SYSTEMATIC REVIEW ON DIGITAL TOOL APPROACHES FOR COMPREHENSIVE URBAN WASTE MONITORING

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Recently Scientists found that more than 1,000 rivers distribute 80% of plastic waste. They also found that most of that waste is carried by small rivers through densely populated urban areas, bringing urban waste is one of the critical threats to urban area sustainability. The process of monitoring by using Digital tool approaches is the efficient way to handle these issues. This article provides a systematic review to see a comprehensive review of digital tool approaches in monitoring urban waste in urban areas. An indication of the urban waste issue alongside the rami*cation of the analysis is discussed. The collection of articles, manuscript, thesis, and other publication types on remote sensing, Geographical Information system (GIS) and crowdsourcing usage are compiled. At the same time, the diverse applications worldwide using digital tools are described. The finding shows that the approaches of digital tools can be maximised, especially on remote sensing and GIS approaches. Finally concluded the proof of the capability of digital tools in ensuring future earth sustainability and resiliency.

Keywords: Remote sensing, GIS, Plastic waste and urban waste

INTRODUCTION

An increase in urbanisation has resulted in an enormous amount of waste generation. More than half per cent of the world population lives in urban areas. It is expected that close to 70 per cent of the global population will be living in urban areas by 2050. Urban waste or municipal solid waste (MSW) is defined as waste collected by the municipality or disposed of at the municipal waste disposal site. This urban waste usually consists of all types of solid wastes produced by domestic and commercial enterprises. Such as textiles, plastics, paper, glass, rubber, metals, and kitchen waste are generally found in the MSW in developing countries (Hoornweg et al., 2015; Singh, 2019). The waste generated from urban areas is increasing at a pace double that of urbanisation itself. Thus, the waste generation will increase approximately two times by 2045. Currently, solid waste landfills in and around cities are contributing to high levels of air pollution, which harms the health of millions of people worldwide.

Additionally, as global population growth increases rapidly, the consumption of resources for material goods is skyrocketing. This creates an urgent need for us to rethink the way we dispose of waste in the cities. As a result, waste generation will increase by 70% based on the current level of generation. The overall global waste generation, which was 2.01 billion tons in 2016, is expected to become 3.4 billion tons in the next 30 years (World Bank, 2019). Urban waste includes liquid, solid, plastic, paper, tins and metals, ceramics, glass and demolition waste. The UNEP reports that globally, 22– 43% of plastic is disposed of in landfills, which have a limited capacity, thus increasing the costs of waste management and waste security over time. When looking forward, global waste is expected to grow to 3.40 billion tonnes by 2050, more than double population growth over the same period (World Bank 2021). Despite most plastic originating on land, plastic pollution is now one of the most severe threats for healthy marine ecosystem functioning. Most urban waste comes from a residential district, commercial area, and other sources. The sort of waste pollution which will be found are decomposable organic, paper, plastic, textile, glass, metals, rubber/leather, wood, ash, et al. Many rising growths of plastic waste came from the changing of lifestyle. Recently, all food packaging, bottles, glasses, and other wrapping are from plastics, which plastic waster gives other consequences in solid waste management.

The aforementioned problems of waste management could be effectively solved by using some geospatial techniques. During the previous couple of decades, researchers have extensively used remote sensing (RS) and GIS techniques to solve waste management problems worldwide (Martínez-Vicente et al., 2019; Singh, 2019; Youme et al., 2021). Traditionally, because of spatial and temporal restrictions, it was only possible for scientists to make inferences on the spatial distribution of litter based on small samples of data. Nowadays, hundreds of millions of people are equipped with incredibly accurate geospatial data collectors. It can be used to map and crowdsource geospatial data not just on plastic pollution, but to some extent, the litter caused by the products and economic activity of a handful of global corporations. Depending on the nature of projects and the data collection methods, this crowdsourcing of data is commonly referred to as Citizen Science and Volunteered Geographic Information (VGI) (Lynch, 2018). The digital tools via geospatial commonly used remote sensing and GIS approach to analyse the objects, events, or phenomena that have a location on the surface of the world, including location information. Which is typically coordinated on the earth, attribute information, and sometimes also temporal information. Such study would typically employ software capable of rendering maps processing spatial data, and applying analytical methods to terrestrial or geographic datasets, including utilising geographic information systems and geomatics. The geographic information systems (GIS) sector started as early because the 1960s were computed, and therefore the early concept of quantitative and computational geography emerged. The geospatial approach can widely use in several waste pollution studies.

The systematic literature review (SLR) is a systematic way of collecting, critically evaluating, integrating, and presenting findings from multiple research studies on a research question or topic of interest. It is “systematic” since it adopts a consistent, widely accepted methodology (Pati & Lorusso, 2018). Therefore, this paper reviews a comprehensive review of the digital tool approach in monitoring urban waste in urban areas. An indication of the urban waste issue alongside the ramification of the analysis is discussed. The articles, manuscript, thesis, and other publication types on remote sensing and Geographical Information system (GIS) are compiled. At the same time, the diverse applications worldwide using digital tools are described.

URBAN WASTE POLLUTION

Urban waste has been studied since 1964 and has been tackled under environmental aspects of studies. The other fields that studied urban waste are engineering, social sciences and earth and planetary sciences. Total 5160 publications related to urban waste for the year 2015-2022. This time includes the field of energy study but still most of the studies on engineering with 1071 total of publications. Urban waste pollution is waste by activity, and consumption by the urban population cause the generation of copious quantities of waste. Waste discharges, including industrial effluent, are the primary sources of pollution. The wastes originate from residential, commercial, and recreational areas, offices, and institutions, like hospitals and schools. They include food waste also as paper, batteries, glass, plastics, textiles, excreta aerosol cans, and far more (Biney, 1982; Mensah, 1976). Managing the quantity of waste poses a severe challenge to the town authorities, especially ensuring that the waste generated is collected for disposal. Urban waste pollutions are divided into three sorts of pollution which are land, air, and pollution.

These accumulated pollutants aren't only esthetically unattractive but also demonstrate the environmentally threatening and devastating effects on the performance of the urban system. A study conducted in Melbourne, Australia, has noted that urban areas contribute 20–40 kg of gross pollutants per hectare to the stormwater, like approximately 60,000 tons or 230,000 cubic meters of gross pollutants, with the generation of two billion plenty of litter annually. The growing population, built-up areas and industrialisation could directly or indirectly affect the hydrological processes. Eventually, the eroded sediment would be deposited within the waterways and contribute to the surface imperviousness.

Plastic waste causes a plethora of problems when it leaks into the environment. Plastic bags can block waterways and exacerbate natural disasters. Plastic bags can increase vector-borne diseases like malaria by clogging sewers and providing breeding grounds for mosquitoes and pests. High concentrations of plastic materials, particularly plastic bags, have been found blocking the airways and stomachs of hundreds of species. Plastic bags are often ingested by turtles and dolphins who mistake them for food. There is evidence that the toxic chemicals added during the manufacture of plastic transfer to animal tissue, eventually entering the human food chain. Styrofoam products, which contain carcinogenic chemicals like styrene and benzene, are highly toxic if ingested, damaging the nervous systems, lungs and reproductive organs. Plastic waste is often burned for heat or cooking in developing countries, exposing people to toxic emissions. Disposing of plastic waste by burning it in open-air pits releases harmful gases like furan and dioxin. According to a United Nations Environment report, the economic damage caused by plastic waste is vast. Plastic litter in the Asia-Pacific region alone costs its tourism, fishing and shipping industries $1.3 billion per year. In Europe, cleaning plastic waste from coasts and beaches costs about €630 million per year. Studies suggest that the total economic damage to the world's marine ecosystem caused by plastic amounts to at least $13 billion every year.

For the past five years, the number of publications on plastic waste in the scopus database stated the 17, 367 publications involving journals articles, books, book chapter, Conference proceedings, etc. Malaysia stated 94 publications that were mostly produced as research articles. Figure 1a shows the total number of publications since 2015-2022 based on scopus databases extracted in September 2021. While the publications on plastic waste studies using geospatial remote sensing and GIS recorded only 43 documents from 2015-2021. None of the publications is recorded for future 2022. The tabulation also can be referred to in figure 1b.

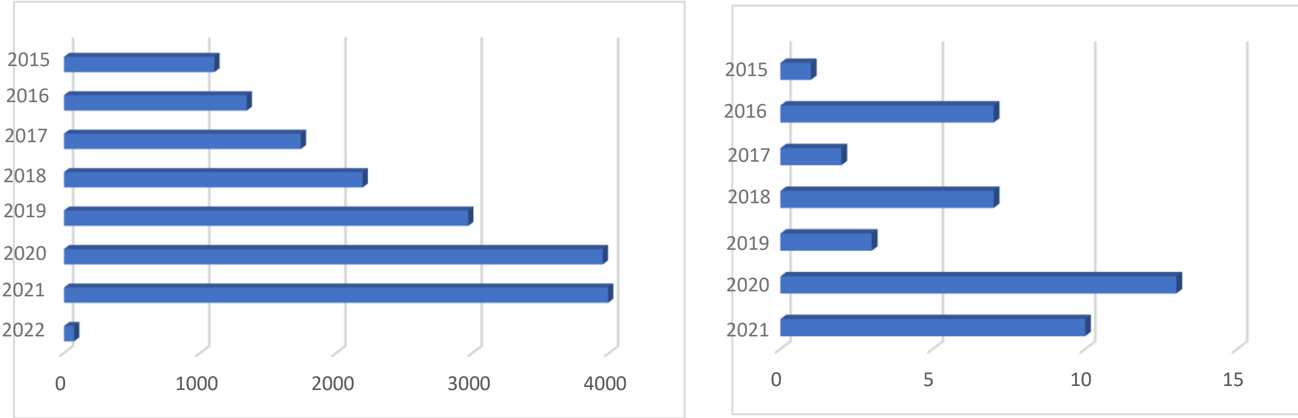

Figure 1: a) total publication on "Plastic waste" for year 2015-2022 in scopus database b) total publications on "Platic waste + GIS and remote sensing" for year 2015-2021.

DIGITAL APPROACHES FOR URBAN WASTE MANAGEMENT

The Digital approach is a rapidly growing area of development, deliberation, and reflection. Digital research, Internet research, online research, e-research, and e-science are concepts often used interchangeably. Although they are not identical, they all suggest the fast-developing and highly transformative role of information, communication, and networking technologies in conducting scientific study and research. Many areas can only be covered to a limited depth, whilst others have been omitted because they are not implemented in the current mainstream Geospatial Approach. The geospatial approach means operations such as map overlay, simple buffering, and similar basic functions.

During a previous couple of decades, researchers have extensively used remote sensing (RS) and GIS techniques to solve waste management problems worldwide (Hannan et al., 2015; Khan and Samadder, 2014; Rada et al., 2013; Vaskan et al., 2013; Arebey et al., 2011; Chang et al., 2008; Sener et al., 2006). These techniques provide essential support to effectively locating waste bins (Church, 2002). The potential benefits of using RS and GIS in the MSW (Municipal Solid Waste) organisation are manifold. For example, Ghose et al. (2006) developed an optimal routing approach for finding the economical and proficient accumulation ways for carrying the MSW in India. Similarly, Tavares et al. (2009) developed a GIS-reliant strategy to facilitate reduced fuel utilisation for MSW accumulation in Cape Verde. Ratnapriya and De Silva (2009) used GIS thematic maps of land use and socioeconomic characteristics to find the appropriate sites for constructing the treatment plants for non-point source pollutants. Sharma et al. (2011) successfully used geospatial techniques to evaluate land utilisation rate with a growing population.

Innovative geospatial technologies such as Remote Sensing (RS) and Geographic Information System (GIS) methods can be used for the allocation and utilisation of resources efficiently (Goel 2008). Both techniques are used for database design followed by database development and operation, which leads to the analysis of manipulated data. RS is used for sensing the earth surface, its environment and its resources without being in physical contact with it. RS can provide a synoptic view of a large area with the capacity of repetitive coverage (Nishant et al. 2010). GIS can be used for collecting, storing and recovering spatial data, which can then be transformed, analysed and displayed for various applications. GIS is being used in solid waste management because of its inefficiently relating spatial attributes to its operations. GIS deals with the time and cost of solid waste management in each step and allows evaluation and implementation of best management practices with various alternatives**.**

RS and GIS have been helpful in the allocation of a suitable site for solid waste. For example, vector GIS has been used to identify landfill sites (Basagaoglu et al. 1997), solid waste disposal sites in the Philippines (Cruz 1993), and animal waste application sites in Australia (Basnet et al. 2000, 2001). Kallali et al. (2007) focused that GIS and expert knowledge are used as a decision support system to determine adequate potential soil aquifer treatment sites for groundwater recharge of the aquifer. These sites are identified using a single-objective multi-criteria analysis (Chang et al. 2008). Geographical Information System (GIS) is a tool that can provide spatial and non-spatial information for urban planning and management. Typically, a Geographical Information System is used for handling maps of one kind or another. These might be represented as several different layers where each layer holds data about a particular kind of feature. Each feature is linked to a position on the graphical image on a map and a record in an attribute table. GIS allows us to view, understand, question, interpret, and visualise data in many ways that reveal relationships, patterns, and trends in the form of maps, globes, reports, and charts. The Geographic Information System (GIS) is recognised as one of the most promising approaches to analyse complex spatial phenomena. GIS has been successfully employed for various applications, such as geology, protection and management of natural resources, risk management, urban planning, transportation, and various modelling aspects of the environment. A GIS will also help us answer questions and solve problems by looking at your data quickly understood and easily shared way. GIS technology can be integrated into any enterprise information system framework. GIS allows us to create and store as many layers of data or maps as we want and provides various possibilities to integrate tremendous amounts of data and map overlays into a single output to aid in decision making (Chang et al. 1997).

GIS can be combined with Global Positioning System (GPS) and Remote Sensing (RS) in recording spatial data and directly using the data for analysis and cartographic representation (Chalkias and Lasaridi 2009). GIS has proved to be very helpful in reducing time and is also very cost-effective. GIS has applications in urban planning, transportation, protection and management of natural resources, forestry, natural disaster management, health services, environmental modelling and engineering (Brimicombe 2003). The spatial data in GIS may take two layouts, i.e., raster or vector. Every vector attribute is positioned to a similar arrangement in the vector layout, and charts are prepared for polygons or points. While, in the raster layout, the charts are ready for a cluster of lattice cells, with every cell have a shading value (Bishop et al., 2000). Table 1 shows the summary of various studies on urban waste using GIS and remote sensing.

Table 1: The various studies of Digital tool approaches on Remote Sensing and GIS for urban Waste Management

No	Types of digital RS@GIS	Technique	Type of data	Aspects of plastic	Country	Years
30	GIS	Short-wave infrared (SWIR)	JPL-ECOSTRESS, USGS and WorldView-3 (WV-3) satellite data	A challenge to identify plastics on terrestrial surfaces	Ghana, West Africa	2021
35	GIS	ArcGIS (ESRI, ArcGIS Desktop: Release 10.2.1.	Commercial satellite image	Household waste collection	Sfax city, Tunisia	2021
13	Remote Sensing	Sentinel-2 technique	Multispectral aerial and satellite image	Plastic pollution in coastal	Dublin, Ireland	2021
10	Remote Sensing	UAVs and GoPro Camera	EXIF timestamp and coordinate	Floating Plastic Debris at sea	Rotterdam, Netherlands	2021
23	GIS	The manual image screening strategy: and tagged with the OSPAR code number	Digital Surface Model and Orthophoto	Macro-litter on coastal dunes	Coimbra, Portugal	2021
2	Remote Sensing	MODIS and GLCNMO	Land use land cover (LULC)	Marine plastic waste	Bandung, Indonesia	2021
3	Remote Sensing	Sentinel-2 technique	Multispectral aerial and satellite image	Floating plastic litter	Limassol, Cyprus	2020
1	Remote Sensing	Sentinel-2, Landsat 5–8, and MODIS	QuickBird and Ikonos satellite images	Agricultural plastic mulch	Xinjiang, China	2019
6	Remote Sensing	Very high resolution (VHR) remote sensing	MLC and Iknonos images	Urban green plastic cover	Jinan, China	2020
8	Remote Sensing	Multispectral proximity sensor	Worldviews-2 satellite	Plastic waste in river	Bologne, Italy	2020
17	Remote Sensing	Worldview-2, Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) and Synthetic Aperture Radar (SAR)	Light Detection and Ranging (LIDAR) imagery and high-resolution commercial satellite data	Marine Plastic Debris in Bay Islands of Honduras	Caribbean Sea	2020
26	GIS	ArcGIS (ESRI, ArcGIS Desktop: Release 10.2.1.	ARGOS satellite transmitter	The movement of plastic pollution	Ganges, India	2020
26	GIS	ArcGIS (ESRI, ArcGIS Desktop: Release 10.2.1.	ARGOS satellite transmitter	The movement of plastic pollution	Ganges, India	2020
7	Remote Sensing	Sentinel-2, Landsat 8	QuickBird and Ikonos satellite images	Marine microplastic litter	Nothern Italy	2019
12	Remote Sensing	Copernicus Sentinel fleet and VIIRS and Landsat series)	Sentinel 2B Multi Spectral Imager	Marine Plastic Debris	Whitsand Bay, United Kingdom	2019
14	Remote Sensing	Thermal infrared remote sensing	Medium-wave infrared (MWIR) and long-wave infrared (LWIR)	Plastic pollution in natural waters	Aegean Sea, Greece	2019
18	Remote Sensing	Sentinel-2 technique	Unmanned aerial systems (UAS) and open-access satellite imagery	Plastic litter project 2018	Lesvos Island, Greece	2019
20	Remote Sensing	Synthetic Aperture Radar (SAR)	RADARSAT-2 data and dual polarimetric (HH, VV) TerraSAR-X data	Plastic-Mulched Farmland Classification	Hebei, China	2019
21	GIS	Multi-Criteria Decision Analysis (MCDA)	LISS-III satellite image	Solid Waste Landfills for Developing Townships	Burla, India	2019
29	GIS	Synthetic Aperture Radar (SAR)	COSMOS satellite by RKA Recosmos	The use of satellite technology of handling marine plastic debris	Jakarta, Indonesia	2019
32	Remote Sensing and GIS	Landsat 8 Operational Land Imager (OLI) and Landsats 4 and 5 Thematic Mapper (TM)	WorldView-2 satellite image	Detect agricultural land cover	Nanjing, China	2019
39	GIS	Landsat 8 and NDVI, NDMI	ASTER DEM satellite images	Site selection for solid waste disposal	Gondar, Ethiopia	2019

11	Remote Sensing	SEBAL and MODIS	Evapotranspiration (ET) and the water use in PML and NPML	Water-saving efficiency of plastic mulching	Northwest China	2018
16	Remote Sensing	Synthetic Aperture Radar (SAR)	COSMO-SkyMed, StripMap HIMAGE, Level 1B (DGM) images	Microplastic pollution in world oceans	Valencia, Spain	2018
19	Remote Sensing	Airborne shortwave infrared (SWIR)	Red, green, and blue (RGB) and hyperspectral SWIR imagery	Sensing Ocean Plastics	California	2018
27	Remote Sensing and GIS	Normalised differential vegetation Index (NDVI)	Commercial satellite imagery	Plastic waste in lake	Punjab, India	2018
34	GIS	Landsat-8 and phased array type L-band synthetic aperture radar-2 (PALSAR-2)	WorldView-3 (WV-3) satellite data	Plastic pollution due to landslide	Kelantan, Malaysia	2018
37	Remote Sensing and GIS	Landsat 8 and NDVI, NDMI	WorldView-3 (WV-3) satellite data	Pollution checking to the vehicles, reduced the plastic incinerations	Dharwad, India	2018
15	Remote Sensing	Fast line of Sight Atmospheric Analysis of Spectral Hypercubes (FLAASH)	Gao-Fen-1(GF-1) satellite image	Mapping Plastic-Mulched Farmland	Jizhou, China	2017
24	GIS	ArcGIS (ESRI, ArcGIS Desktop: Release 10.2.1. Redlands, CA: Environmental Systems Research Institute	ASCAT aboard the EUMETSAT METOP satellite	Marine debris on the seafloor	Casablanca, Morocco	2017
31	Remote Sensing and GIS	Normalised differential vegetation Index (NDVI)	Rapid Eye Satellite image	Collected traps for urban waste	Al-fayoum governorate, Egypt	2017
33	GIS	ILWIS 3.4 software, HEC-geo RAS and HEC-RAS) in ArcGIS 10 software	Commercial satellite image	Plastic bag used as equipment	West Java, Indonesia	2017
40	GIS	ArcGIS (ESRI, ArcGIS Desktop: Release 10.2.1.	ASTER DEM satellite images	Plastic waste contaminated the groundwater quality	Chennai, India	2017
9	Remote Sensing and GIS	IRS PAN, LISS II, the red and Infrared IRS WiFS Satellite	Indian IRS satellite image	Plastic container as mosquitos breeding habitats	Visakhapat nam, India	2016
38	GIS	ArcGIS (ESRI, ArcGIS Desktop: Release 10.2.1.	Commercial satellite image	Suitability study of existing location of waste collection bins	Kelaniya, Sri Lanka	2016
4	Remote Sensing	LANDSA-8 OLI/TIRS	High spatial resolution aerial/satellite	Agricultural plastic cover detection	Bari, Italy	2015
5	Remote Sensing and GIS	USGS Earth Explorer, Global Land Cover Facility and ISRO Bhuvan.	Landsat thematic mapper (TM), Landsat enhanced thematic mapper (ETM) and Resourcesat-1 (IRS-P6) LISS-3	Plastic industries effect on air quality	Malegaon City, India	2015
28	Remote Sensing	object-based image analysis (OBIA), decision tree classifier (DT) and Landsat 8 OLI	WorldView-2 multi-temporal satellite data	Plastic covering crops	Almería, Spainh	2015
36	GIS	IRS PAN, LISS II, the red and Infrared IRS WiFS Satellite	Indian IRS satellite image	Plastic one of the disease transmitters	India	2015
41	GIS	Landsat 8 and NDVI, NDMI	Commercial satellite image	Plastic waste effect water quality	Malacca, Malaysia	2015

CHALLENGES AND WAY FORWARD

The Agenda 2030 for Sustainable Development, particularly Sustainable Development Goals 6, 11, 12 and 14,8 as well as the Paris Agreement and the New Urban Agenda, all consider waste management as an urgent and critical issue that must be addressed to ensure the future prosperity and sustainability of our planet. However, the lack and inconsistency of global data on waste management and treatment remain a significant challenge. In addition, urban waste represents a largely untapped source of recyclable materials for production, reusable goods, and a source of both heat and electricity when utilised correctly in efficient waste-to-energy plants. Therefore, along with the numerous environmental and health issues caused by our consumption and disposal patterns, this must be addressed to help shape the liveable and sustainable cities of tomorrow.

CONCLUSION

The development of the digital approach is not only a start line to consider people as a sensor, but it also would be an efficient implementation of intelligent technologies in urban waste management. Unmanaged solid waste is one of the main problems in many urban areas. With proper research to tackle the solid waste issue, a geospatial approach can resolve much of this problem. In this paper, we reviewed the application of digital tools via geospatial techniques. Considering GIS and remote sensing can deal with both spatial and non-spatial data and can be used to design successful urban waste monitoring tools. Furthermore, both can provide preferable or optimal short routes which are cheap and efficient. Moreover, it minimises operational costs and updates the information regularly, making urban the monitoring and management of urban space more transparent, timely, and realistic. Urban waste management, commonly known as Municipal waste management, are the main issues to be tackled to sustain urban systems in many cities worldwide. We found many studies focusing on urban waste; however, only a fews that specific to GIS and RS usage between 2015-2022. Since the potential of both tools is well recognised, some effort needs to be explored or conducted to promote the applications in managing urban waste in the future.

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