 2023, 73, 313–320. [CrossRef]

[20] Oelofse, S.; Nahman, A.; Baig, M.B.; Salemdeeb, R.; Nizami, A.S.; Reynolds, C. Food Waste Within South Africa and Saudi Arabia. In Routledge Handbook of Food Waste; Routledge: Abingdon, UK, 2020; pp. 207–224.

[21] ALucca, J.M.; Alshayban, D.; Alsulaiman, D. Storage and disposal practice of unused medication among the Saudi families: An endorsement for best practice. Imam J. Appl. Sci. 2019, 4, 1–6.

[22] Ravindra, K.; Mor, S. E-waste generation and management practices in Chandigarh, India and economic evaluation for sustainable recycling. J. Clean. Prod. 2019, 221, 286–294. [CrossRef]

[23] Giusti, L. A review of waste management practices and their impact on human health. Waste Manag. 2009, 29, 2227–2239. [CrossRef] [PubMed]

[24] Sharma, K.D.; Jain, S. Municipal solid waste generation, composition, and management: The global scenario. Soc. Responsib. J. 2020, 16, 917–948. [CrossRef]

[25] Calabrò, P.S.; Komilis, D. A standardized inspection methodology to evaluate municipal solid waste collection performance. J. Environ. Manag. 2019, 246, 184–191. [CrossRef]

[26] Yaman, C. Investigation of greenhouse gas emissions and energy recovery potential from municipal solid waste management practices. Environ. Dev. 2020, 33, 100484. [CrossRef]

[27] Galicia, F.G.; Páez, A.L.C.; Padilla, R.T. A Study and Factor Identification of Municipal Solid Waste Management in Mexico City. Sustainability 2019, 11, 6305. [CrossRef]

[28] Sinthumule, N.I.; Mkumbuzi, S.H. Participation in Community-Based SolidWaste Management in Nkulumane Suburb, Bulawayo, Zimbabwe. Resources 2019, 8, 30. [CrossRef]

[29] Visvizi, A.; Lytras, M.D. Rescaling and refocusing smart cities research: From mega cities to smart villages. J. Sci. Technol. Policy Manag. 2018, 9, 134–145. [CrossRef]

[30] Visvizi, A.; Mazzucelli, C.; Lytras, M. Irregular migratory flows. J. Sci. Technol. Policy Manag. 2017, 8, 227–242. [CrossRef]

[31] Yukalang, N.; Clarke, B.; Ross, K. Barriers to Effective Municipal Solid Waste Management in a Rapidly Urbanizing Area in Thailand. Int. J. Environ. Res. Public Health 2017, 14, 1013. [CrossRef] [PubMed]

[32] OECD. Financing Climate Objectives in Cities and Regions to Deliver Sustainable and Inclusive Growth; OECD: Paris, France, 2019. 26. OECD. Extended Producer Responsibility: Updated Guidance for Efficient Waste Management; OECD: Paris, France, 2016.

[33] OECD. Household Behaviour and the Environment: Reviewing the Evidence; OECD: Paris, France, 2008.

[34] Radwan, N.; Mangi, S.A. Municipal SolidWaste Management Practices and Opportunities in Saudi Arabia. Eng. Technol. Appl. Sci. Res. 2019, 9, 4516–4519. [CrossRef]

[35] Hadidi, L.A.; Ghaithan, A.; Mohammed, A.; Al-Ofi, K. Deploying Municipal SolidWaste Management 3R-WTE Framework in Saudi Arabia: Challenges and Future. Sustainability 2020, 12, 5711. [CrossRef] Buchanan, R.Wicked Problems in Design Thinking. Des. Issues 1992, 8, 5–21. [CrossRef]

[36] Razzouk, R.; Shute, V., "What Is Design Thinking and Why Is It Important?" Rev. Educ. Res. 2012, 82, 330–348. [CrossRef]

[37] Howlett, M.," Challenges in applying design thinking to public policy: Dealing with the varieties of policy formulation and their vicissitudes", Policy Polit. 2020, 48, 49–65. [CrossRef].

[38] Chen, S.-L.; Liang, T.; Lee, M.-L.; Liao, I.-C., "Effects of Concept Map Teaching on Students' Critical Thinking and Approach to Learning and Studying", J. Nurs. Educ. 2011, 50, 466–469. [CrossRef] [PubMed].

[39] Almasi, A.; Mohammadi, M.; Azizi, A.; Berizi, Z.; Shamsi, K.; Shahbazi, A.; Mosavi, S.A., "Assessing the knowledge, attitude and practice of the kermanshahi women towards reducing, recycling and reusing of municipal solid waste ". Resour. Conserv. Recycl. 2019, 141, 329–338. [CrossRef].

[40] H. Jouhara et al., "Municipal Waste Management Systems for Domestic Use," Energy, Volume 139, 485-506, https://doi.org/10.1016/j.energy.2017.07.162, November 2017.

[41] Muyu Xu, David Stanway, "China Plans to Cut Waste Imports to Zero by Next Year: Official," Reuters, 28 March 2019, available at https://www.npr.org/sections/goatsandsoda/2019/03/13/702501726/where-will-your-plastic-trash-go-now-that-china-doesnt-want-it; see also note 26.

[42] Cole Rosengren et al. "How Recycling has Changed in All 50 States," WasteDive, updated 15 November 2019, archived at https://web.archive.org/web/20200213230213/https://www.wastedive.com/news/what-chinese-import-policies-mean-for-all-50-states/510751/.

[43] Brian Love and Julie Rieland, "COVID-19 is Laying Waste to Many US Recycling Programs," Phys.org, 23 June 2020, archived at http://web.archive.org/web/20200626113718/https://phys.org/news/2020-06-covid-recycling.html.

[44] J. Burgues et al.," Environmental chemical sensing using small drones: A review", Sci. Total Environ. (2020)

[45] U.S. Environmental Protection Agency, Documentation for Greenhouse Gas Emission and Energy Factors Used in the Waste Reduction Model (WARM), March 2015, available at https://archive.epa.gov/epawaste/conserve/tools/warm/pdfs/WARM_Documentation.pdf; see also: Abigail Bradford et al., Frontier Group, Trash in America: Moving from Destructive Consumption to a Zero-Waste System, February 2018, p.12.

[46] Lebreton, L.; Andrady, A." Future scenarios of global plastic waste generation and disposal. Palgrave Commun". 2019, 5, 6. [CrossRef].

[47] Issock, P.B.I.; Mpinganjira, M.; Roberts-Lombard, M., "Investigating the relevance of the traditional marketing mix across different stages of change: Empirical evidence from household recycling", J. Soc. Mark. 2021, 11, 489–506. [CrossRef].

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