

**Universities and Clean Cities: Building Synergies and Partnerships for Sustainable  
Waste Management**

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## **Abstract**

Achieving sustainable development goals entails shared responsibilities (inter-sector partnerships) and synergistic frameworks (integration of knowledge/expertise). While universities are well positioned to take a lead in developing Clean and Green cities, their active role has not yet been felt. This study explored opportunities and constraints for Academia-Public-Private Partnerships (APPP) on sustainable municipal waste management in Uganda. It was premised that universities could bridge municipalities' inadequate human and financial resources for waste management through relevant institutional frameworks. The study investigated drivers and barriers for universities partnerships with public and private sectors on municipal waste management. Data collection was predominantly qualitative using in-depth interviews, literature reviews, documents analysis, focus group discussions, participant observations and content analysis and documentation of experimental trials. Respondents came from universities and research centers; government departments and agencies, industries and business units and Civil Society Organizations (NGOs/CBOs). Preliminary findings reveal that while relevant knowledge exist, waste recycling and reuse have not up-scaled significantly to impact on municipal sanitation. The limiting factors that have been identified and discussed include strong disciplinary boundaries which limits the ability of faculty to transfer skills beyond their areas of speciality; incompatibility between University faculty and community agencies: which hinders joint ventures between staff of respective potential partners; and the policy environment on waste management. A bulk of existing policies focus more on waste disposal than alternative waste management options. The opportunities for promoting synergies and partnerships lie in the fact that municipal waste could easily be recycled into commercial products. Besides, the recycling provides remedy to deforestation and other climate change challenges. Such opportunities could be demonstrated as incentives to attract multiple stakeholders to engage in municipal waste management.

**Keywords:** Waste-recycling; municipal; sustainability; stakeholder; synergies; integration

## Introduction

Urbanization, industrial development and population growth, urban authorities challenge municipal waste management. In Kampala city (Uganda), only about 30% of solid waste generated daily is collected (OAG, 2010). The rest is openly dumped; occasionally in water drainage channels, leading to flooding, health hazards and physical damages. Kampala Capital City Authority (KCCA) spends over \$1.53 million (30-50% of total budget) on collecting only 30 per cent of the waste. Out of the 3.81 million m<sup>3</sup> of wastewater generated annually, less than 10% is connected to sewer lines (Kayizzi et al., 2012). With a total population of 92,000, settlements along the shores of Lake Victoria have less than 20% of needed pit latrine coverage and most human waste find its way into Lake Victoria. Wastewater released from slaughterhouses and fish processing plants in Kampala, Jinja and Entebbe is approximately 0.974 million m<sup>3</sup>/year (Gumisiriza *et al.* 2009). The pollutants in the lakes increase costs of water treatment. This culminates into eutrophication of lakes which affect life therein (Muyodi 2004). In 1997 and 2000, the European Union banned fish imports from Uganda, Kenya, and Tanzania on grounds of poor sanitation (UNO 2007). Oral disease transmission created by poor waste management impacts 96% of Ugandans, particularly infants and young children, costing the country approximately \$177m annually in medical expenses (WHO/UNICEF 2013). The widening demand-supply gap gaps could be addressed through frameworks of Public Private Partnership (PPP). Conceptually, PPP is the combination of public needs with private capability and resources to create a market opportunity through which the public need is met and a profit made. The financial and human resources of the private sector could be tapped to supplement efforts of urban authorities for sustainable management of waste. Given that over 75% of the municipal waste is organic, it is potentially a source of fuels and fertilizers that could generate wealth. This study explored opportunities and constraints for Academia-Public-Private Partnerships (APPP) on sustainable municipal waste management in Uganda.

**Conceptual framework:** New pathways based on stakeholder engagement, partnerships and entrepreneurship are needed to promote and sustain municipal waste management. Equally needed are frameworks for synergies through which resources of the academia, public and private sectors are harmoniously optimized. Presumably, socio-economic incentives could be central in engaging multiple stakeholders to manage municipal wastes sustainably. While the technology of recycling biowaste exists in the country, recycling operations have not up-scaled to levels that impact on municipal sanitation and livelihoods. Appropriate scale could be attained through application of simple and cheap recycling technologies and entrepreneurial models. This could be attained when; a) diverse stakeholders become aware of the critical challenges of bio-waste and opportunities of recycling; b) technical and socio-economic viability of waste recycling is demonstrated; c) communities (particularly urban women and youth) are incentivized and their capacity developed to recycle waste; d) supportive policies and institutional frameworks are streamlined. The study set out to investigate gaps and opportunities for building synergies and partnerships for sustainable municipal waste management. It was guided by the following specific research questions; what are the gaps in establishing synergies and partnerships for sustainable municipal waste management? What are the opportunities for building synergies and partnerships for sustainable municipal waste management? How could the gaps be bridged and how could the opportunities tapped?

## Materials and Methods

The study was conducted using predominantly qualitative methods including review of related studies, documents analysis, key informant interviews, focus group discussions and participant observations.

**Reviews of related literature:** Ideas and facts related to the past, present and prospective reuse of solid waste and wastewater was obtained through reviews of related publications within Uganda, East Africa, Africa and other parts of the world. The information related to prospects, opportunities, barriers and other aspects of waste reuse.

**Documents analysis:** Data was generated through analysis of documents from government ministries, departments and agencies. These included among others, line government ministries/departments (Water and Environment *MoWE*; National Environment Management Authority (*NEMA*); National Water and Sewerage Corporation (*NWSC*); Kampala City Council Authority (*KCCA*), Ministry of Health, Town boards, Town councils and Municipalities and the leading civil society Organizations (*CSO*) that deal with waste management including those under the umbrella of Uganda Water and Sanitation Network (*UWASNET*) and the private service providers (including private waste collectors Associations)

**Key informant interviews:** these were administered to existing investors, officials of above named organizations, selected users of biogas, briquettes and soil nutrients and key opinion leaders.

**Participant observations:** Field studies were carried out on successful waste reuse project sites in central, eastern and Northern parts of Uganda; partly to verify the information that was given during interviews. A number of projects that deal in biogas production were visited included; ten biogas projects, one Biogas & Rolena Stoves project, two briquettes projects, one biogas/ briquettes project and one Electricity (Bio-waste) project.

A series of workshops were conducted and attended by key-stakeholders. Some of them were held at the beginning of the study-project; one in the middle and others at the end of the study period. Participants generated useful insights and helped in filling information gaps created in the earlier data collection processes. The section below describes the findings of the study.

## Findings

During the process of data collection, useful insights were generated and these are described in the various sections below. The findings are presented in line with the specific research questions that guided the study.

### **Gaps in developing synergies and partnerships for municipal waste management**

**Strong disciplinary boundaries:** Within universities, academic staff belong to specific disciplinary clusters which hardly integrate. These clusters are Social Sciences, Natural Sciences, Humanities, Business/management studies, Education and communication studies, etc. University faculty members regularly operate within these clusters and are confined to the strong disciplinary boundaries and structures. However, in the real life context where expertise of university faculty is required, knowledge cannot be compartmentalized. It must be integrated and multi-disciplinary.

**The Ivory tower complex:** close to 70% of respondents from public and private sectors considered university community as too academic; insulated from practical realities of life. Consequently, university faculty are seen as lacking contact with practical aspects of society wellbeing. On the other hand, over 80% of the University faculty interviewed focused on routine operations of university such as teaching and basic research. Most of them indicated that the direction of their research is dictated by two options; *publish or perish*. Appointment, promotion and contract renewals are pegged to publishing in prestigious journals some of which may not focus on local (Ugandan) content. Incidentally, close to 75% of the respondents acknowledged that this form of research rarely address local needs and challenges. Community outreach is

perceived as an extra load, time consuming and expensive to conduct. Consequently, many researchers end up publishing 'for foreign consumption' other than striving to address local needs. Research/project proposals target external funders even when great funding opportunities from local industries and business exist.

On the other side, private sector respondents (industrialists and business communities) who were interviewed agreed that they rarely fund university research. One of the given reasons is that university-based research is not relevant to local production systems. This view was not different from the responses given by respondents from public sectors who indicated that university research is yet to play a central in evidence-based policy making.

***Incompatibility between University faculty and community agencies:*** a number of respondents particularly from the CSO indicated that patterns of work of university faculty do not rhyme well with the rigorous work-schedules of private sector. Work schedules of the latter are characterized by regular report-making, effective communication, cooperation, tight accountability, willingness to compromise and flexibility. It was noted that university faculty seem to be used to being autonomous. Lack of openness on part of university faculty is one of the structural limitations that CSO staff highlight. The documentation systems in universities is yet another challenge that CSO experience. The language is full of academic jargons, theories and models. On the other hand, university faculty also experience challenges interacting with community agencies. The latter are described as ignorant about routine work-schedules of university faculty. On the few occasions when there are joint ventures between university and CSO, the latter show unrealistic expectations about the type and amount of work faculty members could devote to the project.

***The policy environment on waste management:*** document analysis reveal that most of existing policies focus more on waste disposal than alternative waste management options. For instance, operations of private waste collectors is not streamlined towards developing their capacity to recycle the waste they collect. Limited efforts are devoted to putting high tariffs on wood fuels. Consequently, charcoal and firewood trade continue to outcompete briquettes and biogas sales. Besides, private operators reported that that they face undue competition from their counterparts in government institutions such as police, the army, educational institutions and hospitals. Units within public institutions occasionally collect waste at a fee, yet they use public facilities and they are exempted from statutory taxes. By law, local governments are empowered to charge fees on private waste collectors. The private operators find it hard to conduct fair business when their competitors are exempted from taxes and are using public facilities. On their part, respondents from urban authorities indicated that developing and implementing policies is constrained by inadequate resources. Given that waste collection is not prioritized in urban councils, waste management is poorly financed. Policy making related to environmental issues is a function of the central government but implementation of policies and legislation is responsibility of urban authorities. Solid waste management is also a duty of urban authorities as specified in the Public health Act of 1964 and local government act of 1997.

***Absence of inter-sector linkages:*** While there are many stakeholders in the arena of municipal waste management in Uganda, there is limited evidence to suggest that their operations are harmonized. Each of the stakeholders operates in isolation even when they occasionally have common issues and challenges. This deprives them of the opportunity to pool human and financial resources to address their common challenges. However, records showed existence of consortia such as Uganda Water and Sanitation Network (UWASNET). Similar consortia include Private Emptiers Association of Uganda (PEAU).

## **Opportunities for developing synergies and partnerships for Municipal waste management**

Study findings reveal that there are a number of factors that could facilitate municipal waste management. These factors, which could be seen as healthy, environmental and socio-economic rotate around the concept of **Waste to Wealth** (entrepreneurial processes of converting waste into household and commercial products). Findings reveal that investments in waste management make economic sense even in absence of social-benefit accounting. These business prospects could attract entrepreneurs into waste recycling operations. The following are some of the potential facilitating factors;

**Demand for fuel from recycled waste.** Documents analysis and literature reviews reveal that the high calorific and plant-nutrient value in municipal bio-waste make recycling commercially viable. The volatile solids content is between 66-79%; decomposable organic carbon DOC is between 74-86%. Methane emission potential from the wastes vary between .9 and 4.12 Gg/yr. Solid bio-wastes generated daily (1,500 tonnes) have average potential calorific value of 17.3 MUkg TS (Muspratt *et al* 2014). On the other hand, the chemical energy content in wastewater alone is higher than the energy required for treating it (Heidrich *et al.* 2011). The energy can also be used for pumping water and for irrigation. A net benefit from combustion can be obtained at 27 per cent dryness when storage is in actively ventilated greenhouses for drying (Muspuratta *et al* 2014). Currently, over 95% of households rely on wood and charcoal as a source of cooking energy; only 5% have access to electricity. Demand for these fuels is growing at 6% annually. Educational institutions, hospitals and prisons are the biggest potential clients for waste-to-energy products (WEP). Currently, an institution that has 1000 students uses a minimum of 300 tons of firewood annually. Primary schools are estimated to be 22,500; secondary schools are 2,000; Higher education institutions (with an average of 5000 students) are over 80; and Prisons have a population of over 45 092. Briquettes (made from carbonized waste) have almost the same features as charcoal made from firewood.

**Social and health considerations:** The production and distribution value chain of briquettes could employ thousands of urban people some of whom are already engaged in the production and distribution of firewood and charcoal. The “black gold” (as charcoal is perceived by many traders in Kampala), is considered by urban households as a reliable, convenient, affordable and accessible cooking fuel. Because charcoal compares favourably with liquefied petroleum gas (LPG), urban households depend on charcoal cook-stoves as backups. Briquettes and biogas have lower environmental impacts than fossil-fuels which produce toxicity, carcinogenic emissions and respiratory effects (Miliute & Staniskis, 2010). Compared to the open-fire cooking on firewood, users of briquettes or biogas in cooking are less susceptible to respiratory complications. Nine out of ten people who use firewood for institutional cooking get respiratory complications after 30 days exposure to smoke. Besides, recycling and reusing waste reduces diseases that are transmitted through poor waste management.

**Opportunities in the agricultural sector:** existing studies suggest that soil nutrients from bio-char reduce dependence on chemical fertilizers. Over 75% of the generated waste is organic; constituting 62 % agricultural waste from peels (banana, potatoes and cassava), 22 % food waste, 9 % market waste and 11 %) crop residues. 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. On average 1800 Mg of nitrogen, 260 Mg of phosphorus and 1900 Mg of potassium are wasted away in landfills annually in Kampala even when the rate of depletion of soil nutrient (Henao & Baanante, 2006). Besides, bio-char retrieved from wastewater sludge is a soil conditioner (Diener *et al.*, 2013). Bio-slurry from AD has more diverse nutrients than other commercial fertilizers (Qadir *et al.*, 2007).

**Existence of private sector actors and umbrella organization:** for both solid waste and wastewater handling, there are private firms that provide services for a pay. One of the most outstanding one is PEAU and UWASNET. Interventions that promote waste reuse could make use of these opportunities.

### **Bridging Gaps and Tapping Opportunities: Synergies and Partnerships Initiated by Ndejje University**

In developing Synergies and Partnerships for sustainable municipal waste management, it was imperative to make an analysis of gaps and opportunities. The following section describes initiatives taken by Ndejje University over the last 21 months.

**Multi-disciplinary integration:** beginning from October 2014 seminars and workshops were conducted for staff across various faculties in Ndejje University to identify common themes for multidisciplinary research and innovations. It was aimed at overcoming rigid disciplinary boundaries that constrain knowledge transfer. The current research is focused on harnessing synergies across four sectors of community welfare which are; *Food, Energy, Water and Ecosystem (FEWE)*. The four sectors are organically and symbiotically inter-linked in important ways; a) Agricultural/food waste could be used as raw materials for producing bio-energy (biogas/briquettes); b) Bio-energy could power irrigation, post-harvest preservation and agro-processing; c) Water is needed for crop irrigation; bio-energy powers water pumping and distribution; d) Wastewater sludge is processed into biogas, briquettes and soil nutrients; e) bio-energy is an alternative to charcoal and firewood; reduces deforestation. Integrated faculties include; **Engineering;** for generating bio-energy from organic wastes; **Agriculture;** for producing bio-char and compost for municipal greening initiatives; **business/management;** for developing business models for up-scaling municipal waste recycling and; **Social sciences, ICT & education;** for popularizing waste recycling and reuse.

**Academia-Public-Private-Partnerships (APPP):** noting that inter-sector partnership were vital for the optimizing resources of key stakeholders, the following steps were taken at Ndejje university; a) participatory needs assessments between faculties and public-private-sector agencies; b) joint planning, piloting, implementation, monitoring and evaluation of projects; c) knowledge dissemination (workshops, seminars, conferences and exhibitions). This phase was occasioned by a corporate dinner for the launching of the first Academia-Public-private partnership on 17<sup>th</sup> February 2017, graced by a representative of the president of Uganda. The prominent partners for Ndejje University include among others; Kampala Capital City Authority; Municipalities of Masaka; Mbarara; Jinja; Kira and Nansana. Government agencies include National Environment Management Authority (NEMA); National Water and Sewerage Corporation; National Council of Science and Technology; National Industrial Research Institute; National Agricultural Research Institute; The Civil Society organizations include: Uganda Environment Education Foundation (UEEF);

**Developing institutional frameworks:** steps for developing institutional frameworks involved; 1) creating public awareness on prospects of waste-recycling; using user-friendly multimedia platforms; 2) capacity building in technical, managerial and financial operations of waste recycling; 3) Demonstrating technical and financial feasibility of waste recycling; 4) developing business/entrepreneurial models for waste recycling; 5) proposing supportive policy framework on waste recycling; 6) knowledge dissemination occasioned by the first international scientific conference on bio-waste recycling in Uganda on 26<sup>th</sup> -28<sup>th</sup> September 2016 opened by Minister of Energy/mineral resources and closed by Minister of Water and Environment. A Mission Green Youths Expo is slated for 4<sup>th</sup> and 5<sup>th</sup> August 2017 in St Kizito High School Namugongo.

**Youth's engagement through educational entertainment (Edutainment);** Education, training and engagement initiatives have been supported by a combination of print, electronic and human interactive media. Entertainment and education are seamlessly woven together in such a way that there is no clear dividing line between the two. Social values related to waste management have been built within music, dance and drama (MDD); poems, debates, quiz, essay writing contexts and call-in radio and television programming.

In summary, the full impact of the above described initiatives are being monitored with time. As already pointed out, many of these activities have been initiated within a period of 22 months. Monitoring and evaluation procedures are being polished to help in assessing the impact of the initiatives.

## **Discussions**

### ***Universities and clean cities***

Preliminary studies by Kakembo (2011; 2012a; 2012b, 2014) and UNU-INWEH (2014) have identified some of the factors limiting bio-waste recycling in Uganda which include; a) inadequate awareness of values of bio-waste recycling; b) psycho-social sensitivities on reusing bio-waste (specifically human excreta); c) Inadequate technical skills on bio-waste recycling; poor designs and material choice for plants; d) absence of relevant business and entrepreneurial models on bio-waste recycling; e) Inadequate capital for start-up and/or scale-up operations; f) absence of streamlined policies and institutional frameworks supporting bio-waste recycling. Consequently, there is no commercial-scale production of biogas, briquettes and fertilizers. At the moment, most resource recovery and reuse (RRR) initiatives heavily depend on subsidies and remain small, often not surviving beyond their pilot phase. The few WEE players are trained and funded by meagre resources of NGOs/CBOs. These resources are inadequate to generate commercial-scale production that could offset firewood and charcoal consumption.

***The ivory tower complex:*** The traditional disengagement between universities and external agencies deprives the institutions from opportunities of first-class research and innovations. On the rare occasions when university-community interactions take place, the relationship is one of deficit model. The community is seen as a laboratory for university researchers to 'generate new knowledge for purposes of staff promotion or for higher degrees for students (Perry & Menendez 2011). The knowledge is presumably used to 'address community needs' but in reality it serves opportunistic purposes for individual researchers. Full benefits can only materialize if the university and society are organically linked; when needs of society are at the centre university's activities. Occasionally, university outreach is narrowly perceived to be a one-way process of transferring knowledge and technology to communities. However communities also have something to offer to universities. Communities could have knowledge reserves (Traditional Knowledge or Local Knowledge) that universities could tap from. As Tagoe (2012) remarks, there is a need for a drift from unidirectional engagement in which communities are considered "pockets of need and laboratories for experimentation; towards bidirectional engagement. Communities are no longer 'passive recipients' of university expertise.

***Broadening the stakeholder base:*** Sutz (2005) points out that in many developing countries, small-scale collaborations between researchers, industry and other actors have failed to grow into national trends. The process of building partnerships for municipal waste management begins with stakeholder-mapping and analysis of their core values. Some of the stakeholders could be considered primary while others could be peripheral. Primary stakeholders include

urban authorities, line government Departments (Water and Environment; Agriculture, Energy and mineral resources; NEMA, NWSC, etc.). Peripheral stakeholders could be those whose attachment to waste management initiatives is temporal and opportunistic. These include media personnel, business communities, and the private service providers. Forging entrepreneurial relationship with communities and community agencies calls for flexibility on part of the university faculty and management (Etzkowitz 2012). Universities should consider organizing open forums where the identified stakeholders brainstorm on municipal waste management issues, challenges and prospects. For instance industrialists (polluters and potential research funders) could be willing to cooperate with universities to find remedies for sustainable waste handling.

***Income diversification for Universities:*** a typical private university in Uganda operates a budget that relies almost 100% on tuition from students. Public universities are supported by government funding but to a limited extent. Investment in Academia-Public-Private Partnerships (APPP) on municipal waste management has potential to diversify the income base. Up-scaling waste recycling operations presents an opportunity for the university not only to radically transform existing funding; but also broaden the networking structures. Partnerships and collaborations around waste recycling are likely to resolve the critical funding gaps that many universities are currently experiencing. As observed by Hart and Northmore (2011) and Pike *et al.* (2011), Partnerships and collaborations are key to long-term sustainability of quality operations in universities.

***Addressing Environmental and social concerns:*** By generating cooking fuels (briquettes and biogas) from municipal bio-waste, millions of trees that are cut down for firewood and charcoal could be saved. Because 95% of the population in Uganda uses charcoal and firewood for cooking (GIZ 2011), demand for these fuels is growing at 6% annually. Over 80,000 hectares of private and protected forests are cleared annually for charcoal and timber (IRIN 2012), an increase from the estimated 50,000 hectares in 2004 (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). While charcoal is used predominantly at household levels, firewood is used massively by educational institutions, prisons, hospitals, brick/tile and cement industries. The municipal recycling operations could potentially employ thousands of urban youths that are currently jobless. In the process, cities would benefit from the abundant human resource whose cost would be borne by the associated business entities.

### ***Innovative communication and engagement approaches***

Given that sustainable waste management is influenced by cultural norms, attitudes, perceptions and beliefs; awareness initiatives ought to address the associated psychosocial constraints. Appropriate interventions are those that apply edutainment approaches. By seamlessly weaving entertainment and education campaigns could capture the attention of people; particularly the youths, who are unlikely to pay attention to conventional social messages. Edutainment programs developed by Ndejje University on waste management put emphasis on *social norming*. This is an approach that strives to influence behavior to levels where sustainable waste management becomes routine norm. Edutainment as a tool for social norming promotes social acceptability of good waste handling practices which; a) reduce reckless littering or dumping; b) promote waste-sorting and waste recycling; c) value greening initiatives; d) promote acceptance to consume recycled products. Conceptually, compliance to ideal waste handling practices could be driven by peer pressure and group influences. Based on the *Social Cognitive Theory* (Bandura 2002), edutainment enables the application of social

marketing techniques to promote sustainable waste management. The approach exposes both positive and negative behaviour and practices particularly those related to waste handling.

The edutainment approach is particularly handy in engaging the urban youths. Given that youth constitute over 75% of Uganda's population, it is worthwhile investing in transforming their knowledge, attitudes and skills to manage waste sustainably. Their innovativeness and creativity in problem solving enables them to address challenges effectively. Specifically, school-based capacity building initiatives could have multiplier effects; enabling youths to be focal points for sensitization of home communities; local markets, worship places, towns and municipalities on environmental issues. It is a way of gaining entry into communities and building up trust and social capital. Youths are highly vulnerable to effects of environmental degradation. Engaging them through participatory process could safeguard the future sustainability of actions and also address their specific needs.

## **Conclusion**

Sustainable municipal waste management calls for integration of multiple disciplines and engagement of diverse stakeholders. Reasons for lack of joint ventures between Academia, Public and private sectors include a lack of buy-in from one or more key stakeholder groups. The needs of cities and municipalities present opportunities for first-class research/innovation/consultancy which urban authorities could pay for. In the context of the constrained universities funding, the linkages enable universities and staff to diversify their funding. Universities' human resources could be optimally utilized through entrepreneurial models of research and projects on waste management. Urban authorities do not have sufficient capacity to fill the demand-supply gaps in delivery of social services (Kakembo 2012). Universities need partners and collaborators who bring along with them a clear understanding of community needs and issues. With wide experiences, practical approaches and social networks, partners bring on board grassroots legitimacy because they are assumed to represent a long-term commitment to local communities. Organizational factors such as policies, structures and programmes do impact on institutional commitment to partnerships. Specifically municipal waste management must be facilitated by specialized and multidisciplinary units that can coordinate and provide community related activities and services. Components of university research should provide remedies to societal needs. The three-fold mission of higher education entails placing emphasis on the synergistic relationship that strengthens the three functions (teaching, research and community engagement). It also calls for organic linkages between university faculty, public agencies and private sector and the community. The three functions ought to be seamlessly integrated such that there is no dividing line between them. On the part of universities, municipal waste management could be integrated into teaching and research activities. This would encourage interactions between the specialized units and the traditional academic units. Research has to lead to technological innovations, business models and market-based products. Research and innovations should be disseminated and diffused in local platforms whereby user-friendly formats and expressions are employed. Industrialists, government agencies, civil society, communities and other stakeholder's local communities need to be convinced that universities have transformed. The expected transformation is from 'ivory tower's; to benevolent agencies that impact on the day-to-day lives of the grassroots communities. Besides, universities stand to benefit from the business prospects offered by sustainable municipal waste management. Other opportunities are in the funding and networking prospects that community engagement present. Universities should maintain open forums where identified stakeholders brainstorm on various developmental issues, challenges and prospects and get directly involved in quality assurance initiatives. One way of developing structures for community engagement is the promotion students-centred clubs and associations.

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## Appendix 1

### Diagrammatic representation of Synergies for food-energy-water-ecosystem nexus (FEWE)

<b>Synergies for Food-Energy-Water-Eco-system Nexus</b>	
<b>Discipline</b>	<b>Relevancy to the FEWE nexus</b>
<b>Engineering</b>	1) Structures to generate renewable energy (biogas, solar, briquettes); 2) Irrigation schemes powered by renewable energy; 3) solar drying facilities for post-harvest preservation; 4) Greenhouses for climate change mitigation; 5) Agro-processors set-ups; 6) chilling facilities for post-harvest preservation; 7) wastewater treatment
<b>Agriculture</b>	1) Agro-wastes are raw materials for renewable energy; 2) gardens are potential destiny for bio-waste (Bio-slurry, treated Wastewater sludge) in form of fertilizers
<b>Environment /forestry</b>	1) Benefits from renewable energy initiatives (saving forests); 2) tree nurseries benefit from bio-char: 3) saw-dust from lumbering is raw material for bio-energy
<b>Business/ management</b>	1) Demonstrate socio-economic benefits of innovations; b) Promote sustainability of interventions; c) Provide reliable livelihood options at grassroots levels; d) Conduct feasibility studies; e) Develop business models and; f) Marketing structures for recycled products
<b>Social sciences</b>	1) Promote public acceptability of innovations; 2) Reduce socio-cultural sensitivities towards consuming products of recycled products (from bio-wastes); 3) Promote constructive values, knowledge, attitudes and practices for sustainable development.
<b>IEC (ICT)</b>	Multimedia programs create awareness and sensitize communities on innovations Capacity building through training, exhibitions and demonstrations

## Appendix 2

### Illustration of the Structure of Academia-Public-Private-Partnership (APPP)

