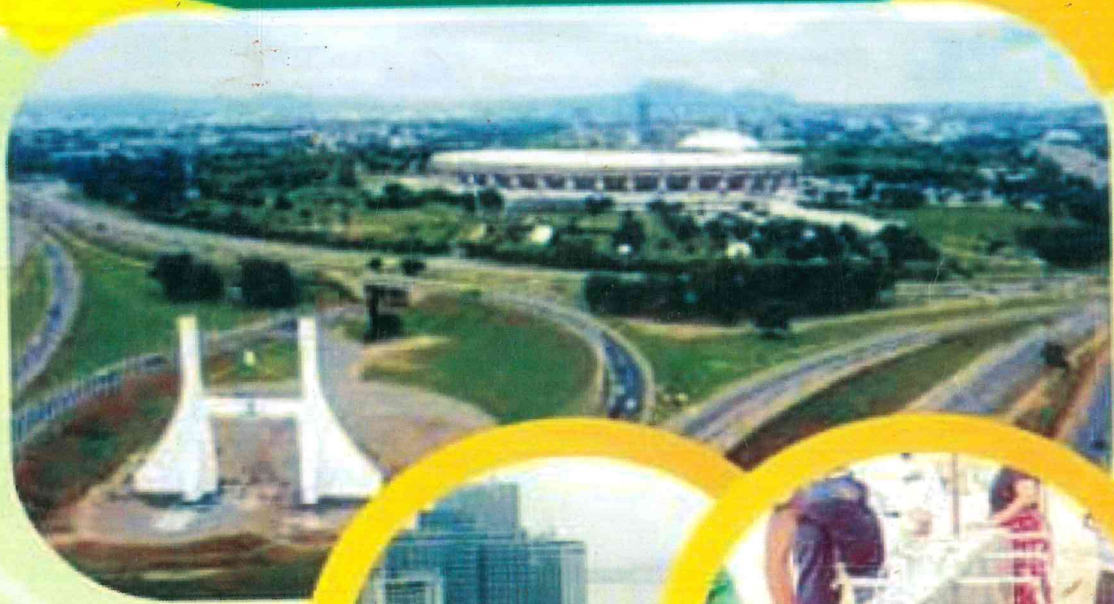


PLANNING AND MANAGEMENT OF SUSTAINABLE INFRASTRUCTURE DEVELOPMENT IN NIGERIA



A Book in Honour of
Professor Nurain Bolanle Tanimowo

Edited By
RAFIU BABATUNDE IBRAHIM
AKEEM BAMIDELE MUILI

PLANNING AND MANAGEMENT OF SUSTAINABLE INFRASTRUCTURE DEVELOPMENT IN NIGERIA

In honour of

Professor Nurain Bolanle Tanimowo

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PLANNING AND MANAGEMENT OF SUSTAINABLE INFRASTRUCTURE DEVELOPMENT IN NIGERIA

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PLANNING AND MANAGEMENT OF SUSTAINABLE INFRASTRUCTURE DEVELOPMENT IN NIGERIA

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The publication of this academic Book of Reading in honour of Professor Nurain Bolanle Tanimowo is informed by the quest to give honour to whom it is merited. The past and present students of Prof. Tanimowo constituted the book project committee from among themselves. This committee displays high level of commitment and perseverance.

The tireless efforts of the book project committee have indeed won accolades. This attests to the deep obligation to the academic scholarship. We're highly indebted to Dr. E. A. Toyobo, Dr. S. B. Adedotun, Dr. M. O. Jelili, Dr. R. B. Ibrahim, Dr. A. B. Muili, Dr. W. M. Raheem, Dr. M. A. Asani and Dr. D. S. Ogundahunsi, for their efforts in the publicity of the call for papers and other logistics. The valuable suggestions of Dr. D. V. Ogunkan for the success of this book is also appreciated.

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We hereby place on record special thanks to all our Book Reviewers who, out of their tight schedules, found time to do a thorough review of all the researched articles published in this Book. Everlasting Glory is due to Almighty God for making the publication of this book a success.

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EDITORS' NOTE

This book is published in honour of Professor Nurain Bolanle TANIMOWO who is due for retirement from full-time academic endeavour by the year 2020. Prof. N. B. Tanimowo has, made indelible marks in the profession of Town Planning. His footprints in academics, practice and administration have no doubt impacted on many lives across Urban, Regional and Rural enclaves.

It is then considered that this erudite scholar and astute administrator who has made such marks in academic and lives of many should be celebrated. How then can we celebrate his exit from full-time academic activities? The best way is to publish a book that will show the various areas where he had touched academically, professionally and administratively. Thus, a book titled: "Planning and Management of Sustainable Infrastructure Development in Nigeria" is published in honour of Prof. N. B. Tanimowo's retirement from active academic works.

Academic researchers and professionals that have something to do with teaching and practice of urban, regional and rural environments made contributions in the book. The topics discussed in each of the chapters of this book are based on in-depth research by the various authors who are seasoned scholars. The book is an epitome of 43 chapters, structured to encapsulate salient and contemporary facets of urban infrastructure planning and management. The topics which are universal in scope and coverage are succinctly presented.

Infrastructure is inevitable for the socio-economic development of any nation including Nigeria. A country that lacks infrastructure will remain underdeveloped and dependent on other economies for its survival. Therefore, it is a catalyst that accelerates economic growth, reduces poverty and unemployment. He also empowers and makes people to be self-reliant. Good quality infrastructure is a key ingredient for sustainable development. All countries need efficient transport, sanitation, energy and communication systems etc., if they

are to prosper and provide a decent standard of living for their population.

The 43 chapters of the book consist of nine (9) Infrastructure categories. The categories are used as sections and are listed: Sustainable Transportation systems; Sustainable Potable Water Supply and Management; Sustainable Sanitation and Sewage Management systems; Sustainable Solid waste management; Sustainable Energy systems; Sustainable Information and Communications Technology (ICT); Sustainable Cultural Heritage Assets; Sustainable Urbanization and Building constructions; as well as Sustainable Tourism and Recreation.

This book is therefore an appropriate tribute to a man who has distinguished himself as a University Administrator, Scholar and Professional. He is known globally in the prestigious Town Planning Profession with specialized area of Transportation in particular and in the built environment as a whole.

As a matter of fact, posterity will not forget so soon, your administrative dexterity as a former Head of Department (HOD), Department of Urban and Regional Planning, and erstwhile Dean, Faculty of Environmental Sciences, LAUTECH, Ogbomoso. As you disengage from active service of LAUTECH, this book - Planning and Management of Sustainable Infrastructure Development in Nigeria- will no doubt remain with us as an enduring legacy. It will also go with you as a splendid remembrance.

R. B. Ibrahim
A. B. Muili

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Peer Review and Scientific Publishing Policy
January 5th, 2020

TO WHOM IT MAY CONCERN

We like to state that all the papers published in Planning and Management of Sustainable Infrastructure Development in Nigeria Book have passed through the peer review process which involved blind review of full chapters by minimum of two reviewers, forwarding of reviewers' comments to authors, submission of revised chapter by authors and subsequent evaluation of submitted chapters by the Editors to determine content quality and adherence to each module.

All chapters are only published based on the recommendation of the reviewers and the Book Editors.

Editors,

Planning and Management of Sustainable Infrastructure Development
in Nigeria Book

CHAPTER SEVENTEEN

INNOVATIVE MEANS OF TRANSFORMING WASTE TO WEALTH IN NIGERIA: AN OVERVIEW

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ABSTRACT

Due to rapid urbanization in Nigerian cities, the quantity of waste generation and its associated challenges has been on the increase requiring adequate attention. Effective management of waste is difficult as it requires time, energy, and cost. The reformation now is that, wastes should not be just discarded rather; wastes should be viewed as resources which have potentials that can be transformed into valuable products. This paper therefore reviewed solid waste management practices in Nigeria, the economic value of wastes and an overview of some innovative ways through which solid waste can be transformed to wealth in Nigeria.

Keywords: Waste, Wealth, Innovation, Urbanization

INTRODUCTION

Waste is a term used for worthless or unwanted materials discarded after primary use. United Nations Environment Program (1992) defined wastes as substances or objects, which are disposed of, intended to be disposed of, or are required to be disposed of by the provisions of national law. Waste is also defined as any product or material which is useless to the producer (Basu, 2009). The term waste is however subjective because an object regarded as a waste by one individual, may be a resource to another. Therefore, a material can only be regarded as a waste when the owner labels it as such (Dijkema *et al.*, 2000).

Currently, about 54% of the world's population live in cities, expected to increase to 66% by 2050, with the highest rates of urban growth expected in developing countries such as Nigeria (UN, 2017). As a result of this rapid urbanization, the quantity of waste generation and its associated challenges have been on the increase requiring adequate attention (Amasuomo and Baird, 2016), unlike the pre-historic period when due to small population and vast land, the environment easily absorbs waste released without significant degradation (Tchobanoglous *et al.*, 1993). However, migration of population from rural to urban areas which started in the sixteenth century during the industrial revolution led to population explosion that in turn led to a surge in the volume and variety of wastes generated within the urban areas (Wilson, 2007).

Effective management of waste is difficult as it requires special processes that entail time, energy, and cost. Wastes therefore should not be disposed merely, but considered as vital resources that have valuable potentials. This process of conversion of waste to a product that can be put to primary use can be viewed as a process of generating wealth, hence the phrase 'Waste to Wealth', (Egun, 2012). This paper therefore reviewed waste management practices in Nigeria,

the economic values of wastes and presents an overview of some innovative ways waste can be transformed to wealth in Nigeria.

CLASSIFICATION OF WASTE

Common characteristics used in the classification of waste includes: the physical states (solid waste, liquid waste and gaseous waste) (White *et al.*, 1995); Source of production (such as: domestic waste, industrial waste, agricultural waste, commercial waste, demolition construction waste and mining waste) (Demirbas, 2011); Biodegradability (biodegradable and non-biodegradable); and environmental impact (hazardous waste and non-hazardous waste) (Dixon and Jones, 2005). The most common types of solid waste in Nigeria are: domestic waste (garbage and rubbish produced by individuals and households), commercial waste (solid waste coming from business places such as stores, markets, office buildings, restaurants, shops, bars, etc.), and industrial waste (produced by factories and processing plants).

Waste will remain a part of our lives for as long as we exist. While some people may produce more wastes than others, everybody produces it every day as leftover food, dirty water or garbage. Waste is not entirely useless because there are people and businesses that will pay to have them. This paper however, focuses on how solid wastes can be transformed to wealth.

SOLID WASTE SOURCES AND CONTENTS

Solid waste comprises all the waste arising from human and animal activities in solid form (Abdul-Rahman, 2012). The composition of municipal solid waste varies greatly from place to place and from time to time. It predominately includes food waste, household waste, market waste, packaging materials and products which are no longer useful. The sources can be residential, commercial, institutional and industrial.

Table 1. Solid Waste Sources and Contents

Source	Typical Waste Generator	Solid Waste Contents
Residential	Single and multiple households/ dwellings	Food wastes, paper, cardboard, plastics, textiles, leather, yard wastes, wood, glass, metals, ashes, special wastes (e.g., bulky items, consumer electronics, batteries, oil, tires), and household hazardous wastes.
Commercial	Shops, Stores, Hotels, Restaurants, Markets, Office, Malls etc.,	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes
Institutional	Schools, Hostels, Hospitals, Government and Private Office Complexes	Paper, cardboard, plastics, wood, food wastes, glass, metals, special wastes, hazardous wastes.
Construction and Demolition Waste	Construction sites, road repairs, renovation sites, demolition of buildings	Wood, steel, concrete debris, glass, sand, tiles, bituminous concrete etc.

Municipal Services	Street Sweeping, landscaping, Cleaning of parks, beaches, other recreational areas	Street sweepings; drain silt; landscape and tree trimmings; wastes from parks, beaches, and other recreational areas
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Source: Government of India (2017).

A study by Sani, 2016, shows that waste composition in Minna includes: Paper, carton and pack (7.0%); Plastic and rubber (16.0%); Organic or vegetables and food item (34.2%); Glass and ceramic (4.7%); metal (1.8%); Wood (3.8%); Textile (9.2%); Garden and animal waste (5.9%); Medical waste (0.7%); Electronics (2.2%); and Diapers and pads (14.4%). The paper, carton and pack category have the highest percentage of composition while textile and medical waste is the least of the waste composition in the study area.

Solid Waste Management in Nigeria

Nigeria, with population exceeding 140 million (NPC, 2006) estimated to be about 170 million in 2018, is one of the largest producers of solid waste in Africa. Nigeria generates more than 32 million tons of solid waste annually, out of which only 20-30% is collected (Bakare 2016). Solid waste management is the discipline associated with the control of generation, storage, collection, transfer and transport, processing, and disposal of solid wastes in a manner that is in accord with the best principle of public health, economics, engineering, conservation, aesthetics, and other environmental considerations (Sridhar and Hammed, 2014). In Nigeria, solid wastes are managed in an indiscriminate manner. Sani (2016) study presented that the waste disposal method practiced in Minna is mostly by open dumps, which is uncontrolled free-range disposal on streets, drainages, stream and vacant lands (see Figure 1). Other method of waste disposal includes: Controlled tipping,

where Niger State Environmental Protection Agency (NISEPA) transfer waste from collection points to refuse dump site; Incineration which is mostly done in households but in an open manner because few households in Minna have chimney; and composting of which little percentage of the respondents agree that they practice it.

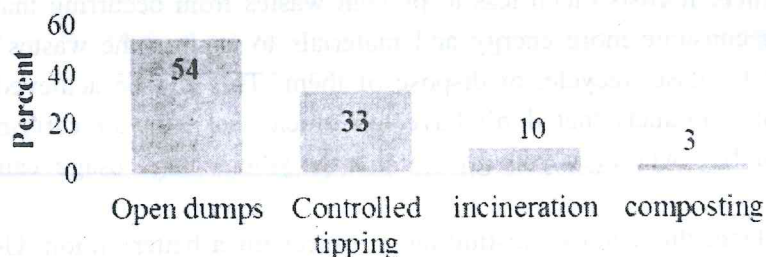


Figure 1: Waste disposal methods in Minna

Source: Sani (2016)

THE Rs PRINCIPLE OF SUSTAINABLE SOLID WASTE MANAGEMENT

The Intergovernmental Panel on Climate Change attributed three percent of global anthropogenic greenhouse gas emissions to waste disposal; however, the mitigation potential through adopting sustainable waste management practices including the Rs concept is estimated at 15-20 percent (IPCC, 2014). The Rs concept has been used to promote sustainable waste management. First it was the 3Rs: Reduce reuse and recycle. Later the 5Rs (Refuse, Reduce, Reuse, Recycle, Recover) principle emerged. And currently we have the 8Rs principles (ASTEC, 2017), which are a combination of the 3Rs and 5Rs. They include: Reduce, Replace, Reuse, Recycle, Recover, Refuse, Re-gift and Rethink.

The 8Rs Principle offers a sustainable, environment friendly alternative to deal with the enormous challenge posed by waste with its obvious impact on human health, environment and natural ecosystems. It looks at waste as a resource at every stage of its life cycle. The Assam Science Technology and Environment Council (ASTEC) (2017), explained the 8Rs principles with additional examples as follows:

- i. **Reduce:** It costs much less to prevent wastes from occurring than to later consume more energy and materials to capture the wastes and then to reuse, recycle, or dispose of them. This can be achieved by buying products that don't have too much packaging or carrying a cloth bag wherever you go, so that polythene bags usage can be avoided.
- ii. **Replace:** this entails substituting an object for a better option. Using durable items instead of one-off disposable items (e.g. replace paper/plastic cups with mugs/glasses). Replacing paper towels with hand-dryers or cloth towels.
- iii. **Reuse:** It involves using resources in their existing forms after being used without further reprocessing thereby minimizing additional cost required for recycling. This is typical in returning soft drinks bottles back to the vendor, or using all writing paper on both sides, or using silverware and dishes instead of disposable utensils.
- iv. **Recycle:** It involves transforming resources into a form that can be used as an input to a new process i.e. taking a product or material at the end of its useful life and turning it into a usable raw material to make another product. Useless office documents can be recycled into tissue papers.
- v. **Recover:** Resource recovery occurs after reduce, reuse and recycle have been attempted. It entails conversion of waste materials for the

recovery of resources such as electricity, heat, compost and fuel or as metals, glass, etc. through thermal and/ or biological means.

- vi. **Refuse:** This entails avoiding unnecessary consumption and make life style choices by selecting items that use least packaging, require the least resources to produce and can be used multiple times.
- vii. **Re-gift:** One always have the choice to give out unwanted materials like clothes to another instead of outright disposal.
- viii. **Rethink:** It is ultimately up to us to really start thinking about what we buy, why we buy it and how we dispose of it.

The waste hierarchy recognizes that some types of waste, such as hazardous chemicals or asbestos, cannot be safely recycled and direct treatment or disposal is the most appropriate management option (ASTEC, 2017).

CREATING WEALTH FROM SOLID WASTE

In Nigeria, waste is generated at the rate of 0.43 kg per head per day and 60 to 80 per cent of it is organic in nature (Sridhar 2006; Ogwueleka 2009). Waste generated producing cow meat alone is about 328.4 kg in the form of dung, bone, blood, horn and hoof (Sridhar and Hammed, 2014). The study of Olukanni *et al.* (2018) in a Private tertiary institution in Nigeria presented that 330Kg of waste is generated on a daily basis from the campus which cut across: Polyethylene Terephthalate (PET) bottles, paper, plastic food packs, nylon, tin cans, tetra packs and food waste (see Table 2). The economic value of recyclable waste generated daily from the institution is about ₦39,834.80 this is equivalent to ₦14,340,528.00 in a year.

Table 2. Economic Value from Recycling Waste Materials in a Private Tertiary Institution in Nigeria.

Recyclable Waste Materials	Average Percentage of Each Item in the Waste Stream (%)	Waste Generated per Day (kg/day)	Prices of Recyclables in Naira/kg	Total Value of Waste Generated (in Naira)
PET bottles	12.69	292.66	55	16,696.30
Paper	3.79	87.53	5	437.65
Plastic food packs	11.92	274.72	30	8241.60
Nylon	9.07	209.29	30	6278.70
Tin cans	4.41	101.85	35	3564.75
Tetra packs	5.72	131.88	35	4615.80
Food waste	52.40	1207.87	Compostable	-
Total	100.00	2305.80		39,834.80

Source: Olukanni *et al.* (2018).

The pivotal point of creating wealth from waste has to do with recycling. Recyclable wastes are non-biodegradable materials which can be put to use again in the same or different form. Inorganic waste, such as PET and plastics, waste paper and tetra packs are now increasingly recycled. Recycling waste of useful materials puts them back into circulation for consumers. Table 3 presents the various recyclable wastes and the resources they can be recycled to.

Table 3: Recyclable Solid Wastes and Their Products

Waste	Recyclable Value or Use
Hair, bristles, wool, feather	Brushes, lanol, fertilizer, wigs, blankets, carpets, fabrics, yarns pillows Mattresses
Hoofs, horns	Buttons, combs, hair pins, novelties, washers, glue, gelatin fertilizer
Bones	Buttons, cutlery, handles, ornaments, glue, gelatin, bone meal
Hides, skins, feet	Horse whips, seats, belts, hand bags, book binding, shoes, gloves, Oil, Glue, Gelatin
Intestines	Stock feed, surgical ligature, musical (guitar) strings, tennis strings, sausages and Putty containers
Blood	Fibrin foam, purified bovine albumin, dried blood and blood meal
Ruminal contents, excreta	Methane gas, manure
Fats	Soap, machine oil, candles, leather dressings
Glands and special organs	Pharmaceutical products (insulin, gall stones, corticosteroids), Pepsin, Cholesterol, Liver extract, Cartilage
Aluminium	Soft drink and beer cans, cutlery
Paper	Newspaper, packaging materials, crate of egg, tissue paper
Plastics (various types)	Bottles, milk jugs, pipes, thin film
PETE/1	packing, battery casings etc.
Glass	Various glass products, decorative pieces, brick aggregates
Ferrous metal	Tin cans, metal works
Non-ferrous metal	Aluminium, copper, lead, etc, various items
Yard wastes, organic wastes	Compost, biogas

Construction wastes	Filling materials
Tyres	Road paving, building, shoe soles
Batteries	Recycling for lead, copper, plastics and reuse
Waste oil/Rice husk	Reuse after refining Briquettes, cement substitute etc.

Source: Sridhar and Hammed (2014).

The initiative of promoting commercially viable products out of solid waste has already taken effect in Lagos, Nigeria such as the compost plant at Ikorodu used for treatment of waste and generating about 42,000 tonnes of compost within six months used for agricultural activities, and waste to energy plant at Ikosi market which generates biogas from market waste that is used to power a 2KVA generator at the market (Iriruaga, 2012). Also, various studies have produced significant contributions on the waste to wealth initiatives presented by Sridhar and Hammed (2014) as follows.

- i. A 10-ton per day capacity "Pace Setter Organo-mineral Fertilizer Plant" was designed and built for Bodija market in Ibadan (1998), Nigeria which is the first prototype demonstration project in the country. The Technology is available under the Environmental Development Foundation.
- ii. A 5-ton per day capacity organo-mineral fertilizer plant was designed and built for Ayeye community, Ibadan (2002) where sorting of non-biodegradable and biodegradables were practiced; recyclables and the organo-mineral fertilizer are being sold.
- iii. A 5-ton per day capacity food residual conversion to compost (2002) was developed for a flow station at Shell Petroleum Development Company, Forcados, Delta State; the compost produced is being used for maintaining their lawns and gardens.



Plate I: Products of Recycled Paper

Source: tetrapak.com (2015)

- (ii) **Plastic:** This is arguably one of the most common forms of waste in African cities. Waste plastics such as plastic bottles, used plastic tins and containers and shopping bags can be melted and formed into an amazing range of new and reusable products. Potential buyers of processed plastic include: plastic product manufacturers, industries, and middlemen. Approximately 700,000 plastic bottles can be used to make a one kilometre stretch of road.

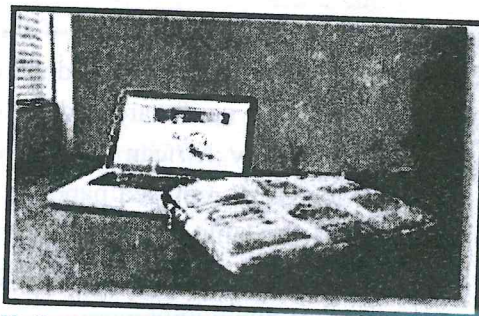


Plate II: Laptop Bag made from sachet water waste

Source: The African Fabric Shop (2015)

(iii) **The Biogas Plant:** A single simple solution to answer two major problems we face: high cost of energy and accumulated biodegradable wastes is Biogas plant. Incorporating biogas plant in homes or community houses does not only save cost of constructing separate septic tank for toilet but also converts waste to energy. Since the biogas plant is underground construction it also minimizes land use. Generation of a renewable valuable energy source is the key resource of biogas plant. low capital cost; low operating cost; long life span. It is eco-friendly, has minimal maintenance, produced little sludge, insignificant odour, and less handling risks. Raw materials such as kitchen wastes food wastes and toilet wastes are used to generate green energy include biodegradable material.



Plate III: Enjoying Biogas Flames from a Biogas reactor in a kitchen
Source: Abdul-Rahman (2012)

(iv) **Metal:** Scrap metals, auto wrecks, aluminium (beverage) cans, used copper wires and used metal sheets can be melted to produce new metal products. Potential buyers of scrap metals include aluminium and metal Industries, scrap dealers and foundries.

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