REMOTE SENSING, GEOGRAPHIC INFORMATION SYSTEM APPROACHES: ENVIRONMENTAL TECHNOLOGY TOOLS FOR FORECASTING, EARLY WARNING AND RESPONSE IN DISASTER RISK REDUCTION IN NIGERIAN STATES WASTE MANAGEMENT, CLIMATE CHANGE IN COVID – 19 ERA.

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Abstract

The purpose of this paper is to create awareness of Environmental Technology Tools for Forecasting, Early Warning and Response in Disaster Risk Reduction in Nigerian States Waste Management in Covid – 19 Era. It is in contribution to addressing obsolete waste management practices and technological challenges faced in Nigerian states. Remote sensing (RS) and Geographic Information System (GIS) approaches as environmental technology tools impacts environmental management, improving framework development principles, natural resource management, national intelligence, forecasting, early warning and response and disaster risk reduction associated with waste management. Fuzzy set theory and Technological Acceptance model 2 (TAM2) adopted method to aid RS/GIS application towards sustainable waste management practices. Environmental problems emerged from inappropriate methods and technologies in managing waste with Consequences such as pollution of air from gases leading to global warming, land, and water pollution leading to ill-health, flooding of blocked drainages, and loss of lives, lands, and environment. Use of RS/GIS technologies facilitates dumpsite/location, detecting gaseous substances, precise data analysis, storage skills, spatial information, and decision-making in management. The objective of this paper is to build capacity, skills, awareness, and education for monitoring, collecting geo-spatial data, analysis/storage, detection/control of gaseous substances, locations/terrains, relocation of waste bins to areas of suitable mapping to dumpsites, evacuation of people to save lives and environment in waste management using RS and GIS Tools. Recommendations: embracing innovations, curriculum review of education sector, taking waste management as vocational course, storage, geospatial analyses, communication, and decision-making process by both public/private sectors to protect our environment.

Keywords: Remote Sensing, Geographic Information System, Waste, Waste Management Forecasting/Early Warning, Response, Disaster Risk Reduction, Environmental Technology.

Remote Sensing, Geographic Information System Approaches:
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Introduction

Wastes have led to climate change's growing attention on threat to humanity. Waste and disaster management on environment to climate change associated with green skills gaps in capacity building to management where degree Celsius of global temperature increase have impact in ways that are not easy to be quantifying United Nations International Centre for Technical & Vocational Education Training, (UNESCO & UNEVOC, 2021). Climate change in Covid -19 era brought new normal and new paradigm for waste management efficiency and reduce environmental impact. Most human activities generate waste (Brunner & Rechberger, 2014). For life cycle of waste management is from waste prevention to safe disposal (Chalkias & Lasaridi, 2011). But Geographic Information System (GIS) and Remote Sensing Environmental Technology Tools provides technical and innovation methods to enhance geospatial data entire region base estimation landfill, analysis and decision-making in forecasting, early warning and response in disaster risk reduction from improper waste management problems of socio-economic and environmental reasons with skills, location of dumpsites, storage mapping, detection/control of gaseous substances to save lives and environment. What then is waste, waste management, RS, GIS?

Waste is a discarded solid, liquid, semi-solid and gaseous material (Nwosu & Pepple, 2016). It is a material bill to dispose of worn-out in liquid or solid form (Nwosu & Chukwueloka, 2020). Therefore, waste is seen as any material that loss original value, after usage and disposed it by user but still a resource to mother person in our environment. Waste management to Nwosu and Chukwueloka (2020) is generational characterization, collection, transportation, and disposal. Waste management therefore involves system combination of techniques, strategies, procedures in planning, funding, law/policy formulations to method, tracking, monitoring, collection, generation, processing, storage evacuation, transportation, engineering, administrative settings, site locations, education, and disposal of waste materials in sustainable manner with environmental consideration precautions. Remote sensing (RS) is a tool for sensing the earth surface interface of object property and measurement in analysis of environment with its resources (Karsauliya, 2013). It provides capacity of large, repeated coverage in view. GIS is defined by Martindale (2022) as a system design to capture, store mumipulate, analyse, manage, and put altogether of geographical data. For GIS according to Nwosu and Pepple (2016) allows users to view, understands, query, interpret and virtualized spatial and non-spatial data in the form of maps in improper disposal of waste. Thus, RS is optimal sitting device, instrument, technique for image capturing, measuring, area object, estimation from distance mapping via satellite. While GIS is computer base software device that collect data, stores, analyses, display spatial data to solving environmental problems as waste management and climate change. Are better gadgets that give spatial information estimation of certain centre region of attraction or happening in an area for quick response, treatment to save lives and environment? A shift to sustainable, low carbon economy, methane emissions require environmental technology. Environmental technology is development of new technologies that conserve, monitor, reduce the negative impact on the environment and consumption of resources as "green or clean technology" (Edimburghsensor.com, 2019).

Climate change is periodic modification associated with earth's climate because of changes in the atmosphere interaction between atmospheric and other geological, chemical, biological with geographic factors observed within earth system (Jackson, 2018). This caused temperature and weather change affecting environment and man. To Hornby (2015) it is a global threat resulting in global warning. Thus, climate change is alternation of the natural chemistry, composition of atmosphere interaction with gaseous substances such as carbon dioxide carbon monoxide (CO), methane (CH_4), Mercury oxide (HgO) among others direct or indirectly to increase in temperature, weather, wind-pattern from man's activities for observable monitoring period of time in planet earth. Forecasting is quick information to enhance the management in emergency face set before, during and after a potential damage (Bruno, Christian, Kuhlicke, Kunz, Pittere, David … Weisse (2020). Early warning system is disaster management system for explicit preparedness response, build back better recovery, rehabilitation, reconstruction and in target to multi-hazard for risk reduction information and assessment (UN. Spider.Org, n.d) while to World Meteorological Organization, (2010) Disaster risk reduction is identification, assess and monitor risks and by enhances early warning of hazards. Natural hazards turn disaster when affected people cannot handle with effects. The potentiality of hazard can damage physical event, human with activities, injury, and loss of life. Other impacts are property social and economic disruption or environmental degradation (Ouma, 2020). Climate change and waste management without forecasting, early warning, and disaster risk reduction capable of unleashing this hazard to man and environment of the vulnerabilities, timely information for preparedness of communities, individual organizations and government in governance is required for effective management.

Globally or locally as Nigeria states, wastes generated come in form of solid, liquid and gaseous threaten climate change and environment. Waste generated tends to exceed the natural system capacity even if the earth has means of handling it wastes (Akuoko, 2017). Challenging fueled by environment is owing to lacking capacity of waste bins in volume of solid waste. To Chalkias and Lasaridi (2011) some bins are small in capacity of 120 to 240 litres wherein total storage bin system is 3 – 4 million litres. Waste collections are done mechanically using wheelie-bins and rear-end boarded completion milks of average capacity of gases. Methane is powerful greenhouse gases for 20% global warming and carbon emission is 250,000 averages from cans of air ambient to climate change improper waste management constitute environmental issues global warning that poses risk (Cassidy & Dauphin, 2021; Euduiburgsensors.com, 2019; Sule, Aliyu & Umar, 2014). Modern wastes management methods adopted worldwide (VIjayalakshmi, 2020) and Skills Development in Capacity building, awareness technical education and vocational training required to solve the wastes, disaster management to climate change (UNESCO & UNEVOC, 2021).

The Benefits of using RS and GIS in Solving Problems of Waste Management to Climate Change according to Kumar (2019) in IBM (n.d) precise location of events and shape features; Sule et al., (2014) support enumeration of optimum location, geographic factors, mapping for waste bins than manual method of site selection of site and analysis in parameters of its

/inhabitants. For relationships in pattern trends, map for most suitable sites in waste disposal to be isolated (Nwosu & Pepple, 2016). Identification of landfill sites and its expansion using vector data and remote sensing (Gautam, Brema & Dhasaratham, 2020). Capturing, handling, and transmitting the require information in a prompt manner of waste disposal problem and its management (Singh, 2019). GIS/RS provide spatial information, platform for data analysis and decision-making to plan evacuation of people at risk and monitor landfill gas (Akuoko, 2017). Methane emission and mapping in detection/control (Cassidy & Dauphin, 2021; Akihito, et al., 2020) density features in space (Martindale, 2022) and Mallick (2021) for slope, terrain/morphology in decision-making processes, human observations, reliability of versality and detection of suitable landfills cost-effective than conservation method in waste management, Covid-19 mapping, vegetation and tornado tracking (study.com, 2022).

Consequences of improper management of wastes potent great danger to man and environment from climate change associated causes. To UNESCO – UNEVOC (2021) accounted for global temperature increase not easy to quantify, communities-value-chain, well-being, and environment. Waste contaminates environment, risk to man, pollution of soil, air and water with hazardous effects on human/earth (Vijayalakhmis, 2020). Waste polluting water in transmission water born infections of typhoid, cholera, gastro enteritis, food borne diseases, ordour, breeding place for flies, ants, scorpions, snakes that end on drainages (Nwosu and Pepple 2016; Kaoje Dankani & Ishiaku 2016). Are drawbacks in waste management systems as the case in Nigeria. Most Nigerian cities on daily basis faced hazard of obstructing traffic flow causing environmental degradation, refuse becoming fertile grounds to flies vectors, health effect (Nwosu & Pepple, 2016). Other health risks on people living near landfill sites to reproductive complications of low birth weight, multiple births, respiratory disorders, skin infection, gastrointestinal symptoms, and cancer (Mallick, 2021).

Attainment of RS and GIS goals towards climate change and waste management is to build capacity skills in usage for disposal of waste, location of dumpsites, mapping detection of gaseous substances, monitor, analyze data, from geospatial information, store terrain/morphology and decision-making processes. Modern waste management is more technical and innovative in methods in view of waste forms such as solid, liquid, and gaseous substances in nature. Application of RS and GIS in waste management with regards to climate change in Covid-19 curbing through enhancement indicated in geospatial data analysis, decision-making, methane emission mapping/control capturing and transmission of information of waste disposal problem (Cassidy & Dauphin, 2021, Akihito et al., 2020; Singh, 2019). Environmental property and processes are related in space and time which climate change and waste, disaster management related in forecasting early warning and disaster risk reduction are following Tobler's (1970) First Law of geography which "states that everything is related to everything else, but near things are more related than distant things" and getting environmental data such as climate change in waste management is time/space through spatial information. Based on the various forms of waste, the paper will focus on solid waste and gaseous waste management using RS and GIS technology tools. In context of Nigeria

supported with the law stated, Fuzzy sets theory and Technological acceptance model 2 (TAM 2) for environmental data to forecasting, early warning and disaster risk reduction that offer better explanation in capturing, analyzing monitoring, location, storage, gaseous substance detection/control to management faced in waste and climate change in Covid-19 era, Nigerian states. This is to provide awareness, skills on the tools for dependable data you need in space or time as geospatial (in form of vector and raster) towards saving life and risk reduction, losses in environment necessitate the study.

Need for the Study

In Nigerian States, solid waste as tangible or loosely flows of materials from human population growth, socio-economic and environmental activities increased waste generations illegally dumping, no principles, procedures framework for waste management gaseous waste natural resources management, environmental and national intelligence led to the loss of lives, lands, aesthetic value causing diseases, pollution of air, land and water leading to climate change.

Objectives of the Study

- Explain the concepts of RS, GIS, waste, waste management/forecasting, early warning, disaster risk reduction, management.
- Various waste sources/methods of management.
- Discuss on modern technologies affairs of RS, GIS, and waste management: The state of the Art in Nigerian States with respect to climate change problem of forecasting, early warning and disaster risk reduction build capacity, skills, location, monitor gaseous/solid waste, awareness, and education.
- Challenges, Limitation of RS and GIS
- Way forward: Application of RS and GIS in solid/gaseous wastes management reference to climate change in Covid-19 Era
- Conclusion/Recommendations.

Explain the concepts of RS, GIS, waste, waste management, forecasting, early warning, and disaster risk reduction.

Conceptual Framework

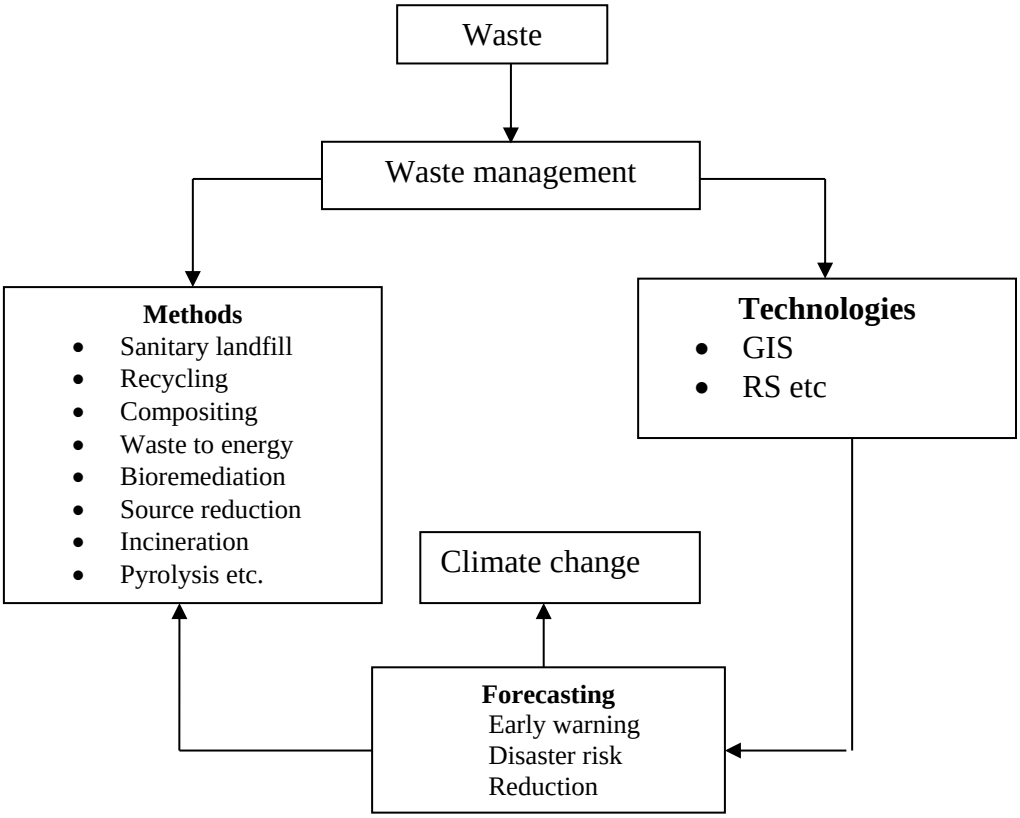


Fig 1: Conceptual framework for waste management in climate change

Waste: Is a material bill to disposed of, worn-out in liquid or solid form (Nwosu & Chukwueloka, 2020) to Basu (2009) waste is any product or material which is useless to the producer. Therefore, waste can also be seen as materials which loss its original value, after usage and discarded of by the users but still a resources to another in our environment. What constitutes waste remain an essential product of human activities man inefficiencies consider it as waste not a resource, but it is a resource to an environmentalists and geographers in nature of forms from critical view point.

Waste Management: Nwosu and Chukwueloka (2020) see it as waste generational characterization, collection, transportation, and disposal to Akuoko (2017) is the discipline associated in control of generation storage collection, transport, and disposal of waste materials in a way with environmental consideration. Waste management to Shagufta (2014) is the practice and procedures that relate to how waste is dealt with. Thus, waste management involve system combination or techniques of procedures in planning, funding, law/policy formulations, methods monitoring, collection, processing, storage, evacuation, transportation, engineering, administrative settings, site locations, education, and disposal to landfills of waste in sustainable manner with environmental consideration with precautions.

Remote Sensing (RS): Is an active device that directly measure area emission and advanced current estimation methods or techniques (Gardiner, Hahmore, Innocenti & Robison, 2017). It is an art of obtaining information about object or areas from distance using aircraft/satellites (Vijayalaksami, 2020). RS is a tool that interface object property and measurement analysis of environment/resources (Kansauliya, 2013). Hence RS can be seen as digital optimal siting device or instrument or techniques of image capturing, measuring area, objects estimation from afar mapping and information detection via satellite in our environment. It is space science techniques for geospatial information.

Geographic Information System (GIS): Is a datasets and spot devices joining of the spatial examination in areas (Vijayalakshmi, 2020) GIS is a high-resolution digital photogrammetry with multispectral image device is spatial information data analysis and store data (Akuoko, 2017) hence, GIS is a computer-based device that modelling to collect, stores, analyses, visualized and displays spatial information to solve environmental problem. GIS and RS devices are modern gadgets that give spatial information on our environment and waste management techniques innovation and information communication technology (ICT) tools to solving mirage problems such as located in waste management. Singh (2019) developing countries faced with infrastructure weakness in observation to waste management problems.

Forecasting to Gujarati, Porter and Gunasekar (2012) is vast specialize and important analysis which exhibit wide swings for an enhance time of phenomenon comparative tranquillity in volubility clustering (i.e., time series data) of exponential single and simultaneous for solution. Forecasting composed of monitoring of precursors, forecasting of probable event and notification of warning/alert of catatrophic (De-Leon, n.d). Thus, is prediction information set before any hazard towards management. **Early warning**, to Bruno, *et al*., (2020) is capacities to generate and disseminate timely, meaningful information to individual communities and organization threaten by hazards to prepare, responded appropriately with sufficient time to reduce harm or loss possibility. Also be seen as sensing possible harms with management readiness. **Disaster risk reduction** is the concept and elements set with possibilities to minimize vulnerabilities and disaster risk to prevent, limit adverse impacts of hazards in sustainable development (Ouma, 2020). It could be seen as responsive to harmful and hazard effects lifesaving event on environment.

Classes of Waste Sources and Various Methods of Waste Management:
Some Sources of Wastes:
They are:

(1) **Municipal Wastes:** Are waste collected in city from local government authorities consist of refuse, household, food waste, cloths, plastics polythene, glass etc. Vergara and Techobanoglous (2012) see municipal solid waste as reflective in the lifestyles and customs of people who produces them, having negative impact on wellbeing of the public and environment if properly managed. To Bakare 2020 in Nwosu and Chukwueloka (2020), Nigeria generated over 32 million tons of solid waste yearly and only fraction is collected.

(2) **Hazardous/Gaseous Wastes:** Are poisonous and gaseous emission from dumpsites such as methane (CH_4), Mercury (Hg), Carbon dioxide (CO_2) either solid, semi-solid and liquid that affect human and environment.

Methods/Techniques of Waste Management:

Pyrolysis Method: Is an advance thermal technology involving thermal decomposition of organic component in the complete absence of oxygen under pressure at elevated temperature (Shagufta, 2014). **Recycling Method:** It involve the collection of the waste materials from different sources, places, sorting, segregating, and packaging them according to the nature of products are used as recyclable processes. **Composting Method:** Is an organic wastes method that involve segregation from wastes and allow decomposing by microbes for a period in a pit dug. **Landfill Method:** Landfill method is one of the best methods of managing solid waste as final disposal site. According to Gautam, *et al*., (2020) remain treatment option globally, as case of India 68.8 million tons yearly of solid waste are generated, 35% of those are generally sent to landfills only. Landfill method involves an engineering, planned, funded and properly location of dumpsites outside residential areas but not too distance from urban centres, such rural areas for close monitoring/control measures. Methane emission is monitor and control using GIS/RS (Akihito, et al., 2020). **Incineration:** This involves burning the waste or high temperature known as incineration method. To avoid air pollution proper air filters are used, for sludge control direct incinerator method without anaerobic digestion is sustainable approach (Hao, Chan, Van, Loosdrecht & Juing, 2020). **Source Reduction:** Is method employ by reducing waste at source using separating of materials into various form for easy evacuation and transportation, disposal on dumpsites. **Bioremediation Method:** It involves the using of microbes and bacteria process in natural form to remove the impurities, pollutants and poisonous substances from soil waste and other environment. **Waste-to-Energy Method:** Is a form of electricity or heat from the primary treatment of waste process to create energy. According to Zhang et al., (2020) china has employed anaerobic digestion technology for energy recovery, identified is effective way to minimizing degree of Green House Gases (GHG) emissions treatment. To Malav, Yadau, Gupta, Kumar, Sharma, Krishnan and Bhattacharyya (2020) Waste-to-Energy (WTE) technologies such as pyrolysis, gasification, we incineration and bioremediation are said to convert municipal solid waste, as most proper source of renewable energy into useful as energy.

Affairs of RS and GIS Technology in Nigerian States for Waste Management with Respect to Climate Change Problem of Forecasting, Early Warning and Disaster Risk Reduction

Certain RS and GIS proved to evidence in solid waste management, but gaseous wastes remain threat as Nigeria to capacity building, awareness, and education about climate change in forecasting, early warning and disaster risk reduction. Jimoh, Chuma, Moradeyo, Olubukola and Sedara (2019) studies of waste disposal environmental assessment and management Lagos State result providing digital way in storing, retrieving, manipulating, analyzing of geographically data for ecological, biological, demographic, and economic information, value

tool in environmental and engineering services, estimation, and planning. Study by Sule, *et al*., (2014) in Chanchaga LGA in Niger State using GIS revealed location of waste at dumpsites. Site selection and analysis study of solid waste dumpsites in Ile-Ife Osun, Nigeria GIS usage provide understanding, query, interpret and visualize spatial and non-spatial relationship of pattern and trend forms from maps (Nwosu & Pepple, 2016). To Adie (2015) use of GIS in research conducted in Obudu urban Cross River State shows suitable areas for landfill sites. And Kaoje, *et al*., (2016) study adopted RIS/GIS for site suitability analysis of solid waste disposal in Birnin Kebbi, Nigeria result indicate better site for urban solid waste disposal, landfill from generated map. There is not maximum evidence in Nigeria for solid waste management using GIS and RS in detecting gaseous substances as play in forecasting, early warning, and disaster risk reduction. This is because of the Nigeria still an infancy stage of research finding (Nwosu, & Pepple, 2016). And this corroborated Mudiare, *et al*., (2016) of Nigerian urbans areas lacking strategies to disposal of solid waste management. GIS and RS technology tools provides technical, mechanical in transportation for waste in routes tracking and innovation to management of solid wastes. Used in mapping and visual representation in physical as noted by (Study.Com, 2022).

Factors are affecting in Nigerian States of modern methods with technical mechanical and innovative technologies. According to UNESCO & UNEVOC, (2021) capacity building awareness, education, funding research, skills gaps to waste and disaster management, policy implementation causes understanding strategies in waste management and disaster risk reduction management in Nigeria climate change. Proper sources of identification, inadequate hardware/software facilities, lack of education and indigenous research in Nigeria of GIS/RS (Nwosu & Chukwuebuka, 2020). Influencing factors all choice of refuse disposal method of physical characteristic availability of land quantity/quality character waste disposed nature of regions varies and financial capability expensive to manage (Tajuddeen, 2003 in Nwosu & Pepple, 2016). To Vijayalakhmisi (2020) modern methods adopted worldwide to peaceful and healthy environment. Low level technology/no technological and disposal solid waste management processes in Nigerian urban areas (Nwosu & Chukwueloka, 2020; Mudiare, Folorunsho, Abdulkarim & Onaolapo, 2016; Adie 2015). Increase population and consumption growth result of quantities of waste with hazardous compounds (Chalkia & Lasaridi, 2011). Improper disposal, location of dumpsites, well planned and still infancy see continue solid waste emerged in Nigerian States daily (Nwosu & Pepple, 2016). For inefficiency on parts of those responsible for solid waste management in towns and cities, environmental problem, Sule *et al*., (2014). Proper solid and gaseous wastes management approaches will control different types of pollution resulting to diseases environmental restoration and the resources; for modern waste methods present numerous stages, procedures, principles, framework and advance technologies tools as RS and GIS are after adopted to reduce wastes contributing to climate change in Covid-19 Era.

Other factors militate against solid waste and gaseous waste management. In Niger State study by Mudiare, *et al* (2016) open dumping and burning management strategies practice, key players are government and individual household of solid waste generation at 74% exceeded

waste disposal at 49%, burying 63%, 84% burying solid wastes and 14% dumping consider effective. Noted by Nwosu & Chukwueloka (2020) are technological strategy waste minimization strategy and Traditional solid across waste management in Nigeria all phases of the management processes brought in low success rate in waste management strategies necessitating roadmap for integrated solid waste management. No substantial national waste management plans are open dumping method common of solid waste disposal in most Nigeria cities, (Kaoje, *et al*., 2016). To Karsauliya (2013) is morphological analysis of parameters and Mallick (2021) funding, inadequate facilities, parameter for morphometric analysis, spatial variance, disposal, and management decision-making. National waste management policies and legislation not providing needed services for recycling and recovery (Chalkias & Lasaridi, 2011). Martindale (2022) asserted that actual location using GIS of attribute data from spatial information, in education, taught, student capacity builds up from the attribute data. The issue of gaseous substance seldom research upon in Nigeria solid waste management to climate change in Covid-19 era.

Thus, there could be logical deduction from use of GIS and RS in solid waste, management in most parts of the world and Nigeria in particular. It is proven that reasonable decision-making comprehensive improving data analysis, collection, geospatial data location of dumpsites bins reallocation of suitable areas, detection of gaseous substance, control, terrains/morphometric analyses and skills are being facilitated in application of the technology tools. Nwosu & Pepple (2016) criticized GIS getting rid of massive waste while Mallick (2021) ratio scale to explain crip values of evaluation criteria, priorities in data that lead to change in past decision-making problems. Data uncertainty/ambiguity of human choice create problems of correct numerical weight (Mallick, 2021). While RS has radiometric calibration errors to gaseous emissions leakages; the outliers above the uncertainty level of 0.056 ppb/ppm of ΔXCH_4 (Akihito, et al., 2020). Multiple heterogeneous emission sources (Gardiner, *et al*., 2017). The next part, therefore, will discourse on the factors and challenges of GIS and RS in solid waste and gaseous waste management to climate change in forecasting early warning and disaster risk reduction using Fuzzy set theory and TAM 2 so aid it application.

Challenges of solid/gaseous waste management in Nigerian States

- Methods practice/Technological strategies adopted.
- Skills development gaps in capacity building, awareness, and education
- Funding Research

Limitations of RS and GIS

- RS has radiometric calibration errors and gaseous emission leaks.
- Correct numeric weight in GIS.
- Outliners above uncertainty level of 0.056 ppb/ppm of ΔxCH_4 estimation
- Multiple heterogeneous sources emission.

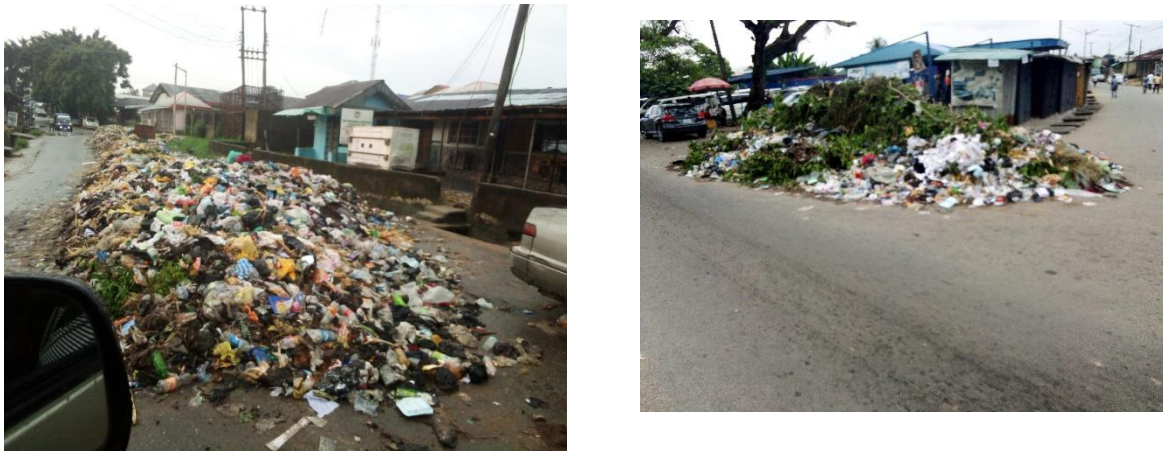
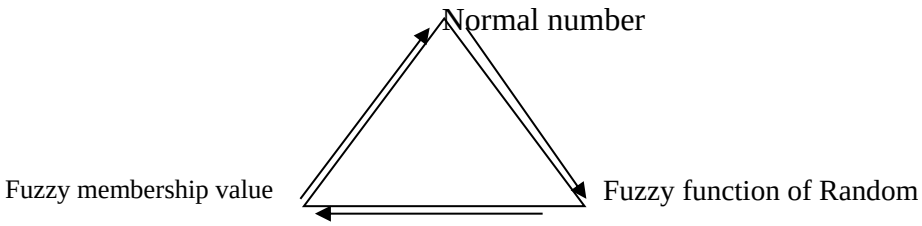


Fig. 2: Indiscriminate waste dumped on one of the Nigerian States, Cross River

Way Forward: Application of GIS and RS in Solid and Gaseous Wastes Management Will Reference to Climate Change in Covid-19 Era

Despites the criticisms of the GIS/RS, the used of Fuzzy set theory by L. A. Zadeh (1965) Venkatesh and Davies Technological Acceptance Model 2 (TAM 2) aid application to solutions of forecasting, early warning and disaster risk reduction management in Nigerian states climate change and solid/gaseous waste management faced.

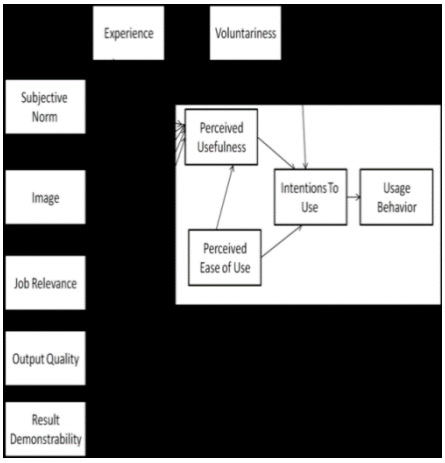
Zadeh, L. A. (1965). Fuzzy sets Theory (Information and Control).



Exclusion and contradiction axioms for complementing each other on the **Tenets**: (1) **Normal membership**: Is said to be distribution of function of random variables that deal with

uncertainty case of statistical tools. (2) **The function of Randomness:** Is on the principle of consistency of member element take value in the distribution function of a random event complementing one another. (3) **Membership Value:** To give equal value real number can be explain in the probabilities sense of generalization using smendent method. The basic ideas behind the Fuzzy set's theory are detrice classes domain for recognition. Communication of information, abstraction, natural way of deal with problems defining criteria membership rather random variables, regrates related to distance unentantity (Dubois & Prade, 2015) great utility in world scientific application with information and document, principles, and method. Measure theoretic sense how elements of three matter presented (Baruah, 2011).

Venkatesh V. and Dauis, F. O. (2000). Technological Acceptance Model 2 (TAM 2):



SOURCE: (Venkatesh and Davis, 2000 Technology Acceptance Model 2 (TAM 2) [28])

Tenets: (1) External Variables (EV): Integrating a new technology in teaching and learning process to deal with challenges of accessibility, conduction network, are limited ICT facilities, for time teacher's competency in schools. **(2) Perceived Usefulness (PU):** Deals with degree to which using a particular technology would enhance job performance, changes practices tools such as GIS/RS. **(3) Perceived ease-of-use (PEOU):** System would be used to free from effort (such as waste management problems) clear and understandable, easy to remember. **(4) Attitude towards use (ATU):** Deal with positive or negative feeling about targets behaviour (such as challenges on gaseous substance, solid waste might mention) factor will depends upon easy perceive using ICT tools like GIS & RS to waste management as apply in the classroom teaching. **(5) Behaviour Intention (BI):** Deals with formulated conscious plans and define specific behaviour in future. **(6) Social Influence Processes (SIP):** Norm, voluntaries, image and cognitive instrument processes to output quality result determinant for its usefulness and usage intention as applied to waste management use of GIS and RS technologies tools.

Basically, it is for people use of computers and their attitudes towards them using ICT a managerial system refers to TAM 2 for testing model with 107 adult users (to predicted intentions strongly linked to computers usage (Ghavifekr, Kunjappan, Logewary & Annreetha, 2016). Using Fuzzy sets theory and TAM 2 applications to solid wastes and gaseous substance waste management to climate change in forecasting, early warning and disaster risk reduction and analysis, locations geospatial information, skills, and decision-making.

Methods/Technologies in Waste Management

Landfill method is best disposal of solid waste management threat globally (Vijayalakhmi, 2020; Gautam, et al., 2020; Akihito et al., 2020 & Adie 2015). Application of Fuzzy set theory

to solid waste management according to Mallick (2021) on research conducted using GIS/RS municipal solid waste landfill site selection based on Fuzzy-AHP and geo-information technique Asir Saudi Arabia finding indicate analyzed ambiguous data, mapping possible landfill location criteria priorities are active forecasting dangers in Fuzzy environment, potential zones, interpretation of impact factors, complex crisp numbers, key ground water controls, slope, elevation terrain function density, different vegetation index distance and geology. High-reliability landfill site map base on versality of Fuzzy membership functions. It can generate accessibility on early warning and disaster risk reduction management of solid waste, Akuoko (2017) study using GIS and RS provide platform for data analysis decision-making, geospatial information that determine risk reduction plan evacuation of people, spatial distribution in map location, characteristics sources wastes in management. Early warning application of GIS supported modelling on waste management planning, landfill siting, thematic maps, recycling drop-off centres optimization of collection and transportation. RS assist in recording of spatial data analysis (Chalkias & Lasaride, 2011). Their application, bring integration of various environmental multispectral images, gas estimation on landfill waste, generation, waste bins reallocation, difficult task socio-economic data.

Early warning and disaster risk reduction, application of GIS in research carried by Jumoh, *et al* (2019) GIS based appraisal of waste disposal for Guiron mental assessment and management, Lagos State Nigeria provided useful assessment and management of waste disposal sites, support decision-making system in Lagos metropolis of assessed, evaluated and spatial data distribution in solid waste management: In Osun, Ile Ife Nigeria Nwosu and Pepple (2016) research on site selection and analysis of solid waste dumpsites using GIS (Archis 10.1) method three research question, posed geomorphology, in water sources, slope, land value/uses soil property, economic, distance cost from population centers of dumpsites suitable of geo-information techniques and recommended suitability analysis model builder. In Niger State Sule, *et al* (2014) application of GIS in solid waste management using ArGIS 9.3 reconnaissance survey method, revealed disposal sites in urban complex, groundwater of a site with health parameters on inhabitant and effect means analysis to mental method. Prevention of contamination of streams, reduce harmful effect, data base allows easy access to condition of waste disposal units, location, storage and future updating. **Early waning**, disaster risk reduction and forecasting, studies by Suryabhagavan (2019) solid waste dumpsite site selection using GIS based much criteria spatial modelling: Case of Logia Town Ethiopia today's show groundwater, river, slope, land use/land cover, geological, fault, soil, road network suitability poor solid wastes near river causes ecological, agricultural and health problems totally individual of 37.34%, 18.38%, 12.48% and 5.9% unsuitable, user suitable, moderated suitable and highly decision-making facilitates high in dumpsite alternative location. Polluted River Yamuna on solid waste India study by Karsauliya (2013) using RS/GIS result indicated 17 suitable locations of 3.902% total area best for solid waste management, Time and cost of site selection spatial data related to pollution.

Funding Research

Forecasting, **early warning and disaster risk reduction** for gaseous waste emission detection/control, monitor in waste management to climate change and capacity building skills, on awareness and education, Cassidy and Dauphin (2011) used of GIS approach in NASA Model Mapping Methane Emission in California, methane as contributing 20% of global warning greenhouse gas, AVIRIS-NG instrument detected multiple plumes of methane arising from sunshine Canyon landfills underground infrastructure to store, transport all can leak gas and organic materials and broken down by bacteria in anaerobic conditions. GIS assimilate publicly available geospatial data sets (re source of methane emissions VISTA-CA) developed maps that help quick methane match plume sources. Gardiner, *et al* (2017) study on field validation using remote sensing methane emission measures in UK, problem of heterogenous emission sources were actively remote sensing by used of Lidar that offer the potential to directly measure the area emission and advancement beyond correct estimation methods. Akihiko, *et al* (2020) conducted research a detection of methane emission from local source using GOSAT Target observations in application of RS radiometric calibration errors were multiple scattering by aerosols clouds bidirectional reflection on earth's surface, uncertainties in line with parameters and solar model added **Aliso Cayon CH_4 gas blowout** improved spatial resolution to the scale of the emission area, differential XCH_4 (LT) measurement significantly enhanced for accurate estimation of local CH_4. This research seldom found in the Nigeria context of solid wastes and gaseous waste substances to climate change management.

Skills Development Gaps in Capacity Building, Awareness and Education

On another perspective, waste and disaster management study conducted by UNESCO and UNEVOC (2021) skills development and climate change action plans enhancing TVETS combustion across the world, finding revealed Nigeria capacity building, education and awareness, how priority ability at all level of pre-primary, primary, secondary and tertiary (TVET) part of Nigeria education system is issues of gaps between policies and practices, capabilities, funding and poor use of technology and skills in curriculum whole addresses climate change tools for adaptation and mitigation. This finding could callouts greatly to forecasting, early warning and disaster risk reductions often faced as a nation about environmental degradation and globalization problems. Australia was enabling tertiary education with emphasized an analysis, vocational education, and training to address climate change, Myamar access technical/vocational education training with relevant primaries and private sectors for employable, skills to address climate change (UNESCO & UNEVOC, 2021). Nigeria needs to change attitudes, social and behaviours to perceive, uses of technology from our computers to encourage proper funding policies implementation and planning as TAM 2 model offer explanation when adopted better for education sectors in climate change mitigation and adaptation processes. Other environmental technology to complement of GIS and RS is direct air capture (DAC) is an environmental technology removing carbon dioxide from atmospheric climate change mitigation to help **Paris** climate change agreement goal to reduce emission (Edinburghsensor.com, 2019).

Conclusion/Recommendations

In conclusion, application of geographic information system, Remote sensory provided insight awareness, education and build skills. It helps to facilitate geospatial information data analysis, detection/control of gaseous substances, storage, retrieval, morphology/terrain, tracking vehicle routes, dumpsites location suitable and decision-making procedures framework of natural resource, management, national intelligence for forecasting, early warning and disaster risk reduction to serve lives and environment of prefers consumptions of goods and services as cause of waste generation to change climate with modern methods and innovation technologies of environmental management.

Recommendations

- Sanitary landfill, source reduction, recycling and wastes-to-energy methods recommended.
- To adopt GIS/RS technologies tools in decision-making, data analyses, storage locations of dumpsites, for bins proper reallocation, mapping, and transportation routes in waste management.
- Gaseous substance detection/control via monitoring for quick forecasting, early wary and disaster risk reduction for evaluation effected population areas on time before during and after reconstruction of adverse harmful effect to man and environment.
- **Education**: Incorporate into our curriculum review technical education and vocational from relevant to waste management full course in tertiary institutions ministries and private sector employable skills in capacity building to address climate change.
- **Funding/Planning**: Climate change and waste management is capital intensive both government and private sectors encourage funding research that address climate change and waste management problems faced on earth in mitigation measures and adaptations plans back with potential will to policy formulation/implementation.

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