American Journal of
Agriculture
(AJA)

UTILISATION OF BIODEGRADABLE SOLID WASTE TO BOOST CROP PRODUCTION AMONG FARMERS IN MBARARA CITY, SOUTH WESTERN UGANDA

Naboth Twesigye, Dr. Medard Twinamatsiko, and Mr. Wycliffe Tumwesigye

AJP

American Journal of Agriculture
ISSN 2520-4678 (Online)
Vol.4, Issue 1, pp 47 - 57, 2022

www.ajpojournals.org

UTILISATION OF BIODEGRADABLE SOLID WASTE TO BOOST CROP PRODUCTION AMONG FARMERS IN MBARARA CITY, SOUTH WESTERN UGANDA

[1]* Naboth Twesigye, [2]Dr. Medard Twinamatsiko, [3]Mr. Wycliffe Tumwesigye

[1]Post Graduate Student of Bishop Stuart University

[2,3]Lecturer, Bishop Stuart University

*Corresponding Author's Email: bbytsz@gmail.com

ABSTRACT

Purpose: Determining the utilisation of biodegradable solid waste in boosting crop productivity among farmers in Mbarara City.

Methodology: Mixed methods were used with simple random sampling and purposive sampling to obtain 111 and 31 respondents respectively - altogether constituting 142 respondents. Data was collected from the respondents using a questionnaire and an interview guide. The study adopted both descriptive and correlational data analysis.

Findings: The study identified some practices that were used in managing biodegradable solid waste for application in boosting crop productivity among farmers in Mbarara city. These were communal collection, door-to-door collection, and others like roadside dumping and dustbins. The application of biodegradable solid waste in boosting crop productivity among farmers of Mbarara city was found to be relatively low, notwithstanding the fact that for those who applied the biodegradable solid waste in farming, it increased crops yields. The study further identified compositing of biodegradable solid waste as the main innovative strategy for proper utilization of solid wastes towards crop productivity. This was because the strategy is environmentally friendly at the same time it enriches the soil with both soil and crop growth support nutrients.

Unique contribution to theory, practice and policy: A strong cooperation between the community and the city council authorities should be cultivated for purposes of enhancing community participation in the management of biodegradable solid waste hence enhancing food crop production in the area. There is also need to explore the opportunities of reducing, reusing, recycling and rethinking and composting in waste management among urban communities to minimize waste and increase economic benefits. Successfully adoption of sustainable methods of waste management by the communities can be done by making awareness programmes simple and accessible to change the mind-set of urban residents to perceive waste as resources rather a problem.

Keywords: *Solid waste, biodegradable, utilization of biodegradable solid waste, crop productivity.*

1.0 INTRODUCTION

Municipal solid waste (MSW) is solid waste collected by the municipality or disposed of at the municipal waste disposal sites and includes residential, industrial, institutional, commercial, municipal, and construction and demolition waste (Hussein & Mona, 2018). Municipal solid waste management (MSWM) is a critical element towards sustainable metropolitan development. It comprises segregation, storage, collection, relocation, carry-age, processing, and disposal of solid waste to minimize its adverse impact on environment. Population increase, rapid urbanization, booming economy, and the rise in the standard of living have greatly accelerated the rate, amount and quality of the Municipal Solid Waste (MSW) generation and management (Hussein & Mona, 2018).

One of the areas of MSWM, is the appliction of solid waste to improve crop productivity—increasing the ratio of agricultural outputs to agricultural inputs (Chen, 2020). Agricultural productivity is becoming increasingly important as the world population continues to grow (Gollin, et al., 2014). The population growth rate has been characterized by urbanization particularly in Asia and Africa (Iheke & Ukandu, 2015). Improvement in crop productivity is hence believed to be an important contributor to the urbanization process (Rupasinghe & Leelamanie, 2020). The argument is that higher agricultural productivity provides food and other agricultural products with less manpower and thus allows for a shift of labor out of agriculture and into industry (Iheke & Ukandu, 2015). With increased urbanization in form of municipals and cities, population has also sprung necessitating the need for innovation in agricultural productivity (Fuglie & Rada, 2013).

Global production of solid waste has practically doubled over the past ten years and is expected to reach 2.5 billion tons per year in 2025 as a result of the combined effect of urban development and changes in consumption patterns (Ruttle, 2013). The quantity and the composition of the municipal solid waste are critical for the determination of the appropriate handling and management of these wastes (Alhassan & Mohammed, 2013).

In most African countries, management of solid waste is the responsibility of local authorities, which have low capacity in terms of financial, operational, institutional structures, management, and inappropriate technologies, which affect the availability or sustainability of solid waste management services (Olivier, 2018). Trends show that in major urban centres in Africa the problem of waste management has become serious that has overwhelmed most efforts by city authorities to collect and dispose the generated solid wastes (Alhassan & Mohammed, 2013). The problem is compounded as these countries continue to urbanize rapidly. It is estimated that most municipal authorities can only collect and dispose of 20 – 30% of the generated solid waste (Akintola, 2013).

In Uganda, major townships and villages are wallowing in waste (SWAGEN, 2021). Heaps of wastes are found in many places with land fill sites continuously running out of space for new waste generated while other options are fast depleting. This poses serious consequences for the public service including pressure on budget of government, growing demand for space consumed by waste as in landfill sites and the environmental, health and other social problems associated with improper waste management (Okot & Nyenje, 2011). There is thus the urgent need for efficient and alternative ways of generating and managing waste (Marshall & Farahbakhsh, 2013). The World Bank proposed consuming fewer resources and converting waste into

agricultural resources through techniques that can bring the high waste creation down leading to enormous environmental and socio-economic benefits (World Bank, 2019).

Municipal solid waste can be treated as renewable resource for a variety of valuable products (Christensen et al., 2014). The organic fraction of MSW provides an excellent opportunity for production of different value-added by-products through the bio-refinery techniques (maximum utilization of waste resource), further fuelling the circular bio-economy (maximizing resource efficiency with least waste generation through which socio-economic and environmental stability is achieved (Christensen et al., 2014). Moreover, a good organic proportion of MSW can also be used directly in the fields or can be converted into compost which can be used as fertilizer supplements in the fields that in turn enhance crop productivity with less negative impacts on the environment (Behzad, et al., 2019).

Agricultural utilization of MSW is one of the most promising and cost-effective options for disposal of MSW (Araujo et al. 2010). It is an important tool for recycling of MSW, which would otherwise be landfilled, leading to groundwater contamination, air pollution and many other health problems (Yousuf, et al., 2018). This is not to disregard the potential threat to the soil fertility as MSW contains different pathogens and pollutants (e.g. heavy metals, pesticides and other organic pollutants) (Bastidas-Oyanedel & Schmidt, 2018). The long-term application of MSW in agricultural field may lead to heavy metal accumulation (Yousuf, et al., 2018), which may enter at elevated level through the progression of food chain. That said, proper waste management presents great opportunities, not only to do away with the harmful consequences that comes with waste, but also to recover resources, gain social, economic and environmental benefits and to take a step on the road to a sustainable future (Marshall & Farahbakhsh, 2013).

1.1 Statement of the Problem

Farmers in peri-urban areas of Mbarara have been facing the challenge of declining crop productivity as a result of decrease in soil fertility (Katongole, et al., 2012). Uganda's efforts to promote agriculture through initiatives like Plan for Modernization of agriculture (PMA) for the last three decades have not yielded impressive results (Bateganya & Olobo, 2017). In this regard, crop productivity in Mbarara City has continued to decline (Behzad, et al., 2019). Katongole, et al.(2012) noted that despite the efforts made by the city council and other development partners to enhance adoption of the use of biodegradable solid wastes in urban and peri-urban areas, the rate of biodegradable solid waste use for crop farming has remained low yet enormous heaps of this resource are generated daily. Only 30% of the households have adopted this approach. A result, crop yield has dropped from 45% in 2010 to 19% in 2019. This is in tandem with raised concern on meeting food needs of the ever growing city population. There is lack of information on biodegradable solid waste utilization to enhance crop productivity among farmers in Mbarara Municipality. Thus, to fill this gap, this study evaluated the influence utilisation of biodegradable solid waste in crop productivity among farmers in Mbarara City.

1.2 Objective of the Study

1. To document the management of biodegradable solid waste among farmers towards crop productivity in Mbarara City.
2. To assess the application of biodegradable solid waste among farmers towards crop productivity in Mbarara City.

3. To identify innovative strategies for proper utilisation of biodegradable solid waste towards crop productivity in Mbarara City.

2.0 LITERATURE REVIEW

This study was pinned by Utility Maximization Theory by Bentham and Mill (1990). The theory is premised on assumption that a entities derives maximum utility as much as possible from their efforts which depends on expected utility to be obtained from either adopting or not adopting the new technique (Tey & Brindal., 2012). For smallholder farmers, the reason for a technique adoption is not necessarily profit maximization (Dwivedi, et al., 2015). They could have other primary objectives such as maintenance of social status, fulfilling minimum subsistence requirements and others. To achieve the objectives, which can be represented by maximum utility, a farmer needs to adopt new techniques (Dwivedi et al., 2015). Generally, based on the expectation, farmers decide either to adopt or not adopt new techniques (Chen, 2020). The assumption is that an entity derives maximum utility as much as possible from his/her efforts which depends on expected utility to be obtained from either adopting or not adopting the new technology (Gollin, Lagakos, & Waugh, 2014). As such, Utility Maximization Theory was used to explain utilisation of solid waste in crop productivity among farmers (Tey & Brindal., 2012).

2.1 Empirical review

The element of solid waste collection includes not only its gathering, but also the hauling of waste after collection to the location where the collection vehicle is emptied (Alhassan & Mohammed, 2013). Marshall and Farahbakhsh (2013) dealt with municipal solid waste (MSW) and found out that compost is increasingly used in agriculture not only as a soil conditioner but also as a fertilizer. Proponents of this practice consider it an important recycling tool since MSW would otherwise be landfilled and critics are concerned with its often-elevated heaps of solid waste concentrations (Dika et al., 2019). However, this is not to down play the fact that unsorted solid waste with metals and kindred contaminants can move through the soil profile into groundwater (Fernández-Nava et al., 2014).

Several approaches have been used to reclaim salt-affected soils that include physical amelioration (subsoiling, deep ploughing, sanding), chemical amelioration (gypsum, calcium chloride, limestone, sulfuric acid, sulfur, iron sulfate), electro-reclamation and biological amelioration (crops, stems, straw, green manure, farmyard manure, sewage sludge) (Murtaza et al., 2019). However, compost amendment has useful effects on the saline-sodic soils, improves soil structure and permeability, thus enhancing salt leaching, and releases carbon dioxide during respiration and decomposition (Marshall & Farahbakhsh, 2013). Application of compost to the plants provides essential macronutrients such as nitrogen (N), potassium (K) and phosphorus (P), and micronutrients, i.e., iron (Fe), magnesium (Mg), copper (Cu), zinc (Zn), and boron (B) and enhances microbial activity (D'Hose et al., 2014). Nutrients are released slowly due to strong association of compost with organic matter (Nikos et al., 2012). This property makes compost an excellent alternative to inorganic fertilizers as leaching and volatilization losses are reduced (Murtaza, et al., 2019). Adejumo (2011) showed that the adoption of organic fertilizer has positive impact on the agricultural productivity. Organic fertilizer adopters get better yield hence more farm income compared to their non-adopter counterparts. Araújo et al (2010) argued that productivity can be increased by more than double if organic fertilizer is used. This shows that

the adoption of organic fertilizer is important for improving productivity thus contributing to increased farmers farm income.

Apanovich & Mazur (2018) stated that organic fertilizers through composting is one of the waste treatment technique that make it possible to use organic waste as a fertilizer in populated dwellings, like cities. It plays a key role in soil fertility improvement, and hence crop productivity (Bastidas-Oyanedel & Schmidt, 2018). Composting is two-pronged: reduces the volume of biodegradable solid waste (Bateganya & Olobo, 2017); and organic fertilizers improves agricultural production (Fuglie & Rada, 2013).

According to Ferronato, et al. (2018), processing and recovery is among the upstream methods of utilising Biodegradable sold wastes for various activities including agriculture. The element of processing and recovery includes all the technology, equipment, and facilities used both to improve the efficiency of other functional elements and to recover usable materials, conversion products or energy from Biodegradable solid wastes (Apanovich & Mazur, 2018). In the recovery, separation operations have been devised to recover valuable resources from the mixed solid wastes delivered to transfer stations or solid waste processing plants (Bogdan & Biklen, 2007).

Araújo, Melo, and Singh (2010) viewed source reduction as any action that reduces the volume or toxicity of solid waste prior to its processing and disposal in incinerators or landfills. Another innovative strategy is sanitary land filling, which includes confining the waste, compacting and covering it with soil (Coffie, 2010). On the other hand, composting process uses microorganisms to degrade the organic content of the waste (Okot & Nyenje, 2011). According to Araújo, Melo and Singh (2010), composting is the option that, with few exceptions, best fits within the limited resources available in developing countries

3.0 RESEARCH METHODOLOGY

The study adopted both descriptive and correlational research designs. The descriptive research design was used because it describes the phenomena associated with the subject population, estimates the proportion of the population and discovers the relationships among the study variables. Correlational research sought to figure out if two or more variables were related and, if so, in what way. The design necessitated the use of a mixed methods approach that exploited both qualitative and quantitative approaches to data collection and analysis. Qualitative research involved studying things in their natural settings and attempted to make sense of or interpret phenomena in terms of the meanings people bring to them (Kothari, 2004). It gathered information verbatim in a detailed and complete form. The approach included use of interviews to capture opinions and views form key informants. Quantitatively, involved gathering information using close-ended questions, while analysis, use of descriptive statistics—generating: tables, graphs, and Charts.

The study covered Mbarara City located in western Uganda. It is the main City, administrative, and commercial centre of Ankore region (Gumisiriza & Kugonza, 2020). The choice of the City was due to its growing population and tons of unutilized waste. The area faces a bigger problem of managing biodegradable solid waste generated. So the biodegradable solid waste's effective management and application in urban and peri-urban agricultural farming beg attention. The study population comprised of farmers and local leaders (local council chairmen and

councillors), City council leaders including Town Clerk, Production Officer and Community Development Officer. Farmers in this study were targeted because they were directly concerned with the problem of soil fertility exhaustion.

The study utilized a sample size of 142 respondents dwelling on Gay's (1992) minimum acceptable sample being between 10% and 20% for a small population of about 5000 persons. According to the housing and population census (2014) Mbarara city had an estimated population of 195,013 and according to Mbarara city records 8% of the population was engaged in crop farming related activities. The study employed both purposive and simple random sampling techniques in selecting different categories of respondents as per (Sekaran, 2003). The purposive sampling was used purposive in sampling local leaders and City council authorities. Simple Random Sampling was employed to sample farmers because it ensured that each member of the target population had an equal and independent chance of being included in the sample.

Both primary and secondary data were collected and used for the study. Primary data was collected on utilization of Biodegradable solid waste and crop productivity using a structured questionnaire and an interview guide. Participation in the study was voluntary, and informed consent was obtained from each participant at the time of the study after explaining to them the study objectives and how findings would benefit them.

The validity of the instrument was determined using the Content Validity Index (CVI), where responses of the respondents were checked against the research objectives as indicated by Amin (2005), where if CVI is more than 0.7, the instrument is viewed as legitimate. The CVI was 77%. The reliability of the research instruments was determined by computing Cronbach Alpha. Alpha of at least 0.65 for the tool is deemed reliable. The piloted participants were not involved in the last study. The instrument was distributed to 10% of the participants selected from farmers in other districts, whose alpha turned out to be 0.65. For quantitative data, after thorough cleaning, it was captured into the Statistical Package for Social Scientists (SPSS) and descriptive and inferential analysis done. Descriptive statistics were generated and linear regression analysis carried out.

4.0 PRESENTATION OF FINDINGS, ANALYSIS AND INTERPRETATION

The study findings confirm that biodegradable solid wastes in Mbarara city is managed using different methods. Waste management chain starts right from generation, segregation, transportation to disposal. It was found that biodegradable solid waste was collected using a number of methods, including: communal collection, set out, curb side, door-to-door collection and other systems like roadside dumping, sacks and dustbins. Roadside dumping and communal collection were described as unfair to majority of the respondents. In some instances, solid waste was collected from sources and transferred to storage sites. However, due to low community participation, there was poor knowledge and awareness of turning solid wastes into a resource. Many still collect and store all the assortment of solid waste in same sacks without segregating it, which end up into open dump sites as problem rather a resource - causing obnoxious odors and smoke in and around the city. It was also found out that waste collection and transportation is done by private companies with limited capacity and financial resources.

Collecting and transporting un-segregated solid waste makes turning waste into an agricultural resource to enhance crop productivity problematic and costly. As a result, biodegradable solid

waste management and use to enhance crop productivity through recycling and composting remains is limited. This is in line with Falås et al. (2016) who stated that the magnitude to the problem of solid waste management worsens due to lack of community participation, shortage of expertise, financial resources, legal and administrative enforcement of environmental regulations. Consequently, people dispose biodegradable solid waste carelessly since the issue has not been practically adopted as a priority in the city. This is in agreement with Gasu & Mohammed (2017), who observed lack of community's participation in recycling practice, which would increase the probability for solid waste recycling to benefit farmers.

The knowledge base about turning biodegradable solid waste into an agricultural resource among the residents of Mbarara city was limited. The people know little about biodegradable solid waste management and this in itself forms a barrier to waste sorting. This is comparable to findings by Kjerstadius et al. (2016) who stated that ecological awareness and citizen participation to segregate waste at source, door-to-door collection, and disposal in appropriate collecting bins is imperative.

The study findings indicated that the application of biodegradable solid waste to boost crop productivity among farmers of Mbarara city was relatively low. The results were statistically significant in utilisation of biodegradable solid waste towards crop productivity among farmers. The correlation matrix between biodegradable solid waste (compost) and crop productivity was at 5% level of significance. The bivariate analysis of compost and its application in agriculture was significant (r= 1.985, p=0.001). This is in agreement with Adejumo (2011) who stated that the adoption of organic fertilizer has positive impact on the agricultural productivity. The reasons for low management and utilization of biodegradable solid waste in agriculture included: lack of awareness, poor knowledge and skills, shortage of labour and finance, high transaction costs in process, poverty, lack of information, as well as lack of animals to provide manure

The study findings showed that innovative strategies for proper utilization of biodegradable solid wastes increases crop productivity. Among all the strategies, compositing was the main innovative strategy that would boost crop productivity. This was because it is environmentally friendly at the same time enriches the soil with crop growth supporting nutrients. Composting is a controlled and microbial mediated decomposition process that converts biodegradable waste into a stable product that is ultimately used as soil amendment. This finding is supported by Marshall and Farahbakhsh (2013) who stated that turning these municipal biodegradable wastes (crop residues and animal manures) into organic fertilizers (through composting) is one of the waste treatment techniques that make it possible to use organic waste as a fertilizer. Composting also reduces the volume of the waste, hence solving serious environmental problems concerning disposal of large quantities of waste, kills pathogens that may be present, decreases the germination of weeds in agricultural fields, and reduces offensive odour. This finding is in line with Okot and Nyenje, (2011) who expounds that composting process uses microorganisms to degrade the organic content of the waste.

5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary of Findings

Relevant theoretical aspects relating to the value of application of biodegradable solid wastes to boost crop productivity among farmers were highlighted through the Utility Maximization

Theory by Bentham and Mill (1990). The theory pinning the application of biodegradable solid wastes to boost crop productivity among farmers was evident in the analysis that formed part of this study.

5.2 Conclusion

In conclusion, the study revealed that communal collection and door-to-door collection are prominently used in managing biodegradable solid wastes towards crop productivity among farmers in Mbarara city. These practices are applied right from collection, transportation to final disposal. Poor management of biodegradable solid wastes towards crop productivity among farmers was observed. Level of biodegradable solid waste application towards crop productivity among farmers of Mbarara city was relatively low and this was attributed to lack of awareness, shortage of labour and finance. This is notwithstanding that proper application of biodegradable solid waste evidently enhanced yield of crops. Biodegradable solid waste compositing was the main innovative strategy for proper utilization of solid wastes towards crop productivity. This is because the strategy is environmentally friendly at the same time enriches the soil with both soil and crop growth support nutrients.

5.3 Recommendations

Efforts should be directed towards educating and emphasizing community members about their role in managing biodegradable solid wastes to enhance crop productivity. This will enhance their participation in managing solid waste properly. Emphasis should be directed towards promoting sustainable alternative approaches of managing solid waste such as composting and recycling through use of site formal groups. This will also contribute to enhanced urban agriculture as well as income generation.

A strong cooperation between the community and local city council authorities should be cultivated for purposes of enhancing community participation in the management of biodegradable solid waste hence enhancing food crop production in the area.

There is need to explore the opportunities of reducing, reusing, recycling and rethink and composting in waste management among urban communities to minimize waste while at the same time providing social (clean and healthy neighbourhood) and economic benefits. Successfully adoption of sustainable methods of waste management by the communities can be done by making awareness programmes simple and accessible to change the mind-set of urban residents to perceive waste as resources rather a problem.

References

Akintola. (2013). *Prospects of solid waste management in Ibadan City.* University of Ibadan, Department of Geography. Ibadan: University of Ibadan.

Alhassan, M., & Mohammed, J. (2013). Households' demand for better solid waste disposal service. *Journal of sustainable development, 6*(11), 16-25.

Amin, M. A. (2005). *Social science research: conception methodology and analysis.* Kampala: Makerere University.

Apanovich, N., & Mazur, R. E. (2018). Determinants of seasonal food security among smallholder farmers in south-central Uganda. *Agriculture & food security, 7*(87), 1-10.

Araújo, A. S., Melo, W. J., & Singh, R. P. (2010). Municipal solid waste compost amendment in agricultural soil: changes in soil microbial biomass. *Reviews in Environmental Science and Bio/Technology volume, 9*, 41–49.

Bastidas-Oyanedel, J.-R., Fang, C., Almardeai, S., Javid, U., Yousuf, A., & Schmidt, J. E. (2016). Waste biorefinery in arid/semi-arid regions. *Bioresource Technology, 215*, 21-28. doi:10.1016/j.biortech.2016.04.010

Bateganya, N. L., & Olobo, C. (2017). *Kampala waste treatment and disposal, project teaser.* Kampala: Kampala Capital City Authority.

Behzad, M., Gohar, Z., Muhammad, I., Ghulam, M. S., Muhammad, A., Naveed, A., . . . Ghulam, M. (2019). Municipal solid waste compost improves crop productivity in saline-sodic soil: a multivariate analysis of soil chemical properties and yield response. *Communications in soil science and plant analysis, 50*(8), 1013-1029.

Bentham and mill (1990). *Contemporary Utilitarianism*. Doubleday: Anchor Books.

Bogdan, R., & Biklen, S. (2007). *Qualitative research for education: an introduction to theories and methods* (5th ed.). London: Pearson.

Chen, C. (2020). Technology adoption, capital deepening, and international productivity differences. *Journal of Development Economics, 143*, 102388.

Christensen, D., Drysdale, D., Hansen, K., Vanhille, J., & Wolf, A. (2014). Partnerships for development: Municipal solid waste management in Kasese, Uganda. *Waste Management & Research, 32*(11), 1063–1072. doi:10.1177/0734242X14539029

Coffie, F. M. (2010). *Landfill sites management challenges: the perceived effect and willingness to for improvement.* Kumasi: Kwame Nkrumah University of Science and Technology.

Dika, G., Nemie, A., & Birhane, E. (2019). Household's willingness to pay for improved solid waste Management in Gulelle sub City, Addis Ababa. *Energy environ eng, 6*(1).

Dwivedi, A., Dev, I., Kumar, V., Yadav, R. S., Yadav, M., Gupta, D., . . . Tomar, S. S. (2015). Potential role of maize-legume intercropping systems to improve soil fertility status under smallholder farming systems for sustainable agriculture in India. *International Journal of Life Sciences Biotechnology and Pharma Research, 4*(3), 145.

Fernández-Nava, Y., Río, J. d., Rodríguez-Iglesias, J., Castrillón, L., & Marañón, E. (2014). Life cycle assessment of different municipal solid waste management options: a case study of Asturias (Spain). *Journal of Cleaner Production, 81*, 178-189. doi:10.1016/j.jclepro.2014.06.008

Ferronato, N., Portillo, M. A., Lizarazu, E. G., Torretta, V., Bezzi, M., & Ragazzi, M. (2018). The municipal solid waste management of La Paz (Bolivia): Challenges and opportunities for a sustainable development. *Waste Management & Research, 36*(3), 1-12. doi:10.1177/0734242X18755893

Fuglie, K., & Rada, N. (2013). Resources, policies, and agricultural productivity in sub-Saharan Africa. *USDA-ERS Economic Research Report, 143*.

Gollin, D., Lagakos, D., & Waugh., M. E. (2014). Agricultural productivity differences across countries. *American Economic Review, 104*(5), 165-70.

Gumisiriza, P., & Kugonza, S. (2020). Corruption and Solid Waste Management in Mbarara. *Journal of Environmental and Public Health*, 1-10. doi:10.1155/2020/4754780

Hussein, I. A.-S., & Mona, S. M. (2018). Solid waste issue: Sources, composition, disposal, recycling, and valorization. *Egyptian journal of petroleum, 27*, 1275–1290.

Iheke, O. R., & Ukandu, I. (2015). Effect of Urbanization on Agricultural Production in Abia State. *International Journal of Agricultural Science, Research and Technology in Extension and Education Systems, 5*(2), 83-89.

Katongole, C. B., Nambi-Kasozi, J., Lumu, R., Bareeba, F., Presto, M., Ivarsson, E., & Lindberg, J. E. (2012). Strategies for coping with feed scarcity among urban and peri-urban livestock farmers in Kampala, Uganda. *Journal of Agriculture and Rural Development in the Tropics and Subtropics (JARTS), 113*(2), 165-174.

Kothari, C. R. (2004). *Research methodology: methods and techniques* (2nd ed.). New Delhi: New Age International Publishers.

Marshall, R., & Farahbakhsh, K. (2013). Systems approaches to integrated solid waste management in developing countries. *Waste management, 33*(4), 988-1003.

Murtaza, B., Zaman, G., Imran, M., Shah, G. M., Amjad, M., Ahmad, N., . . . Murtaza, G. (2019). Municipal Solid Waste Compost Improves Crop Productivity in Saline-Sodic Soil: A Multivariate Analysis of Soil Chemical Properties and Yield Response. *Communications in soil science and plant analysis, 50*(8), 1013-1029. doi:10.1080/00103624.2019.1603305

Nikos, T., Sofia, G., Eleni, D., Christos, S., Maria, P., Dimitrios, G., & Thrassyvoulos, M. (2012). Use of fertigation and municipal solidwaste compost for greenhouse pepper cultivation. *The scientific world journal*, 1-8.

Okot, O., & Nyenje, R. (2011). Municipal solid waste management under decentralization in Uganda. *Habitat international, 35*(4), 537–543.

Rupasinghe, I., & Leelamanie, D. A. (2020). Comparison of municipal and agriculture-based solid waste composts: short-term crop-yield response and soil properties in a tropical Ultisol. *Biologia* .

Ruttle. (2013). Methods of compost preparation. *Proceedings of workshop on resource efficient farming methods for Morogoro, Tanzania*, (pp. 58-63). Morogoro.

Sekaran, U. (2006). *Research methods for business: a skill building approach.* London: John Wiley & Sons.

Support for Women in Agriculture and Environment (SWAGEN). (2021). Solid Waste Management in Slum Areas of Kampala. Retreived from https://swagenafrica.org/program-areas/solid-waste-management-in-slum-areas-of-kampala/

Tey, Y. S., & Brindal., M. (2012). Factors influencing the adoption of precision agricultural technologies: a review for policy implications. *Precision agriculture, 13*(6), 713-730.

World Bank. (2019, September 23). *Solid waste management.* Retrieved March 4, 2020, from The World Bank: https://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management

Yousuf, A., Bastidas-Oyanedel, J.-R., & Schmidt, J. E. (2018). Effect of total solid content and pretreatment on the production of lactic acid from mixed culture dark fermentation of food waste. *Waste Management, 77*, 516-521. doi:10.1016/j.wasman.2018.04.035