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Environmental health efficiency and urbanization: The case solid waste management in Bor municipality of South Sudan

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Abstract

This paper is aimed at studying the environmental health efficiency of solid waste management in Bor Town, South Sudan. Many studies have been carried out about efficiency of solid waste management in many developing countries, but no such study has been done in Bor Town so far. In light of the increasing urban population, the chronic absence of data on domestic solid waste management practices, lack of waste management facilities, weak institutional capacities and inadequate financial resources, the households and the municipality are finding it difficult to efficiently management solid waste in Bor town. To meet the objective, the study have assessed the existing waste management practices, determine waste generation rate and composition as per income groups, develop the performance indicators and apply these indicators in assessing the capacity of waste management institution in managing solid waste effectively.

Keywords:

Waste management constitutes an important approach to effective management of various environments. This is because all living organisms, as part of their normal life activities generate and exude various forms of wastes on a daily basis. In addition, every activity of man leads to the generation of wastes, some of which are hazardous and cause danger to humans, other life forms and degrade the environment. Accumulation of refuse in the environment leads to the pollution of land, air and water, thereby increasing the likelihood of the spread and transmission of air-borne and water–related diseases (Opara, 2015).

For effective waste management and disposal, we require proper knowledge and classification of the different waste types generated, identification of collection centres and the employment of reliable waste collection and disposal strategies. There is also the need to define waste dumping and elimination sites and regular evacuation practices to avoid accumulation (Opara, 2016).

In many cities of the developing countries such as South Sudan, there is insufficient collection of the municipal solid wastes being generated (UNEP, 2010). The current practices of collecting, processing and disposing of municipal solid wastes in south Sudan are considered to be insufficient. The typical problems are low collection coverage, irregular collection services, crude open dumping and burning without air and water pollution control (Remigios, 2010). That poor municipal solid waste management in the developing countries is a major threat to public health and environmental quality and reduces the quality of life, particularly for the poorer residents in both urban and rural areas (Wagner *et al*., 2011).

According to Okot-Okumu (2012), only less than 30% of the urban population has access to proper and regular garbage removal in developing countries".

According to him, although considerable efforts are being made around the globe by many governments and other entities to tackle waste-related problems, there is still much to be done. The World Bank (2012) estimates that in developing countries, municipalities spend up to 50 per cent of their available budget on solid waste management. However, despite this remarkable expenditure across the developing world, a large proportion of urban solid wastes remain uncollected.

The condition of waste management in the city of Bor in South Sudan is worsening well above the curve of these worrying global trends. Bor's population is continuing to grow rapidly as a result of migration due to the conflict. Exact figures are not available and the existing data is somewhat contradictory. The 2008 Census held the population of the city to be 26,800, but other sources, including the United Nations (UN) and UNEP, estimate that it is now over 100,000 (UNEP, 2012).

Whatever the precise numbers it maybe; Bor is one of the fastest growing cities in south Sudan. The city has already overstretched the waste management systems to cope with the increase in demand precipitated by this population growth. Therefore, there is an urgent need of review and improvement in the waste management practice

Methodology

The study area

Bor Town is Jonglei State's capital city in south Sudan. It is approximately 195 kilometers (120 mi), north of Juba, the capital and largest city in the country. The town is located on the east bank of the White Nile. According to the 2008 population census Bor Town population was estimated at about 26, 800.

Bor town is of historical importance to the people of South Sudan. It was in Malek, a small village about 19 kilometers (12 mi) south of Bor, that the first modern

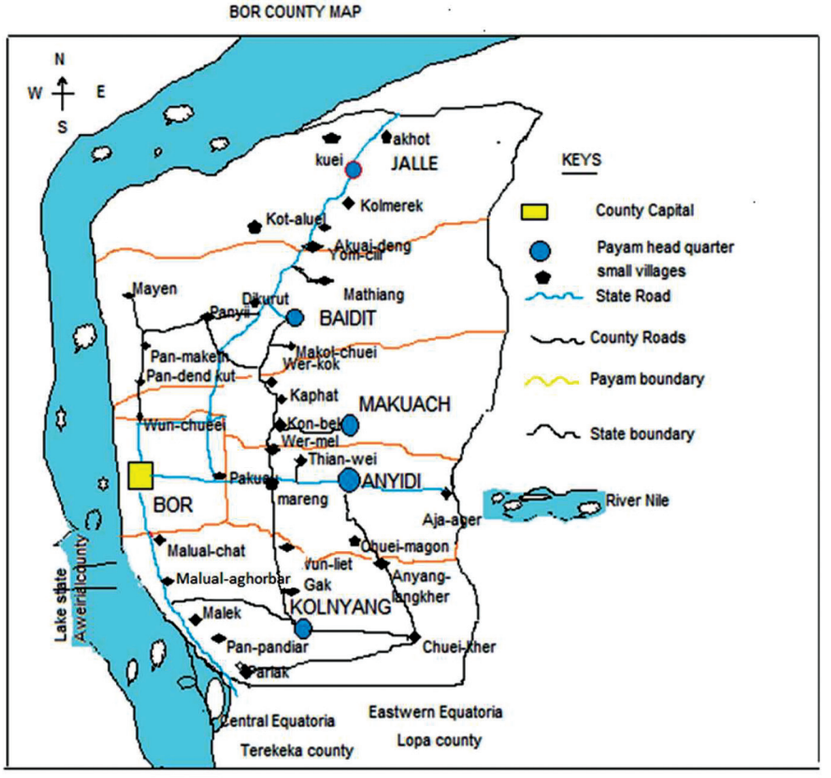


Fig. 1: Source: Winrock international, 2012

Christian mission in present-day South Sudan was established by Archibald Shaw in December 1905. Bor became the first area to host a Church Missionary Society station in 1905. Malek was turned into a missionary stronghold in the Upper Nile Region. Shaw opened the first primary school in Malek. This school produced the first indigenous Anglican bishop to be consecrated in Dinka land, Rt. Rev. Daniel Deng Atong.

In (1899-1956) Bor became an administrative centre under the Anglo-Egyptian Sudan condominium rule. Again Bor was the epicenter of the Second Sudanese Civil War which broke out in 1983. Dr. John Garang De Mabior, an officer in the Sudanese Army led a revolt in the town of Bor, in May of 1983, leading to the birth of the Sudan People's Liberation Movement and Sudan People's Liberation Army (SPLM/SPLA). Bor was also the scene of the 1991 Bor massacre, where approximately 20000 people were killed. Following the 2013 South Sudanese coup d'état attempt, Bor was contested in several weeks of combat between the national army and rebels led by Riek Machar.

In terms of education, the John Garang Memorial University of Science and Technology, one of the seven public universities in the country, is located in Bor. The university was named after the freedom fighter, late Dr. John Garang de Mabior.

Because of the historical important, the town has grown in terms of the population as it attracts a lot of people. The growth of the town is generating the kind of demand that could be a driver for the increase in the generation of municipal solid wastes. The challenge is for Bor municipal council to come up with a mechanism that will address these issues. Hence, the need for evaluation of solid waste management efficiency so that a database can be obtained that will assist in the development and implementation of efficient, effective and sustainable waste management practices was recognized.

Assessing and characterizing existing waste management practices

Characterizing how the communities and municipalities handle solid waste generated is one of the functional elements in the waste management systems. Therefore to find out the waste management practices in Bor town, questionnaires were distributed to the households in the six villages for them to state the method they use in handling their waste. Interviews were also conducted with Bor municipal council to explain the waste management practices the use in the town.

Field visits to the communities were also conducted in two weeks to make observation on the waste management practices commonly used by the households. This activity was done in order to ascertain the information obtained from the households and the municipality.

Stratification of villages based on socio economic status

To be able to make comparison on how socio economic factors affect efficiency of solid waste management, the villages were stratified based on their socio economic status. For this activity, the settlement pattern that was outlined by the ministry of housing and physical infrastructure in 2007 was adopted. The residents of Bor were grouped into high income class, middle income class and low income class areas according to their socio economic status which suits them. This classification was adopted because the delivery of social amenities to the residents is based on this stratification.

High class income areas are those areas with proper road network connection, clean water supply as well as good sanitation service, whereas middle income areas have some of those good services while others are lacking. However, in low income areas, almost no basic amenities are provided.

A statistical analysis using one way ANOVA was used to determine whether there is significance difference in the efficiency of solid waste management and the income groups.

Development of performance indicators

Solid waste management's institutions require tools to assess the efficiency of their programs

both environmentally and from the economic and social perspectives, and thus take the appropriate decisions to improve the performance. One of the objectives of this study was to develop an assessment tool through a set of indicators that measures the effectiveness in which programs operate with solid waste management.

The most relevant indicators were chosen through a selection process that included opinions from experts, literature review based on relevance and applicability to different waste program settings. The selected indicators were indicators on generation and composition of solid waste, collection coverage, disposal, Cost, technical and institutional. These indicators will help decision makers optimize the performance of their waste management programs.

MSW generation, collection, deposal and composition indicators

These are group of indicators, whose tracking is utmost importance not only in monitoring but also for MSW management planning. The percentage of materials such as paper, metals, glass and plastic in the MSW stream is an indicator for the success of separation at source programs. The same applies for the percentage of organic materials when those are collected. To obtain the percentages of each component, site specific methodology was used because this methodology is useful in defining a local waste stream where sampling, sorting, and weighing of the individual components of the waste stream was used. The plastics bags were distributed to the respondents for them to keep different types of waste separate, after that the waste collected were weighed, recorded and the daily solid waste generated and the composition were finally calculated.

MSW generation

For this category the following indicator was proposed: Daily MSW production per capita (kg/cap*day). Waste production per capita is one of the most common indicators used to describe the waste generation rate in a country, and it can be expressed as kilograms per person per year or per day. By tracking the per capita waste disposed over time, the effectiveness of waste prevention programs offered can be monitored, as well as forecasts can be estimated and future MSW management planning can be supported. This is a very common indicator used by local, regional and national authorities.

MSW collection indicators

For this category the following indicator was proposed: Population covered by MSW collection service (%). These indicators provide an integrated approach to the sanitation services offered to the citizens. Depending on the collection system of certain waste streams (e.g. metals) indicators can be expanded for those streams as well.

MSW disposal

For this subcategory the proposed basic indicators are:

(a) Total amount of MSW land filled per capita (kg/cap*annum): This indicator is a measure towards waste management performance. High amounts of waste land filled indicate the lack of waste infrastructure.

(b) Percentage of population served by sanitary landfills (%): Is an indication for the sanitation conditions in a certain region or country.

(c) Available landfill lifespan (m^3 capacity/m^3 incoming waste per annum): Monitoring landfill lifespan is critical in assessing whether available landfills can meet medium to long-term demands. This indicator is a key indicator for planning and permitting of new landfills at local, provincial and national levels. This indicator can be reported on as landfill lifespan in years, calculated as available volume/incoming waste volume per annum (m^3/m^3 per annum).

Cost indicators

The proposed indicators for this category are:

(a) Average cost per MSW collected: This indicator is one of the main indicators used by local authorities in order to monitor their collection

costs. Its use for comparing different countries is not accurate since those costs depend mainly on the personnel expenses which significantly vary from country to country.

(b) **Income spent on waste management per capita (SSP/cap):** Indeed, the important consideration is the impact the total costs on waste management tariffs have on citizens. This is especially important because the issue of affordability and willingness to pay needs to be evaluated carefully to ensure that the main beneficiaries of the solid waste services (private households, businesses, public institutions, etc.) will accept the waste management scheme in place.

Results and Discussion

Existing solid waste management practices

Characterizing how the communities and municipalities handle solid waste generated is one of the functional elements in the waste management systems. Figure 2 below illustrates the practices used by the residents of Bor Town in managing their wastes.

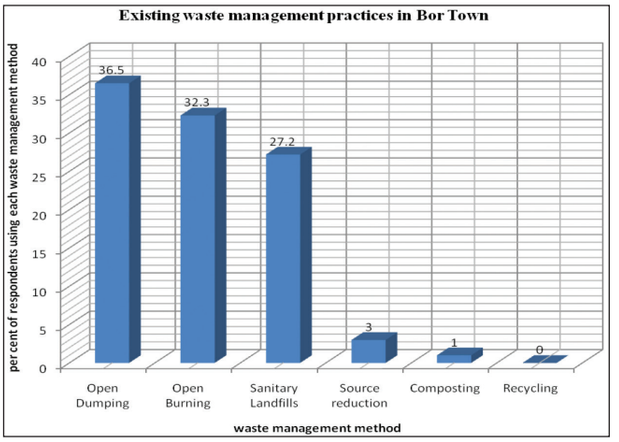


Fig. 2: Waste management practices in Bor Town

Open dumping

From figure 2 the solid waste management practices that was commonly used by the residents of Bor was open dumping (36.5 per cent). This method was commonly used in the low class residential areas of Bor Town such as Arek, Langbar and Achiengdier. The main reason for this was that the dustbin ratio to the population in the low class residential areas was 1:276 as opposed to the acceptable standard of 1:15 (as indicated by the municipality). This means that the average population a dustbin served was 18 times greater than the standard maximum population a dustbin was supposed to have served. This explained why the respondents resort to dumping waste at roadside, open spaces, nearby drains, or backyard as means to deal with their domestic waste in the area. This resulted in littering and heaping of waste thereby making the environment filthy. Therefore, the possibility of outbreak of cholera and other environmental related diseases could be high if such practice continues.

This research finding correspond to the finding of the research that was done by Momoh and Oladebeye (2010) in Nigeria which showed that the common practices of solid waste management in developing countries includes indiscriminate dumping on open land, drains roadside, unauthorized sites and river channel.

According to Al Sabbagh (2012), this early century practices of disposing waste are no longer viable in today modern era with rapid population increase, urbanization, economic growth and unsustainable lifestyles. In the modern era, the methods of managing solid waste include source reduction, sanitary landfills, composting, recycling, and incineration (Achillas *et al*. 2013).

Open burning

The second most used waste management practice according to the research in Bor town is open burning. This methods of waste disposal also happened in the low class residential areas as mentioned above. However, some few people in middle class residential areas of the town such as Leudier and Lekyak also practice this method. This happened because in the whole of Bor town, there is only one operational truck for waste transportation to the disposal sites. So it could take several weeks without even accessing

some villages, thus leaving people with no option but to burn their waste as a mean of getting rid of the huge volume.

However, though this method is still being used by the people in Bor Town, it is no longer an option for efficient solid waste management because it generates gases that pollute air, thus harmful to human health and environment. In today modern era, incineration is the preferred option than open burning. According to Abbas *et al*., (2013), incineration is a controlled combustion process for burning combustible waste to gases and reducing it to a residue of non-combustible ingredients. Incinerators have the capacity to reduce the volume of waste drastically, up to nine fold than any other method (Khalili, 2013). According to him incineration can also recover useful energy either in the form of steam or electricity.

Sanitary Landfill

Of the total amount of solid waste generated a year in Bor Town, 21500 tonnes goes to the landfills, the rest remained in the open. This was equivalent to 57.25% of the total waste that goes to the landfills. The final disposal site of solid waste in the Bor town is located at Tibek, about 13 kilometres away from the city centre. A visit to the site showed that, it was in a bad shape. Ideally, a sanitary landfill should have the following functional elements: Leachates collection system, Gas recovery and Location should be far away from human settlement and existing water body. This was not the case with the landfill in Bor town. The landfill has no Leachates collection system and Gas recovery. In fact it is typical of open dump instead of sanitary landfills. The community was about 2 kilometres (2km) away from the site. Worst of it all burning of waste occurred at the site.

According to Philipsson (2011), sanitary land filling includes compacting, confining the waste and covering it with soil. It not only prevents burning of garbage but also helps in reclamation of land for valuable use (Pries A, Martinho & Chang, 2011). Of the basic management options of solid waste, landfills are the only management technique that is both necessary and sufficient.

According to Coelho and Lange (2012) some wastes are simply not recyclable, many recyclable wastes eventually reach a point where their value is completely dissipated and they no longer can be recovered, and recycling itself produces residuals. He further highlighted that the technology and operation of modern land fill can assure the protection of human health and the environment.

Source reduction

Source reduction is described as a method that involves the reduction of waste materials to minimize quantities at the place where they are produced (Medina, 2010). However, this method is used at a very minimal scale in Bor town (BMC, 2010, & Observation, 2016). Of all the respondents that were interviewed, only three per cent were found to have practiced source reduction at their home, and those were mainly from the middle and high class residential areas. The residents in these areas reuse reusable shopping bags instead of throwing them away as mean of minimizing waste generation. Women also reused plastics bottles to sell milk, oil and petrol. However, this was not the case in the low class residential areas. This problem was exacerbated by the lack of knowledge about steps that can be taken by citizens to produce less waste (BMC, 2013).

The ever-increasing amount of per capita waste generation rates indicates that a source reduction strategy remains neglected in Bor Town. Perhaps an educational awareness could encourage source reduction initiatives in most communities.

According to UN HABITAT (2010), Austria, the Netherlands, and Denmark developed a waste management processes to efficiently resolve the waste disposal problem by essentially coaxing their citizens to separate their domestic solid waste into glass, paper, plastic categories; thereby enabling easy collection and consequently reuse. As suggested by the author, one way of effectively managing solid waste is to minimise solid waste generation through source reduction.

Composting

Despite food waste being the major waste composition in Bor town, only one per cent of the total waste generated was composted. Also of all the respondents interviewed, only one per cent of the people said to have practiced composting at the backyard of their houses. While some middle income and most high income households had flower gardens at their frontage or within their compound, this was not the case in the low income homes.

Although potential gardening space was observed in some cases; only few middle income households had both a flower garden and a small vegetable garden. Lack of ownership of place of residence, little gardening space or little knowledge of composting may be possible reasons for non-popularity of this option (Observation, 2016). According to the Hudgins (2011), composting is the option that, with few exceptions, best fits within the limited resources available in developing countries.

According to Zurbrügg, Caniato & Vaccari (2014), a low-technology approach to waste reduction is composting. He further says that in developing countries, the average city's municipal waste stream is over 50 per cent organic material.

Recycling

According to Momoh and Oladebeye (2010) recycling has been viewed as a veritable tool in minimizing the amount of household solid wastes that enter the dump sites. According to him, it has been established that, it is the best, efficient and effective method of solid waste management system.

However, despite all these value attached to recycling, the people in Bor town are completely not practicing this method. According to the survey results, the residents and municipality are both not practicing recycling of waste. The reason could be that, maybe this method is not cost effective in a developing country like south Sudan due to inadequate knowledge and lack of resources required for efficient waste recycling.

Wyse (2011) has also added that, recycling is the most positively perceived and doable of all the waste management options. According to him recycling will return raw materials to market by separating reusable products from the rest of waste stream. Recycling is well perceived by developed nation as a mean of reducing the waste volume as well as recovering useful products from waste materials. For example, according to the Institute of Waste Management cited by Rogge and De Jaegae (2012), UK recycles only 11 per cent of its household waste, Italy and Spain only 3 per cent, Netherlands 43 per cent, Denmark 29 per cent, Japan 33 per cent and Austria 50 per cent respectively.

Socio – economic characteristics of the households

Socio – economic refer to the study of the behaviours and other characteristics of groups of human beings in terms of statistics (Rouse, 2005). Socio-economic data was required in this study in order to develop projections in the future. Therefore, this section reports the major findings on the socio-economic characteristics of the population in the study area as per the survey questionnaire in 400 households in Bor Town.

Distribution of respondents by Gender

It is significant to note that in average there were more female (57.49%) in the study area compared to male (42.51%). This is probably explained by the fact that there could simply have been more females living in the area as suggested by BMC (2009). Moreover, the 2008 Sudan's housing and population census also indicates that there were more females than males in South Sudan.

It is also observed that in the study area the number of females decreases with the increase in socio economic class and the number of males increases with increase of social classes. For instance the number of Females in low class areas was (63.96%) and that of males was (36.04%)) as compared to middle class (55.17%: 44.83%) and high class (53.33%: 46.67%) respectively.

This observation may be attributed to the influence of culture of the societies which promotes the passing of responsibilities by men to women in the homes (Scheinberg *et al*., 1999). The extent of this practice,

however, varies with socio-economic groups. Commonly, husbands and wives in homes of high socio-economic status share responsibilities (World Bank, 1999).

The distribution of women and men respondents is presented in Figure 3 below.

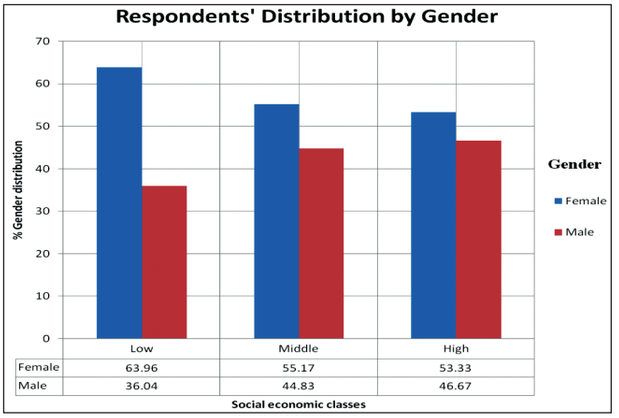


Fig. 3: distribution of respondents by gender

Distribution of respondents by age

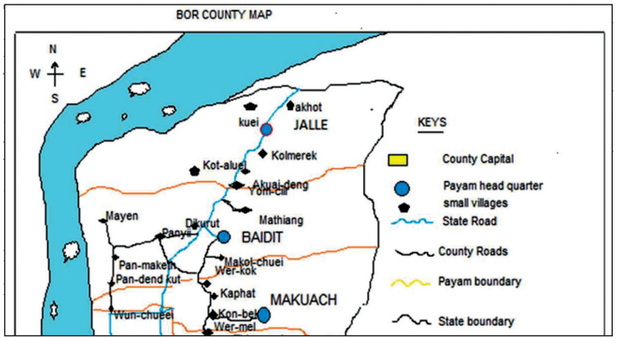


Fig. 4: Respondents distribution by age

The age of respondents appears to be related to a number of waste management issues such as street cleaning and litter. Figure 5 below indicates that the no concern for street cleaning and litter increased disproportional with age. To this end, the study has noted that youth (less than 31 years) were less concerned about clean streets and litter. On the basis of these findings, it was concluded that the younger persons in the study area had less regard for the environment.

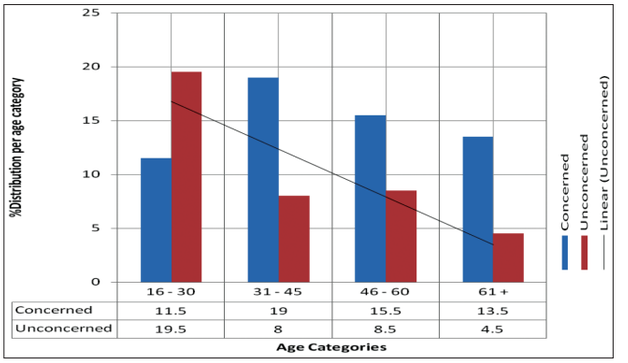


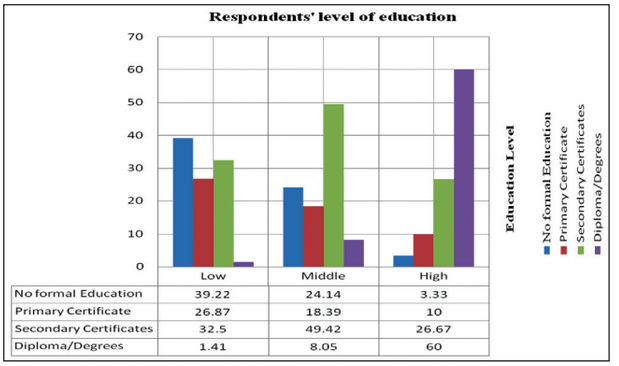
Fig. 5: Concern for street cleaning and litter

The lack of interest among the young age groups was attributed to the fact that young people in most societies often have little sense of responsibility, as they assume that someone else will take care of problems such as environmental issues. The older people who showed no interest might be due to generally inactivity and thus lose interest in community issues.

It has been suggested that past experiences of older people living in developing communities where local governments failed to provide adequate waste collection and street cleansing services had forced people to accept the fact that they live in degraded environments. The resultant effect of such experiences is a negative interaction between people and the environment (UNEP, 2013).

Educational level of the respondents

The educational qualifications ranged from no formal education to diploma/degree level of education. A comparison of the educational qualifications of respondents in the three socio-economic classes in the study area is illustrated in Figure 6 below. A notable trend is the higher proportion of households ranging from no formal education to primary certificates level of education, and far fewer persons with university education in low class residential areas as compared to the other two areas (middle and high social classes) in the study area.



	Low	Middle	High
No formal Education	39.22	24.14	3.33
Primary Certificate	26.87	18.39	10
Secondary Certificates	32.5	49.42	26.67
Diploma/Degrees	1.41	8.05	60

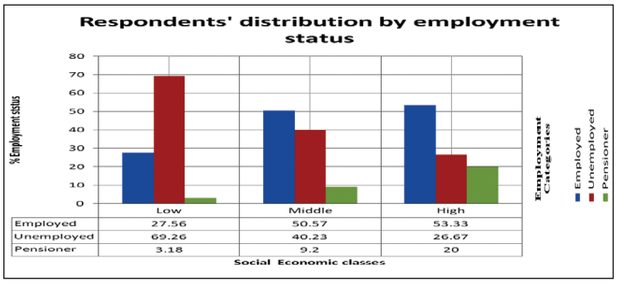
Fig. 6: Respondents level of Education

These results are consistent with those of Hoornweg (2012). The high number of households with low level education in low socio-economic areas was attributed to the influence of external factors like unemployment and poverty. Like most communities in developing countries which are ravaged by poverty, most families in low social classes cannot afford the high costs of education, hence the higher percentage of individuals with low education levels was found.

It is clear from the results of this study that the overall education levels were low in areas with low socio-economic status and that a high level of inequality between different social status population groups existed. These findings are supported by those of 2011 national literacy survey in South Sudan which found that 90% of the citizens lacked basic literacy skills (SSCC, 2011). The analysis of education profile of the respondents was of paramount importance for two reasons. First, knowledge about educational status of the respondents is vital in assisting the service providers in developing strategies to enhance environmental education by taking into account the low overall education levels of some sectors of the population. Second, is that level of education relates to attitudes towards solid waste services as it was mentioned in the literature. Education is significant for sustaining waste management programmes because people can only be convinced if they understand the messages they receive about improving their environments.

Employment status of the respondents

Employment status of respondents was assessed. Employment status of the households receiving domestic solid waste services is an important indicator for the setting of service charges. Figure 7 exhibits employment of respondents in Langbar, Achiengdier, Arek, Leudier, Lekyak, and block two residential areas.



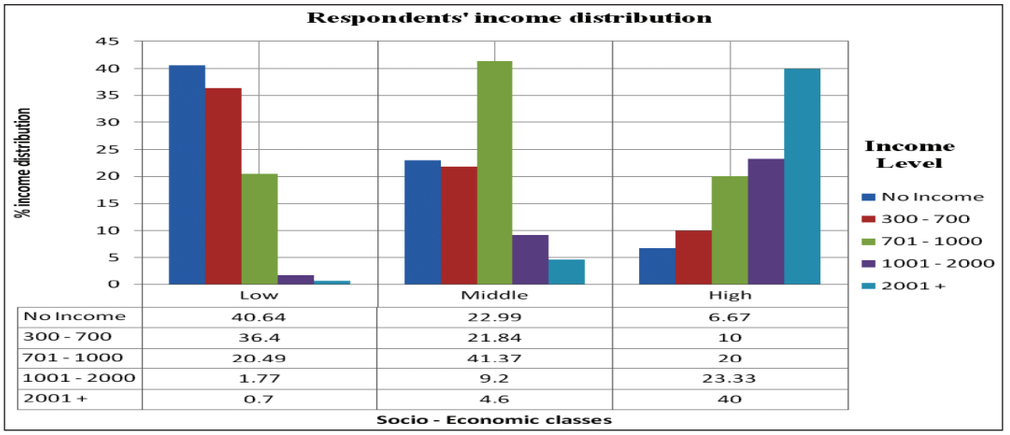
	Low	Middle	High
Employed	27.56	50.57	53.33
Unemployed	69.26	40.23	26.67
Pensioner	3.18	9.2	20

Fig. 7: Employment status of the respondents

The results reflected that the majority (45.39%) of all respondents were unemployed, followed by those employed (43.82%). The rest of the respondents were found in pension category with (10.79%). Results showed that 69.26% of all unemployed respondents were from low socio economic status as depicted in Figure 7. The high unemployment rate could negatively interrupt on solid waste management system in terms of ability to pay for the services. Unemployment is a good indicator to the local waste management authority to come up with appropriate community-based waste collection systems that could attract job opportunities for the local residents.

Income distribution of the respondents

The income status of the respondents was investigated. Figure 8 below has illustrated the distribution of income according to the social classes of the respondents.



	Low	Middle	High
No Income	40.64	22.99	6.67
300 - 700	36.4	21.84	10
701 - 1000	20.49	41.37	20
1001 - 2000	1.77	9.2	23.33
2001 +	0.7	4.6	40

Fig. 8: Respondents' income distribution

Results have indicated that the majority (40.64%) of respondents in low socio economic class fell in the no income category with few families (0.7%) earning SSP2001+ per month. Most families in middle class socio economic areas (41.37%) earned SSP 701 – SSP1000 with 4.6 % earning above SSP 2000. Not surprisingly, in Block Two (high income area) (40%) of the respondents reported a household incomes of more than SSP 2000 per month. Judging from the results of this study, there is enough evidence to suggest that there is a link between the distribution of income, unemployment, education, gender and the socioeconomic status of a residential area. Such a link was attributed to the observations that the lower income households were concentrated in areas with low socio-economic status, a high rate of unemployment, poor education records and predominantly occupied by female residents.

Knowledge about income distribution of households therefore serves as a fundamental indicator of inequality in society and is significant for planning sustainable waste management programmes, taking into consideration the differences in perceptions due to income disparity.

Relationship between income level and efficiency of solid waste management

A one way ANOVA was conducted to determine if efficiency in solid waste management was statistically different with different income levels. The income levels were classified as low, middle and high income level. As shown by table 1 below, there was statistically significant different between income groups and efficiency of solid waste management as determined by one way ANOVA {F (2, 4) = 26.686, $p<0.05$}.

Table 1: Results of one way ANOVA

Anova					
Efficiency					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5930.898	2	2965.449	26.686	.005
Within Groups	444.501	4	111.125		
Total	6375.398	6			

A tukey post – hoc test was conducted to determine where the actual differences lie. The test revealed that there is significant difference in efficiency of solid waste management between low income and high income groups and between middle income and high income groups. The differences between low and high income areas, middle and high income areas are attributed to the differences in social amenities being provided in those areas such as sanitation services.

However, there is no significant difference between the low and middle income areas. There may be several reasons for non significant differences between the low and middle income level. Most of the people in the middle class like in low class residential areas are unemployed thus do not have the proper resources to manage their own waste.

Secondly, households in middle income areas unlike the high income areas do not recycle some types of waste such as glasses, plastics and papers, thus increasing the amount of waste that need disposal.

Performance indicators

Waste generation and composition

Waste generation encompasses those activities in which materials are identified as no longer being of value and are either thrown away or gathered together for disposal (Momoh and Oladebeye, 2010). According to the 2015 state of the environment report for Jonglei State (BMC, 2015), the town generate about 37,552 .32 tonnes of solid waste a year. This is about 0.767 kg/per capita/ day, which is typical of developed country than of a developing country (by comparison, the figure in UK is 0.73kg, 0.87kg in Singapore and 0.3 kg in Nepal).

Bor town capacity to treat, store, and dispose of that high volumes of waste are limited and it is predicted that seven (7) out of the twelve villages in Bor Town will have landfills shortages within the next decade (Win rock international, 2012). The four tables below illustrate waste generation as per income groups in Bor Town

Table 2: Result of Tukey post – hoc test

Multiple Comparisons						
Dependent Variable: Efficiency Tukey HSD						
(I) Income Level	(J) Income Level	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Low Income	Middle income	-19.48833	9.62311	.222	-53.7850	14.8083
	High Income	-69.70333*	9.62311	.004	-104.0000	-35.4067
Middle income	Low Income	19.48833	9.62311	.222	-14.8083	53.7850
	High Income	-50.21500*	10.54159	.019	-87.7851	-12.6449
High Income	Low Income	69.70333*	9.62311	.004	35.4067	104.0000
	Middle income	50.21500*	10.54159	.019	12.6449	87.7851

*. The mean difference is significant at the 0.05 level.

Table 3: Solid waste generation per income group

Income Category	Total solid waste generation daily (Kg)	Average solid waste generation (Kg/person/day)
Low income	25700	2.27
Middle income	16750	4.80
High income	14450	11.73
Total	56900	3.55

Based on the results in table 3 above, total solid waste generation in the three income group was 56900 kg, and the average waste generation per capita was 3.55 kg /person/day. There was a difference in solid waste generation in the three income level areas. Block two which is a high income area has the highest per capita waste generation rate as compared to Leudier and Lekyak (middle income areas) and Arek, Achiengdier and Langbar (Low income areas). The differences might be influenced by the differences in socio-economic status in the area where the quantity of solid waste generation is mostly associated with the economic status of a society (De Feo, 2010). Besides that, the solid waste generation varies in different cities depending on the standard of living, life style, social and religious tradition, and the eating habits of the people (Downmore and Daniel J., 2011).

Table 4: Solid waste generation and composition in low income areas (Arek, Achiengdier and Langbar)

Type of waste	Total solid waste generation daily (Kg)	Composition (%)	Average solid waste generation (Kg/person/day)
Food waste	11475.05	46.65	1.01
Plastics	6255.38	24.34	0.55
Papers	3855	15	0.34
Glass	2654.81	8.33	0.23
Metal	824.97	3.21	0.07
Other e.g. wood	634.79	2.47	0.06

Table 5: Solid waste generation and composition in Middle income areas (Leudier and Lekyak)

Type of waste	Total solid waste generation daily (Kg)	Composition (%)	Average solid waste generation (Kg/person/day)
Food waste	7403.5	44.2	2.12
Plastics	4556	27.2	1.31
Papers	2177.5	13	0.62
Glass	1524.25	9.1	0.44
Metal	552.75	3.3	0.16
Others e.g. wood	536	3.2	0.15

Table 6: Solid waste generation and composition in High income area (Block Two)

Type of waste	Total solid waste generation daily (Kg)	Composition (%)	Average solid waste generation (Kg/person/day)
Food waste	6167.26	42.68	5.01
Plastics	3817.69	26.42	3.10
Papers	1676.2	11.6	1.36
Glass	1445	10	1.17
Metal	736.95	5.1	0.60
Other e.g. wood	606.9	4.2	0.49

As shown in the three tables above, at 25,045.81 kg, food waste generation is higher than other types of waste. Plastic waste generated about 14,629.07 kg, were higher than paper at 7,708.7 kg. Based on these results, every person generates 1.56 kg of food waste per day and food waste contributes over 44% of the total waste generated in the study area. Meanwhile, plastic waste is also prevalent in the study area at 25.71% of the total, while paper waste generated is about 13.55%, glass 9.88%, and metal 3.72%. However, other waste generated (3.12%) includes bulky waste, furniture, wood, etc.

A study by Su J – P Hung (2010) also found that food waste dominated over the major portion of the waste generated in most developing countries in Asia such as China, India, Sri Lanka, and Thailand (Su J – P Hung., 2010).

Solid Waste Collection

Solid waste collection is an important process in the waste management system. It ensures proper disposal of solid waste. However, collection of waste in Bor town is constrained by lack of enough facilities. After thoroughly analysis of the survey data that was collected from the communities, it was found out that waste collection coverage was 49.68%. This figure is far below the waste collection coverage in most developed countries (by comparison, the figure in UK is 98-100%, 84% in Egypt etc.). Table 7 below illustrates the amount of waste generated and the amount collected in the six villages of Bor Town.

As shown in table 7 below, there is an inequality in the provision of waste management services across the social classes. The low class residential areas in Bor town receive less collection attention (24.98%) compared to the high class residential areas (94.67%). This explained why solid waste stayed in heaps in the low class residential areas such as Langbar, Arek and Achiengdier. Also there is inequality in the mode of collection being used across the three social classes. Door to door collection was carried out in high class residential areas compared to communal collection which predominately happened in low and class residential areas.

Inequalities in waste collection service by income status have been observed in developing countries. In Accra, Ghana, container systems are used in low and middle income areas, often with too small and too few containers, while kerbside collection is used in high income areas (Gentil & Christensen, 2011). Containers are emptied less frequently in poor areas in Accra than in medium income areas. As a result, the containers in poor areas overflow and residents dump waste elsewhere (Fobil, May & Kraemer (2010). In Mexico, low income areas

Table 7: collection coverage of waste in the villages in Bor Town

Residential area	Waste generated in a day (Tonnes)	Waste collected in a day (Tonnes)	% Efficiency of collection
Low class			
Arek	10.9	3.81	34.95
Achiengdier	8.93	2.87	32.14
Langbar	5.87	0.46	7.84
Medium class			
Lekyak	9.21	4.11	44.63
Leudier	7.54	3.34	44.30
High class			
Block Two	14.45	13.68	94.67
Total	56.9	28.27	49.68

tend to receive sporadic, or no collection (Medina, 2010). The higher collection rate in high income areas of Mexico is attributed to the lobbying efforts of the wealthy, while people in low income neighbourhoods lack the resources and political connections to lobby successfully.

Conclusion

In the study, the following objectives were set to be achieved. The first objective was to characterize and describe the existing solid waste management practices in the study area. Therefore, the survey established that the major practices of handling waste in Bor Town were open dumping, open burning, landfills and composting.

The second objective was to find out whether social economic factors affect efficient solid waste management. The survey revealed that areas with low socio economic status have poor solid waste management than areas with high socio economic status. Thirdly, the research seeks to develop performance indicators of solid waste management systems in Bor town. These were developed with regards to social, economical, institutional capacity and environmental effectiveness.

Furthermore, the study intended to assess the capacity of waste management institutions particularly in terms of physical resources to effectively manage waste in the town. The main equipment used for waste storage and collection were dustbins and skips. These equipments were not enough to ensure effective waste collection and disposal.

Therefore, all the objectives set were achieved and with regard to the main objective of the study it can be concluded that the following are indeed the key factors affecting effective waste management in Bor Town. These include inadequate skip and dustbins supply for storing waste; lack of routine collection of waste, poor methods of waste management and inadequate resources for waste management institutions to effectively collect the waste generated.

To effectively tackle the problems enumerated, the following measures are recommended; Provision of adequate skips and dustbins, Regular collection of Waste, Use of Integrated Solid Waste Management, Proper Management of Landfill, and Adequate resourcing of Waste Management Institutions. If the above recommendations given are well taken and implemented, it will bring about effective solid waste management; ensure a clean environment and curb any possible outbreak of diseases in Bor town.

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