Opportunities and Constraints of Low Carbon Waste Management Technologies for South Africa

F. Machete. Faculty of Sciences, Tshwane University of Technology, South Africa. mtec.dr@gmail.com

ABSTRACT
Household energy consumption, transport and waste disposal contribute 51.2%, 32.8% and 16% of anthropogenic carbon to the atmosphere, respectively. Although most of the waste based carbon is convertible into various forms of energy for households and transport needs, much of the available technologies are not sufficiently used in South Africa. Thus, the aim of this study was to explore the existing opportunities and constraints of implementing existing waste management technologies among South African households. Descriptive analysis of secondary data are employed and ultimately, inductive and deductive lines of reasoning are followed in drawing inferences and synthesis about the results. The results show that more than half of municipal waste generated in South Africa is organic, and is indiscriminately dumped, leading to a myriad of public health and environmental risks. The opportunities for energy and compost generation are the primary opportunities missed. It is also identified that lack of knowledge of available waste management technologies, awareness and research are constraints inhibiting investment into low carbon waste management technologies. Thus, this study concludes and recommends that awareness and investment be redirected towards entrepreneurial development around waste management technologies such as waste-to-energy technologies.

1. INTRODUCTION

Integrated waste management, in particular the use of low carbon waste management technologies serves as climate change mitigation and socio-economic growth (poverty eradication) trajectory. Chen and Lo (2016) attribute 3-4% of total the total anthropogenic carbon emission to waste disposal in Taiwan. However in China (Xu, Tan, Chen, Yang, & Su, 2015) reported that 16% of the anthropogenic carbon emission is associated with waste disposal, and the remaining 51.2% and 32.8% are attributable to household energy consumption and, respectively.

Although most of the waste based carbon is convertible into various forms of energy for households and transport needs, much of the available technologies are not sufficiently used in South Africa. Thus, the aim of this study was to explore the existing opportunities and constraints of implementing existing waste management technologies among South African households.

Anthropogenic induced carbon emission is a well-known main cause of climate change in the world. A study in China found that an urban household emits approximately 5960 kg of carbon (CO_2e) per annum (Xu et al., 2015). From the total carbon emission, l, 51.2% of the carbon was attributed to household energy consumption. The remaining 32.8% and 16% come from daily transport and waste disposal activities, respectively (Xu et al., 2015). Although was disposal represents only 16% of the total carbon emission from the China study, waste management is also a potential resource for energy and transportation fuel generation. Thus, the different waste management technologies used in various communities or municipalities are central to the broader means of reducing anthropogenic carbon emission.

Research shows predicts that the global energy demand will triple by 2035 and that about 90% of the demand will be in developing economies (Colenbrander, Gouldson, Sudmant, & Papargyropoulou, 2015). Attempting to meet the tripling demand through orthodox coal fired power generation can increase global temperature by 2℃ by the year 2100. Increase of global temperature by 2℃ is projected to cause severe climate change that will reverse human developments gains (Colenbrander et al., 2015; Messner, 2015). Unfortunately, the importance of reliable energy supply for social and economic growth of communities, is critical that the emerging triple demand be met in order to ensure future development. Furthermore, literature highlights that the highest ratio of the waste stream generated among African communities is organic (Dladla, Machete, & Shale, 2016).

In the 21st century, there are a number of waste management technologies (WMT), can be used to recycle carbon from waste disposal to energy and fuel generation. These technologies have the potential of providing for most of the household energy and fuel for transport needs of communities. Ultimately, the significant amount of household energy, transport and waste disposal related carbon emissions could be prevented or reduced. It is evident therefore from this discussion that certain WMT's are potential climate

change mitigation adaptation measures. Consequently, two main benefits of WMT are identified from Ferdan, Samplak, Zaviralova, Pavlas, and Fryba (2015), namely: (1) recycling and re-use carbon from waste into energy and, (2) energy resource substitution (replacing natural resource exploitation by using waste as materials input for generation).

The feasibility of WMT in addressing carbon reduction, in addition to other available technologies is evident from Colenbrander et al. (2015) who has concluded that about 24.1% of carbon emissions from developing countries can be reduced and/or prevented. (Colenbrander et al., 2015) point out that 12.2% of carbon can be reduced by simple saving regional electricity from grid. Machete, Hongoro, Nhamo, and Mearns (2015) identify alternative (preferable low carbon) energy supply, as one of the three primary active energy saving method in addition to behaviour change and engineering. In this study, WMT fits well as a low or zero carbon alternative energy resource, as defined by Machete et al. (2015).

In advancing WMT in among developing economies of households, this study intends to ensure a balance between people's happiness (social) and economic efficiency, as recommended by Dou (2013). Dou (2013), however points out that while happiness depends on social and economic growth, high economic efficiency doesn't certainly promote social and economic growth. As a result, the success of WMT in this study will not be measured by its high economic efficiency, but through social and potential economic efficiency within households or communities, including entrepreneurial opportunities for local communities.

Anthropogenic carbon emissions are responsible for the disastrous global and local climate change that threatens human survival (Nhamo & Shava, 2015; Xu et al., 2015). Available literature shows that 16% of anthropogenic carbon emitted to the atmosphere can be prevented by re-directing waste disposal to different waste management technologies such as recycling, composting, anaerobic digestion and fermentation processes, incineration, pyrolysis and gasification (Mohee, Mauthoor, Bundhoo, Somaroo, & Soobhany, 2015; Wang & Chang, 2014; Xie, 2014). The exploration and adoption of different waste management technologies over landfilling is a promising social and economic opportunity to local communities, given the high prevalence of indiscriminate dumping, with 58% of the total solid waste indiscriminately dumped in most African countries, including South Africa and the knowledge that an estimated 52% of the total solid waste in organic, the main waste materials required for energy generation (Dladla et al., 2016; Mohee et al., 2015).
Despite a myriad of literature on WMT, not enough research has been conducted in South Africa about the opportunities and threats of these technologies. Thus, information about the threats, and the social, economic and environmental benefits or opportunities of waste management technologies remain sketchy for possible implementation by authorities and communities.

2. RESEARCH METHODS AND TECHNIQUES

This paper followed a meta-analysis approach to systematically review 40 peer reviewed journal articles (Creswell 2009). The reviewed articles were published between 2005 and 2016 and were taken from credible studies conducted in 11 African countries. The systematic review involved a selection of specific qualitative and quantitative types of interval, nominal and ordinal data. A thematic method based on topics relevant to the research aim of this paper was used in the selection of the relevance of each reviewed articles as recommended by Machete, Hongoro, Nhamo and Mearns (2015). Descriptive statistics was used to organise, summarise and present data in a convenient and informative way, as recommended by Keller (2014). The data and information was thus presented using graphs and numerical techniques. Microsoft Excel 2013 was used for all statistical calculations. However, to analyse qualitative data, an explanatory analyses was used as a replicate from Creswell (2009). Thus conclusions of this paper were drawn from both qualitative and quantitative data.

3. RESULTS AND DISCUSSION

In a study between 11 African countries, Dladla, Machete and Shale (2016) identified that more than 50% of the total waste composition among 11 African (including South Africa) is organic. Organic waste has the potential to create unattractive, unsightly and smelly residential settlements and the leachate content can lead to land degradation, poor soil fertility and contamination of ground and surface water bodies. However, this waste material is the most suitable resource for energy generation (figure 1)

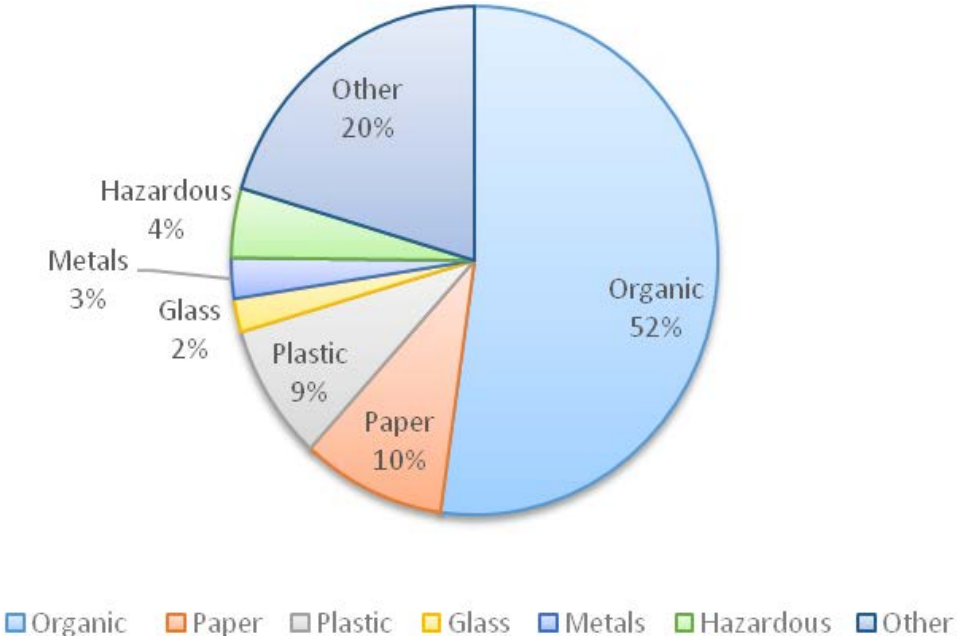

Figure 1. Proportions of waste stream (from Dladla et al. 2016)

From the figure above, it is clear that the organic waste is the most produced waste and glass is the least, and that the highest quantity of the waste generated can be used for income and energy generation in different communities to create jobs. Research shows that in most instances, this waste is indiscriminately dumped in communities (Figure 2), and the primary factors that lead to high waste generation include population growth, urbanisation, irregular refuse collection and lack of resources. It is clear that indiscriminate dumping is the main waste disposal method used in African countries, followed by landfill, other methods, open burning and recycling, respectively. The most commonly used methods of waste disposal pose environmental and health risks as they can be traced to the human body through the terrestrial food chain, drinking water, biological vectors and air. Authorities could however be examples to communities by finding innovative methods of waste disposal such as being involved in and encouraging recycling projects and prohibiting the burning of waste in landfill sites.

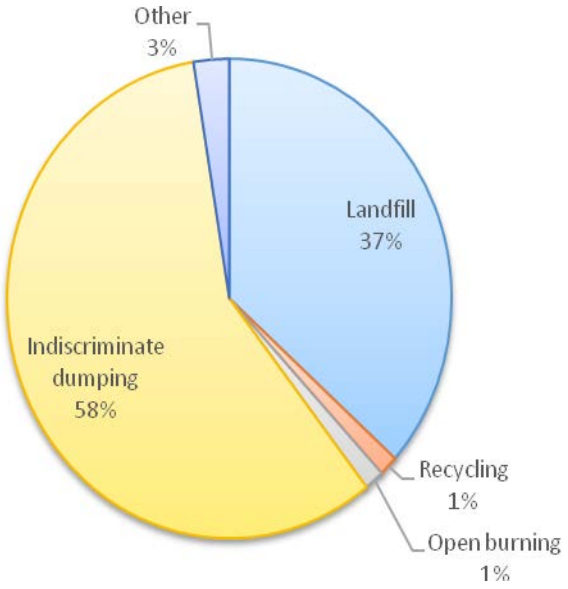

Figure 1: Most common methods of waste disposal (Dladla et al. 2016)

Despite new approaches in waste management in countries around the world, such as waste reduction and avoidance, it is evident that recycling is still the least considered method of waste disposal in African countries despite its benefits, which include prolonging the lifespan of landfill sites, and less usage of raw materials in production. As demonstrated in Figure 2, indiscriminate dumping emerges as the most used method followed by land-filling of waste in those countries which clearly indicates the loss of recyclables. Despite the rich biomass opportunities that exist in the continent, particularly in South Africa for biogas, pyrolisis and biofuel generation, these biomaterials are indiscriminately dumped (figure 3).

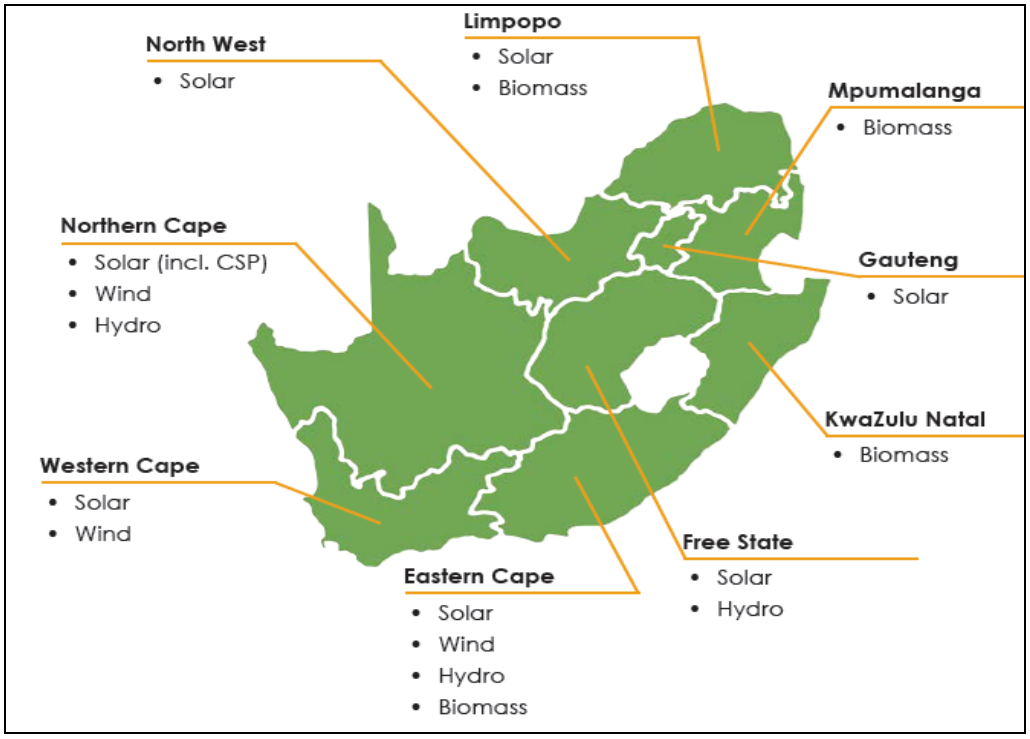

Figure 3. Potentials for clean energy per province (from *Department of Energy 2015:54)*

It is evident from figure 3 that the Limpopo, Mpumalanga and Kwa-Zulu Natal are identified as high potential provinces for biomass energy generation.

4. CONCLUSION

The aim of this study was to assess opportunities and constraints of low carbon waste management technologies in South Africa. The results show that 52% of the total waste materials generated in than South Africa and other African countries is organic. Although currently, this and other waste materials are poorly disposed of, the opportunities of using organic waste remain high. In South Africa, a study has shown that Limpopo, Mpumalanga and Kwa-Zulu Natal provinces are high potential areas for biomass energy opportunities.

REFERENCES

Bundhoo, Z. M. A., Mauthoor, S., & Mohee, R. (2016). Potential of biogas production from biomass and waste materials in the Small Island Developing State of Mauritius. *Renewable and Sustainable Energy Reviews, 56*, 1087-1100. doi: http://dx.doi.org/10.1016/j.rser.2015.12.026

Chen, Y.-C., & Lo, S.-L. (2016). Evaluation of greenhouse gas emissions for several municipal solid waste management strategies. *Journal of Cleaner Production, 113*, 606-612. doi: 10.1016/j.jclepro.2015.11.058

Colenbrander, S., Gouldson, A., Sudmant, A. H., & Papargyropoulou, E. (2015). The economic case for low-carbon development in rapidly growing developing world cities: A case study of Palembang, Indonesia. *Energy Policy, 80*, 24-35.

Creswell, J. W., Hanson, W. E., Clark, V. L. P., & Morales, A. (2009). Qualitative research designs: selection and implementation. *The Counselling Psychologis, 35*, 236-264.

Depatment of Cooperative Governance and Traditional Affairs. (2015). The Municipal Demarcation Board makes final determination on the South African municipal landscape in 2016. Retrieved 25 July, 2015

Department of Energy. 2015. State of Renewable energy in South Africa. Accessed online (03-05-2016. www.energy.gov.za

Dladla, I. M., Machete, F., & Shale, K. (2016). Factors associated with indiscriminate dumping in Africa. *African Journal of Science, Technology, Innovation and Development*, in press.

Dou, X. (2013). Low Carbon-Economy Development: China's Pattern and Policy Selection. *Energy Policy, 63*, 1013-1020.

Ferdan, T., Samplak, R., Zaviralova, L., Pavlas, M., & Fryba, L. (2015). A waste-to-energy project: A complex approach towards the assessment of investment risks. *Applied Thermal Engineering, 89*, 1127-1136.

Leedy, P. D., & Ormrod, J. E. (2010). *Practical research planning and design* (9 ed.). United State of Amerca: Pearson Education Limitted.

Machete, F., Hongoro, C., Nhamo, G., & Mearns, K. (2015). Influence of energy saving on the quality of lighting services on selected hotels in Mpumalanga, Republic of South Africa. *African Journal of Science, Technology, Innovation and Development, 7*(4), 301-305. doi: 10.1080/20421338.2015.1082369

Messner, D. (2015). A social contract for low carbon and sustainable development. Reflections on non-linear dynamics of social realignments and technological innovations in transformation processes. *Technological Forecasting & Social Change*.

Mohee, R., Mauthoor, S., Bundhoo, Z. M. A., Somaroo, G., & Soobhany, N. (2015). Current status of solid waste management in small island developing states: A review. *Waste Management, 43*, 539-549.

Mouton, J. (2013). How to succeed in your masters and doctoral studies: A South African guideline and resource book. Cape Town: Van Schaik Publishers.

Nhamo, G., & Shava, S. (2015). *Climate Change Education in the SADC School Curriculum* (G. Nhamo & S. Shava Eds.). Pretoria: African Institutte of South Africa.

Scarlat, N., Motola, V., Dallemand, J. F., Monforti-Ferrario, F., & Mofor, L. (2015). Evaluation of energy potential of Municipal Solid Waste from African urban areas. *Renewable and Sustainable Energy Reviews, 50*, 1269-1286. doi: http://dx.doi.org/10.1016/j.rser.2015.05.067

Tan, S. T., Hashim, H., Lim, J. S., Ho, W. S., Lee, C. T., & Yan, J. (2014). Energy and emissions benefits of renewable energy derived from municipal solid waste: Analysis of a low carbon scenario in Malaysia. *Applied Energy, 136*, 797-804. doi: http://dx.doi.org/10.1016/j.apenergy.2014.06.003

Tan, S. T., Ho, W. S., Hashim, H., Lee, C. T., Taib, M. R., & Ho, C. S. (2015). Energy, economic and environmental (3E) analysis of waste-to-energy (WTE) strategies for municipal solid waste (MSW)

management in Malaysia. *Energy conversion and management, 102*, 111-120. doi: http://dx.doi.org/10.1016/j.enconman.2015.02.010

Wang, N., & Chang, Y.-C. (2014). The evolution of low-carbon development strategies in China. *Energy, 68*, 61-70.

William, F., & Mohamed, S. B. (2012). *A guide to managing research*. Cape Town: Juta & Co Ltd.

Xie, H. (2014). Legal Regulation of Low-Carbon Economy. *IERI Procedia, 8*, 170-175.

Xu, X., Tan, Y., Chen, S., Yang, G., & Su, W. (2015). Urban household carbon emission and contributing factors in the Yangtze River Delta, China. *PLoS One, 10*(4), e0121604. doi: 10.1371/journal.pone.