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The Viability of Reuse as a Motivation for Sustainable Management of Faecal Waste in Ogun State, Nigeria

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Abstract

Objective: This study attempts to determine the extent to which faecal waste reuse in Ogun state, Nigeria, can be a viable strategy for sanitation enhancement and economic empowerment. **Methods/Statistical analysis:** It adopted a four-level multi-stage approach in arriving at 330 sample size for quantitative data, while qualitative data rather adopted the purposive approach in scoping down to 33 key informants. After editing, and screening for errors and outliers, the SPSS software (Version 22.0) was employed for descriptively analysis, and the qualitative data, which was obtained from key-informants was related in order to make informed conclusions. **Findings:** The study shows that about 27.3% of households in the study area do not to have toilets, in line with earlier work of WHO that Nigeria is among such countries where at least one person in five cannot access improved sanitation services. Moreover, the dominance of the non-recovery means of faecal waste management (51.7%) seriously constrains any quest for resource recovery. Faecal waste is currently not being used in the study area, and most households would not be willing to sell faecal waste for reuse. This, of course, presently constrains faecal resource reuse potentials as being canvassed in existing literatures. **Application/Improvements:** The study recommends awareness-raising in respect of the diverse reuse opportunities of faecal waste to spinoff a paradigm shift that can encourage acquisition of capacity required to develop and maintain faecal waste reuse technological applications and management means that allow for easy recovery.

Keywords: Faecal Waste, Management, Open-Defecation, Recovery, Reuse, Sustainable Sanitation

1. Introduction

In[1] described the state of sanitation in Nigeria as the worst country in Africa and the third worst globally. This is so because more than 58 million of its urban dwellers still exist without access to a safe, private toilet.

Nigeria was ranked by same report as third on a list of countries with the most number of city occupants still indulging in open defecation and tenth on the list of countries with the most proportion of urban-dwelling open defecators. This is corroborated by[2] that had considered Nigeria the sixth worst of the most people defecating in the open. The estimation was premised on the average number Nigerians defecating (46,017,300), and the number of open defecators per square kilometre, which was estimated at 50 per square kilometre for Nigeria.

The foregoing is not too different from recent assessment of Joint Monitoring Programme — a body set up by UNICEF and the World Health Organization as reported by[3] in respect of the percentage of Nigerian population that do not have safe and improved toilet (67%), proportion of the population that lacks access to clean water (33%), and the fact that 26% of Nigerians practice open defecation. The present state of faecal waste management in Nigeria is equally captured in the 2016/2017 Multiple Indicator Cluster Survey of the UNICEF Nigerian that reported the fact that open defecation is still prevalent in 771 out of 774 Local Government Areas in Nigeria[4]. The survey further reported that 25% of Nigerians still defecate in the open. The consequences and costs of this sanitation situation are dire. Economically, Nigeria loses over 2% of its Gross Domestic Product, (USD 3 billion) to open defecation and badly managed sanitation (Daily Trust[5]). This can be appreciated within the context of an earlier study by World Bank (6) that revealed that persons practicing open defecation expends practi-

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cally 2.5 days a year finding a private location to defecate. The huge man-hour loss by over 25% of the population, when translated to monetary costs, the cost of treating sanitation based diseases, the cost of burying casualties of sanitation related diseases, and the mostly unquantifiable cost of stunted mental development of under-age survivors mostly account for this huge sanitation cost.

The health cost is mostly in the perennial occurrence of neglected tropical diseases such as schistosomiasis, trachoma and intestinal worms, which are associated with poor sanitation.

Diarrhoeal diseases related deaths climaxed to about 130,610 cases and account for 6.85% of total deaths in Nigeria[6]. Moreover, about 60,000 children under the age of five in Nigeria were estimated to be casualties of diarrhoeal diseases mainly due to poor sanitation (3).

According to[7], faecal waste challenges are enormous especially in Ogun state, including parts of the state's capital such as Itoko, Ake, Ilogbo, where due to the rocky nature of landforms, toilets are difficult to construct and access to water is also strained. Most households, who can be classified as poor, in the absence of means to bore wells and maintain toilets, recourse to open defecation in bushes, on rocks, and in incidental open spaces. This situation had been better statistically described by[8], which showed in their study that while 70% of rural households in Ogun state have access to toilets, majority of those (55.6%) who have toilets rather depend on unimproved sanitation systems like pit latrines. This lack of toilets, prevalence of unimproved sanitary facilities, and inadequate access to water, make open defecation a practice in 771 of 774 Local Governments in Nigeria, including all the 20 Local Governments in Ogun state (4). The recent cases of cholera and gastroenteritis in the state brings to fore the health risks associated with poor sanitations in affected parts of the study area (Water and Sanitation Program[9], The Guardian Newspaper[10], The Vanguard[11]). Nigeria's faecal waste management issues would continue to get more complex as its current population of 193.3 million people[12], currently the seventh-most populous country in the world, is expected to be greater than the population of United States and become the third-most populous country in the world by[13]. Nigeria's already limited budgets would become more strained as more resources would be expected to be voted to water, hygiene, and sanitation. The situation of the already impoverished population may become worse in the face of rising population, more complicated sanitation crisis, and strained budgets at national and regional levels.

Yet there exists opportunities in the sanitation value chain that can be unleashed, if the enabling environment is activated, to absorb teeming unemployed as a win-win between economic empowerment and environmental sustainability. As canvassed by[14], faecal waste is a resource that can be recovered and reused to spinoff incentivizing opportunities to nudge households to consider the containment of their faecal waste by way of constructing toilets a profitable endeavour. This is premised on the diversifying reuse opportunities associated with faecal waste, beyond its known sphere of land treatment[15–17]. Faecal waste has also been reported by[18] to be invaluable as a nutrient source for aquaculture livestock. In[19] noted that high energy char can be derived from faecal waste when subjected to microwave thermo-chemical conversion process between 180°C and 200°C. This particular product can be a veritable greener variant to firewood and charcoal –the main unsustainable cooking energy sources of poor households in Africa, and helping to address associated negative impacts.

Furthermore, faecal waste can also afford the recovery of Biogas which can be used to generate electricity[20–22]. According to[23], sludge incineration's ash, can be applied as additives in the manufacturing of construction products such as cement, tile, bricks, and artificial lightweight aggregates. This study attempts to adopt the mixed mode technique to elicit information from households- producers of faecal resource, and active and potential players in the sanitation value chain such as emptiers, farmers, construction industry, environmental regulators, etc, in order to ultimately determine the viability of faecal waste reuse in Ogun state, Nigeria, as a strategy for sanitation enhancement and economic empowerment.

2. Methods and Procedures

The study adopted the convergent parallel variant of the mixed-mode technique, which involves the conflation of quantitative and qualitative method of data collection. For the quantitative element, the multistage approach, in a four level manner was adopted. This is inclusive of all senatorial districts, local governments, wards, and polling units in the geographical scope of Ogun State. This sampling approach is without bias to class, density, and level of settlement's development.

The first stage involves the classification of Ogun state into its three main senatorial districts, viz: Ogun East Senatorial District, Ogun West Senatorial District, and Ogun Central Senatorial District, as shown in Figure 1.

As shown in Figure 2, Ogun East Senatorial District consists of nine local governments, which are: Ijebu East, Ijebu North, Ijebu-Ode, Ikenne, Ijebu North-East, Odogbolu, Sagamu, Ogun Waterside and Remo North.

Ogun West Senatorial District, as shown in Figure 3, consists of five local governments, which are: Ado-Odo/Ota, Yewa North, Yewa South, Imeko-Afon, Ipokia.

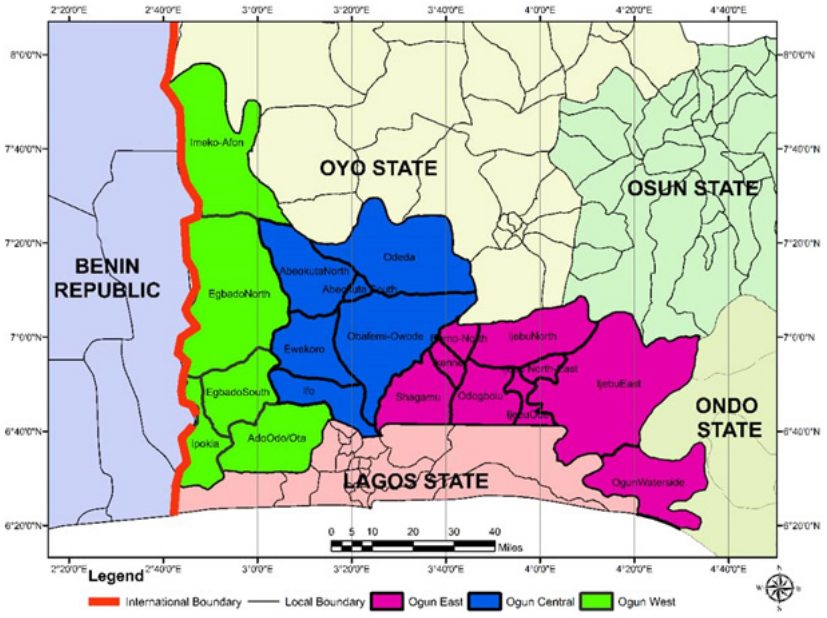

Figure 1. Map of Ogun State Showing Ogun East, Ogun West and Ogun Central Sampling Senatorial Districts in the Study Area

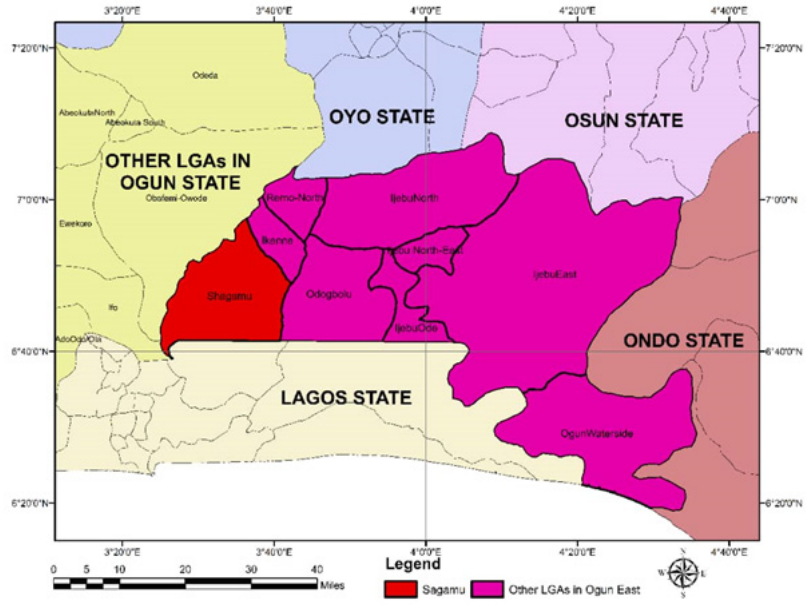

Figure 2. Map of Ogun East Sampling Senatorial District Showing Sagamu Local Government Area

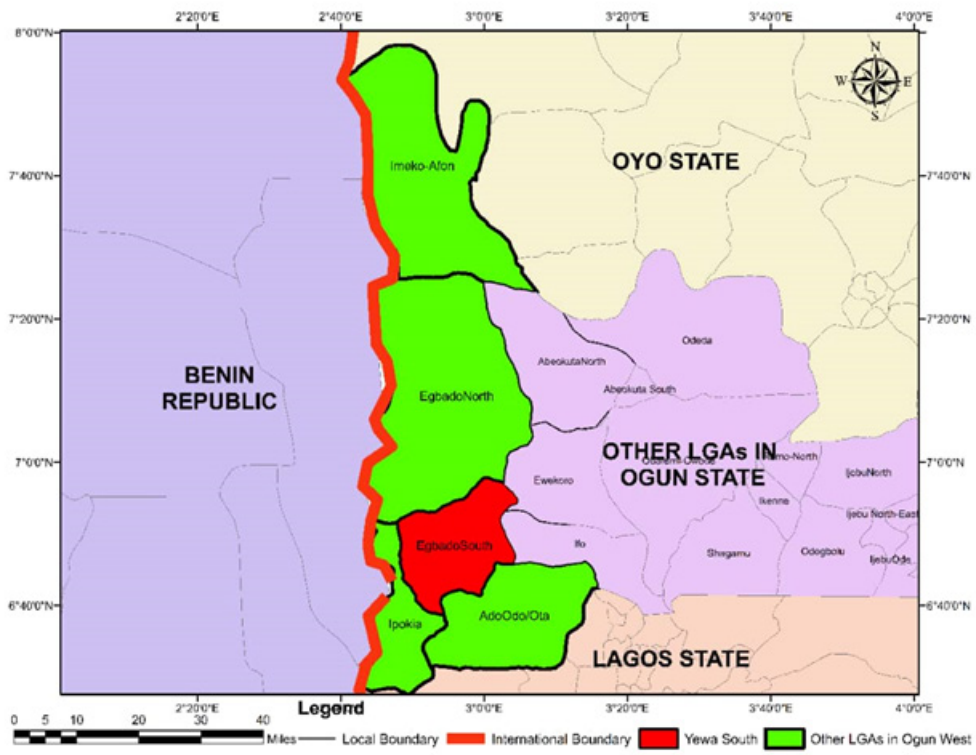

Figure 3. Map of Ogun West Sampling Senatorial District Showing Yewa South Local Government Area

Furthermore, as shown in Figure 4, Ogun Central Senatorial District consists of six local governments, which are: Abeokuta South, Abeokuta North, Obafemi/ Owode, Odeda, Ewekoro and Ifo.

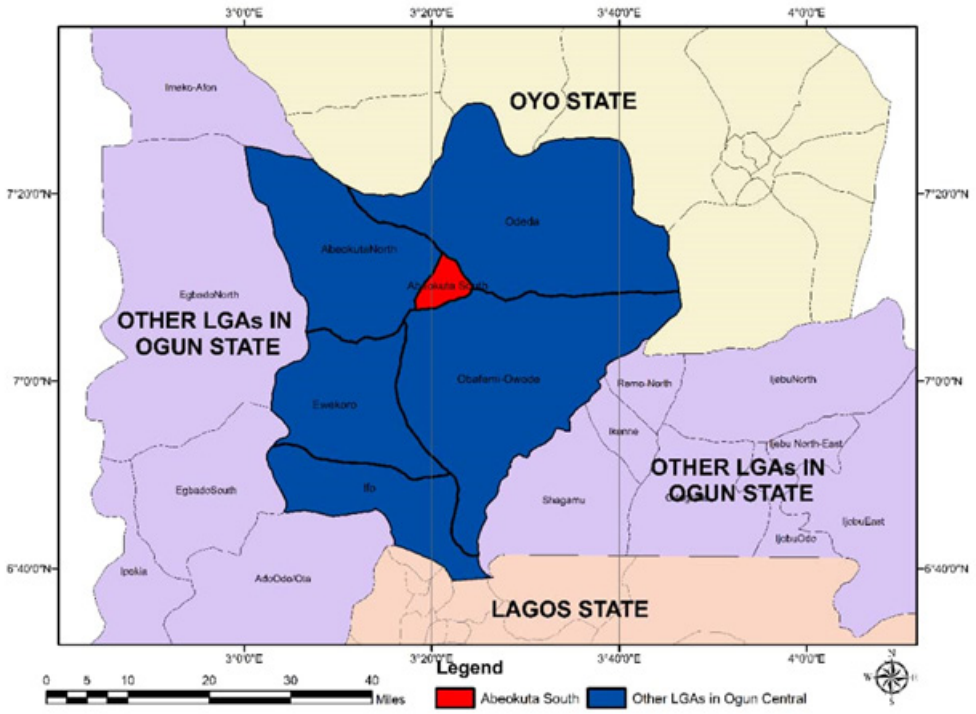

Figure 4. Map of Ogun Central Sampling Senatorial District Showing Abeokuta South Local Government

The second stage involves the random selection of Sagamu, Yewa South, and Abeokuta South Local Governments as the sampling Local Governments in Ogun East Senatorial District, Ogun West Senatorial District, and Ogun Central Senatorial District, respectively. The third stage involves the random selection of a representative ward, based on the wards and polling units' delineations of Independent National Electoral Commision (INEC), from each of the sampling Local governments. In Sagamu Local Government, which consists of 15 political wards, as shown in the first column of Table 1, Ogijo/Likosi ward was randomly selected as the sampling ward. Out of the 10 political wards in Yewa South, as shown in the second column of Table 1, Ilaro I was randomly selected as the sampling ward. Further, Sodeke/Sale-Ijeun II was randomly selected as the sampling ward in Abeokuta South Local Government, which encapsulates 15 political wards, as shown in the third column of Table 1.

Table 1. The political wards in the sampling local government areas

	The 15 Political Wards in Sagamu	The 10 Political wards in Yewa South	The 15 Political Wards in Abeokuta South
1	Oko/Epe/Itula I	Ilaro I	Ake I
2	Oko/Epe/Itula II	Ilaro II	Ake II
3	Ayegbami/ Ijokun	Ilaro III	Ake III
4	Sabo I	Iwoye	Keesi/Emere
5	Sabo II	Idogo	Ijemo
6	Isokun/Oyebajo	Oke Odan	Itoko
7	Ijagba	Owode I	Ijaye/Idi-Aba
8	Latawa	Owode II	Erunbe/ OkeIjeun
9	Ode -Lemo	Ilobi/Erinja	Ago-Egun/Ijesa
10	Ogijo/Likosi	Ajilete	Sodeke/Sale-IjeunI
11	Surulere		Sodeke/Sale-Ijeun II
12	Isote		Imo/Isabo
13	Simawa/Iwelepe		Igbore/Ago Oba
14	Agbowa		Ibara I
15	Ibido/Ituwa/ Alara		Ibara II

The fourth stage involves the random selection of polling units in each sampling ward, and the random selection of buildings occupying targeted households and locating within 1 kilometre radius from the polling units. The polling units are nationally recognized landmarks for further categorising spatial entities into smaller homogenous units. All the polling units in each of the sampling wards were identified. In Ogijo/Likosi ward, out of the available 19 polling units, 10 as shown in Table 2 were randomly selected. In Ilaro I, out of the available 17 polling units, 10 as shown in Table 3 were randomly selected. Moreover, in Sodeke/Sale-Ijeun II, out of the available 25 polling units, 10 as shown in Table 4 were equally randomly selected.

Table 2. Polling units in Ogijo/Likosi wards, and the randomly selected polling units

	All Polling Units In Ogijo/Likosi Ward	Randomly Selected Polling Units(Ogijo/ LikosiWard)
1	St. Paul's School Igbode	St Paul's School Igbode
2	Osigboyede Village I	St Micheal Rcm Fakale
3	St. Michael R.C.M. Fakale	U.A.M.C School Iraye
4	U.A.M.C. School Iraye	St Francis School Igbosoro
5	St. Francis School Igbosoro	St John School Ogijo I
6	St. John School Ogijo I	LG School Erefun
7	St. John School Ogijo Ii	LG School Igbaga
8	Front Of Lisa's House Ogijo	A.U.D School Imushin-Ogijo
9	Wesley School Erefun	Wesley School Sotunbo
10	L.G School Erefun	And CAC School Ogijo I
11	L.G School Igbaga	
12	Mosimi Village	
13	L.G. School Ita - Merin	
14	A.U.D. School Imushin - Ogijo	
15	Eyin Egbe Village	
16	Wesley School Sotunbo	
17	C.A.C. School Ogijo I	
18	Ewu Oloja 0	
19	L.G School Ajaregun I	

Table 3. Polling units in Ilaro I ward, and the randomly selected polling units

	All Polling Units In Ilaro I Ward	Randomly Selected Polling Units (Ilaro I Ward)
1	State Hospital	Idowu's House(Otegbeye Street)
2	Opp. Soyinka's House I	Opp Soyinka's House I
3	Opp. Soyinka's House Ii	State Hospital
4	Near Idowu's House/ Otegbeye Street I	U.A.M.C School Pahayi
5	Near Idowu's House/ Otegbeye Street Ii	Orita Kajola
6	Oba Fasina Close Juncton I	Eleja(Oke-Ola)
7	Oba Fasina Close Juncton Ii	Poly Gate
8	Egbo Alaparun	Library/Rural Health Care Center;
9	U.A.M.C. School Pahayi	Egbo Alaparun
10	Orita Kajola I	Ita Iyalode
11	Orita Kajola II	
12	E.S.L.G. School Ijanna	
13	Ita Iyalode	
14	Oke-Ola - Area	
15	Poly. Gate	
16	Library/Rural Health Centre	
17	Orisun Iran/Ilodo	

Table 4. Polling units in Sodeke/Sale-Ijeun II ward, and the randomly selected polling units

	All Polling Units In Sodeke/Sale-Ijeun II Ward	Randomly Selected Polling Units(Sodeke/ Sale-Ijeun II, Ward)
1	Onjoko Mosq Oke-Bode Ii	Onijoko Mosque Okebode Ii;
2	Opp. Oke-Itoku Mosq. I	Opp Oke-Itoku Mosque Ii;
3	Opp. Oke-Itoku Mosq. Ii	Ile Ogboni Oke Itoku;
4	Near Ile-Ogboni Oke-Itoku	Near Town Planning;
5	Near Ile-Ogboni Oke-Itoku Ii	Open Space Ojulakijena;
6	Near Town Planning - I	St Joseph Rcm. Oke-Bode I;
7	Near Town Planning - II	Primary School Idipape I;
8	Open Space Ojulakijena I	All Saint School Kobiti;
9	Open Space Ojulakijena Ii	Open Space Kemta Odutolu Mosque;
10	Inf. Of O.G.B.C. Imo II	Opp. Bustop Bata Itoku
11	Inf. Of Obamewa's House I	
12	Inf. Of Kehinde's House	
13	St. Joseph R.C.M. Oke-Bode I	
14	St. Joseph R.C.M. Oke-Bode Ii	
15	Open Space Near Ago-Otun I	
16	Open Space Near Ago-Otun Ii	
17	All Saint School Kobiti	
18	Open Space Kemta Odutolu Mosq	
19	Opp. Bus Stop Bata Itoku	
20	Opp. Bus Stop Bata Itoku II	
21	Open Space At Odunbaku Close	
22	Inf. Of Akinsola's House	
23	Open Space Beside Itoku Mosque I	
24	Open Space Beside Itoku Mosque Ii	
25	Pry Sch Idi-Ape I	

This made the total number of polling units within the radius of which households were surveyed in the study area to be 30. Random selection in the three last stages was achieved through the lottery method canvassed in[24]. All the areas available for sampling are numbered. The numbers are written on different pieces of study and shaped into ball-like objects of same sizes. The objects for each sampling stage are mixed together in a container, and the requisite numbers of cases are selected one after the other. Using the systematic sampling technique on the basis of the 5th building interval, 11 households were administered questionnaires within 1 kilometer radius of each of the 10 randomly selected polling units in Ogijo/Likosi

ward; 10 households were administered questionnaires within 1 kilometer radius of each of the 10 randomly selected polling units in Ilaro I; while 12 households were administered questionnaires within 1 kilometer radius of each of the 10 randomly selected polling units in Sodeke/Isale-Ijeun II. Based on the foregoing, a total of 330 questionnaires were administered to representative households in the study area. This implies that 110, 100, and 120 questionnaires were administered in Ogijo/Likosi; Ilaro I, and Sodeke/Sale-Ijeun II, respectively, on the basis of ratio 1.1 : 1.0 : 1.23, which reflects the variance in population of 1,250,435 (33%), 1,112,761 (30%), and 1,387,944 (37%) for Ogun East, Ogun West and Ogun Central, respectively. The total of 330 households that was surveyed through the probabilistic methods adopted actually represents about 0.06% of the 535877 households in Ogun state.

The qualitative data adopted the interview approach. This involved the adoption of flexible semi-structured instrument to interview key informants, which are knowledgeable in key aspects of the research. Altogether, as shown in Table 5, the total number of interviews conducted in respect of qualitative data is 33.

Table 5. Showing the distribution of interviewees considered for the study

Category of Interviewee	Sagamu Local Government Authority	Yewa South Local Government Authority	Abeokuta South Local Government	Total
Faecal Waste Emptiers				
Manual Emptiers	2	2	2	6
Mechanical Emptiers	2	2	2	6
Potential Reusers				
Crop Farmers	2	2	2	6
Fish Farmers	2	2	2	6
Brick Industry	2	2	2	6
Regulatory Authorities.				
Environmental Sanitation and Water Supply Departments.	1	1	1	3
				33

3. Results and Discussions

3.1 Household Income

As shown in Figure 5, the highest number of people (44.2 %) claimed to live on a monthly income of between ₦16,000–₦30,000 (44USD–83USD), which when compared with World Bank Classifications would be ranked as falling within the poor to the lower middle class category. This is followed by 24.2% who live on monthly income of between ₦7500–15,000 (21USD–42USD); 15.8% who live on monthly income between ₦31,000–₦60,000 (86USD–167USD); 8.2% who live on monthly income between ₦61,000–₦100,000 (169USD–277USD; 5.8% who live on monthly income of less than ₦7500 (42USD); and 1.8% who live on monthly income between ₦101,000 – ₦150,000 (281USD–416USD).

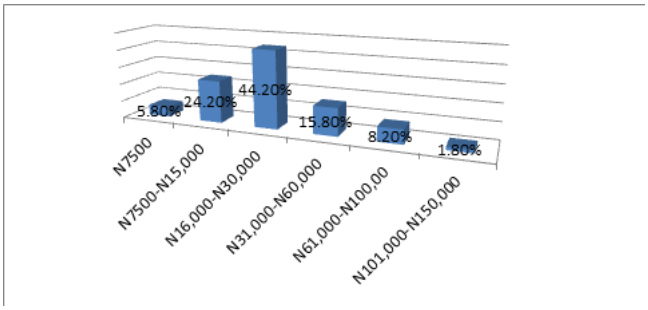

Figure 5. Households Income

3.2 Households' Sanitation Profile

As shown in Figure 6, majority of the households in the study area (72.7%) own toilets, while the remaining 27.3% claimed not to have toilets. This profile reflects a larger

national concern and close to the revelation of WHO[25] that Nigeria is among such countries where at least one person in five cannot access improved sanitation services.

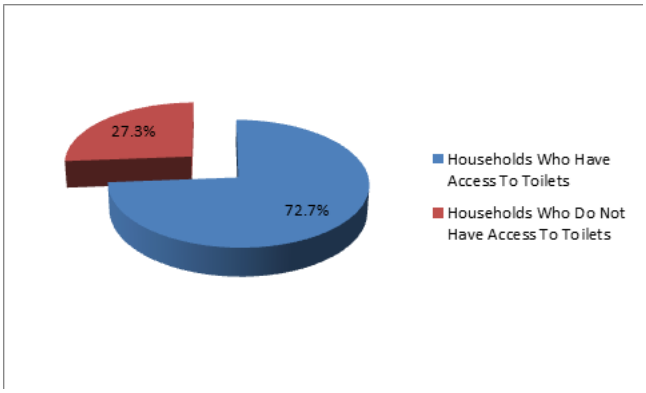

Figure 6. Households' Access to Toilets

In the ranking of the important reasons why the 27.3% of the households do not have toilets, it is evident from Table 6 that lack of pressure from environmental authorities with the mean value 4.26 ranks highest as the reason households do not have toilets. This is followed by the factor of space (3.54); unsuitability of the soil condition of households' sites to support the construction of the type of latrines they can afford (2.94); non-affordability of the cost of maintenance of toilets (2.27); and non-affordability of the cost of construction of toilets (1.96).

Table 6. Reasons households do not have toilets

	N	Mean	Std. Deviation
Pressure from environmental authorities as reason households do not have toilets	90	4.26	.906
Space as a reason households do not have toilets Unsuitable condition of soil in the building's site as a reason households do not have toilets	90 90	3.54 2.94	1.530 1.352
Unaffordability of cost of maintenance as a reason households do not have toilets	90	2.27	.747
Unaffordability of the cost of construction as a reason households do not have toilets	90	1.96	.970

The lack of pressure from environmental authorities could be due to inadequate monitoring as a result of staff's paucity. Interviews conducted to Directors of environmental sanitation departments in the study area, which responsibilities are to ensure sanitation within the local government by inspecting schools, industries, residential milieus, and commercial precincts, and also issue certificate of habitation to premises, reveal that the departments across the three regions where interviews were conducted are grossly understaffed, and this constrains their ability to optimally perform their duties.

However, in the absence of toilets, and as shown in Figure 7, the greatest chunk of the households (51.1%) finds the nearest bush to defecate. This is followed by 27.8% who share toilets with neighbouring buildings; 14.4% who just find a space, not necessarily bushy, to defecate; 4.4% who defecate in bowls, known in local parlance as 'Pos', and subsequently throw away in the open; and 2.2% who patronize public toilets.

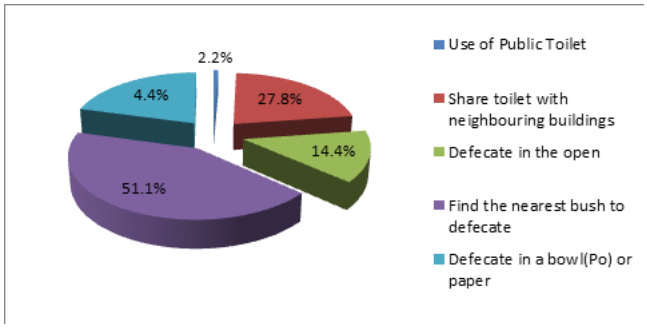

Figure 7. How Households Who Do Not Have Toilets Defecate

As shown in Table 7, of the total number of households who do not have toilets, 63.3% claimed they practice open defecation on daily basis. This is followed by 21.1% who defecate in the open every other day; 6.7% who defecate 3 days a week; 5.6 % who defecate occasionally and 3.3% who claimed never to defecate openly. The latter are most likely households who use their neighbours toilets or public latrines all the time.

Table 7. Frequency of open defecation by households who do not have toilets

	Frequency	Percentage
Daily	57	63.3
Every other day	19	21.1
< 3 days a week	6	6.7
Occasional	5	5.6

	Frequency	Percentage
Never	3	3.3
Total	90	100.0

The foregoing does not deviate significantly from the 2017 revelations of Joint Monitoring Programme — an entity established by UNICEF and the World Health Organization that about 26% of Nigerians defecate in the open. In[26] had earlier canvassed that people practicing open defecation in the country expends practically 2.5 days a year in order to locate a private space to defecate, which culminates in huge economic losses (3 billion dollars cumulatively) and make others vulnerable to pathogens. As evident in Figure 8, majority of households who claimed to have toilets (77.5%) still defecate in the open. Only 22.5% of respondents claimed they, under whatever circumstance, do not openly defecate.

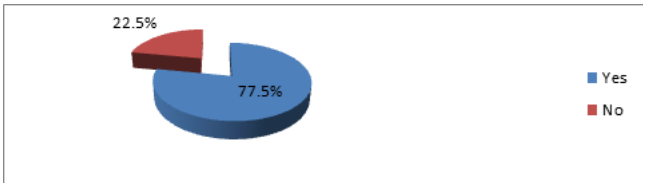

Figure 8. Does Households with Toilets Still Sometimes Defecate in the Open

However, as shown in Table 8, majority of households who have toilets (65.4%) claimed to only defecate openly occasionally. This is followed by 20.8% who claimed they do not defecate in the open, under whatever circumstance, 5.0% that claimed to defecate openly on daily basis; 5% who claimed they practice open-defecation every other day; and 3.8% who openly defecate within three days in a week. Such occasion of open-defecation arises in instances when households' latrines get filled and yet not evacuated; sewers linking water closets to septic tanks get clogged; water extremely scarce; and most importantly when household members are not at home when pressed.

Table 8. Frequency of open- defecation by households who have toilets

	Frequency	Percentage
Daily	12	5.0
Every other day	12	5.0
< 3 days a week	9	3.8
Occasional	157	65.4
Never	50	20.8
Total	240	100.0

3.3 Households Faecal Waste Management and Viability of Reuse

As shown in Figure 9, majority of households (31.7%) adopts the Non-Recovery Management (NRM) means of burying their latrines with sand, and digging another pit within the same compound. This is followed by households who empty their latrines with the aid of manual emptiers (23.3%), 20% who use the non-recovery management means of shrinking sludge with chemicals, and 16.2% who empty their latrines with mechanical emptiers. However, 8.7% of households were yet to empty their latrines.

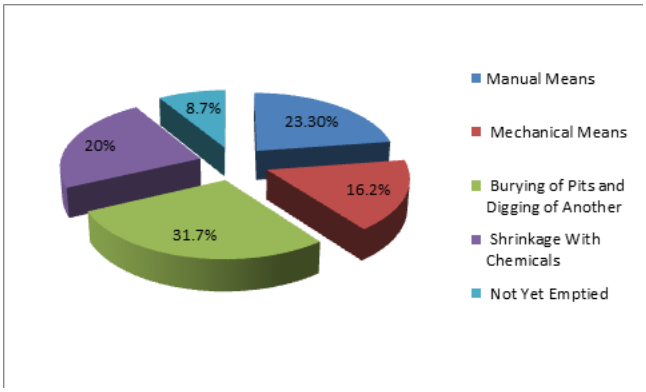

Figure 9. How Households Latrines are managed

The dominance of the non-recovery management means seriously constrains any quest for recovery. Information obtained through interviews revealed that faecal waste emptying business is gender sensitive, hence dominated by the male gender. Further, mechanical waste emptiers in the study area depend on their own trucks fitted with suction machines and pipes to provide their services, except for mechanical emptiers A and B in Yewa South Local Government, who rather hire trucks from other local governments, as there is no single functioning suction truck in their locality. The manual emptiers in the study area are mostly plumbing experts, who also offer faecal waste evacuating services, and essentially depend on tools like gloves, ladder, nose-masks, pales, diggers, shovels, kerosene, and disinfectants. The services are essentially rendered at night, owing to the associated disruptive smell. Further, the departments of environmental sanitation and water supply who are officially saddled with the responsibility of over sighting sanitation in the study area currently do not offer faecal waste emptying services.

They also do not offer any form of subsidies to households, as they are too financially incapacitated to offer subsidies to households for the purpose of their faecal sludge emptying. Hence, households essentially depend on the services of private business operators who specialise in manual and mechanical faecal waste emptying. Frequency of latrine emptying, burying or shrinkage is informed by factors such as population of users, size of latrines, and porosity of soil and underground water level in the environment where toilets are located[27]. The dominance of the non-recovery latrines management means may be borne out of their relatively cheaper costs. The modal amounts spent by households who manage their waste with non-recovery management means of latrines burying and the digging of another pit and the shrinkage of sludge with chemicals are N15,000 (42USD) and N10,000 (27USD), respectively. The modal amounts are higher, at 30,000 (83USD) and 100,000 (277USD) respectively, for households who use recovery means like the manual and mechanical means of latrines emptying. These do not stagger significantly from information gathered through interviews conducted to both mechanical and manual emptiers in respect of service charges. Mechanical emptiers charge between N80,000 to N150,000 (222USD–416USD) on their services. This is depending on the size of latrines, availability of trucks, and negotiating ability of households. However, manual emptiers claimed that they charge between N10,000–N70,000 (27USD–194USD), depending on latrine size and the depth of the new pit where faecal waste will be buried or reused as latrine, in the case where households prefer the burying of existing filled latrines, and households' negotiating ability. From interviews conducted to mechanical emptying service providers, the huge cost is due to factors such as scarcity of trucks used for the service, which could be as lowly as just 2 in a whole senatorial district; low level of demand; high cost of fuel; high cost of maintenance of the truck; and the social stigma attached to the service.

Furthermore, as presented in Table 9, only 2.1% of households claim that faecal waste generated from their households are reused.

Table 9. What happens to sludge after emptying

	Frequency	Percentage
Buried onsite	141	58.8
Buried offsite	16	6.7
Reused	5	2.1
Unknown	21	8.8
Dislodged in River bodies	57	23.8
Total	240	100.0

Information gotten through interviews conducted to faecal emptiers reveals that the perception of knowledge of circular economy of faecal waste in the study area is only within the sphere of the traditional application in farmlands. Other uses such as applications of faecal waste in biogas production, biochar, additives in construction materials, as established by studies such as[17-19] are not part of the purposes faecal waste are reused for, and few of the households are aware of such reuse opportunities. The majority of the households (58.8%) claim that the faecal resources are rather buried. This is followed by a great chunk of households (23.8%) who claimed their faecal waste are disposed in river bodies, not necessarily for the planned nutrient benefit for fishes, but also for easy disposal; 8.8% of households who claimed not know how and where their faecal wastes are disposed; and 6.7% of households that claimed that their faecal waste are disposed offsite, mostly in incidental open spaces or bushes not too distant from their neighbourhoods. These do not deviate from the information gotten from emptiers through interviews. While the mechanical emptiers claimed that they dispose evacuated waste into distant bushes, which are not in use for farming activities, the manual emptiers claimed to bury evacuated faecal waste in pits dug within the environments of latrines where faecal waste are evacuated. The Directors of the departments of sanitation interviewed agreed that open-defecation was still being practiced in their area of operations, and emptiers still indiscriminately discharge faecal waste in bushes and sometimes in river bodies, in a manner that increases their biological oxygen demands. They however claimed they have been creating awareness about environmental sanitation by mobilizing Community Development Associations (CDAS), and sensitizing them on the benefits of sanitation.

Information extracted qualitatively to explore the significant factors of faecal waste reusability were considered from the point of views of the emptiers, potential reusers, and the environmental regulators- the other major actors in the faecal waste management value chain. Half of the mechanical emptiers (Mechanical emptiers D, E, and F), claimed they would deem faecal sludge a resource, which

they could buy at price ranging from N3000 to N10,000 (8USD to 27USD) provided they could cover the cost of their services from the price they will sell to end-users. Others claimed they won't pay to households but they could reduce the prices of their services, provided there are going to be buyers of the resource. Majority of the manual emptiers claimed they would deem faecal sludge a resource, which they could buy at price ranging from N3,000 to N5,000 (8USD to 13USD) provided they could cover the cost of their services from the price they will sell to end-users. Others (Manual emptiers D and E) doubted the possibility of households willingly assenting to the idea of selling their faecal waste, as most households could be suspicious of whether their faecal waste could be used for diabolical fetish purposes. All the manual and mechanical emptiers interviewed claimed they have not been selling faecal waste evacuated from household latrines, but they would be selling provided that the selling price would compensate for the loss of not charging households who produce the evacuated resource. The farmers are aware of the effectiveness of faecal waste as a veritable manure source, but they currently do not make use of the resource. They use synthetic fertilizers like NPK and sometimes cow dung. They mostly claim faecal waste smells, attract flies, and can occasion the spread of diseases. However, they all agreed they would pay an amount ranging from N5,000 to N12,000 (13USD –33USD) per truck filled for faecal resource if it had been de-watered, well treated, odourless and well packaged. The fish farmers mostly are not aware of[18] finding that faecal waste can be beneficial in the production of fodder or feeds for livestock in aquaculture. They claim aquaculture business is very expensive, and they would not want to risk feeding their breeds with substances that could have adverse effects on their breeds. Similarly, operators of construction companies are not aware of[23] finding in respect of the usefulness of incinerator ash in the construction industry. They currently do not make use faecal waste, and really do not see the need to adopt its usage since they are not aware of its advantages. Furthermore, the Directors of Water Resources and Environmental Sanitation Departments interviewed agree that reuse possibilities of faecal waste can create value for recovered waste and represent an incentive to households in the construction of toilets.

Director A operating in Yewa South Local Government jurisdiction specifically claimed his department had in the past supported an engineering initiative that was aimed at making households install sanitation technologies that can allow the conversion of faecal waste to biogas for their domestic use, but the project failed because of the prohibitive cost N1,200,000 (3,333USD) proposed by the project's inventor.

4. Conclusion

For an economy described as the poverty capital of the world, where open defecation is still being practiced in 771 out of its 774 Local Government Areas, and with 25% of the national population still practicing open defecation, it is logical to explore the extent to which reuse can help disrupt the open defecation behaviour and also indiscriminate disposal of faecal waste, as a win-win for environmental sanitation and economic opportunities. The non-recovery management means (burying of pits and adoption of chemicals to shrink sludge) mostly adopted by households who have toilets due mainly to neatness, cheapness and fear of faecal waste being exploited for fetish diabolical purposes constrain the opportunity of recovery and eventual reuse. These concerns that favour the adoption of non-recovery latrine management means perhaps could have been inconsequential had household and potential reusers been aware of applications of faecal waste in biogas production, biochar, additives in construction materials. Yet, information garnered qualitatively offer a clue on how effective treatment and better packaging of faecal waste products like manure and bio-char, which can be a good measure of reining in deforestation occasioned by constant felling of trees for cooking charcoals, could spur households to be more disposed to placing values on their faecal waste. Given that punitive measures, governmental interventions, and psychologically exploiting behavioural change tactics adopted by governmental authorities around the world still would not prevent over 800 million people from defecating in the open, the study strongly recommends a rather more flexible and households-led economic incentive approach to open defecation eradication, in line with the paradigm of green and circular economy.

Based on the implications articulated in respect of this study, social and cultural acceptability of faecal waste is yet a challenge that can be surmounted with improved marketing of awareness-raising and social/commercial marketing campaigns by both sanitation inclined non-governmental organizations and the public authorities. This is expected to spinoff a paradigm shift that can gal-

vanize placement of value on faecal waste generated and equally encourage acquisition of capacity required to develop and maintain faecal waste reuse technological applications and management means that allows for easy recovery.

There is the need for the invention and adoption of locally inspired and affordable simple onsite low-cost technologies that can improve on existing systems such as Urine Diversion Dry Toilets (UDDTs) and anaerobic biogas latrine, and afford in-situ resource (energy or nutrient) recovery, that can represent a business model or energy cost reducing measure for poor households and ultimately culminate in the improvement of households' sanitation. The reuse dimension to improving sanitation should be more compelling to regulators, as the economic and environmental opportunities of reuse can be better articulated and demonstrated by them. It should be more compelling, from the regulatory point of view, that investment in treatment plants and expanded researches into technology leveraging innovative opportunities of faecal reuse afford the authority the opportunity to expand business vistas in the faecal waste management value chain, improve the state of utilities, and ultimately improve environmental sanitation. For instance, government of Ogun State may decide to build treatment plants in each local government area, where faecal waste can be bought from emptiers to produce biogas which can be used to drive turbines that can generate electricity and harnessed by the local community as an alternative to epileptic supply from the national grid. This of course further accentuates the faecal waste's circular economy, as regularity of electricity for lightening in homes would go a long way in reducing open-defecation, especially at nights.

The residue of the biogas conversion process can be treated and packaged into odourless and well packaged pelletized manures and bio-chars that can be marketed back to the public, especially in poor rural communities where poor people who rely on charcoal as their source of cooking energy are also mostly the farmers who would need cheaper and more organic options as fertilisers. With the minimum population of 3751140, based on the un-updated records of the Nigeria's National Population Council, the entire Ogun state can generate a minimum of 487.65 tonnes of faecal waste based on estimation that human beings produce a daily average of 130 grams of faecal waste. The case of Safi Sana treatment plant in the neighbouring Ghana, which has a digester of 25000m^3 capacity for stabilising faecal waste and producing biogas for the generation of electricity, is an existing model that can be studied and improved upon.

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