Developing the Circular Economy in Uganda: Prospects for Academia-Public-Private-Partnerships

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Abstract

Issues: Circular economy is a production system that optimizes the reusability of by-products/waste as raw materials. As the global population threatens to reach 9 billion by 2050, consumption levels grow proportionally, raising food, material, and energy demands. In Uganda, soil nutrient depletion and energy poverty are key challenges faced by urban and rural communities. Rampart depletion of natural resources calls for transit from the linear economic models towards sustainable production/consumption technologies. This study investigated prospects for APPP to optimize the reusability of by-products/waste as raw materials. **Approach**: Quantitative and qualitative tools were used to collect data via document analysis, interviews, and participant observations. The tools were administered to municipal authorities, private waste-collecting agencies in cities and municipalities; officials in Ministries of energy and Agriculture; officials in universities research units and entrepreneurs that deal in agricultural and energy products; officials from civil society organizations. **Findings**: there are a number of sustainability projects being undertaken by Universities and High schools, Government agencies, companies, and civil society organization isolation. Single-handedly, individual agencies lack the requisite capacity to develop closed-loop production/consumption models. Analysis of a few successful RRR projects suggests that APPP is positioned to promote CE. Transiting towards a circular economy requires joint ventures to optimize human, technological, and financial resources and develop policy and institutional frameworks. In Uganda, recycling biotic by-products can promote environmental sustainability; reduce stress on natural resources; enable cost savings; promote green entrepreneurship, and create jobs/livelihoods.

Conclusion: working jointly, CE could be enhanced via technical and business models by the academia, private capital investment by companies, community engagement by CSOs, and development of supportive policy and institutional frameworks to facilitate decision-making processes. The APPPs are positioned to use interactive platforms

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for creating awareness and promote sensitization about green values through education and multimedia communication platforms.

Introduction

Circular economy (CE) is a system of resource utilization that promotes waste reduction, reuse and recycling, and the restorative capacity of natural resources. Growing population, urbanization and changes in consumption patterns increase the demand for energy, food and other essential necessities of life. Linear production models which require large quantities of cheap materials and energy create scarcity in natural resources and culminate in environmental degradation (Mont, 2008). Innovative management of resources utilizing secondary and renewable materials could address scarcity (Ellen Macarthur foundation, 2018). Attaining resource efficiency entails that products and materials circulate at the highest level of utility to reduce wastage (Ellen MacArthur Foundation 2017). Conceptually, maximum utilization of waste and by-products promotes value creation by reducing; a) cost of raw materials in the supply chain management; b) cost of delivery of raw materials; c) dependence on mining of natural resources. While industrialization improves and comforts life, it raises sustainability issues (Szirmai, A., 2012). The Industrial sector in the conventional linear economic model is extractive in nature, dominated by mining, consumption, and disposal of waste (MacArthur Foundation 2013). The production of goods is directly connected to material and energy flows (Elia et al., 2017), and the model makes the world a garbage producer and collector (Masi et al., 2017). Therefore, it is imperative to develop a resilient production system that enables the current generation to meet present-day needs without compromising the ability of future generations to meet their own needs.

The concept of Circular Economy: Products and materials approaching the end-of-life stage are regenerated through resource recovery and reuse (RRR). Efficiency is achieved when by-products or waste are retrieved for use in other production processes. CE ecologically makes the world clean and livable by meeting bottlenecks of resource scarcity and waste disposal (Homrich et al 2018). Value creation for sustainability calls for great innovation, creativity and adaptation to maintain the value of products, materials and resources at the highest level of utility in the economy for as long as possible (EC 2015). CE not only builds resilience, it also creates opportunities for delivering economic, social and environmental benefits. Within the circular value chain, organizations retain and regenerate values to products, making them secondary raw materials through reverse logistics. The closed-loop cycles of reuse, remanufacturing, and recycling regulates consumer behaviour to sustainable levels (Peattie, K. and Belz, F., 2013). Regenerative value is created by practicing sustainability in human resources, procurement, technology and firm infrastructure.

Resource scarcity issues in Low Income African Countries (LIAC): Within LIAC, energy demands outstrip the supply levels as exemplified by; a) high dependence on candles and kerosene lamps for lighting' and lack of access to electricity 89% of households (IEA 2014); b) poor accessibility to clean cooking fuels (World Bank 2017) and reliance on traditional biomass for cooking (Sehgal et al 2018); c) over dependence on biomass (firewood, charcoal, dung, agricultural residues) for cooking; d) use of inefficient traditional stoves and open fires for cooking (World

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Bank 2016). There is potential in LIACs to generate over 40% of renewable energy (RE) needed to accelerate economic growth by 2040 (IEA 2014). However, the abundant solar, wind, hydro, geothermal and biomass energy resources are underdeveloped and under-exploited (IREA 2015). The abundant organic materials for waste-to-energy development, are not processed into usable solid, liquid, or gaseous fuels; but combusted directly for cooking/heating purposes for both domestic and industrial processes (Hafner et al 2018). Limitations include initial big capital costs, weak environmental policies, poor institutional framework and poor infrastructure (Kemausuor et al 2018). Achieving sustainable, clean and affordable energy for all by 2030 calls for creativity and optimal use of existing reusable resources.

Resource availability issues in Uganda: Currently, over 95% of households rely on wood and charcoal as a source of cooking energy; only 5% have access to electricity (GIZ 2011). Given that these fuels are used by educational institutions, prisons, hospitals, industry (brick/tile, tea curing, cement and others) their demand grows at 6% annually. Over 80,000 hectares of forests (private and protected) are cleared annually (Knöpfle 2004). About 4 million tonnes of wood are consumed every year: accounting for over 70% of deforestation in Uganda. Between 1990 and 2010, the country lost over 36% of natural forest cover (MEMD 2010). At this rate, a total depletion of forestry resources would occur by 2050 (NEMA 2008). Existing initiatives on increased efficiency of kilns for charcoal production and cook-stoves improvement may not suffice in absence of alternative fuels. One of the alternatives is production of biofuels from bio-waste, particularly carbonized briquettes. The 1,154,160 tons of bio-waste generated annually in Kampala could be recycled into 192,360 tons of briquettes which could serve 3206 educational institutions and save 1,920,000 tons of trees. This could generate income equivalent to $ 1,937,200 and employ 43,281, youths (each earning 100 USD monthly). Other socio-economic benefits include reduced water pollution and improved sanitation.

The other aspect of resource scarcity is related to high soil nutrient depletion (Henao & Baanante, 2006). Whereas agricultural output in Uganda is 21% of the GNP; and despite the fact that 4.2 out of 5.7 million households are engaged in agriculture (NEMA 2010), use of fertilizers is quite low, at 3% (NETWAS 2011). Given that most small-scale farmers cannot afford to buy mineral fertilizers, Uganda has one of the lowest agro-chemical usages in Africa (ACODE 2006). Organic waste could be recycled into biocides and soil nutrients for food production. Bio-waste recycling for biocides, fertilizers take advantage of the abundant biomass resources in the country. The decrease of the world's remaining sources of mineral phosphorus justifies nutrient recycling (Berg et al. 2005) particularly in Uganda where $ 899 million is lost annually due to effects of malnutrition. Wastewater sludge could also be used as a soil conditioner for farming purposes (Diener et al., 2013; NetWas, 2011). The chemical-energy content in wastewater sludge is more than needed for treating it, pumping water, irrigation and other purposes (Heidrich et al. 2011). For briquettes production, a net benefit from combustion of feacal matter is obtained at 27% dryness when stored in ventila-ted greenhouses (Muspuratta et al 2014).

The Conceptual framework: CE centers on resource efficiency and economically competitive solutions (EC 2015). Being restorative and regenerative, circular economy bridges gaps in the existing linear economy which is

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characterized by take, make and dispose. In CE, waste is directly or indirectly minimized following the waste hierarchy; reduce/prevent, reuse, recycle, recovery and (as the last option), safe disposal (EC 2016). This study focused on bio-based materials; consisting of substances originally derived from nature. Because Uganda is non-industrialized, more than 90% of all waste generated is organic and only a small percentage constitutes plastics, paper and metal. It is typically a bio-based economy dealing with agriculture, forestry, fisheries, food and related products. Bio-based circular economy centers on renewable biological resources (e.g., crops, forests and animals) and products that are wholly or partly derived from materials of biological origin (EC 2017a). Conceptually, bio-based circular economy is a closed loop system that maintains the value of biological products Medkova et al 2017).

Despite the economic and environmental benefits of the CE and despite the growing global attention from academia, policymakers and businesses, implementation projects for CE in Uganda are scarce. Presumably, this is attributed to limited linkages between the academia, public and private sector agencies. As observed by Ellen MacArthur Foundation (2014), cooperation is the key for functional circular economy. In light of this observation, the purpose of this study was to investigate the role that Academia-Public-Private-Partnerships (APPP) could play in the development of the CE in Uganda.

The specific objectives of the study were.

1. Investigate the opportunities and prospects for development of the CE in Uganda
2. Establish gaps and limitations in development of the CE in Uganda
3. Determine how Academia Public and Private Partnerships could optimize opportunities and bridge gaps for development of CE in Uganda

Materials and methods

A multi-dimensional approach was adopted to investigate the role that APPP could play in the development of the CE in Uganda. While the study was predominantly qualitative, some aspects of quantitative data collection methods were used. The following section describes the approaches used in conducting the study.

Desk reviews: secondary sources of information were used; specifically focusing on national and global trends of recycling of organic materials. At the national level, documents analysis was done, and the focus was put on public and private sector records (proceedings, action-plans, policies, etc.) Attention was devoted to establishing evidence of linkages and partnerships for CE between Academic, Public-Private sector agencies.

semi-structured interviews: these were administered to various categories of people including; urban communities particularly those engaged in (and affected by) existing forms municipal waste management; personnel in government agencies (especially National Environment Management Authority {NEMA} and Kampala Capital city Authority {KCCA}); officers of private sector agencies (mainly operators of private waste management companies). The interviews were used in the baseline and feasibility studies on the prospects of waste recycling (existing knowledge, attitudes and practices); opportunities barriers, Information-Education-Communication (IEC); capacity building needs; and start-up and scale-up financial and technical requirements. Existing costs of energy and fertilizers

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were established to determine viability of proposed renewable energy projects. Marketing processes and distribution networks of products of waste recycling were also examined.

Participant observations: checklists and inventories were used to determine availability of key aspects of recycling within various organizations visited. For instance, in academia, government and private sector agencies, expected items included regulations, guidelines, policy briefs, research findings, journals, consultancy reports, partnership deeds, business records, exhibitions, conference/workshop proceedings, etc.

Proof of concept pilot projects: experimental trials were conducted to determine the practicability and feasibility of production and consumption of the following: briquettes, biocides, fertilizers, disinfectants, ornamental crafts, pavers.

according to the study conducted by GGGI (2017); a) there are more than 3000 people directly employed in informal solid waste-related activities. Existing waste value chains for metals, banana peelings, peels, paper cardboard and plastics could be empowered to handle bio-waste recycling activities; b) over 100 formal private waste collecting companies are registered; c) over 40 NGOs and CBOs actively support waste management operations. All these constitute a potential work force for developing the recycling industry.

GGGI (2017) also reports that KCCA spends 8.5 billion annually on waste collection and disposal; constituting about 40% of their total budget to cover only 45% of the total waste generated. The opportunity is that KCCA could be convinced to invest in waste recycling schemes to save the costs.

Findings

Opportunities for recycling Municipal Bio-waste (MBW) in Kampala city

	Aspect	**Opportunities and prospects**
1	Annually 1,154,160 tons of municipal bio-waste (MBW) is generated in Kampala city alone. Capacity of landfills have been overstretched; poorly designed landfills emit methane to atmosphere and allow leakage of into the underground ground water reservoirs; smell and scattering of waste by animals/birds becoming a menace to neighbouring communities.	Could produce 192,360 tons of briquettes; Sold at $ 0.27 @ Kg, generate $ 1,937,200; serve 3206 schools; save 1,920,000 tons of trees; employ 43,281 people; save 40% of municipal budgets; reduce indoor air pollution; reduced water pollution. About 3-5 times more municipal waste generated in other urban centres could produce more impacts. Bio-waste could be diverted from landfills to be recycled into bioenergy, biocides and fertilizers.
2	On average, MBW has 1.65 % nitrogen, 0.28 % phosphorus, 2.95 % potassium; av. PH; 5.7-6.9 %; moisture content 50-75%; relative humidity 75-155%.	Average gross energy content is 17 MJ/k. volatile solids content 66-79%; decomposable organic carbon (DOC) 74-86%. Ideal for big-scale biofuel and soil nutrients production. Recycling reduces methane emission (which vary between 0.9 & 4.12 Gg/yr).

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3	High soil nutrient depletion; high cost of imported fertilizers; increasing global shortage of phosphorous	Recycling of bio-waste (including faecal sludge) into fertilizers for farming; Small scale farmers of ornamental plants are willing to pay for the processed faecal sludge and urine at a cost of USD 2 for a 20 Litres.
4	Rising costs of firewood and charcoal (attributed to reducing trees/forests); cost of electricity is very high constituting 20% of the household budgets	Business prospects of bioenergy are growing; market for recycled products likely to rise steadily.
5	Existence of private waste collecting companies (for solid and liquid waste) under umbrella associations Umbrella organization exist such as Uganda Water and Sanitation Network (UWASNET) to bring together NGOs, CBOs and others	Their capacity could be developed (through training and financing) to extend the scope of their operation beyond waste collection and disposal; to processing for commodification. Potentially, these are platforms for community awareness and training; for advocacy and collective bargaining
6	Renewable energy umbrellas exist; include Uganda National Renewable Energy and Energy Efficiency Alliance (UNREEEA), Biomass Energy Efficiency Technologies Association (BEETA), Uganda National Alliance for Clean Cooking, Kirchner Solar Group, Uganda National Biogas Alliance-UNBA.	There is potential for pooling of human, technical and financial resources to undertake big scale projects on development of renewable energy via recycling of bio-waste There is also a potential platform for collective bargaining with government agencies and for collaboration with the academia and business communities.

The environmental, social and health challenges experienced at Kitezi landfills could mount pressure on NEMA, KCCA and other stakeholders to promote recycling as an avenue for diverting bio-waste away from landfills. The challenges include the bad order that discomforts nearby households and business entities; the untreated leachate discharged directly into the underground water sources; the holding capacity of landfill which is being over stretched.
Despite the opportunities and prospects described above for development of CE in Uganda, projects have not scaled to sufficient levels.

Gaps and limitations in the development of the CE in Uganda

There is a general lack of awareness of value in bio-waste among a big section of the population. Over 90% of people who pick waste concentrate on metallic and plastic components for sale to medium/large scale recycling companies. There is a significant gap in bio-waste recycling despite the fact that 80-90 % of waste generated in Kampala is organic. Findings from interviews, documents analysis and literature reviews attribute this to the following.

Psycho-social factors; recycled products from faecal matter (biogas and fertilizers) are resented due to perceptions; cultural and psycho-social sensitivities.

Economic factors: commercial biogas and briquettes production schemes are constrained by high initial capital costs. Opportunities for securing start-up finances are not well known to many prospective investors; particularly

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those whose educational levels are low. Financial institutions fear to grant loans to projects whose viability and feasibility is not well understood; especially in absence of successful commercial-scale projects.

There is lack of relevant business and entrepreneurial models for recycling enterprises to enable potential entrepreneurs to emulate and start the businesses.
Producing briquettes/biogas entails costs which translate into high price (compared with charcoal or firewood) whose production costs are low indeed.

Compositing operations are constrained by the low demand for fertilizers in urban and peri-urban areas where farming is less prominent. Besides, usage of fertilizers in Uganda is very low indeed.

Private waste collecting companies abandon routine services in the low-income areas because of the inability of the latter to pay for waste collection services. Incidentally, such areas generate the biggest amount of waste given the fact that they are densely populated.

Most biogas installations are family-sized plants; designed for household consumption. Because of the low economies of scale, cost per unit of gas produced is very high. Some households lack adequate number of animals to generate enough feedstock for bio-digesters. Even where the number of animals is big, semi nomadic, and free grazing system complicate collection of dung to feed the digesters which fails to meet costs of feedstock collection. Besides, technology of packaging biogas is too complicated and costly to make business sense.

Technical factors: bio-waste recycling projects are constrained by inadequate technical skills; poor designs and material choice for recycling plants, inexperienced contractors and operators, poor-quality plants, poor choice of materials and lack of routine maintenance and repair.
Absence of waste sorting cultures makes waste complicates recycling. Employees/Loaders spend much time sorting various stream of waste (metallic, plastic, polythene, and paper).
Lack of access roads in hard-to-reach informal settlements complicates collection of waste for recycling. Cesspool trucks hardly access specific residences to drain the sewage. Besides, toilets are not appropriately lined to enable safe draining/emptying.

Non-streamlined Institutional frameworks: There are no centrally organized waste recycling schemes. Existing activities are conducted by the informal sector; particularly by groups commonly known as 'scavengers' This is partly attributed to non-streamlined policies and support networks to support commercial-scale recycling.
There is a clear lack of economic instruments such as tax holidays for investors in organic waste recycling, or levies on charcoal and firewood. On the occasions when regulations are passed conservation of trees, enforcement of compliance is poor.

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Dealers in recycling schemes operate in isolation; and fail to optimize joint resources (human, technical, financial). This reduces opportunities for enjoying benefits of joint ventures.

In light of the above, the circular economy in Uganda is at its infancy stages. The few resource recovery and reuse (RRR) initiatives heavily depend on subsidies and operate at a small scale, often not surviving beyond pilot phases for domestic consumption. The few operators are trained and funded by meagre resources of NGOs/CBOs; inadequate to generate commercial-scale production.

Role of APPP in optimizing opportunities and bridging gaps for CE development

Presumably, resources of the Academia, public and private sector agencies could be pooled to bridge recycling gaps and limitations. The section below examines the strength of each of the sectors and proposed how it could work with others in developing CE in Uganda. The insights were generated through in-depth interviews, documents analysis, participant observation and reviews of related studies.

Academia: most of the respondents expressed the view that Universities and research stations are positioned to do the following; **a**) conduct research and produce scientific innovations for CE development; **b**) generate data (through research) for evidence-based policy development; **c**) document and disseminate research findings; **d**) diffuse innovations in CE; **e**) develop technical and business models for up-scaling CE projects; **f**) design and develop public awareness and training for projects related to CE: **g**) set up demonstration units to illustrate the technical and financial viability of scalable CE enterprises; **h**) create networked platforms for sharing technical, scientific and business information related to CE development.

Being major consumers of energy (electricity and cooking fuels), educational institutions are expected to practice energy-efficiency; develop and demonstrate initiatives for reduction of fuel wastage; conduct exhibitions, expos and trade-fares and develop or use efficiency appliances. Universities are also positioned to promote RE research and development and to train communities.

However, the general concern of many respondents was that communities are used by universities as laboratories for experimentation. Public and private agencies do not have access to University facilities and resources.

Despite the critical funding gaps facing many universities and research stations, the few joint projects that they conduct are not entrepreneurial; but focused on new knowledge for the sake of it. Within individual universities, research and outreach programs are not multidisciplinary; a typical faculty conducts its own research/projects in isolation of other faculties.

Practical links do not exist between universities, research institutions and potential beneficiary industries; and most of the research is not used in policy development. Generally, there is limited outreach projects by universities and research stations to engage communities in recycling initiatives.

However, information obtained through analysis of records at the Universities of Ndejje and Makerere revealed that some form of partnerships exists. They both have a few joint ventures with selected private and private agencies to develop RE. Makerere has a unit known as Centre for Research in Energy and Energy Conservation (CREEC) that

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focus on renewable energy development. Ndejje University has five integrated research and development centres in areas of energy, water, Agriculture/forestry/environment: business incubation centre and centre for partnerships and civic engagement. The two universities have developed user-friendly technologies for briquettes, biogas, solar and wind energy.

St Kizito High School Namugongo (SKHSN) has established a waste recycling scheme at the school to demonstrate production of briquettes, biocides, fertilizers, pavers (made from silt extracted from water drainage channel within the school). The school uses only briquettes (instead of firewood) for institutional cooking, biocides and fertilizers for horticulture and pavers for landscaping. All these innovations are exhibited to communities via annual green expos and festivals. The Alumni of SKHSN have been assisted by the school to establish two start-up renewable Energy companies (Summit Green Company and WEYE). The companies are currently implementing many of the school's outreach programs.

Public sector: within the government agencies, waste recycling is closely connected to units within Ministries/agencies of Energy, Water, agriculture, local government, Environment). The Local Governments Act, Cap 243, mandates urban councils to ensure safe, reliable and cost-effective treatment and disposal of solid waste. Findings reveal that the units are expected to do the following: **a**) develop policy, regulations and guidelines to facilitate private sector investment in RE; **b**) to assign realistic economic value to trees/forests that enable realistic costing of charcoal and firewood; i. levy tariffs on charcoal and firewood to increase their market prices; ii, allow tax holidays on RE production; iii. Create subsidies on equipment used in CE production. All this may enable biofuels to be competitive on the energy market; **c**) make informed decisions on the disposal of municipal waste in landfills; **d**) coordinate start-up and scale-up capital for CE development; **e**) coordinate capacity building for climate-smart projects; **f**) coordinate funding for the development of new technologies for CE development; **g**) develop incentives for private sector investment in CE development; supporting demand-driven and market-oriented projects; **h**) to enable private sector, universities and research agencies access climate funds and other multilateral grants; **i**) encourage strategic partnerships with academia and private sector agencies.
The following information was obtained from government agencies in regard to bio-waste recycling.

National Environment Management Authority (NEMA) focuses on promoting the Green Economy to maintain health ecosystems, promote sustainable development, eradicate poverty, enhance social inclusion, and create jobs. NEMA aims at enhancing improved human wellbeing; reduced inequalities; reduce exposure of future generations to environmental risks and ecological scarcities. Strategies include a) reducing carbon emissions and the pollution levels; b) enhancing resource efficiency; c) supporting socially inclusive; equitable; sustainable production and consumption patterns and d) promoting the natural capital-base; biodiversity and ecosystem services.
Existing bio-waste projects are conducted in a tripartite partnership with World Bank and 12 municipalities (Mukono, Jinja, Mbale, Soroti, Lira, Kabale, Kasese, Fort-Portal, Mbarara, Hoima, Masindi and Arua Municipal Councils). The projects support composting to generate marketable manure from municipal solid waste. planned activities include

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a) strengthening collection and transportation of municipal solid wastes in project towns; b) reducing greenhouse emission; c) Controlling and protecting water catchments from water source pollution. With support from World Bank, NEMA managed and coordinated the program whereby each municipal council received US$ 350,000 for critical infrastructure (1 MSW composting plant, 1 wheel loader, skip loading truck, at least 20 skip containers and training in sustainable waste management).

In general, NEMA focuses on; **i**. using a community-based approach; co-opting and involving communities in policy formulation; ii. Involving the private sector by enabling them access funding; Creating employment opportunities and income generation for at least 25 people per town; improving farmers' agricultural production and yields; reducing methane emissions; facilitate trade in carbon with revenue inflow of USD 215,000; promoting reuse/reduce/recycling of plastics and other recyclable waste types with savings in material and energy.

National Water and sewerage Corporation (NWSC) prioritizes recovery of resources to solve the sanitation problem. The agency promotes resource recovery to address the growing energy poverty. By 2016, it had 28 sewerage treatment systems, with about 7% sewerage coverage but aimed at 30% by end of 2018. NWSC also has projects that produce soil nutrients for crop farming. Some of the strategies of NEMA include a) creating public awareness on benefits of bio-waste recycling; b) upscaling and marketing successful pilot studies; c) Increasing collaborations and private sector involvement; strengthening institutions and building capacity in the area of Resource recovery.

Private sector: this constitutes; a) individual entrepreneurs and traders dealing in recycling and distribution of products; b) companies dealing in waste collecting, recycling and renewable energy production; c) financial institutions and d) civil society organizations (CSO). The following private sector agencies are expected to; **i.** companies: to invest in recycling initiatives (financing, technology, and human resource); ii CSOs; to provide grassroots structures, training, and leadership for community engagement; coordinate local and global funding; iii. Consumers of firewood/charcoal (tea-curing factories; ceramic industries, poultry farms, sauna operators, educational institutions, and restaurants) are potential clients for briquettes; iv. Private sector potentially funds research/projects on CE and potentially provide internship to students.

A private waste collecting company (named CAD) partnered with SKHSN to provide sorted waste to the school for briquettes production. The school skilled CAD officials to produce briquettes, adding value to their waste management work.

Two Start-up renewable Energy companies (Summit Green Company; and WEYE) produce and distribute briquettes to households and user organizations. They have so far conducted training and exhibitions on renewable energy to over 50 communities in urban and rural areas.

Energy companies and CSOs in Uganda have formed umbrella organizations. They include Uganda National Renewable Energy and Energy Efficiency Alliance (UNREEEA), Biomass Energy Efficiency Technologies Association (BEETA), Uganda National Alliance for Clean Cooking (UNACC) and Uganda National Biogas Alliance (UNBA). Each of them regularly organizes exhibitions, conferences and workshops on renewable energy and invite companies, educational institutions and the public.

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With financial and technical support from GIZ, UNREEEA provided funding to Ndejje University for the development of a one-stop centre on renewable energy (Solar, wind energy, biomass {biogas and briquettes}).
The Global Green Growth Initiative (GGGI) works collaboratively with KCCA. In December 2017, GGGI conducted a study on value chain analysis of Municipal solid waste in Kampala. Recycling is one of the proposed recommendations to divert waste from the landfills which already were being stretched beyond established capacity. GGGI also coordinated finding support to WEYE to work with urban and peri-urban areas.
The above description of activities of various agencies in the APPP reveals that there are efforts by each of them (or a partnership of two or three of various agencies) to promote recycling. What is still lacking is the formalized partnership structure that facilitates inter-sector linkages for mega projects. The section below is a discussion of issues, challenges, opportunities, and prospects for the development of CE anchored on inter-sector-linkages.

Circular Economy in Context of APPP

Circular Economy (CE) and sustainability are twin concepts that require handling of resources in an ecological way to bring back and maintain a clean and liveable world (Homrich et al, 2018). It attempts to meet bottleneck of resource scarcity and waste disposal. Globally, CE has gained increasing attention from academia, companies and policymakers as a promising approach for promote sustainability and competitiveness (Murray et al 2017). Among other countries, China, Japan, USA and the European Union have policies to support the adoption of CE (Ghisellini, et al 2016; Winans, et al 2017). Companies are also expected to step up efforts to promote sustainable productions (Bressanelli, Perona, and Saccani 2019).

APPP and the development of CE in Uganda: presumably, many of the constraints facing recycling operations could be addressed through the framework of Academia-Public-Private-Partnership (**APPP**). Heilman, and Johnston (1992) describe PPP as "The combination of a public need with private capability and resources to create a market opportunity through which the public need is met, and a profit made." The expectation is that technical, human, and financial resources of APPP could be pooled to undertake mega sustainable projects. On the side of universities, partnerships and collaborations are key to long-term sustainability of quality operations (Hart and Northmore 2011). Joint projects with public and private sectors are positioned to generate well-defined roadmaps to support appropriate technologies, infrastructure, community outreach projects and evidence-based policy development. However, as pointed out by Sutz (2005), small-scale collaborations between researchers, industry and other actors fail to grow into national trends. Research conducted by the academia is rarely disseminated in local fora where it could be accessed by practitioners. Publications are done in elite academic journals to enhance staff promotion or for achieve higher degrees for students (Perry & Menendez, 2011). On the rare occasions when it is disseminated in the local media, the technical jargon may not be understood by average policy makers and practitioners. This reduces the likelihood of universities receiving research funding from industry, government agencies and civil society. Etzkowitz (2012) calls for flexibility on part of the university faculty and management.

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Analysing inter-sector linkages for developing CE entails; a) stakeholder-mapping to understand core values, interests and challenges of different agencies within APP; b) determining commitment of various APP agencies towards CE-based production/supply chains and; c) assessing trends among APP agencies towards closed-loop production for preserving natural ecosystems; d) developing technical and business models to attract private investment into CE projects; e) creating public awareness of economic, social and environmental benefits and prospects for CE development).

Private companies' and the promotion of CE: companies that redesign their supply chain for CE may obtain environmental social and economic benefits (Genovese et al. 2017; Ongondo et al. 2013 Cucchiella et al. 2015). In Uganda, prospective clients of RE products include tea curing factories, restaurants, ceramic industries, poultry farms and educational institutions. Currently they depend on firewood and charcoal as a cooking/heating fuel but have shown readiness to shift towards more affordable and sustainable energy sources. While the decision-support framework for supporting innovations encourages a balanced assessment of environmental, economic, and social considerations; the financial motivation takes precedence (Borrello et al 2017). Consideration of companies is focused on reducing operational costs for increasing profits. As Nunez-Cacho et al; (2018) observes, sustainable energy use is mostly motivated by conservation of company financial resources. Companies focus on minimizing production costs (via energy/material savings), supply risk reduction, customer loyalty improvements and opening new revenue streams (Salguero-Puerta et al 2019). Resource-efficiency in production is attained through redesigning, maintaining, repairing, reusing, remanufacturing, refurbishing, and recycling. In a way, green marketing supports the CE practices. While packaging enables companies to advertise and attract customer attention; it is a source of dumping/littering. Scientists are positioned to develop biodegradable packaging materials which government agencies should promote by legislating (Pavel & Supinit; 2017; Hejase, et al., 2018; Ravenstijn, J., 2010)

CE and corporate social responsibility: Waste management can be analyzed from three dimensions; 1) as a social, ethical and civic duty associated with positive identity (Hetherington 2004); 2) as a product of 'awareness of consequences' of failure to take appropriate waste management measures (Tucker and Speirs 2003); 3); as having concrete social and economic benefits to companies in terms of income generation and costs saving. While the consideration of many companies is on economic benefits, the civic duty of promoting social and environmental wellbeing deserves attention. Barr (2005) argues that 'localization' of environmental action to everyday lives of individuals could have a significant positive impact on recycling schemes and participation rates.

Shukor, et al (2018) points out that social and environmental issues have recently attracted attention of private companies. Within the framework of corporate social responsibility (CSR), companies are inclined to finance diverse aspects of sustainability projects. The projects include supporting advocacy initiatives for creating ecological awareness among local populations and authorities) and community welfare initiatives (Gregorio et al 2018). CE requires that companies participate in community development and value sharing for socially responsible consumption (Webb, et al., 2008). In light of this, companies are expected to go beyond the traditional corporate social responsibility (CRS) and practice corporate sustainable social responsibility (CSRS) which presumes extended producer responsibility.

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CE and Waste-to-Wealth Enterprises (WWE): CE is an eco-innovation that promotes sustainable business, job creation and livelihoods for grassroots communities. In this regard, Gregorio & Terceno (2018) conceptualize Bioeconomy (BE) as the production, use and marketing of renewable biological resources. It involves the conversion of bio-waste into bioenergy and other value-added products. Apparently, sustainability conversations that front business interests are likely to attract public attention. Profitability is heightened when products that are approaching a stage of their end-of-life are regenerated and reused as raw materials (Grigorios et al 2019). For instance, a lot of domestic and agricultural waste that ends up in municipalities are raw materials for bioenergy (soil nutrients, biocides, and production of animal feeds). The value of products, materials and resources are maintained as long as possible.

Addressing shortage of raw materials and natural resources: CE decouples economic growth from resource extraction whereby reverse and forward flows of products and materials are allocated equal attention (Spring & Araujo 2017). The various waste streams and emissions are used to create value, to provide secure and affordable supplies of raw materials and to reduce the pressure on the environment. Food-waste, wastewater sludge and biodegradable material from farming, forestry, fisheries, markets bakeries, breweries and mills are prospective raw materials for generating biogas, briquettes, soil nutrients and biocides. The closed-loop product lifecycle minimizes waste generation and transforms waste into raw materials for production (Salguero-Puerta et al, 2019). CE reduces dependency on non-renewable raw materials, and it addresses depletion of resources (Ghosh and Agamuthu 2018). Holistic sustainability is achieved when bio-waste recycling increases energy output. Optimization of secondary raw materials and other renewable resources helps in; a) addressing resource scarcity; b) reducing cost of raw materials; c) overcoming costly supply chain management and d) decoupling economic growth from natural resources consumption (Kjaer, et al., 2018)

CE and social equity considerations: Waste-recycling is the remedy towards clean city initiatives. This particularly empowers urban communities (through skilling and financing) to convert waste into bioenergy, biocides, fertilizers, and animal feeds. The cost of skilling and the start-up financing could be met by city and municipal authorities who ordinarily spend 40% of their budgets on municipal waste management. The savings accrued when waste is managed by multiple stakeholders are sufficient to meet the needed financing requirements. Promoting small and medium scale WWE improves sanitation in the hard-to-rich informal settlements where private waste collectors do not reach. It also creates jobs and livelihood opportunities for urban communities who are likely to engage in the WWE. As pointed out by Gregorio & Terceno (2018), CE promotes social equity, human welfare, Industrial ecology (IE) and Green Economy (GE) (the latter two being attained through reducing environmental risks and minimizing ecological scarcities).

Conclusion

The circular value chain is a process by which organizations regenerate by-products and create value through reverse logistics. CE is based on the three pillars: economic, environmental, and social (profits, planet, and people). The sustainability concept aims at meeting the needs of the present without compromising the ability of future generations to meet their own needs. The beginning points in Circularity "refuse," and the endpoint is value recovery

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(such as bioenergy, soil nutrients, biocides, and animal feeds). Thereafter, the 9Rs principles are addressed in the following order: (1) Refuse: preventing the use of raw materials; (2) Reduce: reducing the use of raw materials; (3) Reuse: product reuse (second-hand, sharing of products); (4) Repair: maintenance and repair; (5) Refurbish: refurbishing a product; (6) Remanufacture: creating new products from (parts of) old products; (7) Repurpose: product reuse for a different purpose; (8) Recycle: processing and reuse of materials; and (9) Recover energy: incineration of residual flows. Given that Uganda's economy is predominantly agro-based, agricultural waste from a variety of crops produced by small, medium, and large-scale farmers constitutes a reliable base for the CE. Other forms of bio-waste are generated from Wood waste (sawdust, shavings, off-cuts), feacal sludge, and other wastes. This abundant biomass base creates a variety of WtE options, soil nutrients, biocides, and animal feeds.

Recommendations: Given that the potential for developing a bio-based Circular Economy is quite big, linkages between the Academia, Public and Private sector agencies should be institutionalized and streamlined. This could be done through; 1) regular scheduled meetings between key stakeholders; 2) conducting conferences, workshops, Green-festivals and Trade-fares and other face-to-face meetings; 3) development of Interactive digital platforms. An example of an interactive digital platform is http://catch.summitgreencompany.com developed by Summit Green Company LTD.

References

ACODE. (2006). Status of Organic Agriculture Production in Uganda. Kampala: Advocates Coalition for Development Environment (ACODE).

Barr S, and Ford N (2005) Defining the multi-dimensional aspects of household waste management: a study of reported behaviour in Devon Resources, Conservation and Recycling 45 172–92

Berg, U., Donnert, D., Ehbrecht, A., Bumiller, W., Kusche, I., Weidler, P. G. & Nuesch, R. (2005). "Active filtration" for the elimination and recovery of phosphorus from wastewater.

Borrello, M.; Caracciolo, F.; Lombardi, A.; Pascucci, S.; Cembalo, L. (2017) Consumers' perspective on circular economy strategy for reducing food waste. Sustainability 2017, 9, 141.

Braungart, M., McDonough, W. and Bollinger, A. (2007), "Cradle-to-cradle design: creating healthy emissions – a strategy for eco-effective product and system design", Journal of Cleaner Production, Vol. 15 No. 13–14, pp. 1337–1348.

Bressanelli, Gianmarco, Marco Perona, and Nicola Saccani. (2019). "Assessing the Impacts of Circular Economy: A Framework and an Application to the Washing Machine Industry." International Journal of Management and Decision Making in Press doi:10.1504/IJMDM.2019.10015915.

Cucchiella, Federica, Idiano D'Adamo, S.C. Lenny Koh, and Paolo Rosa. (2015). "Recycling of WEEEs: An Economic Assessment of Present and Future E-Waste Streams." Renewable and Sustainable Energy Reviews 51: 263–272. doi: 10.1016/j.rser.2015.06.010.

Diener S., Semiyaga S., Niwagaba C. B., Muspratt A. M., Gning J. B., Mbéguéré M., Ennin J. E., Zurbrügg C., Strande L. (2014): A value proposition: Resource recovery from faecal sludge – Can it be the driver for improved sanitation? Resources, Conservation & Recycling 88, 32–38

Published by
Bonn-Rhein-Sieg University of Applied Sciences

ISBN 978-3-96043-083-4
doi:10.18418/978-3-96043-083-4_74

EC. (2015). European Commission. Closing the loop - an EU action plan for the circular economy. [Online document]. [Cited 10 Oct 2017]. Available at: http://eur-lex.europa.eu/legal-content/EN/ TXT/?uri=CELEX%3A52015DC0614

EC. (2016). European Commission. Directive 2008/98/EC on waste. [Online document]. [Cited 10 Oct 2017]. Available at: http://ec.europa.eu/environment/waste/framework/

EC. (2017a). European Commission. Bio-based products. [Cited 10 Oct 2017]. Available at: http:// ec.europa.eu/growth/sectors/biotechnology/bio-based-products_en

Elia, Valerio, Maria Grazia Gnoni, and Fabiana Tornese. (2017). "Measuring Circular Economy Strategies through Index Methods: A Critical Analysis." Journal of Cleaner Production 142: 2741–2751. doi: 10.1016/j.jclepro.2016.10.196.

Ellen MacArthur Foundation. 2013. Toward a circular economy (Vol 2: Opportunities for the consumer goods sector). www.ellenmacarthurfoundation.org/assests/downloads/publications/TCE_Report-2013.pdf

Ellen MacArthur Foundation. (2014). Towards the Circular Economy Vol. 3: Accelerating the scale-up across global supply chains. [Electronic book]. Ellen MacArthur Foundation [Cited 10 Oct 2017]. Available at: https://www.ellenmacarthurfoundation.org/publications/towards-the-circulareconomy-vol-3-accelerating-the-scale-up-across-global-supply-chains

Ellen MacArthur Foundation (2017) Ellen MacArthur Foundation 2017. Circular Economy Overview. [Cited 4 Oct 2017]. Available at: https://www.ellenmacarthurfoundation.org/circular-economy/overview/concept

Ellen MacArthur Foundation. (2018). "MUD Jeans - Pioneering a Lease Model for Organic Cotton Jeans." https://www.ellenmacarthurfoundation.org/casestudies/pioneering-a-lease-model-for-organic-cotton-jeans.

Etzkowitz, H. (2012) MIT and the Rise of Entrepreneurial Science, London: Routledge Press.

Genovese, Andrea, Adolf A. Acquaye, Alejandro Figueroa, and S.C. Lenny Koh. (2017). "Sustainable Supply Chain Management and the Transition towards a Circular Economy: Evidence and Some Applications." Omega 66: 344–357. doi:10.1016/j.omega.2015.05.015.

Ghisellini, Patrizia, Catia Cialani, and Sergio Ulgiati. (2016). "A Review on Circular Economy: The Expected Transition to a Balanced Interplay of Environmental and Economic Systems." Journal of Cleaner Production 114: 11–32.

Ghosh, S., Agamuthu, P (2018). Circular economy: The way forward. Waste Manag. Res. 2018, 36, 481–482.

Gregorio, V.F., Pie, L.,Terceno, A(2018) A Systematic Literature Review of Bio ,Green and Circular Economy; Trends in Publications in the Field of Economics and Business Management. Sustainability 2018,10,4232.

Grigorios L. Kyriakopoulos , Vasilis C. Kapsalis, Konstantinos G. Aravossis; Miltiadis Zamparas and Alexandros Mitsikas (2019) Evaluating Circular Economy under a Multi-Parametric Approach: A Technological Review. Sustainability 2019, 11, 6139; www.mdpi.com/journal/sustainability

Hafner M. Simone Tagliapietra, S Lucia de Strasser (2018) Energy in Africa Challenges and Opportunities; Springer Briefs in Energy https://doi.org/10.1007/978-3-319-92219-5

Hart, A., Northmore, S. (2011) 'Auditing and Evaluating University–Community Engagement: Lessons from a UK Case Study', Higher Education Quarterly, Vol. 65, No. 1, pp. 34–58

Heidrich, E.., Curtis, T.., Dolfing, J. (2011). Determination of the internal chemical energy of wastewater. Environmental Science & Technology, 45 (2):827–832

Heilman, J. Johnston, (1992) The politics of economics of privatization, university of Albama Press P 197

Published by
Bonn-Rhein-Sieg University of Applied Sciences

ISBN 978-3-96043-083-4
doi:10.18418/978-3-96043-083-4_74

Hejase, H.J., Hejase, A.J., Tabsh, H., Chalak, H.C., Wamitu, S.N. and Pavel, S., (2018). Advances in Business and Management. Scientific Research Publishing, Inc. USA

Henao, J. & Baanante, C. (2006). Agricultural production and soil nutrient mining in Africa: implications for resource conservation and policy development: IFDC-An International Center for Soil Fertility and Agricultural Development.

Hetherington K (2004) Secondhandedness: consumption, disposal, and absent presence Environment and Planning D Society & Space 22 157–73

Homrich, A.S., Galvao, G., Abadia, L.G. and Carvalho, M.M. (2018). The circular economy umbrella: Trends and gaps on integrating pathways. Journal of Cleaner Production, 175, pp.525-543

International Energy Agency (2014) Africa energy outlook—a focus on energy prospects in Sub-Saharan Africa (World Energy Outlook Special Report)

https://www.icafrica.org/fileadmin/documents/Knowledge/Energy/AfricaEnergyOutlook-IEA.pdf

International Renewable Energy Agency (2015) Africa 2030: roadmap for a renewable energy future

Kemausuor F, Muyiwa S. Adaramola, Morken J (2018) A Review of Commercial Biogas Systems and Lessons for Africa

file:///D:/2020%20waste%20publications/commercial%20biogas%20systems%20and%20lessons%20for%20Africa.pdf

Kjaer, L. L., Pigosso, D. C., Niero, M., Bech, N. M., & McAloone, T. C. (2018). Product/Service-Systems for a Circular Economy: The Route to Decoupling Economic Growth from Resource Consumption?. Journal of Industrial Ecology

Knopfle, M. (2004) A study of charcoal supply in Kampala. Ministry of Energy and Mineral Development, Energy Advisory Project.

Masi, D., Day, S. and Godsell, J. (2017), "Supply Chain Configurations in the Circular Economy: A Systematic Literature Review", Sustainability, Vol. 9 No. 9, p. 1602.

Medkova., K Vanhamäki S., and Kivelä R (2017) Bio-based Circular Economy Good Practices in Päijät-Häm; Lahti Circular Economy Annual Review 2017 Kirsti Cura (ed.). The Publication Series of Lahti University of Applied Sciences, part 31

Ministry of Water and Environment (2010) Water Sector Performance Report 2010.

MEMD (2006). Renewable Energy Policy for Uganda. Ministry of Energy and Mineral Development. Government of the Republic of Uganda.

Mont, O. (2008), "Innovative approaches to optimising design and use of durable consumer goods", International Journal of Product Development, Vol. 6 No. 3/4, p. 227.

Murray, Alan, Keith Skene, and Kathryn Haynes. (2017). "The Circular Economy: An Interdisciplinary Exploration of the Concept and Application in a Global Context." Journal of Business Ethics 140 (3): 369–380. doi:10.1007/s10551-015-2693-2.

Muspratt A. M., Nakato T., Niwagaba C. B., Dione H., Kang J., Stupin L., Regulinski J., Mbéguéré M., Strande L. (2014): Fuel potential of faecal sludge: Calorific value results from Uganda, Ghana and Senegal. Journal of Water, Sanitation and Hygiene for Development

NEMA (2010). National State of Environment Report for Uganda 2010, National Environment Management Authority, Kampala. Also available at http://www.nemaug.org

Published by
Bonn-Rhein-Sieg University of Applied Sciences

ISBN 978-3-96043-083-4
doi:10.18418/978-3-96043-083-4_74

NETWAS UGANDA. (2011) Market Study on Demand for Use of Wastewater, Excreta and Faecal Sludge and Other Related Byproducts. Final Report.

Nunez-Cacho,P., Molina-Moreno,V., Corpas-Iglesias,F., Cortes-Garcia,F. (2018) Family Businesses Transitioning to a Circular Economy Model: The Case of Mercadona. Sustainability 2018, 10, 538.

Ongondo, F.O., I.D. Williams, J Dietrich, and C Carroll. (2013). "ICT Reuse in SocioEconomic Enterprises." Waste Management 33 (12): 2600–2606. doi:10.1016/j.wasman.2013.08.020

Pavel, S., & Supinit, V. (2017). Bangladesh Invented Bioplastic Jute Poly Bag and International Market Potentials. Open Journal of Business and Management, 5(04), 624

Perry, D., Menendez, C., (2011) 'Impact of Institutions of Higher Education on Urban and Metropolitan areas: Assessment of the Coalition of Urban and Metropolitan Universities', Perspectives in Health Information Management, No. 10, Fall, p. 1.

Ravenstijn, J. (2010). Bioplastics in consumer electronics. Industrial Biotechnology, 6(5), 252-263. Raw Materials Retrieved October 08, 2018 from http://ec.europa.eu/environment/green-growth/rawmaterials/index_en.htm

Salguero-Puerta, L.; Leyva-Diaz, J.C., Cortes-Garcia, F.J., Molina-Moreno, V (2019). Sustainability Indicators Concerning Waste Management for Implementation of the Circular Economy Model on the University of Lome (Togo) Campus. Int. J. Environ. Res. Public Health 2019, 16, 2234.

Sehgal, K (2018). Current State and Future Prospects of Global Biogas Industry. In Biogas; Biofuel and Bio-refinery Technologies; Springer: Cham, Switzerland, 2018; pp. 449–472, ISBN 978-3-319-77334-6

Shukor, J.-A.; Omar, M.-F.; Kasim, M.-M.; Jamaludin, M.-H.; Naim, M.-A. (2018) Assessment of composting technologies for organic waste management. Int. J. Technol. 2018, 8, 1579–1587.

Spring, M.; Araujo, L. (2017) Product biographies in servitization and the circular economy. Ind. Mark. Manag. 2017, 60, 126–137.

Sutz, J. (2005), The Role of Universities in Knowledge Production.

Szirmai, Adam. (2012): "Industrialization as an engine of growth in developing countries, 1950–2005." Structural change and economic dynamics 23.4 (2012): 406-420.

Tucker, P and Speirs D (2003) Attitudes and behavioural change in household waste management behaviours Journal of Environmental Planning and Management 46 289–307

Webb DJ et al. (2007) A re-examination of socially responsible consumption and its measurement. J Bus Res (2007), doi:10.1016/j.jbusres.2007.05.007

Winans, K, A Kendall, and H Deng. (2017). "The History and Current Applications of the Circular Economy Concept." Renewable and Sustainable Energy Reviews 68: 825– 833. doi:10.1016/j.rser.2016.09.123.

World Bank. (2016) Burning Opportunity: Clean Household Energy for Health, Sustainable Development, and Wellbeing of Women and Children. Geneva: World Health Organization.

World Bank (2017). Progress toward Sustainable Energy. Global Tracking Framework 2017, Summary Report. Washington, DC: World Bank

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ISBN 978-3-96043-083-4
doi:10.18418/978-3-96043-083-4_74