

ENVIRONMENTAL AND SUSTAINABLE INNOVATION EDUCATION-PROPOSAL: TOWARDS IMPROVED WASTE-CRISIS SUBSTITUTION, ENVIRONMENTAL CONSERVATION AND IMPROVED PUBLIC HEALTH

K. E. Tabugbo^{1*}, C. A. Eneh¹ and L. A. Ekoh²

¹Department of Agricultural Economics, University of Nigeria, Nsukka

²Department of Educational Foundations, Nnamdi Azikiwe University, Awka

* Corresponding Author, Email: tabugbokenneth1993@gmail.com

Abstract

The potential capacity and bio-economics of pollution-waste substitution is a vital life enterprise area. It can catalyze the extensive understanding and unity to further develop and design opportunities for the creation of prospects that promote harmony throughout the environmental and social realms, without compromising future needs. It is interesting to note that many studies that examined waste failed to account for the actual role played by waste and extensive waste factors on unsustainable development, the relationship among government policy and environmental waste growth; health implications of the direct, indirect and total effects of waste growth and waste poisoning; the relationship of waste growth on private and public spending on health. This study closes these gaps by, evaluating health implications of environmental waste increase both on sustainable economic growth and development and proposes the innovation waste-education towards the achievement of sustainable economic development, reduced impact of air pollution and, improved health moderates of citizens.

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The study recommends the innovation-waste education in an aim to communicate the urgency and unity of environmental recycling and recyclability transformations, conservation; balancing environmental endeavors in a sustainable way, environmental climate change security towards the achievement of, sustainable imperative global standards of living in a way that promotes present wealth and opportunities without compromising future needs.

Keywords: Environmental education; environmental pollution; innovation education; sustainable development

Introduction

In Nigeria, environmental pollution, waste and toxic activities and occupational exposures that are creating environmental security threats and environmental toxic crisis have led to air pollution-related risk health problems such as cardiovascular diseases, respiratory infections, tuberculosis, lower respiratory infections, chronic obstructive pulmonary disease (COPD), chronic respiratory diseases, ischemic heart disease, stroke, and communicable, maternal, neonatal, and nutritional diseases (IHME, 2020; OECD, 2008; Bae and Hong, 2018).

In 2016, as much as 24% of all deaths worldwide were attributable to the pollution of the environment and environmental waste threats (WHO, 2021b). Meanwhile, over 40% of the global burden of disease attributed to environmental pollution and toxic threat factors fall on under-five children. In 2000, more than 4.7 million under-five children died of illnesses aggravated by environmental pollution and toxic threat factors. The scale of individual pain and suffering is immense. Some diseases cause sudden repeated bouts of debilitating illness that keep children anaemic, sick and away from school. Others result in severe deformities, long-term disability, and still others cause blindness, attention deficit disorders and mental retardation affecting children's education and depriving them of their full

emotional and intellectual development (WHO, 2021a). The high death toll is only part of the story.

Other predominant human health impacts associated with environmental pollution and waste threat factors include chronic respiratory diseases, cardiovascular diseases, enteric infections, diarrheal diseases, communicable, maternal, neonatal, and nutritional diseases, resulting in approximately 800,000 deaths and 26 million people living with disability adjusted live years (DALYs) (Gebeyehu *et al.*, 2023). These are a measure of annual environmental pollution and waste threat health burden in Nigeria.

The lower respiratory infection associated with air pollution is an environmental pollution and waste threat factor which has advanced from the 4th in 2007 to the highest ranked cause of death in 2017. These environmental pollution and waste threats are becoming a primary concern in Nigeria, as anthropogenic activities and occupational exposures create them, leading to diverse environmental problems and crisis such as air pollution, water pollution, oil spillage, deforestation, desertification, erosion, and flooding (due to inadequate drainage systems) (Pona, Xiaoli, Ayantobo, and Tetteh, 2021). Thus, a need for this study on achieving waste-crisis substitution, environmental conservation and improved public health via environmental and innovation education.

Food waste: issues and concern

The disposal of food waste poses a large environmental problem. Food waste is abundant: in the UK, approximately 15 million tonnes are wasted annually (234 kg/person/year or 50% of food) (WRAP, 2015; Green Alliance, 2015; James, Mitchell, and Mueller, 2017; Morgan and Mitchell, 2021; James and Mitchell, 2021) and the available disposal options each have substantial environmental impacts. Landfilling produces large quantities of greenhouse gases (GHG) and is therefore being phased out under new EU regulation (EC, 2014), but is still the destination of up to 48% of food waste in parts of the UK (House of Lords, 2014). Incineration

and composting also produce greenhouse gases, and waste-water from anaerobic digestion causes eutrophication and acidification of local ecosystems (Evangelisti *et al.*, 2014, Saleemdeen and Al-Tabbaa, 2015; Whiting and Azapagic, 2014).

To aid the selection of food waste disposal technologies, the EU provides guidelines on which disposal technologies are preferable (EC, 2014). This so-called food waste hierarchy, stipulates that governments should prioritize efforts (in order of most to least preferable) to: (i) reduce food waste, (ii) redistribute it (e.g. to the homeless), (iii) recycle it as animal feed (iv) compost (v) recover energy through anaerobic digestion, and finally, (vi) landfill the remainder. This legislation is, however, notably not applied with respect to the use of food waste as animal feed, because it is currently illegal to use most food waste as feed in the EU (Saleemdeen *et al.*, 2017).

Though food waste is the archetypal pig feed, if it contains meat wastes and is not heat-treated it can transmit diseases, such as foot-and-mouth disease and African swine fever. In 2001, a UK farmer illegally fed uncooked food waste to pigs, precipitating the foot-and-mouth disease epidemic, which cost the UK economy £8 billion (UK House of Commons report, 2002). As a result, the recycling of food waste as animal feed was banned across the EU (EC, 2002). The law still permits the feeding of some food wastes where it can be demonstrated that there is no risk of contamination with animal products, but this represents only a small proportion of all EU food waste. Currently, of the, 89–100 million tonnes of, food waste produced in the EU per year (Monier *et al.*, 2010), only, around 3 million tonnes are recycled as animal feed (zu Ermgassen *et al.*, 2016).

Amid increases and volatility in the price of conventional feed (AHDB Market Intelligence, 2013; 2006), and concerns about the environmental impact of grain- and soybean-based feeds (Nguyen *et al.*, 2012; Nguyen and Lau, 2012), there is growing interest in the potential re-

legalization and promotion of the use of food waste in agri-animal production (The Economist, 2013; The Pig Idea, 2014) given a recent survey of 1195 animal feed practitioners (from industry, academia, and NGOs) that identified the use of food waste as a priority research area for sustainable animal nutrition and sustainable reduced waste poisoning (Makkar and Ankers, 2014).

In other parts of the world, however, food waste continues to be commonly used as animal feed, including in modern systems of pig production. Heat treatment renders food waste safe for animal feed (Edwards, 2000; Garcia *et al.*, 2005; OIE, 2009), and in nations such as Japan and South Korea 35.9% and 42.5%, respectively, of food waste is recycled as feed. There, the use of food waste is closely regulated: legislation governs the heat treatment, storage, and transport of food waste feed (Sugiura *et al.*, 2009; zu Ermgassen *et al.*, 2016).

Environmental pollution: impact and issues

Environmental waste and pollution anthropogenic activities give rise to climate change in Nigeria, as evidenced by increase in temperature, variable rainfall, rise in sea level and flooding, drought and desertification, land degradation, more frequent extreme weather events and changes, which affect fresh water resources and loss of biodiversity. These are basic drivers of environment-crisis' threats, which result in important ecological and landscape processes that can have irreversible impacts on critical renewable resources, such as water, fiber, food, and clean air (Kepner *et al.*, 2004; Luszczek *et al.*, 2006; PreventionWeb, 2021; 2022). World Health Organization (WHO, 2021a) submits that environmental pollution and waste threats are induced by climate change, plastic pollution, global emissions, ecosystem damage, human resource depletion and exposure to humans caused by effluents, emissions, wastes, among others. Technological disaster, environmental threat exposure, and the use of and/or inappropriate use of toxic chemicals also – environmental pollution

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and waste crisis threat factor – impact labour productivity cum output (Asante-Duah, 2017).

Environmental pollution and waste-toxic crisis and anthropogenic threats or risks that include pollution, radiation, noise, land and water degradation and climate change induced waste-crisis driven by the energy, industry, agriculture, transport, and land use sectors pose danger to the ecosystem composure and its inter-dependent human component and physical components and systems that maintain life (Prüss-Ustün *et al.*, 2019). These environmental pollution crisis and issues is seemingly becoming and causing, in Nigeria and the globe, considering the entire range of environmental changes, a clear, large and bumpily-rapid environmental pollution-scale threat relative to the mid-20th century scale and ubiquity. Besides; their cumulative impact is potentially causing changes in human health, familial status and social hierarchies (Lazarus, 2009) especially that of climate change influencing – increasing temperature, variable rainfall; rise in sea level and flooding; drought and desertification; land degradation; more frequent extreme weather events; fresh water resources depletion and loss of biodiversity – that is causing protein and nutrient-insecurity; disrupting significantly, just as in many environments, cosmologically-human-environment relations and, threatening, sustainable socio-economic and human well-being development (Crate and Nuttall, 2009; PreventionWeb, 2021; 2022).

In Nigeria, these environmental changes caused by environmental pollution and waste threats and impacts are obviously threatening on, composite human health and well-being and labour productivity (Olaniyi, Olutimehin and Funmilayo, 2019). Thus, unfortunately, the characteristic labour productivity of agriculture which remains the main stay of the Nigerian economy in spite of oil; employing two-third of the entire working population (IITA, 2019a; b; c; FAO, 2023; FAO, 2019a; b; c; Onwutuebe, 2019; ICRISAT, 2019a; b; c) is; plagued with outdated land tenure system that limits access to land (1.8 ha/farming household), reduced irrigation

development capacity (cropped land under irrigation less than 1 percent), limited access to credits, low adoption of technologies, expensive farm inputs, limited access to fertilizers, inadequate storage facilities and limited market access. All of these fore-gone in addition when, combined with Nigeria's changing climate evident in: increases in temperature; variable rainfall; rise in sea level and flooding; drought and desertification; land degradation; more frequent extreme weather events; fresh water resources depletion and loss of biodiversity; variable durations and intensities of rainfall-producing unsustainable large runoffs and flooding in many places and; increased environmental pollution-waste dump-log crisis have reduced national labour productivity and, agricultural productivity (average at of 1.2 metric tons of cereals/ha) despite high postharvest losses and waste (FAO, 2019; African Cashew Alliance, 2022; Okoye and Adamade, 2016).

Amid these unfortunately, the newness of the discussions on the interrelatedness of environmental pollution and waste security, composite human health and well-being and labour output has yet to produce a unified knowledge. In addition, too, the effect of increased environmental pollution and waste crisis may mean; increase or decrease in the total amount of rainfall and extreme temperature which could have more of a negative effect on staple crops production (Ajetomobi, 2016); change in characteristics and nature of freshwater resources due to rising sea levels and extreme wind events; increase in salinity and shrinking of lakes and rivers that could threaten the viability of inland fisheries and protein security cum optimum food security (Onyeneke, Nwajiuba, Tegler, Nwajiuba, 2020). Specifically, too, in addition, environmental pollution waste crisis and threats – anthropogenic or natural (PreventionWeb, 2021; 2022) is projected to increase rainfall variation with consequent continued cases of heat wave in Nigerian cities especially Lagos described as, one of the most severe heat-waves affected city in 2016 (Olewuiké, 2019; WWA, 2024).

Environmental wastes-debris and E-wastes

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Environmental wastes are debris or discarded materials that are no longer suited for their intended use usually derived from different items – food, groceries, electronics, plastics, agricultural and industrial products. Both E-waste and environmental waste are on the rise (Babatunde, 2023a; b). This rise is attributed to the bang in the, electronics industry, skill-innovation and industrial revolution amidst the rapid growth of technology that has led to the generation of enormous amounts of WEEE (Ravindra & Mor, 2019). Aside these, in recent years, the globe has seen continuous financial and technological growth, which led to the high generation of environmental-waste and e-waste (Attia, Soori, & Ghaith, 2021).

In fact, Michael, Hungund & Sriram (2024); Borthakur & Sinha (2013); Borthakur & Govind (2019); Borthakur & Govind (2017) posit that E-waste is undergoing extraordinary growth in the contemporary years all over the world positing this growth to have further increased after COVID-19 as people became interested in the new work culture, where they depended more on electrical and electronic products. Similarly, a World Bank (Banga, 2023) estimate put the amount of environmental waste generated globally to 2.01 billion tonnes of municipal solid waste annually – comprising, food, groceries, electronics, plastics, agricultural and industrial products and, 33% of which is not managed in an environmentally sustainable manner (UNEP 2024; World Bank, 2018a; b; UNEP, 2023; Zhaoli et al., 2023).

In Nigeria alone, the amount of waste generated daily by each Nigerian is 0.51kg with total waste forecasted to reach 107 million tonnes by 2050. Despite this, open waste disposal is rife in sub-Saharan Africa, South Asia and the Middle East and North Africa with more than half of the total generated waste openly dumped on the streets in these regions (Banga, 2023).

Aside this alarming concern in sub-Saharan African region, Nigeria falls among 30 countries with the worst waste management practices. Hence, landfills are overflowing in states like Borno, Abia, and Osun states.

Over 200,000 tonnes of plastics from Nigeria end up in the Atlantic Ocean. In the year 2022, the international non-profit Clean-Up Nigeria, with consultative status with the United Nations, found that over 172.7 million Nigerians are living in an unclean environment despite, Nigeria among the top 20 nations that contribute 83 percent of the total volume of land-based plastic waste that ends up in the oceans. This puts many at risk for diseases (Babatunde, 2023). Further, Nigeria performed poorly in the environmental waste performance of countries scoring a, way below average score of 12.7 out of 100 showing, a low environmental waste status and decline compared with the performances of its neighbors in Sub-Saharan Africa – Seychelles and Equatorial Guinea with scores of 69.10 and 63.10 respectively (EPI, 2023; Yale Center for Environmental Law and Policy, 2023; Dataphyte, 2023).

These estimates and reports of increasing waste generated daily by each Nigerian and Nigeria is in its growth not sustainable for comprehensive health-well-being and development. In fact, the growth of waste annually may not be environmentally sustainable. Consequently, waste variable and waste management unsustainability measured based on three indicators: controlled solid waste, recycling rates, and ocean plastic pollution was low in Nigeria. The ocean plastic pollution variable that also measures ocean plastic pollution as the absolute quantity in millions of metric tons of plastics a country discharges into the oceans in a year of Nigeria is low. Evident and obvious is that, of the 32 million metric tonnes of waste annually generated in Nigeria, 2.5 million tonnes of this waste are plastic waste and more than half of the total dumped openly in streets, water channels and gutters (Agbo-Jr, 2023; Babatunde, 2023a; b).

With an annual growth rate of 2.4%, waste generation in Nigeria will increase in subsequent years. However, a national strategy to manage and commercialize waste is expected to deliver great value. For example, in February, the Federal Ministry of Environment, the Embassy of Japan in Nigeria, and UNIDO signed a \$2.8 million agreement to support

government efforts to develop sustainable plastic waste management through the promotion of circular economy practices (Agbo-Jr, 2023; Babatunde, 2023a; b).

Environmental waste and e-waste crisis: toxicity poisoning cost of waste surplus

Environmental waste and e-waste toxicity has a poisoning effect on the environment and the composite integrity of the human and other biological components. This can be viewed as a social burden cost from environmental insecurity, environmental degradation and change, and; resource depletion (Zhaoui et al., 2023).

Notwithstanding the multiple effects of the impacts of environmental waste insecurity extensively; environmental waste burden and e-waste toxicity burden of; pollution, E-waste poisoning and, poor sanitation costs Nigeria 455 billion Naira each year. This sum at 2012 is the equivalent of US\$20 per person in Nigeria per year or 1.3% of the national GDP. Similarly, because of failure or inertia in developing sustainable environmental waste and e-waste poisoning cleaning; social processes – essential to sanitation, economic and social values in the prosperity of a developed society from time to time is – challenged and hampered (Baker, 2015). Thus, poor hygiene and open defecation costs Nigeria US\$1 billion per year despite less than 6.5 million latrines needed to be built to eliminate this environmental waste and waste crisis poisoning (World Bank, 2017). Unfortunately, these costs – economic, environmental, productivity and, social burden – fall disproportionately on women as caregivers who may spend additional time, energy and shared or common wealth attending to young children or sick elderly relatives (World Bank, 2017).

This disproportionate cost that may fall on women as caregivers who may spend additional time, energy and shared or common wealth attending to young children or sick relatives especially elderly relatives due to this social burden cost of environmental waste and e-waste poisoning besides

the, cost of US\$2.5 billion lost each year due to premature death is, undermining productivity. Approximately 121,800 Nigerians, including 87,100 children under 5, die each year from diarrhea – nearly 90% of which is directly attributed to significant quantity of, lead, and beryllium (II) oxide – hazardous chemical components in E-wastes and – such practice of open defecation and environmental poisoning effects of polluted water resources (Eneh, 2011a; b; UNICEF, 2024a; b; WHO, 2023; Eneh *et al.*, 2023; Nwokoro *et al.*, 2020).

This disposal (or dermal contact) and washing away by spill or underground acidification (or ingestion) via hazardous chemical components of e-waste may mean that; humans by exhalation (or inhalation), animals, bio-chemical resources, property and the environment are exposed to harm. This harm ranges from, but not limited to, destruction of aesthetics, debris and biomolecules (allelopathy) exposure that can; alter soil, human and chemical compositions of the environment, decrease pH in water, cause ocean acidification, reduce native species competitiveness cum biodiversity especially by prolonged severe adverse conditions of E-waste poisoning and environmental pollution (Eneh *et al.*, 2023; Eneh, 2023; Eneh, 2012b; Eneh, Anichebe and Abugu, 2016; Eneh, 2011a; b; Eneh, 2012a).

Unclean water, poor sanitation and hygiene all, components of W.A.S.H in addition, are contributory factors to the costs from environmental waste toxicity burden. WASH factors including unclean water, poor sanitation and hygiene impact on malnutrition rates and other leading causes of child mortality including; malaria, acute lower respiratory infection (ALRI) and measles measured to instigate a whopping US\$13 million in losses each year aside – productivity losses whilst sick or accessing healthcare. These contributory cost burden of WASH-toxicity factors may include: time absent from work or school due to diarrheal disease, seeking treatment from a health clinic or hospital, and time spent

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caring for under 5's suffering from diarrhea or other sanitation-attributable diseases (Africa Infrastructure Country Diagnostic, 2011).

Public health WASH and hygiene threats issues mean US\$191 million spent each year on health care through diarrheal diseases alone; directly and indirectly via malnutrition (and its extensive consequences for other diseases such as respiratory infections and malaria) influence and in some cases lead to; morbidity or near morbidity. In some cases, these costs associated with health seeking behavior of; consultation, medication, supplementation-diet and in some cases hospitalization; place a heavy burden on households and government spending as currently incurred across sub-Saharan countries (Africa Infrastructure Country Diagnostic, 2011).

Other additional costs also related to WASH-productivity loss are; epidemic outbreak costs and premature death, diverting expenditures for other essential items and, losses in trade and tourism revenue. For instance, funeral cost calculations for premature death borne, directly by households may be significant especially, in Africa. This foregoing burden cost is found on the average in, South Africa, to the equivalent of a year's total expenditure on food and groceries' households spending equivalent for funerals in cases of premature death alone. In Nigeria, these additional related costs are estimated at US\$28.8 million (Tareke, Enyew and Takele, 2022; eThekwini Monitoring, 2011).

On the other hand, the adverse impact of unsafe excreta disposal on water resources is not included in the cost estimation that incurs due to water pollution as figures are not available for Africa. Where this affects drinking water supply, water supply and treatment costs for drinking and other domestic uses – associated costs – are incurred with poor public health and hygiene status. Fecal contamination of the environment too – the root cause of an annual average of 5,400 cases of cholera affecting Nigeria is estimated to be US\$3.5 million each year. Despite this, the economic implications of a poor public health and WASH status especially in outbreaks such as

cholera outbreak go beyond the immediate health system and may usually require non-bargained necessary costs in response (eThekweni Monitoring, 2011; Water and Sanitation Program, 2012).

Important emphatically is the, long-term economic losses related to the adverse effects of poor public health and WASH status on cognitive development. Early childhood diarrhea contributes to under nutrition, stunting and wasting which are associated with malnutrition and in turn reduced long-term cognitive development (Suter, 2008; Fu and Xi, 2020; Neris *et al.*, 2021; Tenebe *et al.*, 2022; Egbueri, Enyigwe, Ayejoto, 2022).

Infection with soil-transmitted helminths on the other hand is also, a cause of impairment in intellectual and cognitive development. Other multiple economic factor-loses relate to tourism which is, hampered convenient travel and tourism competitiveness affecting a, significant source of income, employment and foreign currency. Evidently, the World Economic Forum on Travel and Tourism Competitiveness report (WEF Travel and Tourism, 2011) that ranks countries according to 75 indicators relative to tourism reveal that one of the extensive factors militating travel and tourism sector competitiveness is sanitation status. Based on the report (WEF Travel and Tourism, 2011) and in view to increase current contribution of travel and tourism to GDP, poor public health and poor WASH status in Nigeria needs to be addressed. This could lead to an increase in travel and tourism of an estimated US\$9.4 million annually.

Again, the cost of the current poor WASH and sanitation situation in Nigeria is estimated at US\$ 3 billion. While this figure of US\$ 3 billion is likely to underestimate the true cost of the current poor WASH and sanitation situation in Nigeria, this cost is both significant in sub-Saharan Africa and more tough and hard-hitting if economic and national reserves consecutively decline. Thus, re-use and recycling of excreta is an option that could bring potential economic benefit as, the value of excreta re-use is likely to increase in the future via potential to readily serve as an alternative

supply to world phosphate need given global phosphate reserves continued decline (Bethony *et al.*, 2006).

Waste, pollution and toxicity-health risk and threat exposures: case of water and groundwater resources

A lack of both quality water and water availability (readily access to clean drinking water) – socio-economic issues common in Nigeria and other developing countries – can result in several public health issues (Li and Wu, 2019) which is sine qua non to overall development. Access to water is crucial for human consumption, agriculture, and commercial purposes, especially in Nigeria, other developing countries and the globe. Nevertheless, the sustainability of this resource is under constant threat from environmental waste and environmental waste factors especially human activities (Roşca *et al.*, 2020; Dippong *et al.*, 2019; Zhu *et al.*, 2020). Nearly one-third of the global population relies on freshwater as their primary source of drinking water (Du *et al.*, 2020). In certain arid and semi-arid regions, groundwater is the sole source of drinking water for communities. Water supply has faced more challenges in recent decades, particularly in terms of management and the depletion of freshwater supplies (Garg *et al.*, 2022; Hussien, Rashwan, and Elshemy, 2021; Varol, Sener and Sener, 2021). Overexploitation, geomorphic, hydrological, mineralization, water-rock interactions, including ion exchange, redox reactions, and human impacts are all elements that affect and increase potential health-risk from water use and quality (Wang and Li, 2022; Egbueri, 2020; Dhaoui *et al.*, 2022).

Unfortunately, the quality and quantity of water resources are gradually declining due to the excessive discharge of potentially harmful elements (PHEs) into water resources in many nations (Ghaffari *et al.*, 2021; Neshat *et al.*, 2021). Most of the potentially hazardous elements (PHEs) include arsenic (As), zinc (Zn), lead (Pb), manganese (Mn), iron (Fe), copper (Cu), and nickel (Ni), all of which are released into groundwater due

to natural and human activities. Dermal absorption and ingestion are the most basic human exposure routes to PHEs in both industrial and residential regions. Because HMs are non-biodegradable, they can build up in water and the environment to non-permissible cum dangerous levels that are hazardous for human health (Chen *et al.*, 2020; Khalid *et al.*, 2020; Ricolfi *et al.*, 2020).

Due to technological and financial constraints in most developing countries, water resources are rarely subjected to sophisticated treatment, increasing the health risk associated with PHEs (Amoatey *et al.*, 2021). Furthermore, some of these contaminants are found in higher amounts in groundwater than in surface waters (Abdalla, El Attar and Shamrukh, 2022) – major source of household water requirement in most developing countries including Nigeria. Various health outcomes, ranging from acute to chronic implications (via exposure to polluted water) can lead to; tumors, skin rashes, melanosis, peripheral arterial disorders, respiratory illnesses, and high blood pressure, among others (Gilbert, 2020; Egbueri, Enyigwe and Ayejoto, 2022). If current trends persist, particularly in Nigeria, the lack of clean water and proper sanitation, as well as other risks linked to poverty and inadequate development; exacerbating health disparities are predicted to have a significant impact in Sub-Saharan Africa by 2040 via exposure to polluted water (Dos Santos *et al.*, 2017).

Nigeria has been one of the major contributors to global diarrheal morbidity and mortality – a notable health outcome linked to polluted water. In Nigeria, it is estimated that there are around 151,700 child deaths each year attributed to diarrhea, with peak incidence ranging from 10% to 18.8% (Odo *et al.*, 2021), and 80,968 deaths caused by unsafe water, sanitation, and hygiene (Nwokoro *et al.*, 2020).

This critical resources' (water) capacity based on its uniqueness to deliver hazardous to high exposure levels of key and life-threatening health risks and diseases calls for the innovation-waste education integrated approach of meaningful, reliable information throughout the key period of

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water-pollution health pandemics. Despite this, the ministries of water resources need to be active with water quality and environmental monitoring – quick mitigation cum short-term fix for water pollution and water-pollution health risks-incidence problems in regions such as Nigeria and times like these (Amoatey *et al.*, 2021). Thus, the need for this study to, whilst proposing workable environmental-waste crisis solution; accent that, water quality is crucial, a fundamental human right, a key factor for development and, has significant impact to support fundamental human needs (Li and Wu, 2019).

Advancing national capacity through environmental initiative and innovation waste education

Forecasting a waste tonnage rise to 107 million tonnes by 2050 is – a development that presents both a threat and an opportunity. Funding – threat to increased national expenditure – on the one hand that addresses the entire lifecycle of waste; from generation to collection and transportation and; treatment and disposal opportunity that – creates what is termed the circular economy potential for Nigeria as against a linear economy where, products and resources are made, used and disposed of. Also, the circular economy offers a promising opportunity for economic development of, value creation, and skills development for Africa as, wastes (both E-waste and environmental waste) are, recycled, repaired, and reused in a circular economy. This approach eliminates waste, strengthens resilience, and is fast gaining traction as a new model for sustainable growth, according to a World Economic Forum (WEF) report (World Economic Forum, 2022).

In 2021, Nigeria joined the multilateral initiative against plastic pollution, the WEF's Global Plastic Action Partnership, and established a Nigeria Circular Economy Working Group to advance national efforts to address plastic pollution. Initiatives of this sort including the United Nations Industrial Development Organization (UNIDO) support; support from multilateral institutions like the World Bank finances and advises on solid

waste management projects using a diverse suite of products and services, including traditional loans, results-based financing, development policy financing, and technical advisory can create value from an estimated 32 million tonnes of waste generated yearly and complicates of E-waste and environmental pollution (Anyaoagu, 2022).

However, a national strategy to manage and commercialize waste that is expected to deliver great value, support government efforts to develop sustainable environmental and E-waste management through the promotion of circular economy practices will be better anchored on an environmental waste education-innovation initiative. In addition, this willingness to harness environmental waste and E-waste generated in Nigeria by the Federal Government will be fired by – Environmental waste and E-waste clean-up; transport smart mobility and agricultural smart production models. This will further the value of the two national policies, one on *Solid Waste Management (2020)* and the other on *Plastics Lifecycle Management (2020)* (Anyaoagu, 2020).

Innovation-waste/toxicity education

It is common knowledge that when economic growth and development is not well managed or sustainable across the waste overflows of industrial revolution, E-waste pollution and, environmental waste-toxicity; environmental pollution and degradation increase (Anthemidis, Themelis and Stratis, 2001). This increase coupled with population increase, urbanization, increased human economic and industrial activities that is giving birth to and amid the emergence of, great factories, consumption of immense quantities of resources – especially natural and energy natural assets (coal and other fossil fuels) leads to; increasing rates of E-waste and unprecedented air pollution, large volume of industrial chemical discharges added to the growing load of untreated human wastes. This results in a case of development that is not sustainable (Urhie, Odebiyi, & Popoola, 2017).

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The development of an economy requires growth yet, not just in terms of income but also, in terms of, social-environmental and eco-human health progress such that it evolves higher life expectancy and better health outcomes cum advancement and improvement in the health status and outcomes of her citizens (Urhie *et al.*, 2020). This is cited in goal 3 of the sustainable development goals (SDGs) which is to ensure healthy living and promote well-being for all at all ages by 2030. In line with this goal, it is expected that by 2030 there will be; a reduction in the global maternity mortality rate to less than 70 per 100,000 live births; an end to preventable death of new-borns and children under 5 years of age, a reduction of under-5 mortality rate to 25 per 1,000; and substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination (United Nations, 2024; UNICEF, 2024a; b).

Accordingly, in view of the high rate of hazardous environmental waste and e-waste toxicity poisoning cum pollution, which are on the increase in developing countries (including Nigeria), especially in the urban areas, this study proposes the Innovation-waste/toxicity education. The proposed strategy is set on how to maximize health benefits of economic growth while ensuring that environmental waste and e-waste toxicity pollution is minimized. At the same time, achieving SDG-3 of promotion of healthy living and well-being for all population which unfortunately is no way in view for Nigeria which still has a high rate of under-5 mortality (estimated at 70 per 1,000) and a high maternal mortality rate (120 per 100,000 live births) despite, the 2030 time-mark (United Nations, 2016).

Innovation-waste/toxicity education: Waste management enterprise objective

The objectives of the Innovation-waste/toxicity education are promoting a clean and healthy environment, promoting private sector investments in solid waste management, and creating wealth and employment from waste management for economic development, value creation, and skills

development for Africa. Dedicated to sustainable waste-reforms, Innovation-waste/toxicity education is to advance sustainable use/reuse methods of; storing, e-waste refurbishing and recycling. Thus, food waste, groceries waste, electronic wastes, plastic wastes, agricultural and industrial waste would contribute to a sustainable waste management enterprise impeccable to, cause growth and development in Nigeria.

This objective of Innovation-waste/toxicity education is of the essence – strategic to ensure that – waste production, disposal and management contributes to enhanced national developmental goals, national strategies, policies, and planning. Also, contribute to improve awareness, education and coherence for global partnership on sustainable waste management enterprise development. Consequently, this objective should support the effective public, public-private and civil society partnerships to share and mobilize knowledge, technology, expertise, and financial resources; through action-oriented alliance leading to positive waste management reforms in society.

This sustainability contribution in; knowledge and sustainable development of; the Innovation-waste/toxicity education objective on waste management enterprise would impact extensively; climate change security, food security and poverty alleviation. Further, bring about wealth and business growth, creation, development and evidence based policies to help Nigeria especially, sub-Saharan Africa and the global world in attaining the United Nations SDGs Agenda as enshrined in the United Nations Sustainable Development Goals agenda.

Innovation-waste/toxicity education: Recycling E-waste objective

E-waste can be regarded as the replication of the technological-culture within the community. This, degrades the physical well-being of the human component residing in the polluted environment. In the present world, people are used to dispensing the bulk of their waste especially, electronic goods into the environment particularly in and around urban areas (Kitila &

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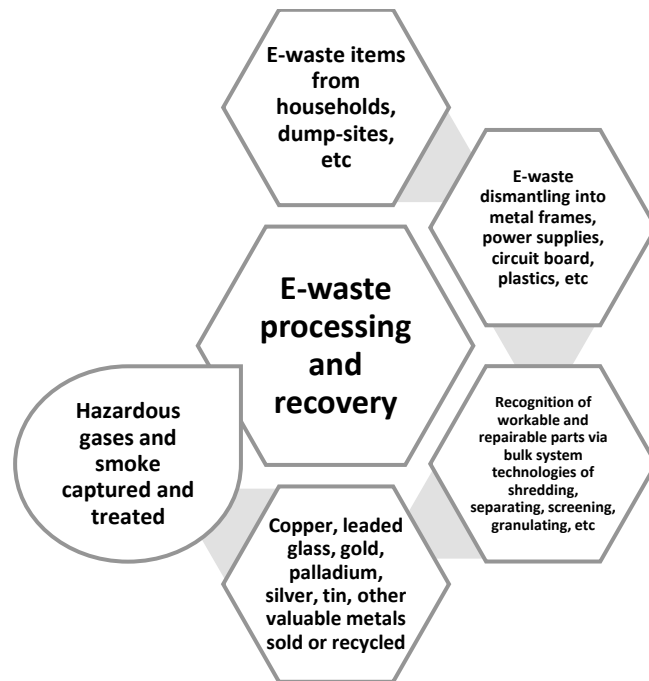
Woldemikael, 2019; Hamdan & Saidan, 2020; Miner, Rampedi, Ifegbesan & Machete, 2020; Almulhim et al., 2022; Sharma et al., 2020).

Considering this and focused on technologies that could improve the recovery rate of valuable metals such as lithium (Shi *et al.*, 2023) – pyrometallurgy and hydrometallurgy methods notable for cost-efficiently recovering LIB are proposed (Rautela *et al.*, 2023). Also, green, cost-effective processes (Liang *et al.*, 2024; Wang *et al.*, 2021; Fu *et al.*, 2024) in terms of beryllium recycling, chemical recycling potential in promoting Beryllium (II) trioxocarbonate (IV) recovery to give BeCl_2 via mechanical extraction, crushing and; channeled to schools and industry for use as catalyst and resource in some organic reactions (Eneh, 2011) and value-key materials (Yang *et al.*, 2024) based on life-recycle are duties that the resource recycling system framework of the Innovation-waste/toxicity education recycling objective focuses on.

Construction of E-waste resource recycling system

Recycling of waste especially e-waste is an idea that hardly exists in Nigeria. This environmental waste frequently produced is dumped in rivers without recycling properly. This is harmful on several levels for both the surroundings and the health of individuals (Garg & Adhana, 2019). This objective of the innovation waste education aims to emphasize the consequence of environmental waste in Nigeria and other portions of the earth; also display the e-waste trends in Nigeria through an evaluation with other nations and; propose the Innovation-waste resource recycling system

Fig 1: Innovation-waste/toxicity education resource recycling flow chart



In addition to, recycling metals from spent electronic the innovation-waste education recycling system helps solve the problem of resource supply and demand (Jiang et al., 2023). The E-waste resource recycling system is to, utilize and evolve cost-efficient valuable processes to retire metals from spent systems such to address pollution while holding great significance for sustainable resource development (Qing *et al.*, 2024).

The driving factors in terms of stakeholders (Tripathy *et al.*, 2023); the economic benefits of the recycling-recovery (Zeng *et al.*, 2023), and

environmental benefits based on life-recycle duties (Wang *et al.*, 2022b; Jiang *et al.*, 2022) considering the extent to which environmental waste and E-waste recycling can alleviate supply shortages of key materials makes the Innovation-waste/toxicity education and her recycling waste objective of the essence. Given this importance consequently and, the high supply risk in the raw material supply chain of, lithium, beryllium and other proposed life-recycle valuables and recovery listings that are potential key materials for various countries (Huisman *et al.*, 2020; Wojewska *et al.*, 2024) especially, China's high demand for lithium resources is, one major resource-recovery and waste-recycle advantage of the proposed Innovation-waste/toxicity education and her recycling waste objective. Thus, with the continued expansion of the lithium-ion battery (LIB) resources demand and LIB industry, largely driven by the rapid development of emerging industries such as new-energy vehicles (NEVs) and energy storage (Jin *et al.*, 2022) concerns, that were previously raised about the related supply risk and value chains-addition at risk of the LIB industry (Jin *et al.*, 2023) the, resource recycling system content of the Innovation-waste/toxicity education and her recycling waste objective becomes a readily and reasonably solution.

Innovation waste education: food-waste-to-feed innovation

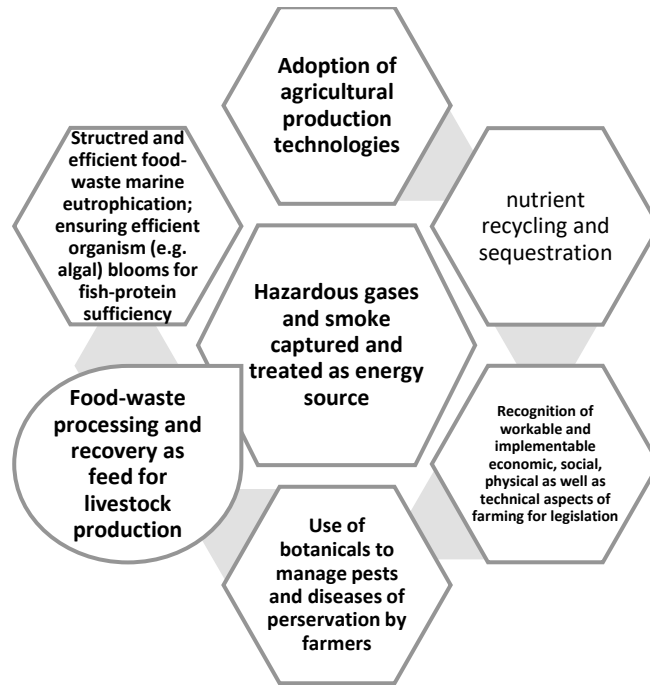
Sustainable development essentially recognizes the importance of the interconnection among ecological, economic, and social values for the development of a society that can prosper from time-to-time (Boström *et al.*, 2018). Thus, the outlook of food-waste-to-feed innovation in the innovation-waste education is on learning sustainably to initiate, nurture, and manage food-waste growth in a circular economic pattern sine qua none to sustainable development. This requires a deep and comprehensive understanding of how societal transformation evolves. Thus, results in a clear 'winner' effect of important waste pattern-tradeoffs using the innovative option of food-waste-to-feed innovative-waste management and

nutrient recycling (The Umweltbundesamt, 2019). This could help to increase available and assessable land for growing feed crops alternative to waste-dump sites; have important potential for inducing land recovery and conversion given indications of consistent positive environmental impact via the removal and use of increased food-waste potential; potential of increased food-waste-to-feed positive impact of more nutritious feed compared to the standard feed; actioned sustainable environment in terms of positive impact of sequestration compared to the non-standard and unsustainable environmental waste practices earlier cited.

This strategic option involves various parties and everyone essential for sustainable development – engaging multiple actors, public participation, and community initiatives in both formal and non-formal environments for sustainable waste development. Similarly, this strategic option supports efforts made to realize sustainable agriculture through organic farming, a type of sustainable farm production that involves eco-friendliness, as well as possible in non-formal education systems to; change the behavior of farmers and agri-producers.

It accents sustainable waste development as not only talking about scientific and technological advances but also deep and lasting social and cultural changes. Furthermore, in the perspective of this innovative strategy is the high-confidence in anchoring it on education and learning. The strategy accents in the existence of structural and cultural inertia that prevents negative social change as well as social and personal conflicts revolving waste-environmental change cum un-sustainable development.

Fig 2: Food-waste-to-feed innovation waste life cycle system



The food-waste-life recycle system further show that the food-waste-to-feed innovation have positive potential and impact compared to the standard feed on four significant environmental issues: reduced global warming (potential), increased and more productive land use (potential), efficient water consumption (potential), and efficient marine eutrophication (potential). The latter's potential in ensuring efficient organism (e.g. algal) blooms due to too many nutrients in an increased ecosystem protein and improved global nutrition-advantage (particularly in Nigeria). This Innovation-waste education strategy is consistent to the adoption of agricultural production technologies such to influence; a wide range of economic, social, physical as well as technical aspects of farming and

achieve improved agricultural production economy, and food security. Thus, causing sustainable environment through nutrient recycling and management

Innovation waste education: Eco-spirituality and Eco-consciousness objective

Eco-consciousness connects social responsibilities towards the earth and the eucharistic spirituality with ecological emphasis in positively contributing to attitudinal changes that can make earth-dwellers more eco-friendly. The above initiatives and others are the strongest that contemporary religious communities' inventiveness can build towards overcoming exploitative approach on creation amid, encouraging a caring disposition for the earth (Rasmussen, 2013; Chryssavgis, 2013). Ecological spirituality objective of innovation-waste education is necessarily inter-religious since, the care for the environment cuts across denominational boundaries and, the care of the environment is a common ground far above doctrinal dialogue.

This movement towards; a deeper realization of creatures' connectivity with nature is a reversal of the modernist ego and age-long anthropocentrism that made human beings the center of everything and; beneficial at arriving at preservation-humanistic principles of the ecosystem from the backdrop of contemporary consumerist culture that promotes an exploitative use of natural resources (Francis, 2015; Nita, 2013; Agouridis, 2013; Tracey, 2004; Duke, 2020). This de-centering from humanity to connectivity among living things has political, economic, social, and spiritual implications. Thus, achieving a three-way approach objective to ecological spirituality: scriptural, self-control, and sacramental concerns – connecting nature with spirituality.

Innovation-waste/toxicity education: major delimitations

Major causes of environmental depletion through E-waste are due to lack of awareness regarding the negative imprints left on sustainability, insufficient

investment, air, and water pollution, insufficient policies to control the production and consequences of environmental waste. Environmental waste management is risky because of the fast-increasing waste and e-waste size and the harm it creates to the environment (Kitila & Woldemikael, 2019). Likewise, approximating the generation waste in governorates/communities is critically required for maintainable and ecologically sound management of waste (Hamdan & Saidan, 2020). However, these factors are possibilities to be overcome with growth of environmental waste education, recycling awareness and recycling legislation – all inherent in Innovation-waste education.

Recommendation and conclusion

Almost more than 2.9 lakh tons of waste and e-waste was produced in Nigeria in 2017 from cellphones, electronics and electronics replacing of damaged parts and, frequently used product upgrades (Miner, Rampedi, Ifegbesan & Machete, 2020). Management of environmental waste and e-waste is of the essence in recent days, specifically in economically growing countries, as inappropriate disposal of waste designates economic damage and harmful effects on the environment and public health (Almulhim et al., 2022). The purpose of this study was to propose the Innovation waste-education – hinged on the energy of a taught, practical and technological structure consistent with households' awareness of waste, environmental issues and connected to inappropriate disposal solution readiness to evolve a standard global circular economy waste management revolution (especially in Nigeria).

Hence, the over usage and more demand for electronic and electrical products have bound the linear economy to a circular economy (CE) (Sharma et al., 2020). Innovation waste education akin to Environmental Management System (EMS) is one most important enabler to affect all the other existing enablers emphasizing and making environmental waste possible. That is, the management of waste can be effective, focused on

producing products that are eco-friendly, growing strict regulations, developing a green environment and associating the producers to apply CE practices. Hinged and semi-education-structured amid inclusive of development and overall stakeholders in its strategic implementation; effectively organized waste needed amongst manufacturers and technological innovations for a developed country prospect of Nigeria is possible particularly if, innovation-waste education inherent basic factors of – collecting, disposal and recycling to, build effective waste management CE revolution are – implemented.

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