

The potential of industrial symbiosis in fostering sustainable entrepreneurship among the micro and small enterprises (MSEs): evidence from a developing country

The potential
of industrial
symbiosis

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Abstract

Purpose – The purpose of this study is to explore the status and potential of industrial symbiosis in fostering sustainable entrepreneurship among micro and small enterprises (MSEs) in Uganda.

Design/methodology/approach – This study is cross-sectional and qualitative in nature. It involved conducting in-depth interviews with MSEs owners in Kampala, and data were analyzed using Atlati Ti.

Findings – The results indicate that industrial symbiosis is a phenomenon that, notably, all MSE owners interviewed were practicing unknowingly, including recycling waste into sellable products, as well as sharing utilities, specialized machines and personnel for the smooth running of their businesses. In addition, participants expressed optimism that industrial symbiosis would be a major tool for business growth, innovation, employment opportunities, diversification and environmental protection for the benefit of the current and the future generations.

Originality/value – This study offers initial evidence on the status and potential of industrial symbiosis in fostering sustainable entrepreneurship among MSEs in Uganda.

Keywords Industrial symbiosis, Sustainable entrepreneurship, MSEs, Kampala, Uganda

Paper type Research paper

1. Introduction

Globally, micro and small enterprises (MSEs) prioritize profit maximization, putting society and the environment at risk from various business activities (Terán-Yépez *et al.*, 2020).

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This suggests that most MSEs overlook sustainable entrepreneurship (SE), which involves “the discovery, creation, and exploitation of opportunities for (future) goods and services that simultaneously sustain the natural and social environment and provide economic and non-economic gain for others” (Johnson and Schaltegger, 2020). As such, the MSE fraternity argues that the uptake of SE is costly, leading them to continue with traditional entrepreneurship that places less focus on conserving the natural environment and the values of the society (Kimuli *et al.*, 2022) in most developing contexts.

In Uganda for example, most of the waste generated from MSEs is irresponsibly handled (Bagire *et al.*, 2021). About 28,000 tonnes (40%) of waste is collected in Kampala and disposed of in the landfill monthly (Ssemugabo *et al.*, 2020). The remainder of the waste generated is indiscriminately disposed of, resulting in environmental and public health problems such as blockage of drainage channels and consequently floods (Abondio *et al.*, 2020). This has ultimately resulted in the loss of lives, property and livelihoods. Thus, sustainability scholars present industrial symbiosis (IS) as a feasible strategy that can unlock the potential of the MSE community to incorporate SE into their operations (Patricio *et al.*, 2018).

Industrial symbiosis (IS) entails the interchange of materials, energy, water and byproducts between geographically close firms to obtain economic and environmental benefits (Chertow, 2000). This implies that MSEs can exchange byproducts and reuse them in their operations, share utilities, infrastructure and services with other enterprises to become more profitable while adding a net-positive impact on the natural environment. Accordingly, Rincón-Moreno *et al.* (2020) reported that uptake of IS feasibly enables entities including the MSEs to balance their economic, social and environmental goals simultaneously. This will undoubtedly strengthen the MSE fraternity in Uganda to create more jobs, enhance productivity and improve the social well-being of the population (National Planning Authority, 2020).

The integration of IS into the operations of MSE will also reduce poverty (Sustainable Development Goal-SDG 1), create decent work opportunities for the youths (SDG 8) and promote responsible consumption and production (SDG 12) and conserve the natural environment for the benefit of the current and future generations (SDG 13). Despite the relevance of IS in triggering SE, extant studies (Lüdeke-Freund, 2020; Kimuli *et al.*, 2020) have focused on sustainability intention, behavioral control, training, innovation, business models and environmental pollution with less focus on IS. In addition, most of these studies are quantitative, which limits our ‘knowledge about the study phenomena (Kimuli *et al.*, 2020). It is also evident that no single study has documented the status of IS and its potential to foster SE among the MSEs in Uganda.

Against that backdrop, the current study addresses two research questions: (1) what is the status of IS among MSEs in Uganda and (2) what is the potential of IS in triggering SE among MSEs in Uganda? The research questions were addressed by the use of semistructured interviews in which twenty-two (22) MSE owners operating in Kampala city and five (5) officials from institutions that regulated the natural environment and operations of the MSEs in Uganda were engaged. Thus, our findings indicate that IS is a phenomenon that, notably, all MSE owners engaged were unknowingly doing. We also noted that participants were optimistic that IS will be a significant tool for business expansion, innovation, employment opportunities, diversification and environmental protection for the benefit of present and future generations.

2. Literature review

2.1 Sustainable entrepreneurship

The current degradation of the natural environment, economic decline and social injustice in pursuit of entrepreneurial opportunities are among the issues that are getting worse by the day. As a result, the exploitation of opportunities and resources by entrepreneurs is changing with a shift from traditional entrepreneurship that focuses mainly on economic gains to associating more with the simultaneous implementation of the social and environmental goals

of the businesses (Sendawula *et al.*, 2021). This presents a need for entrepreneurs to operate their businesses in a way that protects the natural environment and the values of society while maximizing profits, commonly described as SE (Sala, 2020). Thus, it is impossible to dismiss the role that entrepreneurship plays in sustainability (Goel and Joshi, 2017).

In undertaking SE, it is important to ensure active participation of all stakeholders so as to lay a strong foundation for a smooth shift from traditional entrepreneurship (Volkman *et al.*, 2021). Presently, many traditional entrepreneurs are advocating for change; however, challenges that are associated with SE discourage its uptake (Kimuli *et al.*, 2022). Specifically, the authors highlight the costs associated with undertaking it as well as constraints on its uptake, for example, limited skills, knowledge and experience and the greed for economic gains. Thus, it is vital to explore cost-effective strategies like IS that can unlock the potential of MSEs to undertake SE to promote sustainability development.

2.2 Industrial symbiosis

IS is highly acknowledged as a strategic pathway that enables MSEs to upsurge efficient utilization of materials and energy. As a result, this concept is conceptualized differently by scholars. For example, Chertow and Ehrenfeld (2012) indicate that IS looks at the cooperative management and interchange of resource flows, especially materials, energy and water among enterprises. Besides, IS entails sharing infrastructure and services (Yeo *et al.*, 2019). This suggests that IS generally encompasses several business models of exchanging and sharing waste materials, energy, working space, employees who share knowledge, information and expertise, as well as other support services like transport and communication services. From this conceptualization, we note that IS occurs when there is a mutual interaction between different businesses. Albino *et al.* (2016) argued that there should be at least three different enterprises working together in exchanging at least two different resources for IS arrangements to become more successful.

Engagement in symbiotic relationships by the MSE fraternity minimizes poor waste disposal and the costs associated with waste management (Kasmi, 2021). This implies that byproducts that would have been dumped into the natural environment are instead used in the production of profitable products. IS brings about cooperation among businesses that results in the realization of the social, environmental and economic benefits as a result of sharing and exchanging resources (De Jesus and Mendonça, 2018). Specifically, IS reduces the cost of doing business, creates employment opportunities for community members and reduces dumping of waste materials and emissions as well as exploitation of the natural resources from the environment for the benefit of the current and future generations. Despite the increasing studies on IS, its status based on evidence from developing economies such as Uganda is under investigation investigated and thus, we intend to address the following research question.

RQ1. What is the status of IS among MSEs in Uganda?

2.3 Industrial symbiosis and sustainable entrepreneurship

A review of extant literature on SE shows that scholars have mainly focused on environmental commitment (Sendawula *et al.*, 2021), sustainability intention and sustainability behavior control (Kimuli *et al.*, 2020), finance and Information Technology (IT) infrastructure (Orobia *et al.*, 2020), entrepreneurs' competencies and entrepreneurial innovation (Ismail, 2022). However, there seems to be less focus on the potential of IS in fostering SE of MSEs. This could be true because MSEs are resource-constrained and may not have the potential to balance their social, environmental and economic goals simultaneously. As such, scholars present IS as a feasible strategy that can promote sustainable development and SE in particular.

For example, [Al-Quradaghi et al. \(2020\)](#) documented that collaboration among businesses in a symbiotic relationship facilitates the creation of eco-industrial communities that are committed to achieving cross-industry effectiveness through profitable inter-change of waste materials, energy, water and other resources. This enhances their potential to create more employment opportunities for increased profits and environmental protection. In the same vein, [Patricio et al. \(2018\)](#) reported that economic benefits and enhanced environmental performance motivate Small and Medium Enterprises (SMEs) in the European Union to undertake IS. Despite this evidence, it remains unclear whether MSEs in Uganda are likely to be motivated by similar conditions. This is because the nature and characteristics of SMEs in developed economies are significantly different from those in the global south.

Concerning the potential of IS in fostering sustainable development, [Neves et al. \(2020\)](#) indicate that IS positively impacts the natural environment by reducing the quantity of raw materials demanded and effective utilization of waste materials for further production. As such, diseases such as malaria, cholera and Ebola among others that emanate from poor waste management can be minimized for the benefit of the general society. Furthermore, [Kimuli et al. \(2022\)](#) reported waste management as a practice undertaken to protect the natural environment in their study on SE practices. Accordingly, women use waste materials such as old clothes to make other products like pillowcases, rags and trousers for children to enhance their financial position. However, the authors didn't interrogate other aspects of IS such as sharing utilities, infrastructure and services that are crucial in promoting SE. Thus, we intend to explore the potential of IS in fostering SE to address the following research question.

RQ2. What is the potential of IS in fostering SE of MSEs in Uganda?

3. Methodology

3.1 Research design

This study is cross-sectional and qualitative. It involved conducting in-depth interviews with business owners who are members of the Uganda Small Scale Industries Association (USSIA). This is an organization that brings together MSEs engaged in value - additional activities in the country. As such, USSIA supports and empowers the MSE fraternity for sustainable success and economic growth.

3.2 Sample section

This study was informed by 22 participants. These included business owners and government officials from Kampala district because of the knowledge and experience they have about IS and SE in the Ugandan context. The district was considered since it has the highest concentration of business activities in the country ([UBOS, 2021](#)) and ranks top in poor waste management as compared to other regions of the country ([Ssemugabo et al., 2020](#)). Before interviewing participants an introduction and acceptance letter were secured from USSIA and the participating government institutions. Business owners from USSIA were selected purposively by the administrators at the secretariat and after accepting to participate in the study, the researchers got appointments with them for the data collection exercise.

3.3 Data collection tools, data management and analysis

In this study, we used an interview guide to conduct in-depth interviews with each respondent. Recorders and notebooks were used to gather views of the study participants. Interviews were conducted in the English language and lasted between 20 and 35 min.

The collected data was transcribed in correspondence with the respective interview guides to ensure a sequence of information with the designed questions. The transcription exercise was done by a team carefully selected to ensure continued adherence to the oath of confidentiality upheld during the earlier phases of the exercise. The transcribers used pass-worded computers and performed the task in an environment where access was restricted. After the transcription exercise, the researchers formulated themes to guide the coding of the information. Transcripts were thereafter uploaded onto the Atlas Ti qualitative analysis software and coded using the developed themes. The codes were generated in the form of quotes and memos that corresponded to different themes for each question of the interview guide. An extract of various quotes generated was thereafter used for analytical report writing in verbatim and indirect formats.

3.4 Ethical consideration

The researchers observed ethics while conducting this study. Specifically, the study was approved to be conducted by the Makerere University Research and Innovation Fund, which financed a bigger project from which this paper was extracted. While collecting data, respondents first consented to participate in the study and their details as well as those of the enterprises were not captured for confidentiality purposes.

4. Study findings

4.1 Status of industrial symbiosis among MSEs

The status of IS is presented using the attributes of awareness, waste material usage and management, sharing knowledge, equipment and services as subthemes.

4.1.1 Awareness of industrial symbiosis. IS is a phenomenon that notably all MSE owners interviewed were unconsciously practicing. Many intimated to have been co-existing with other businesses but were not aware they were practicing IS. The ignorance about the term also implied that they were not placing much focus on the practice, much to the chagrin of the benefits that come with it. IS was therefore an unpopular term among all the MSE owners interviewed. This ignorance was spread across MSE owners from all walks of life: the highly educated, the aged, the young, the new and the long-existing businesses.

I had not heard about the term industrial symbiosis until I read through your paper. But I found it was something which I was already practicing in my business MSE, leather processing

4.1.2 Waste material usage and management. Given that the MSEs visited were all characterized by lack of enough capital, equipment and personnel, they all opined to be thriving on innovation, cost-sharing and the exchange of knowledge and skills with like-minded persons and businesses. This was noted to be further propelled by the need to make use of wastes that some MSEs otherwise call offcuts. As part of efforts to diversify their product portfolios and co-exist with sister businesses amidst the constraint of inadequate capital, all the 22 MSEs visited practically embraced the idea of recycling waste into sellable products or rather selling them as raw materials to fellow businesses.

besides tailoring and maybe doing shirts, clothes, pillows, we have the off-cuts, these offcuts are used to manufacture door mats. . . . We also use them to make sponges for showering, door mats and indoor shoes. Director, Tailoring, fashion and design enterprise

MSE owners all intimated that the rather adventurous effort of recycling wastes led them to increased revenues, a stronger symbiotic relationship with sister businesses and a profitable conservation of the environment profitably. During the interviews, MSE owners were unscathingly asked about their waste management plan moving forward. Whereas some were yet to come to terms on how better they could manage their waste pointing to the fact

that the residue from their production would result in something unrelated to their products, many had deliberate plans of seeking to leave nothing to waste and turning it into something profitable.

That waste which has been remaining finally has been disposed of, we collect it and then it is picked by the waste collectors. So we have not had any current plan, maybe you can advise us on how to do it as specialists in that area. MD, briquettes, paper recycling and candle-making enterprise

4.1.3 Sharing knowledge, equipment and services. Interactions with all the 22 MSE owners and members of the MSE fraternity revealed varied efforts by the entrepreneurs to share knowledge, and services and rather simplistically share machinery and utilities such as workspace, water and electricity, as indicated in the following statements.

... when you do not have enough machines and they are expensive, you end up using other people's machines, even space and at times electricity ... Director, Food Processing Enterprise

It is evident that each enterprise values the ecosystem in which one has to seek the intervention of the other in a bid to attend to the market need. The most commonly shared attribute among the entrepreneurs was knowledge. In all conversations, there was a mention of a conference, a workshop or rather corridor chats on how to boost sales, innovate more, increase profitability, protect the environment and utilize small working spaces. Other commonly shared aspects were the utilities, specialized machines and personnel.

One time I was at a UN environment conference and there was a company presenting about Industrial symbiosis. That was my first time to hear of it MSE MD, Waste recycling business

We share machines because currently as a company, we have machines for briquettes and paper. Sometimes we get people who are making those products but don't have the machines. So we agree and hire them based on the agreed terms and conditions. MD, briquettes, recycling and candle-making enterprise

Whereas the MSE owners demonstrated evidence of sharing knowledge, equipment, utilities and services, they still had the urge to engage on more diverse platforms where they could acquire new knowledge and skills. It was thus observed that their hunger for knowledge was not quenched by the pre-existing IS; they were desirous of further learning. The tone also clearly showed that every entrepreneur dreamed of operating independently with his equipment, working space and consumption of utilities such as electricity and water.

4.2 Potential of industrial symbiosis in fostering sustainable entrepreneurship of MSEs

In line with the second research question, our findings indicate that IS is a major tool for the conservation of environmental and societal value while fostering business growth, as explained in the following subthemes.

4.2.1 Environmental potential. MSE owners and stakeholders engaged in this study all appreciated that protecting the environment is a responsibility of everyone, most especially those whose actions have a direct consequence of its abuse. There was a shared agreement that if poorly handled, waste has an outright potential to cause disastrous harm to the environment.

... those polythene bags [buvemas] take a lot of time to decompose, even this leather takes a lot of time to decompose than you think. So they end up blocking drainage systems, these things end up in lakes or swamps and stuff like that ... Team leader, Skills Hub Enterprise

Having understood the phenomenon of IS, the MSE owners and key players in the entrepreneurial ecosystem noted that IS held the key to a lasting environmental protection solution. The entrepreneurs held that through IS, waste can be transformed into a lot of

profitable things for the benefit of the enterprise producing it and several others within the fraternity. As much as the MSE stakeholders interviewed were not extensively knowledgeable about matters of environmental conservation, many opined that by recycling waste, the environment is ridden with indecomposable material that would otherwise lead to land pollution and soil contamination. This would in turn have a ripple effect on the prospects of crop germination, rain formation, green vegetation and fresh breathing air. Others shared that by recycling waste, the environment is saved from litter and is thus kept clean and attractive.

... we are helping on cleaning the environment because if you just litter this “kasasiro” (luganda word to mean rubbish) just like this of course you will be creating more diseases and the environment will be dirty ... Director, Fashion and Design Enterprise

... you are promoting a clean environment, and conserving the environment as well ... like for us who use waste to make charcoal, you are teaching people how to make a product without cutting trees ... Director, Candle-making enterprise

MSE owners thus note that given further enlightenment and the sensitization of the business fraternity about the meaning of IS and the benefits it carries, the practice shall be embraced much more by a much wider business and non-business community. With this boost, there is a much higher likelihood that MSEs will establish a support system that will ensure no one is left behind. Businesses will, in return, live beyond their first birthdays, increase their product catalog and moot solidarity for one another. This will thus facilitate prospects for sustained entrepreneurial abilities.

4.2.2 Social potential. Concerning social sustainability, study findings indicate that social benefits are a notion rather similar to the term IS. The MSE operators were cognizant of the fact that they were socially benefiting from IS but could not vividly recall. When guided further on the meaning of social benefits, many were indeed in agreement that IS has yielded social benefits for them. Notably, owners pointed out that working hand in hand with members of the community has fostered unity and harmonious living. They hinted at the desire to transform the societies they live in and through various engagements of research, skills training and exploitation of ways waste can be utilized, it was held that people’s lives were indeed transformed.

The MSE ecosystem is also observed to have grown stronger for enterprises that embraced the exchange of knowledge, equipment and services with their business counterparts. Entrepreneurs have a changed mindset regarding their sister businesses. The ones they would hitherto have looked at as rivals, they now view them as a support function for their businesses. It is therefore needless to mention that when extensively harnessed, IS has the potential to steer healthy and valuable competition within the MSE fraternity.

... let me say I do part of industrial symbiosis in my company, if I tell some other people who are doing the same project that you can use waste, you are promoting friendship between the two companies. There are some people who we have already incubated at our company and they have already started their businesses, that is also a social benefit to the people and the community around us as it creates a good relationship between us and the trainees. MD, paper recycling enterprise

4.2.3 Economic potential. MSE owners stated numerous economic benefits accruing from the networks and colleagues with whom they had a symbiotic relationship. The overarching benefit was the opportunity to diversify production and increase revenue. Some also indicated it was an opportunity to create employment opportunities so that the community people earn an income and improve their standards of living. IS particularly concerning waste usage has led to more tasks within most MSEs making them much more relevant and economically viable.

... when we recycle waste, we get more products, sell and get more money. By so doing, we are also spending less to get the raw material ... MD, briquette-making enterprise

For some business owners, IS has enabled them to recoup the losses they would have otherwise incurred in disposing of the offcuts and unused industrial material. They thus attest that whereas they wouldn't say it's profitable to recycle waste and produce something no matter how little it fetches, it is worth the effort. Relatedly, other entrepreneurs feel recycling waste saves them the cost of hiring a garbage collection company to come collect the waste. This waste is instead put back in the production cycle and even before making a direct financial gain from the output, the company would have greatly saved the garbage collection fees.

... the usage of waste to make other things is helping us in saving the cost of collecting garbage. Like you see in business you need those Nabugabo up deals (garbage collectors) of course they are not picking for free so we don't incur that cost anymore ... Sales Manager, Food Processing Enterprise

... So even using the offcuts, is helping us reduce the cost that will be wasted. So we use them and that means by using waste more, you are gaining more Team leader, Skills Hub enterprise

Further engagement with all the 22 MSE owners interacted with expressed optimism that IS shall be a major tool for business growth, innovation, employment opportunities, diversification and import substitution.

The product of grease am making right now, in Uganda, people who are supposed to make grease let's say Indians, they also get most of the products from outside and they bring and make the product, but if we partner and make it from here, it would save us a lot of money and also create jobs for our people Owner, Oil recycling enterprise

They resolutely shared that IS facilitates a platform for the transfer of knowledge, equipment and skills recounting the benefits they have realized from the hitherto symbiotic relationships in place that were formed naturally and carried on subconsciously.

4.2.4 Challenges the undermine update of industrial symbiosis. Despite the potential of IS to catalyze SE, participants share challenges that undermine their potential to fully integrate the concept into the operations of their businesses. Specifically, barriers to IS included the lack of sensitization on the management of waste among MSEs and communities, low knowledge levels on the exploitation of waste and the potential of IS, inadequate support from government and sector stakeholders, lack of enough manpower and capital to invest in recycling of waste, limited market and minimal returns from products of recycled waste.

Additionally, sections of MSEs, particularly those in the sector of food processing, provided they could only transform waste into manure that many could hardly sell off but rather use in their gardens or give out for free. These entrepreneurs thus retorted that they did not see much benefit in recycling their waste, which in turn killed their morale, thereby developing a negative attitude towards engagements for effective waste usage and management. Others felt that by properly packaging the waste and handing it over to a garbage collection company, they were managing their waste. These two scenarios attest to the fact that some entrepreneurs lack the willingness to explore avenues for the exploitation of waste in a way that is more profitable than handing it over to garbage collectors.

let me give you an example of the cost of the tyres and then the fluctuation. You've got an order and then the price of tyres goes up yet you have already set a price for the customer or you delay so it's like you are using raw materials from other people's waste, someone can come and throw a whole sack and says because you are also going to use it for business, he asks you to sort it out. So at the end of the day you end up with a few good quality tyres yet you would have bought a sack. MD, CBO-tailoring, crafts and community empowerment

5. Discussion

Study results on the status of IS among MSEs in Uganda indicate that IS is not a popular term within the MSE fraternity in Uganda. MSE owners attest to have practiced it along their production chain unknowingly. The few who had heard of the term got the opportunity to participate in conferences for small-scale enterprises. We also note that the practice of reusing or recycling waste materials into sellable or profitable products is highly practiced as compared to sharing utilities, specialized machines and personnel for the smooth running of their businesses. Our findings are in agreement with [Kimuli *et al.* \(2022\)](#), who reported waste management as a practice undertaken by micro-businesses in Uganda to protect the natural environment in their study of SE practices. Specifically, women use waste materials such as old clothes to make other products like pillowcases, rags and trousers for children to enhance their financial position.

[Orobia *et al.* \(2020\)](#) also revealed that IT infrastructure significantly explains the sustainability of women and youth businesses, implying that infrastructure such as phones, and the Internet that are affordable in the Ugandan context, facilitate the sharing of important information on symbiotic practices among businesses through their umbrella bodies like USSIA and Uganda Manufacturers' Association (UMA). However, we note that study findings on sharing utilities, infrastructure and services as other key IS practices are scarce in extant literature. From this study, we provide initial empirical evidence showing that the MSE fraternity is sharing specialized machines, and personnel for the smooth running of their businesses as well as services like warehouses, transport and garbage collection to add a net-positive impact on the natural environment and preserve the values of the society.

In line with the second research question, the study findings ([Table 1](#)) indicate that the concept of IS has greater potential in fostering the uptake of SE in Uganda. As such, MSE owners expressed optimism that IS would be a major tool for business growth, innovation, employment opportunities, diversification and environmental protection for the benefit of current and future generations. This suggests that the MSE fraternity that previously perceived SE as being costly and less attractive will now have an opportunity to utilize waste materials into profitable products or sell them to sister enterprises instead of dumping them into the natural environment. This will result in environmental protection and creation of employment opportunities for community members while enhancing business growth.

Our findings are in agreement with [Al-Quradaghi *et al.* \(2020\)](#), who revealed that collaboration among enterprises in a symbiotic relationship brings about the creation of eco-industrial communities that are committed to achieving cross-industry effectiveness through profitable interchange of waste materials, energy, water and other resources to enhance their potential to create more employment opportunities for increased profits and environmental protection. This is also supported by [Domenech *et al.* \(2019\)](#), who indicated that IS is vital in resource protection, business profitability and natural environment conservation through reducing emissions and poor disposal of byproducts, translating into improved uptake of SE. [Neves *et al.* \(2020\)](#) further added that IS positively impacts the natural environment by reducing the quantity of raw materials demanded and effective utilization of waste material for further production. This implies that instead of using new raw materials, byproducts are reused or recycled into new or significantly improved products for sustainable use of natural resources to benefit the current and future needs of the entrepreneurs.

6. Summary, conclusion and implications

This study aimed to explore the status and potential of IS in fostering SE among MSEs in Uganda. This was achieved through conducting 22 in-depth interviews with MSEs in Kampala, Uganda. As such, our results indicate that IS is not a popular term within the MSE fraternity in Uganda. MSE owners attest to have practiced it along their production chain

Research questions	Themes	Results
What is the status of industrial symbiosis among MSEs in Uganda?	Awareness of industrial symbiosis	<ul style="list-style-type: none"> MSE owners were unconsciously practicing industrial symbiosis Awareness of industrial symbiosis was unpopular among the participants
	Waste usage and management	<ul style="list-style-type: none"> MSEs practically embraced the idea of recycling waste into sellable products Recycling waste led to increased revenues and conservation of the environment Participants demonstrated hunger for more knowledge through research and training to innovate and make use of industrial waste much more Many SME owners had deliberate plans of seeking to leave nothing to waste and turn it into something profitable
What is the potential of industrial symbiosis in fostering sustainable entrepreneurship of MSEs in Uganda?	Sharing knowledge, equipment and services	<ul style="list-style-type: none"> Participants share knowledge through attending conferences, workshops or corridor chats on how to boost sales Other entrepreneurs share utilities, specialized machines, and personnel as a way of reducing operational costs However, SME owners' hunger for knowledge was not quenched by the pre-existing IS; they were desirous of further learning
	Environmental potential	<ul style="list-style-type: none"> Waste can be transformed into a lot of profitable things to the benefit of the enterprise and the environment By recycling waste, the environment is riddled with indecomposable material that would otherwise lead to land pollution and soil contamination The environment is saved from litter and is thus kept clean and attractive
	Social potential	<ul style="list-style-type: none"> Owners pointed out that working hand in hand with members of the community through industrial symbiosis has fostered unity and harmonious living They hinted at the desire to transform the societies they live in, and through various engagements in research, skills training and exploitation of ways waste can be utilized, it was held that people's lives were indeed transformed
	Economic potential	<ul style="list-style-type: none"> The overarching benefit was the opportunity to diversify production and increase revenue Other entrepreneurs feel recycling waste saves them the cost of hiring garbage collectors Industrial symbiosis is tool for business growth, innovation, employment opportunities, diversification and import substitution It provides a platform for the transfer of knowledge, equipment, and skills development
	Challenges undermining the update of IS	<ul style="list-style-type: none"> Lack of sensitization on the management of waste Low knowledge levels on the application of IS Inadequate support from government and other stakeholders Limited manpower, capital and market for the symbiotic products

Table 1.
Summary of the study findings

Source(s): Authors own work

unknowingly. The few who had heard of the term got the opportunity to participate in conferences for small-scale enterprises. However, not so many MSE owners have the privilege of attending such events. Regarding the potential of IS in fostering SE, participants expressed optimism that IS would be a major tool for business growth, innovation, employment opportunities, diversification and environmental protection for the benefit of current and future generations.

Overall, the findings of this study present several implications for academics, practitioners and policymakers. For the academicians, this study contributes to the existing body of knowledge by documenting the status and potential of IS in catalyzing SE among MSEs in Uganda. Thus, scholars may use our findings in their future studies. Entrepreneurial ecosystem actors such as the USSIA, should sensitize SME owners about the concept of IS. This can be done through organized talk shows using different media channels like radio stations, television and social media platforms to appreciate the meaning, relevance and applicability of IS to different businesses as a strategic avenue for fostering environmental protection for social and economic development. It is also important for environmental ecosystem actors in Uganda to train the business community on the application of IS. As a way of creating a market for the symbiotic products that is currently limited in Uganda, there is a need for the actors to strengthen the networking of the MSE fraternity. This will enable SME owners to get relevant information on other symbiotic products that can be made and potential markets where their products can be sold from these networks.

From our results, it is evident that the business community in Uganda lacks the resources, skilled manpower and capital needed to fully implement IS activities. As such, policymakers like the National Environmental Management Authority (NEMA) and Kampala Capital City Authority (KCCA) should create a fund aimed at supporting MSEs to implement symbiotic activities. This fund will support research activities on IS in the context of Uganda, provide start-up capital in form of loans, open more market opportunities for MSE products, set up a center of excellence for waste recycling and management, and create platforms for MSE owners to acquire skills and more knowledge on matters of waste usage and management, as well as infrastructure and service sharing with sister businesses. This would, among other factors, seek to bridge the knowledge gap that is notably common among MSE owners.

Like other studies, our investigation has some limitations which can be addressed by scholars in future research. Specifically, our findings are based on the views of 22 key informants drawn from the MSE community in Uganda and this study is cross-sectional with a focus on the status and potential of IS in catalyzing SE at one point in time. As a result, changes in the symbiotic activities of the MSEs are not captured. Therefore, researchers may need to conduct longitudinal studies based on matched pair, polar and racing case studies to capture the change exhibited by entrepreneurs in their efforts to undertake IS to promote SE. Similarly, researchers may adopt a mixed method design that supports the triangulation of the findings and also validate the current results. Moreover, researchers may conduct similar studies in other contexts to establish the generalizability of our findings. Despite the limitation, our study makes significant contributions to the extant literature in the field of IS and entrepreneurship in general by providing key insights for policymakers, entrepreneurial eco-system actors and the MSE fraternity.

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