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Industrial clusters as a vehicle for circular economy transition: A case study of networks in four industrial clusters in Zimbabwe

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ABSTRACT

Multiple stakeholder partnerships are required to attain a Circular Economy (CE). Circularity can be achieved through industrial clusters in geographical proximity to each other. This research aims to assess the effects of industrial clustering on the adoption of CE in Zimbabwe (Workington, Southerton, Willowvale and Stapleford) in order to develop strategies for strengthening the impact of collaboration on CE practices in industry. The Workington and Southerton clusters were assessed as a joint cluster due to regular joint programming, whereas Willowvale and Stapleford were assessed separately. Interviews, document reviews and site visits were undertaken at selected members within the industrial clusters to understand some CE initiatives being carried out. A waste auditing programme was evaluated, resulting in ecological and economic benefits. Whilst many organisations were located in clusters, not all of them participated in CE activities. The Workington-Southerton cluster consisted of twenty-five (25) active members mainly dominated by private sector organisations in the manufacturing sector whilst Willowvale cluster had four (4) active members and Stapleford had nine (9) active members from industry and community network at the time of assessment. The main types of industries included food and beverages, fertiliser, metal fabrication, cable manufacturing, seed processing. Engineering, transport and bone char production. Collaboration based on geographical proximity allowed the organisations to undertake training, capacity building, workshops and industrial symbiosis. Implementation of the Industrial Waste Auditing Project (IWAP) by the networks, facilitated adoption of CE measures and presented an opportunity of improved waste recycling. It is concluded that geographical proximity can be used as an opportunity to facilitate attainment of a Circular Economy, but on its own is not a determinant of network success. Deeper issues of legal status, governance, value adding activities and financial viability - determine the ultimate impact of industrial clusters. We conclude that due to geographical proximity, there are opportunities of promoting industrial symbiosis. However, these opportunities need financing, technical capacity, governance and external support. Theoretical contributions of the research relate to the need for hybrid financing models to support CE activities and governance frameworks that provide oversight on industrial clusters. Further theoretical contributions relate to the new forms association beyond idiosyncratic organisations and advancing the need for measurable effects of collaboration using hybrid financing. Our theoretical contributions reveal new insights in governance and ownership of networks, especially how this can affect the delivery of CE activities.

1. Introduction

Global concern towards the burgeoning environmental sustainability crises has heightened in both developing and developed regions of the world. The coming of a Circular Economy (CE) to the forefront of sustainability discourse, presents a last gasp chance for humanity to salvage itself from the alley of self-destruction (Ellen MacArthur Foundation, 2012; Ghisellini et al., 2016). Industrial clusters are sustainable business networks of geographically connected organisations in close proximity to each other and can be effective vehicles for promoting a circular economy (Yin et al., 2022). Collaborations through industrial clusters have been studied by (Mbohwa et al., 2010; Mahuni and Bonga, 2016) in Zimbabwe. However, in the context of developing countries such as Zimbabwe, the contribution of industrial clusters to CE transition has limited evaluation, although a few studies existed before the maturity and widespread dissemination of the CE concept worldwide. Studies by (Mbohwa et al., 2010) suggest that industrial clusters have an effect on water management practices improvement, but no effect on effluent

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management. These studies do not specify the existence of any circular products, but cite potential waste exchange possibilities.

In addition, most collaborative research on CE is centred in developed countries (Aisbert et al., 2023; Baah et al., 2023; Blasi et al., 2022; Xu et al., 2023). These studied key issues including how collaboration on green economy facilitated mutual economic gain, research, development and financing. In addition, they also assessed how Circular Economy collaboration facilitated Corporate Social Responsibility (CSR) interventions. Other insights presented by these authors included the fact that geographical proximity had effects on the tourism sector. Furthermore, they analysed how inter-firm conflicts occurred in networks and their potential to affect network success. These studies confirm effects of industrial clusters on sustainability and at the same time also include conflicts (Xu et al., 2023) in collaboration. The main gaps relate to the funding modalities of networks, which are not assessed as well as tracking of the impacts of the networks on selected Circular Economy indicators. In addition, very little is covered about networks on the African continent and Zimbabwe in particular. Similar studies have been done in Europe and managed to demonstrate the effects of clustering and collaboration on supply chain sustainability (Jager and Piscisceli, 2021). Studies in Asia confirm effects of collaboration on circular economy and plastic packaging (Samitthiwetcharong et al., 2023). However, they lack on governance regimes, financing models and tracking specific indicators of progress on CE elicited by the collaboration. This paper is focused on circular processes, products and services that result as a consequence of network collaboration in industrial clusters and not necessarily individual environmental aspects. It approaches circular economy holistically than anecdotally. Some of the previous studies lack adequate information on business models of the networks and effective governance regimes for their sustainability. The studies also lack information on governance regimes and business models of networks.

Industrial development is widely acknowledged as responsible for climate change and global warming. The adoption of cleaner production measures is a key strategy of preventing the negative ecological and toxicological effects of production systems. It has become a norm for organisations to adopt Circular Economy concepts such as cleaner production technologies. Adoption of cleaner production technologies, recycling and industrial symbiosis in manufacturing companies requires technical capacity to implement them. However, it is not every organisation that can implement these novel and emerging CE concepts. (Hart, 1995) cites the need for organisations to acquire tacit skills in order to ensure smooth transition to sustainable production systems.

In different sectors of the economy, collaborative arrangements have been analysed and there have been barriers, opportunities, challenges and lessons learnt from their operations (Bacudio, et al., 2016; Berlin et al., 2022; Hina et al., 2022). Governance of these Sustainable Business Networks has also been proven to have a significant bearing on their success.

Industrial clusters in Zimbabwe play a role in the transition towards a CE (Mbohwa et al., 2010; Mahuni and Bonga, 2016). However, impact of these networks is affected by financing, low participation and governance issues. (Madanhire and Mupaso, 2018) demonstrate that there is even significant potential for industrial symbiosis in Zimbabwe, which has been untapped through utilising industrial clusters. If there is improved networking capabilities and promotion of CE within industrial clusters, there will be a higher uptake of CE measures such as waste recycling (Leising et al., 2018; Jager and Piscisceli, 2021).

Evaluation of industrial clusters is not common in many countries and there is inadequate documented information related to the network performance and implementation of CE. As a result, industrial clusters fail to tap into the learning opportunities. This paper evaluates industrial clusters through a terminal evaluation of the Industrial Waste Audit Project (IWAP) which was implemented by the industrial clusters. The evaluation of the project used the internationally recognised OECD DAC Evaluation Framework (OECD, 2019). Other forms of network collaboration are well-documented in the form of networks (Jager and Piscisceli, 2021; Leising et al., 2018; UNIDO, 2011; Veleva and Bodkin, 2018). Although network participation is influenced by the orientation of the network structure, government policy, innovation and subsidies have a bearing on their outcomes (Yin et al., 2022).

Whilst it is possible to depend on idiosyncrasy and attain sustainable development, there is a high likelihood of leapfrogging other organisations in the same sector, when operating in the inertia of organisational networks due to mimetic, coercive and normative isomorphic pressures acting upon the organisation (Di Maggio and Powell, 1983). Organisations can gradually be made similar due to emulating others, following international standards and being compelled by external factors such as laws, as articulated in the institutional isomorphism theory (Di Maggio and Powell, 1983). Networks through collaboration are a chance to access CE training, capacity building and also avail access to finance opportunities. The vociferous call for network participation through industrial clusters has not necessarily been supported by enough empirical evidence to prove their effectiveness. Assessing the dynamics related to barriers in multiple country contexts requires adequate analysis in Africa. In Zimbabwe, evaluative research on the contribution of industrial clusters to a circular economy is scant and needs to be enhanced through current, cutting edge and inclusive research.

In this research paper, we are seized with the following questions.

i. What is the role of industrial clusters in promoting a Circular Economy in Zimbabwe?
ii. How are the industrial clusters promoting CE activities?
iii. What business models are the industrial clusters using in the promulgation of their CE activities?
iv. What governance regimes exist in the industrial clusters and do these facilitate effective networks?
v. What opportunities for industrial symbiosis and CE implementation exist in the industrial clusters?
vi. Do industrial clusters deliver CE outcomes and what barriers do they face in this process?
vii. Are the industrial cluster activities Effective, Efficient, Relevant, Sustainable and Impactful to the network beneficiaries.

This paper traced the effects of industrial clusters on the adoption of Circular Economy practices Zimbabwe (Workington, Southerton, Willowvale and Stapleford) in order to develop strategies for strengthening their impact in delivering Circular Economy practices. Specific objectives of the research include 1) To assess the role of industrial clusters in promoting a Circular Economy in Zimbabwe 2) To identify the approaches used by industrial clusters to promote CE 3) To analyse business models used by industrial clusters in undertaking CE activities 4) To identify governance models of the industrial clusters 5) To identify models of industrial symbiosis and waste exchange within the industrial clusters 6) To evaluate CE outcomes due to network activities and identify barriers faced by the industrial clusters.

The study is structured in the following sequential arrangements: Section 2 (Literature Review) Section 3 (Materials and Methods) which explains the methodological foundations of the case study, Section 4 (Results) which presents the results of the case study divided according the following thematic areas - history and development; structure and governance; legal status; motivations; business models and financing; drivers as well as communication and knowledge management. Section 5 (Discussion) outlines the discussion of the results and proffers recommendations for the improved functionality of Sustainable Business Networks in the form of industrial clusters and Section 6 (Conclusion) presents the conclusions of the research.

2. Literature Review

Literature on sustainable business networks shows that collaboration amongst organisations has effects on developing circular patterns of

production and consumption. Organisations operating in isolation may fail to innovate faster than those which collaborate with others. Networking amongst organisations facilitates transition to a Circular Economy (Aisbert et al., 2023; Baah et al., 2023; Madanhire and Mupaso, 2018).

Geographical proximity is believed to have an effect on the adoption of CE innovation if the neighbouring stakeholders are having intensive implementation. Studies on renewable energy adoption, confirm signs of geographic proximity and its effect on innovation transfer (Fadly and Fontes, 2019). However, such studies are limited to the specific country contexts and may be inapplicable in other countries. Further critique to the notions that geographical proximity drives innovation is echoed by (Boschma, 2005), who argues that geographical proximity alone does not drive innovation. Furthermore, underestimating each other amongst actors in the geographical proximity, often leads to low impact outcomes. Contrary to this outcome, other scholars cite indifferent outcomes in sustainability due to geographical proximity. (Blasi et al., 2022) unravel both positive and negative correlations between clustering and sustainability behaviour. In the context of industrial clusters, their ability to attain a circular economy transition cannot be left entirely to the convenience of geographical proximity. It is against this background, that the industrial clusters in Zimbabwe must be researched and assessed.

Several theories confirm the essential role of industrial clusters as a building block for effective collaboration for transition to a Circular Economy. Firstly, the Sustainability Theory, anchored on intergenerational equity is a core part of the theoretical foundations of the research (Brundtland, 1987). The Brundtland Commission defined sustainable development as the development model which meets the needs of the present without affecting future generations to meet their own needs (Brundtland, 1987). Secondly, the Organisational Theory supports the assertions of this research, with a specific focus on the Institutional Isomorphism Theory (Di Maggio and Powell, 1983). In this quest for attaining sustainability, organisations can become similar in their corporate behaviour as confirmed by the institutional isomorphism theory (Di Maggio and Powell, 1983). The success or failure of the network actors is determined by the contextual factors acting upon the institutions as elaborated by the Contextual Interaction Theory (CIT) (Bressers, 2007). Despite the theoretical framework on sustainability and collaborative tendencies of organisations, little research has been done to assess the effects of industrial clusters in Zimbabwe. These literature gaps require filling with empirical research. (Mahuni and Bonga, 2016) confirm that industrial clusters are under-developed in Zimbabwe and most literature on clusters is confined to developed country contexts.

Collaboration within networks for a circular economy requires financing to ensure viability. (Kierans and Chen, 2022) confirm the need for proper financing in the transition towards a circular economy. Inadvertently, some SMEs find themselves implementing circular economy initiatives without collaboration; but literature argues that for most SMEs, the transition to circular economy practices is difficult to achieve due to several barriers (Mudavanhu et al., 2013). In the case of Zimbabwe, the urgency of a circular economy transition is urgent due to the challenges affecting the country such as waste management (Ncube, et al., 2022). As industry develops, these problems have increased and cleaner production approaches are inevitable (Nhapi and Hoko, 2004). Proven examples of implementing circular economy practices exist (Samitthiwetcharong et al., 2023) and just require scaling up.

Industrial clusters are geographically grouped organisations with a quest to facilitate industrial transformation. Whether geographically associated or not, collaboration for a circular economy intention has many benefits in managing projects and their governance determine success (Schepman, et al., 2018). Cooperation amongst organisations can uplift SMEs' ability to implement sustainability and circular economy practices (Suchek and Franco, 2023; Xu et al., 2019; Varrichio et al., 2012). Industrial clusters in Zimbabwe are developing in response to the environmental challenges affecting the country. (Sithole, et al., 2023) recognise the urgency of climate mitigation in the context of sustainable development and as a pathway for attaining a circular economy in Zimbabwe.

However, it should be noted that networks and collaboration are not always affirmative and in agreement. Due to the differences amongst organisations, conflict and disagreements are inevitable in networks (Xu et al., 2023; Tura et al., 2019). These may be fuelled by different priorities and different corporate culture. The different priorities that exist within networks can be a source of disagreement and become counterproductive to the attainment of the network goals. Whilst researchers recognise that there is need for collaboration, they also clearly identify some sources of divergence within the ideological foundations of network members (Xu et al., 2023). Whilst the aims of industrial clusters, is to collaborate on CE activities, there is no specific need to make members identical in their understanding and perception of issues.

There is an urgent need to ensure that humanity is able to overcome the compounding sustainability challenges affecting the world, including in areas such as waste management and climate change (Brundtland, 1987). In Zimbabwe, waste management remains a big challenge for municipalities, governments and other key stakeholders (Ncube, et al., 2022).

Previous research in other regions confirms that collaboration can yield positive outcomes in dealing with environmental sustainability challenges. In the case of Brazilian industries, documented literature shows that collaboration can yield innovation through the Collaboration and Network Partnerships Model (Varrichio et al., 2012). The theoretical framework of the research is presented in Fig. 1.

Fig. 1 shows the theoretical framework underlying the research. Theories of sustainable development advocate for development that meets the needs of the present without compromising future generations. As shown in Fig. 1, in order to attain sustainable development through a CE, idiosyncratic organisations will need to be collaborative with others. Their collaboration is influenced by institutional isomorphism and the desire to conform to laws and emulate other organisations. The figure also explains the effect of the context within which a network operates, as a critical factor determining its success, as explained by the Contextual Interaction Theory (CIT). External factors and organisational contexts both play a part in network success.

The industrial clusters presented in this research are all located in Harare, the capital city of Zimbabwe. One of the industrial clusters (Southerton-Workington) is based on exclusively industrial organisations only, whilst the other industrial cluster (Stapleford) is based on a combination of industrial and community members. Whilst emerging research has been undertaken in Zimbabwe by (Mbohwa et al., 2010; Mahuni and Bonga, 2016), it is not yet clear whether CE improvements can be attributed to the collaboration or they are as a result of individual idiosyncratic tendencies of the network actors.

Although previous literature in Zimbabwe recognises the effect of industrial clusters on environmental improvements such as waste water management, it is essential to further assess whether this network collaboration regime on geographic lines of proximity, is effective in comparison to dispersed networks formed by the desire to forge transition to a circular economy. It is also not clear whether these industrial clusters are self-sustaining in their business models and it is necessary to determine strategies for improving their effect on corporate sustainability performance. (Mbohwa et al., 2010) cite some weaknesses in Zimbabwean industries on selected sustainability topics such as wastewater management, although there are promising improvements in water savings.

Knowledge gaps identified by this research include the lack of identification of traces some industrial symbiotic relationships within existing industrial clusters in Zimbabwe and limited evaluation of the extent to which improvements in waste management performance can be attributed to the industrial cluster network. Due to economic challenges, some industries closed operations and this had an effect on the

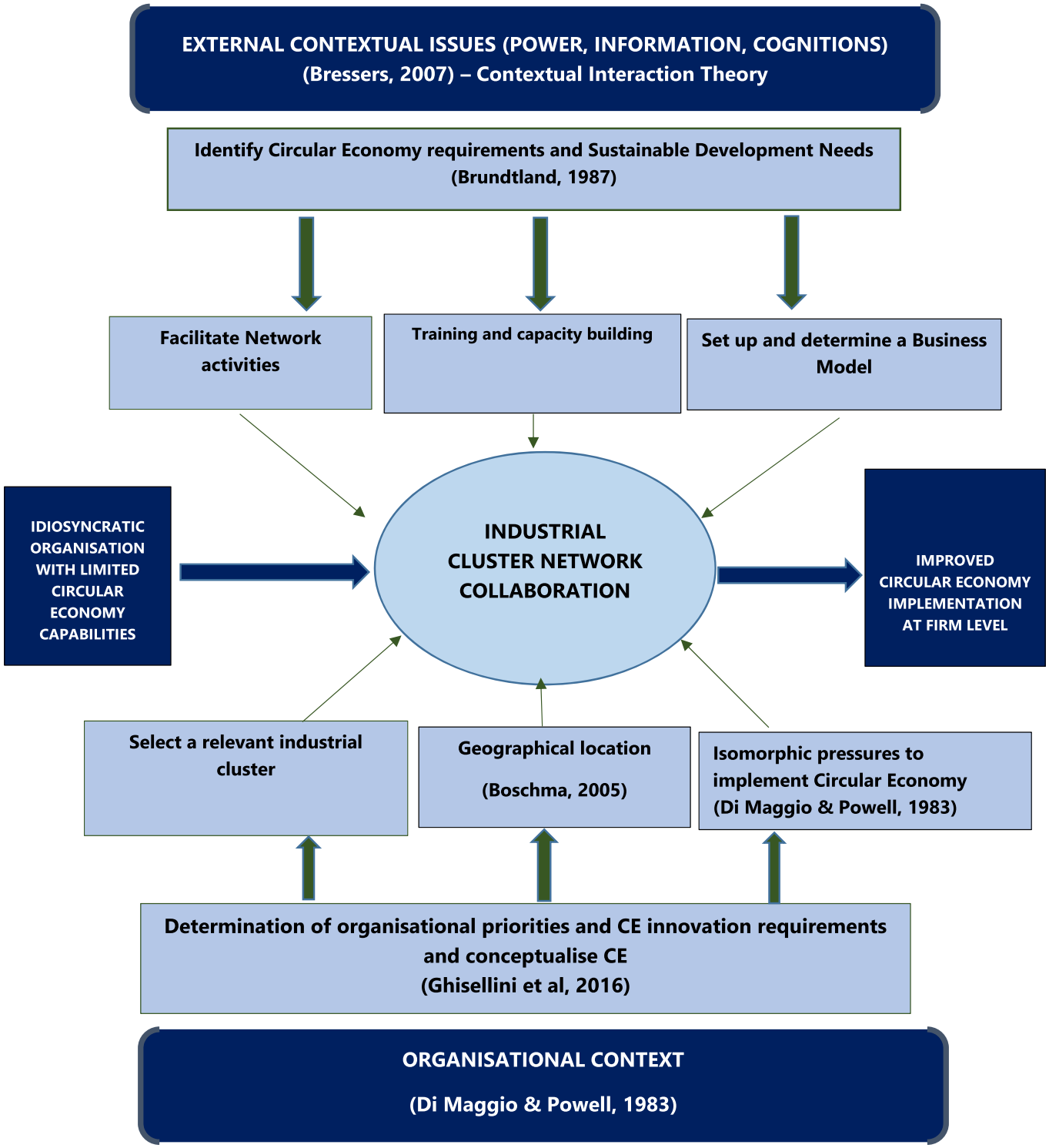

Fig. 1. Theoretical framework.

momentum of CE activities, thereby triggering a need to convince and re-orient new members.

Although organisations are located in geographical proximity to each other, not all of them are interested in industrial cluster activities centred on the Circular Economy. This research is mainly focused on those members who are focused on the CE activities and voluntarily participate in the industrial clusters, meetings, and activities.

3. Materials and Methods

3.1. Research methods

The research was based on a case study approach using the three (3) industrial clusters as case studies. Case Study research allows for deeper understanding of research phenomenon. Case Studies of industrial clusters were used to enable a thorough understanding of depth rather than breadth. Furthermore, case studies allowed further exploratory

analysis of phenomena and the research units (Yin, 2003). Key informant interviews were undertaken with selected representatives of the three (3) cluster networks, who work for the thirty-eight (38) cluster member companies. There were also interviews with key informants and sector experts with knowledge in industrialisation and circular economy. Documents were reviewed, including cluster records and performance metrics recorded by the network.

Direct observations were undertaken in selected companies in the industrial clusters, including non-alcoholic beverages, beverages, seed processing, food, fertiliser, metal fabrication, cable manufacturing. Engineering, transport and bone-char production.

A questionnaire was developed and sent to the industrial cluster representatives to access data on their CE activities, governance, business models and barriers. In order to ensure data validity and reliability, there was triangulation of data and triangulation of sources. Selection of the case study was based on the criteria specified in Fig. 3.

A second questionnaire was distributed to the cluster members in order to obtain specific information regarding waste management practices and waste auditing capabilities. The sampling process was strategic sampling as it was targeted at specific organisations who were members of industrial clusters in Harare. Questionnaires were semi-structured and consisted of 4 key sections.

i. Organisational profile
ii. Waste Management Practices
iii. Effect of Industrial Cluster on Waste Management Practices
iv. Training needs

Therefore, the research disseminated questionnaires at two levels and key informants as follows. The questionnaires were administered to.

i) Network representatives e.g. Network Chairpersons and Executive Committee Members to respond on behalf of the networks.
ii) Network members to get the view of benefits accruing due to the collaboration.

The responses to the questionnaires were used to ascertain the level of development in terms of implementation of waste management and waste auditing. The geographic location of the clusters was put into consideration as well as their thematic focus on Circular Economy. Networks targeted, were those located in Zimbabwe, South Africa and Kenya. In this case study, all were drawn from Zimbabwe. The selection was also based on organisations whose collaboration was voluntary and they are not being forced to collaborate with other organisations. Both qualitative and quantitative analysis was carried out to determine trends in the network participation and activities. Case study research allows for deeper analysis and can be in the form of single case or comparative case studies (Veschuren and Dooreward, 2010). Within the different case studies of industrial clusters, each cluster was assessed and then comparisons were undertaken amongst clusters. Due to the evaluative nature of the research, the Organisation for Economic Cooperation and Development Assistance Committee (OECD DAC) criteria was used to

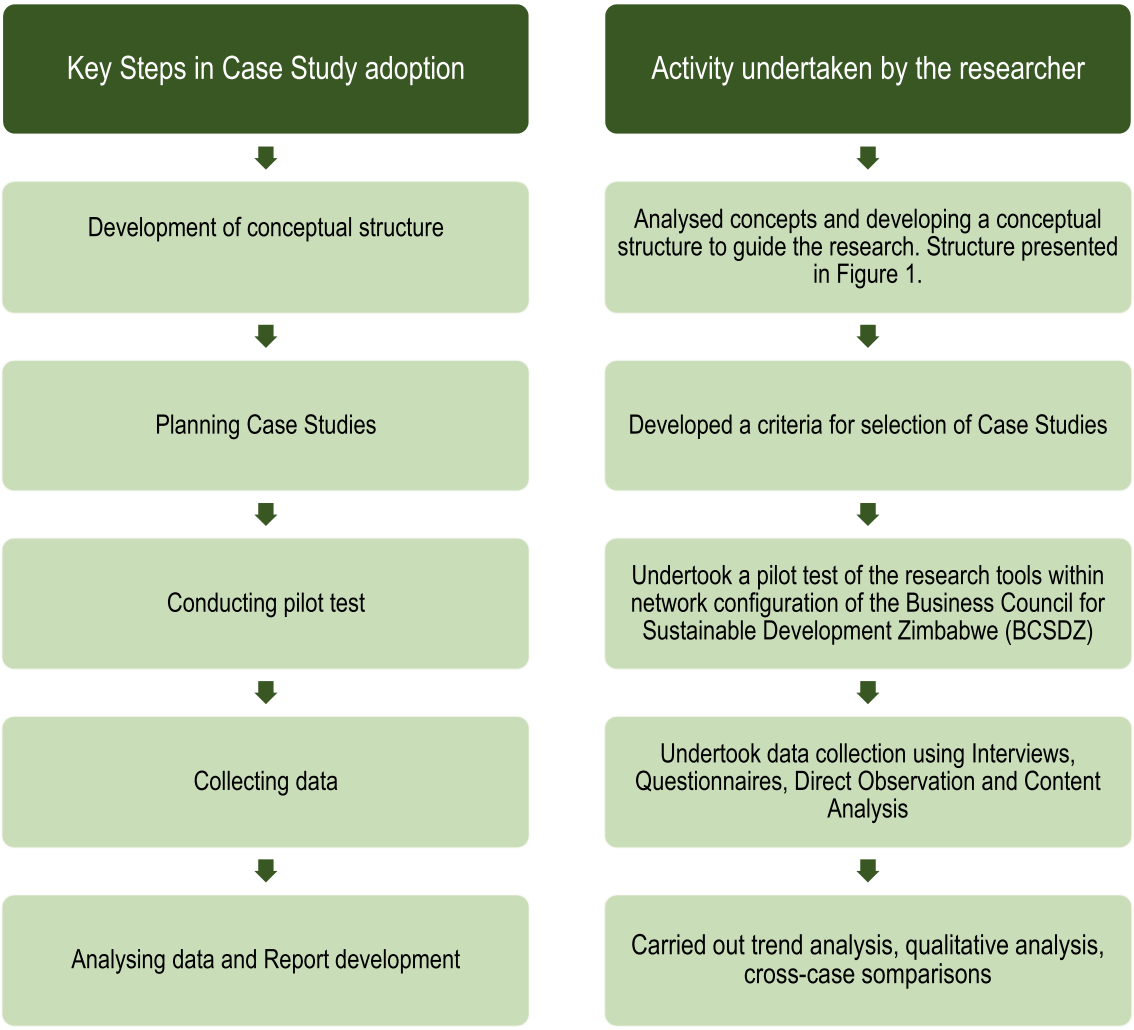

Fig. 2. Key Steps in Case Study adoption.

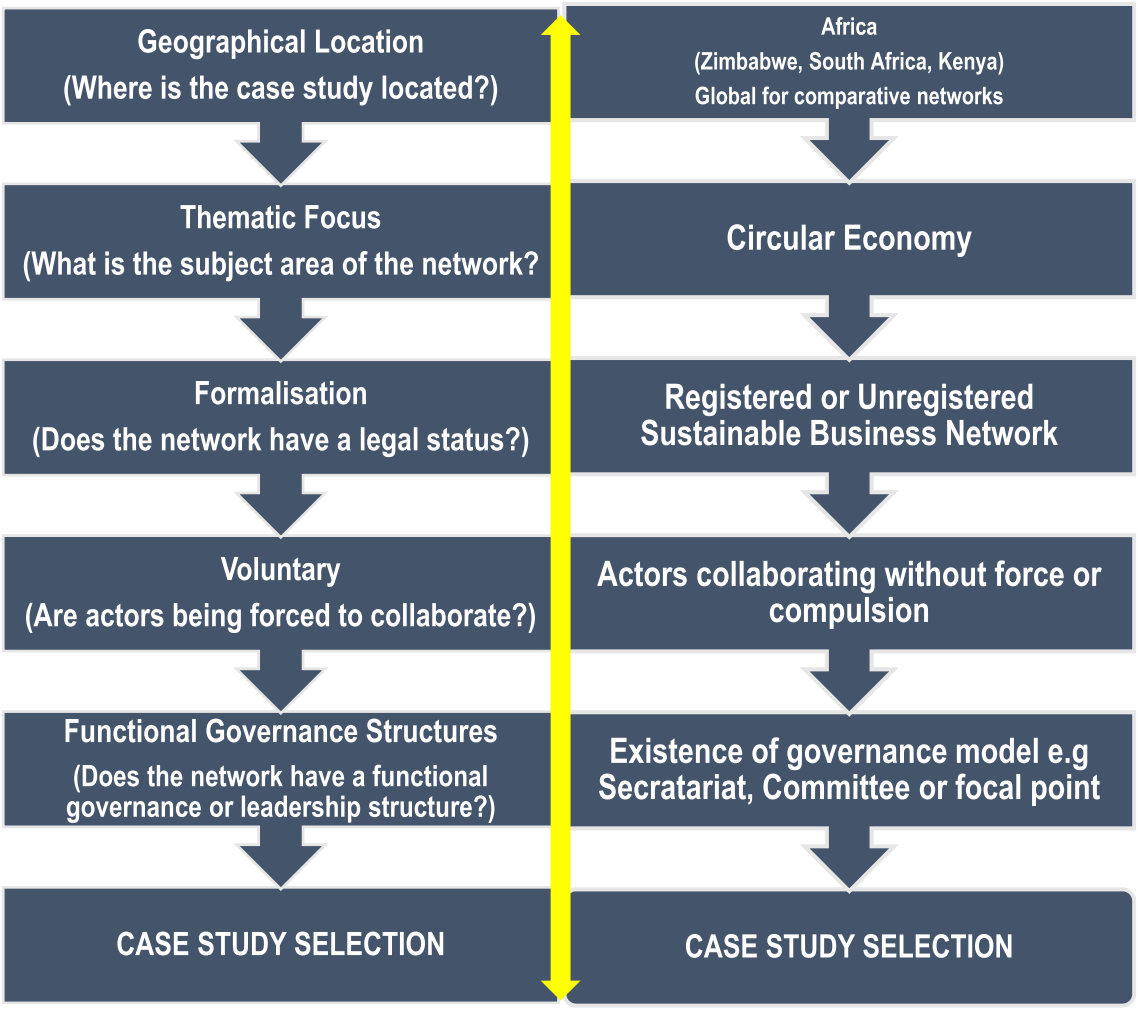

Fig. 3. Selection criteria for sustainable business network case studies.

assess the cluster network performance. The assessment was based on the criteria of *Effectiveness, Efficiency, Relevance, Sustainability and Impact.* (OECD, 2019).

In order to ensure that there was a systematic process of Case Study development the sequential steps of Case Studies were used namely.

- Development of conceptual structure
- Planning case studies
- Conducting pilot test
- Collecting data
- Analysing data and report development.

This approach was adapted from (Yin, 2017) in order to ensure that Case Study was systematic. The systematic steps of adopting the case studies is illustrated in Fig. 2.

In order to select Case Studies, a systematic process was undertaken; following pre-determined procedures. Firstly, the research defined concepts such as networks, industrial symbiosis, collaboration and industrial clusters; were assessed. These concepts enabled the development of a conceptual model of the research. Secondly the research developed criteria for selecting case studies, with a specific focus on those case studies which were geographically associated together in the same locality. Thirdly, a pilot test of the research instruments was undertaken, using selected members of the BCSDZ in order to assess the viability of the research tools. Furthermore, data was collected from the industrial clusters through questionnaires sent to cluster representatives, observations on selected sites and content analysis. Lastly, there was a process of data analysis, with specific focus on qualitative analysis.

In order to collect data for the inferential purposes of the research, the data was collected during the Industrial Waste Audits Programme (IWAP) and then there was further data collection at network level with the key informants network representatives from January to May 2023. Interviews were at two different levels, including cluster member level and then cluster administration level. At cluster level, information such as number of Circular Economy activities; number of CE training sessions; number of workshops, events and seminars; symposia as well as number of organisations benefitting from each cluster was collected. Qualitative information relating to business models of operation, barriers, types of waste and specific information about the Industrial Waste Audit Case Study were collected. Cluster documents were assessed for a period of 10 years from 2013 to 2023 in order to ascertain specific activities undertaken by the clusters in the context of CE. Information for deriving results was collected from interviews, document review of cluster records and observation of processes at cluster members' premises. Waste streams were identified through direct observation and the number of recyclable waste streams was divided by the total number of waste streams observed in order to determine the total percentage of waste streams recyclable. Observations collected data on types of waste streams, waste management practices, opportunities for industrial symbiosis, collaborative activities, waste and waste disposal facilities.

Data collection included a number of indicators of network CE

activity such as network Circular Economy Activities, events, waste generated, waste types, legal status, structure and governance, Number of Circular Economy Training Sessions, Number of Circular Economy Projects, Number or organisations benefitting from the sustainable business network, existing cases of industrial symbiosis, number of network activities undertaken, cluster meeting and number of members carrying out CE activities. This information was analysed using descriptive statistics. A questionnaire that was used as part of the data collection is inserted in Appendix A.

The interviewees were senior representatives of industrial clusters such as cluster Chairpersons and Executive Committee members. The selection of senior representatives of clusters was purposive, due to the fact that they had power to make decisions and also they had more significant information about the network. Organisations who were members of the industrial clusters were also interviewed to verify some claims of the industrial clusters. The members were interviewed during cluster training events and also during the Industrial Waste Audit Project industrial visits facilitated by Environment Africa. A total of 38 organisations were interviewed from a total of 3 different industrial clusters located in Harare. At organisational level, the interviews mainly targeted individuals responsible for implementation of Circular Economy and in the case of most Zimbabwean companies, it was Safety, Health, Environment and Quality (SHEQ) Managers and Officers. The interviews were not recorded, but were transcribed. Information collected from the interviews included organisational profile, waste management practices, industrial cluster participation, benefits of network participation and governance regimes. Interviews were undertaken with individuals and not in groups. This was to deal with issues of group dynamics and prevent selected individuals from dominating the process. Field records which were made include checklists of the waste management situation and Circular Economy practices at the visited organisations. Content analysis approaches utilised deductive analysis based on information already known about the clusters through access to their cluster documents. These documents included cluster records, meeting reports, cases studies, charters, waste records and audit records. In order to ensure the trustworthiness of the content analysis, there was an adoption of a systematic sequence based on preparation, organisation and reporting or case studies as promulgated by (Elo, et al., 2014; Elo and Kyngäs, 2008) in order to strengthen the trustworthiness of the research. Results were categorised by content including thematic areas such as structure, governance, business models, waste types, cluster activities, financing, barriers, drivers and examples of industrial symbiosis activities. (Elo and Kyngäs, 2008) propose that qualitative analysis should be sytematic, in order to facilitate trustworthiness of the qualitative analysis.

At each stage of the case study cycle, either triangulation of methods or triangulation of sources was undertaken. The triangulation was carried out in order to strengthen in validity and reliability of the research data collected and to enhance credibility of the findings. Triangulation was done by considering documents of the cluster, interviewing personnel and analysing questionnaire responses. In addition, observations facilitated verification of the information presented on questionnaires and offered another layer of triangulation with the pre-existing methods. There was also triangulation of sources of information including company documents, cluster documents and research records. Some of the respondents preferred anonymity and confidentiality due to the fact that the information in the research presents the environmental performance of their companies. Therefore, individual identity was not specified for all entities in this research. Inferences in this research were made at industrial cluster level without pointing out to individual firms and information of the individual respondents.

The systematic selection of Case Studies is presented in Fig. 3. Firstly, geographical location was considered. Preference was given to case studies of industrial clusters which were located in the 3 target countries of the research – mainly Zimbabwe, South Africa and Kenya. In this case study, precedence was given to industrial clusters in Zimbabwe. Secondly we looked at the thematic focus of the industrial cluster. The clusters which were selected, included those which had a focus on Circular Economy and related concepts such as industrial ecology and sustainable development. The third element of selection included aspects of formalisation. Both formally registered networks and organised networks without registration were considered. We further selected those industrial clusters whose collaboration is based on voluntary collaboration and not compulsion to collaborate. Furthermore, consideration was given to networks which were based on functional governance structures such as secretariats, committees and focal points. From a progressive analysis of the aforementioned factors, Case Studies were determined. This systematic process ensured repeatability and objectivity in the selection process of case studies.

Due to the fact that the industrial clusters implemented a project called Industrial Waste Audit Project (IWAP), the research evaluated interventions of industrial clusters based on internationally recognised OECD-DAC criteria. The criteria was used as it is the methodology mostly used in evaluating development programmes and has been used since 1991 by international organisations for more than 30 years (Chianca, 2008). The framework is the most preferred by international development agencies and applied to various development projects. The evaluation of the network project, was employed as a means of triangulation of data and demonstrating the effects of networks on circular economy implementation. Cluster documents that were assessed included policies, procedures, working instructions, waste records, project records, constitutions and evaluation reports. In order to address the proportion of waste recycled and organisations implementing CE measures, arithmetic computations were undertaken based on the responses from cluster members. These metrics were calculated based on the number of recyclable materials divided by the number of total waste streams and expressed as a percentage, in order to determine the recycling potential of the clusters. The proportion of organisations implementing waste reductions was calculated by number of organisations implementing waste reduction measures suggested by the cluster and divided by the total number of organisations and expressed as percentage.

Effectiveness, Efficiency, Relevance, Sustainability and Impact were interrelated to the objectives in the following ways.

i. Effectiveness: Measures the extent to which CE goals of the industrial cluster are attained
ii. Efficiency: Assesses the extent to which CE objectives are attained with minimal resources
iii. Relevance: Relates to the degree of appropriateness of the CE measures recommended by the industrial cluster.
iv. Sustainability: Assesses the ability of the beneficiary to sustain CE activities emanating from the industrial cluster
v. Impact: Refers to the to the effects of the CE measures on the cluster members and to the wider society. Effects can be intended or unintended.

These criteria enabled us to assess the nature of effects promulgated by the collaboration and specific programmes initiated by the industrial cluster. Strategies were therefore developed on how the network could improve its effectiveness, efficiency, relevance, sustainability and impact.

3.2. Project location

The Southerton-Workington Industrial cluster is located in the industrial hub of Harare, the capital city of Zimbabwe and it combines 2 industrial zones in Workington and Southerton. Workington is located about 7.2 km from the Central Business District (CBD) and the distances of the furthest part stretches further to 10 km, depending on the direction taken. Southerton is located about 7 km from the CBD and depending on the direction taken, distance from the furthest industry varies. Workington is located on the South-Western part of Harare. In

addition to manufacturing sites, the area has banks and commercial space for emerging activities such as vehicle servicing and warehousing. The area is characterised by both heavy industries and medium scale industries. The sectors prevalent in this area include food, beverages, chemicals, petrochemicals, cable manufacturing, fertiliser, paint, battery manufacturing, plastic making, transport and haulage, detergents, tobacco processing, vehicle servicing, catering services, baking, pharmaceuticals, paint manufacturing, meat processing, thermal power generation, dairy garment manufacturing, sugar processing, cotton processing and animal feed processing.

Stapleford industrial cluster lies about 24 km outside the Central Business District of Harare (CBD). Stapleford is located in the north-western part of Harare near the proposed new capital city of Zimbabwe to be built near Mt Hampden. Stapleford comprises a combination of seed processing, alcohol and spirits manufacturing, brick making and chemicals. The Stapleford industrial cluster is also embedded within the Stapleford community. The weather patterns prevalent in the study area consist of wet and dry seasons. The rainy season is between November and March, whilst April to October are dry months. The coldest months are June and July.

Harare sits on a plateau and is located at 1483 m above sea level. Rainfall averages 840 mm per annum whilst average temperatures are about 18 °C. Harare is located in a region which is part of the Miombo Woodlands, dominated by savannah vegetation. The most dominant species are the *brachstergia spirciformis,* musasa and *julbernadia globifora*, munhondo. Within the industrial zones, there is not much vegetation as the areas have been developed by industrial development activities. The map of the location of the industrial clusters is shown in Fig. 4, Figs. 5 and 6.

4. Results

4.1. History and development

The Southerton-Workington industrial cluster was formed in 2009 and the Stapleford cluster was formed in 2009. However, some of the organisations were registered as entities before that. These clusters were formed by organisations which had a desire to promote sustainable development within their operations. The association of the organisations by geographical proximity was not based on any coercion, but by the collective desire to develop and upscale techniques that would help the organisations to deal with emerging environmental sustainability challenges. There was not much evidence of emphasis on subscriptions to be part of the network, because by virtue of geographical proximity, an organisation was already an eligible member of the network.

Environment Africa played a catalytic role in initiating the Industrial Clusters Concept, trying to bring the organisations already in proximity to each other to start cooperating on CE. Environment Africa implemented various programmes with industrial clusters in Zimbabwe namely Workington, Southerton, Willowvale and Stapleford. Through the technical support of the non-government organisations, the cluster concept flourished and also organisations developed ownership of the initiative. In selected times, cluster members associated on their own.

4.2. Structure and governance

Fig. 7 shows how the industrial cluster is governed and managed. This structure was synonymous for all the three industrial clusters assessed. The structure of the typical industrial cluster in Zimbabwe comprises a Chairman, who leads the coordination of network activities. The Chairman is assisted by an Executive committee that comprises representatives from different organisations from within the cluster. There are currently no oversight bodies such as the Board of Directors. With regard to the leadership style, the industrial cluster uses democratic and transactional leadership styles (see Fig. 7).

There is currently no system established to evaluate the effectiveness of network governance bodies and document areas of improvement. The lack of governance bodies in industrial clusters and similar networks can cause excessive demands on the few representatives in Executive and also may limit the ability to separate management and governance functions of the network.

Goals, responsibilities and strategies are not formally defined, although the network is currently undertaking activities, there is an opportunity that should be utilised of formalising the goals, responsibilities and strategies as well as communicate them to members. When members have a shared vision of goals, responsibilities and strategies, it is possible to scale-up CE activities and ensure that members understand the clear aspirations of the network. Major CE activities are presented in Fig. 8 training, projects, workshops membership benefitting.

4.3. Legal status

The Southerton-Workington, Stapleford and Willowvale industrial clusters are not formally registered as entities. They have no formal legal status. Their existence is not driven by the formalisation of the network, but by the geographical proximity without much institutional rules and formalities. The network activities are driven by geographic proximity amongst its members rather than institutional cognitions of a CE transition. In certain situations, both geographical proximity and institutional cognitions are coinciding in facilitating corporate relationships. Geographical proximity alone cannot facilitate the network collaboration in a CE regime unless supported by genuine cognitions, leadership and governance of the network actors. In areas of convenient cooperation and ability to transfer materials from one organisation to another, the organisations cooperate without formal structures.

The research also found evidence that there was no strategic plan established yet for the industrial clusters. Most activities are member-driven and ad-hoc in response to prevailing issues. A more structured approach to CE activities anchored on a strategy for each cluster is required in order to improve the impact of the network. It is essential to develop a strategy to explain how aspects of the CE are to be mainstreamed. In order for sustainable business networks to attain a higher level of impact in Circular Economy activities, a strategic approach to undertaking network activities is necessary in order to ensure the scaling up sustainable development activities.

4.4. Motivations

A variety of motivations were responsible for establishing the networking facility alongside cluster lines. One of the key drivers was the emergence of environmental legislation which was demanding on industry, especially at the turn of the millennium. The establishment of the Environmental Management Agency (EMA), coupled with the promulgation of the Environmental Management Act 20:27 acted as motivations, as business tries to develop mechanisms of ensuring compliance and demonstrating self-regulation.

Other motivations included the need to access green financing and opportunities for technical; assistance. It was also noted that organisations were motivated by corporate image pressures, especially wanting to be considered as sustainable businesses by different stakeholders. There were cognitions related to meeting stakeholder requirements and avoiding conflicts with the communities.

A very special arrangement was observed in the Stapleford Industrial Cluster. In this industrial cluster there was a motivation to meet needs of the community as well as the needs of industrial organisations. The nexus between organisational requirements and community CE interests presents evidence that industrial clusters and Sustainable Business Networks can be adapted to different operational modalities in order to suit the requirements of the country and its stakeholders.

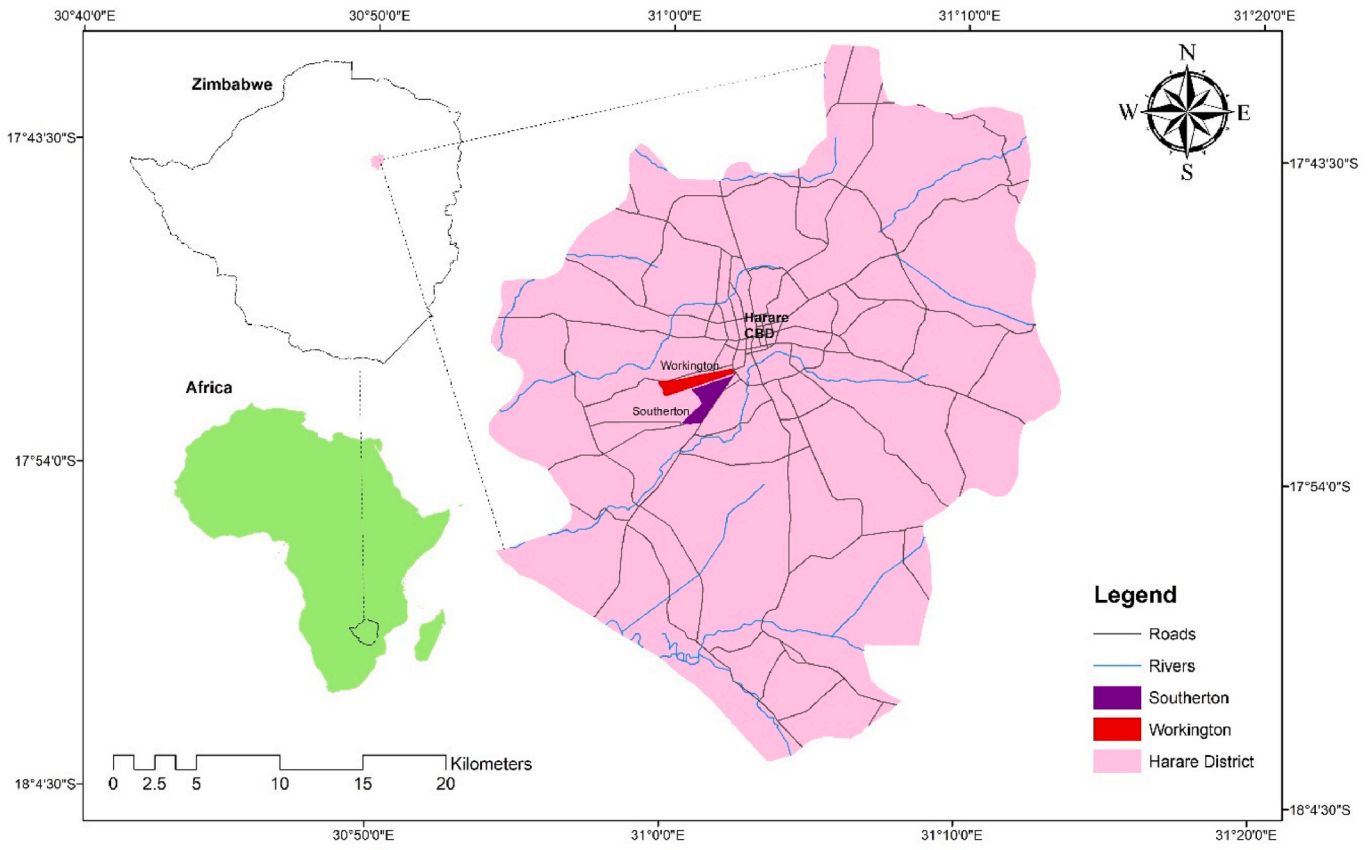

Fig. 4. Workington-southerton industrial cluster map.

4.5. Business model and financing

The business model of the industrial cluster networks was self-financing. Cluster members were expected to finance any CE activities. This model is very different from many other networks which were based on subscriptions. However, even without subscriptions, some members do not attend networking activities. Self-financing networks prevented dependency of network members on network financing. However, the model is detrimental when organisations do not have financial resources to support CE technologies and activities within their organisations. The financing of circular economy activities was dependent on what the organisations could afford on CE. If there was no commitment from the top management of respective organisations, transition to a CE was greatly affected. The organisations in the clusters experienced different levels of sustainability maturity and different levels or top management commitment.

The industrial clusters were open to funding from external financiers such as UNIDO and UNEP through the Climate Technology Centre and Network (CTCN). In addition, industrial clusters benefitted from technical support through Industrial Waste Audit Programme which were sponsored by Environment Africa. Whilst cluster members finance their activities on CE, it was also observed that they sometimes benefitted from support emanating from not-for profit organisations. The only major challenge was that most of the technical support was restricted to assessments and audits evaluating areas of improvement and very little was focused on financing the identified areas of improvement. As a result, most network actions and recommendations on CE went without implementation. The self-financing models to finance identified CE options did not gather much success, especially when most organisations were facing operational challenges and financial constraints.

4.6. Communication and knowledge management

The means of communication implemented by the industrial clusters included *"cluster meetings"* and written communication to network members. Social media was also used as means to communicate knowledge. However, there were no databases of CE performance or resource efficiency measures for the clusters. The effectiveness of these measures was not being tracked or assessed. Through the cluster events such as trainings, seminars and cluster audits, it was possible to carry out communications on CE and sustainability related concepts.

A knowledge management strategy has not yet been developed and information is transferred from one member to the other on ad-hoc basis. Organisations generally shared CE information, but avoided information which was proprietary to their operations due to fears of industrial espionage.

4.7. Key activities and project implementation

Waste audits were undertaken as a project undertaken in collaboration with a local non-governmental organisation called Environment Africa. Some of the key findings from the waste audits included the following – recycling opportunities, reduced waste generation and industrial symbiosis relationships. A total of 15% of the cluster members undertook waste reductions due to the effect of the activities undertaken at cluster level. Out of the 72 waste streams which were identified, a total of 17 were recyclable. This represented 24% proportion of recyclable waste streams. This information was based on direct observation, document review and responses from cluster members and cluster representatives in the domain of the different waste types. Deriving recyclable portions of the waste streams arithmetically determined by considering the number of waste streams which were recyclable and dividing by the total waste streams identified. The most common waste

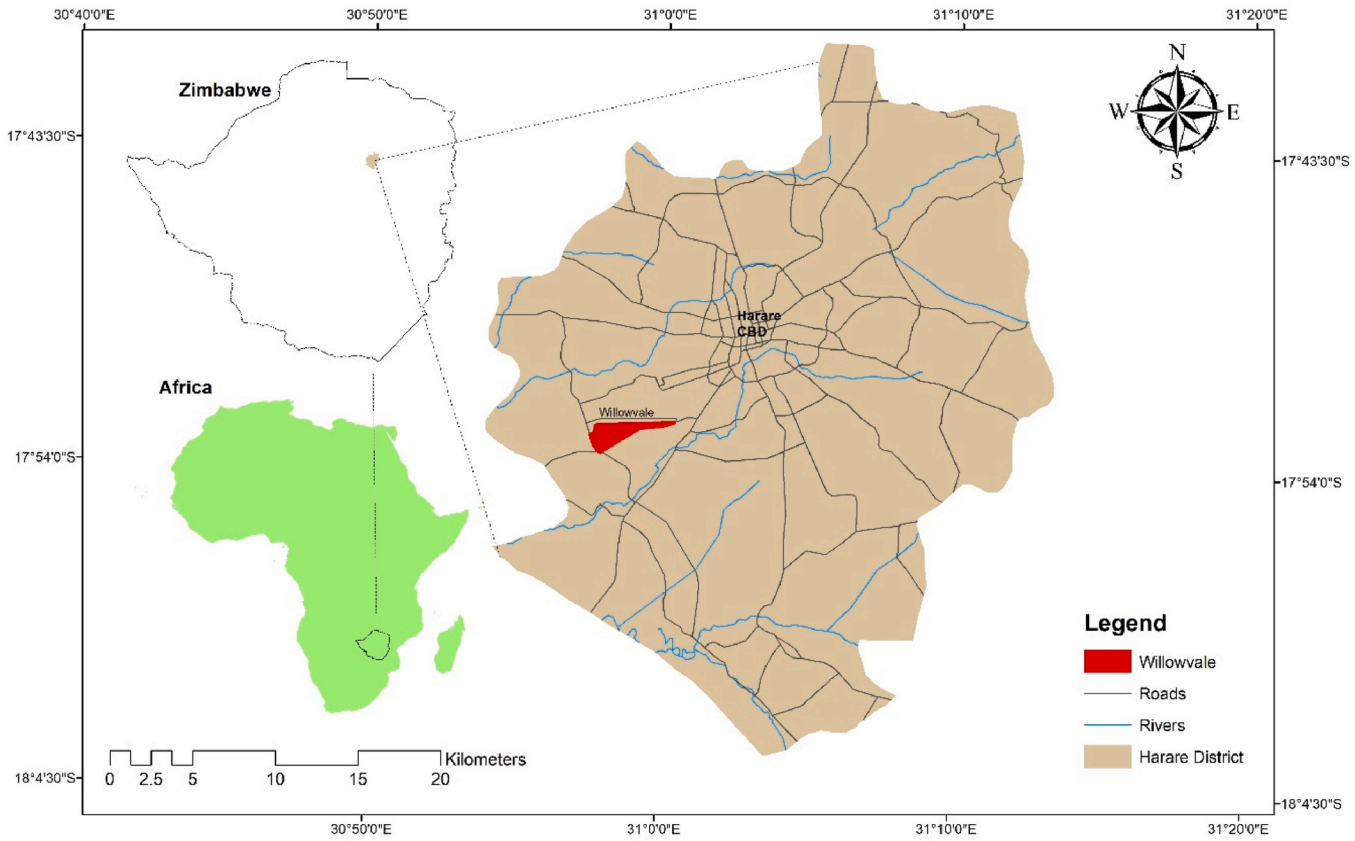

Fig. 5. Willowvale Industrial Cluster map.

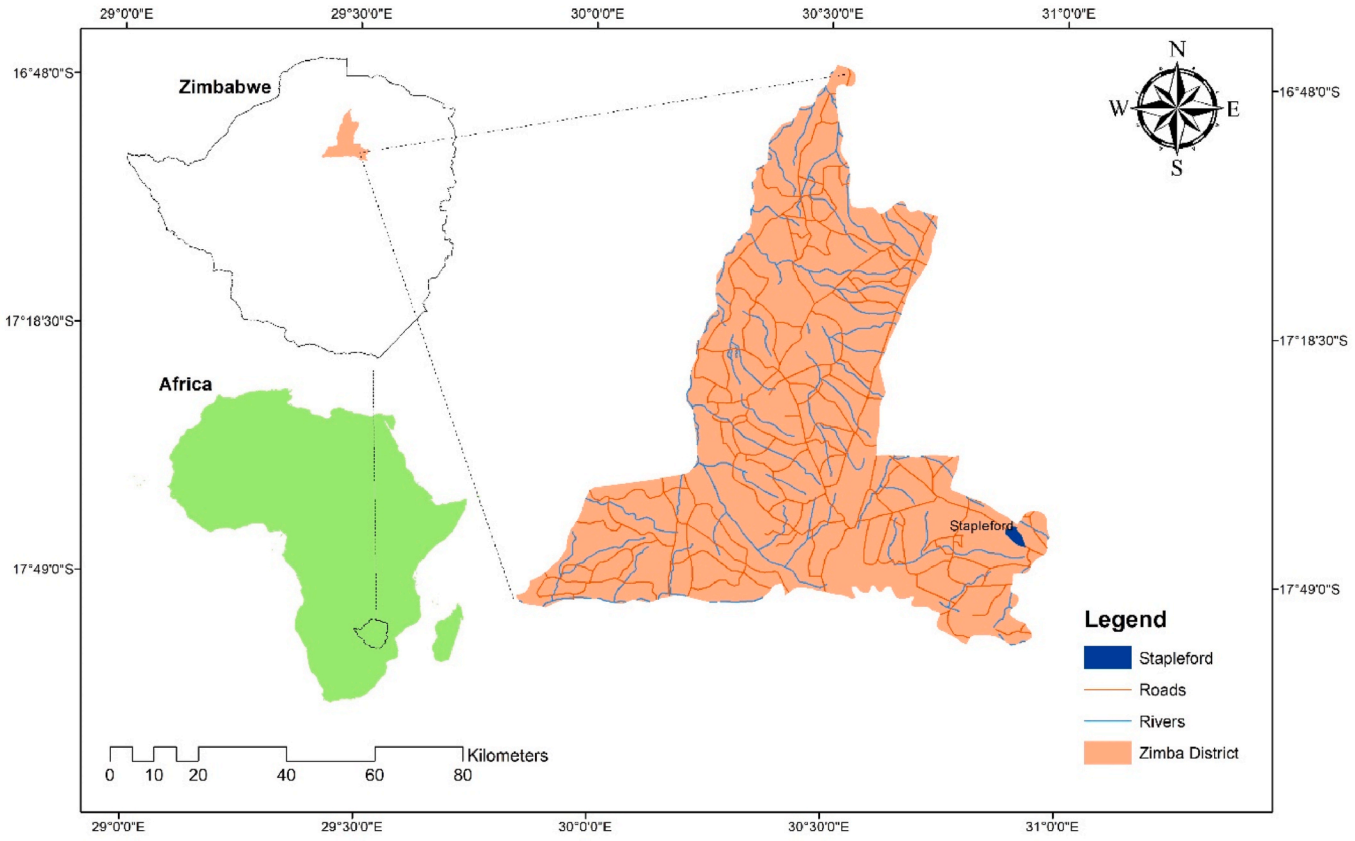

Fig. 6. Stapleford industrial cluster map.

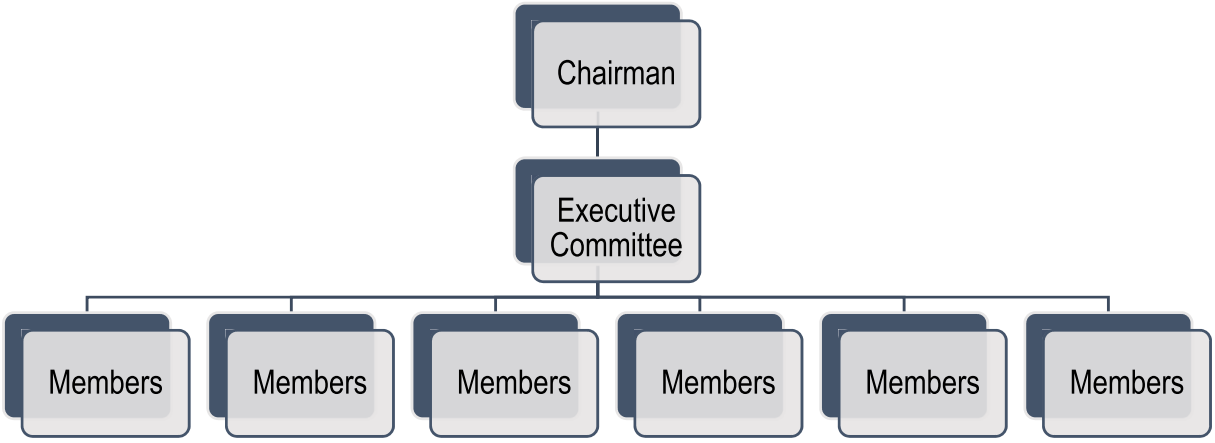

Fig. 7. Structure and Governance of the Southerton-Workington Industrial Cluster network.

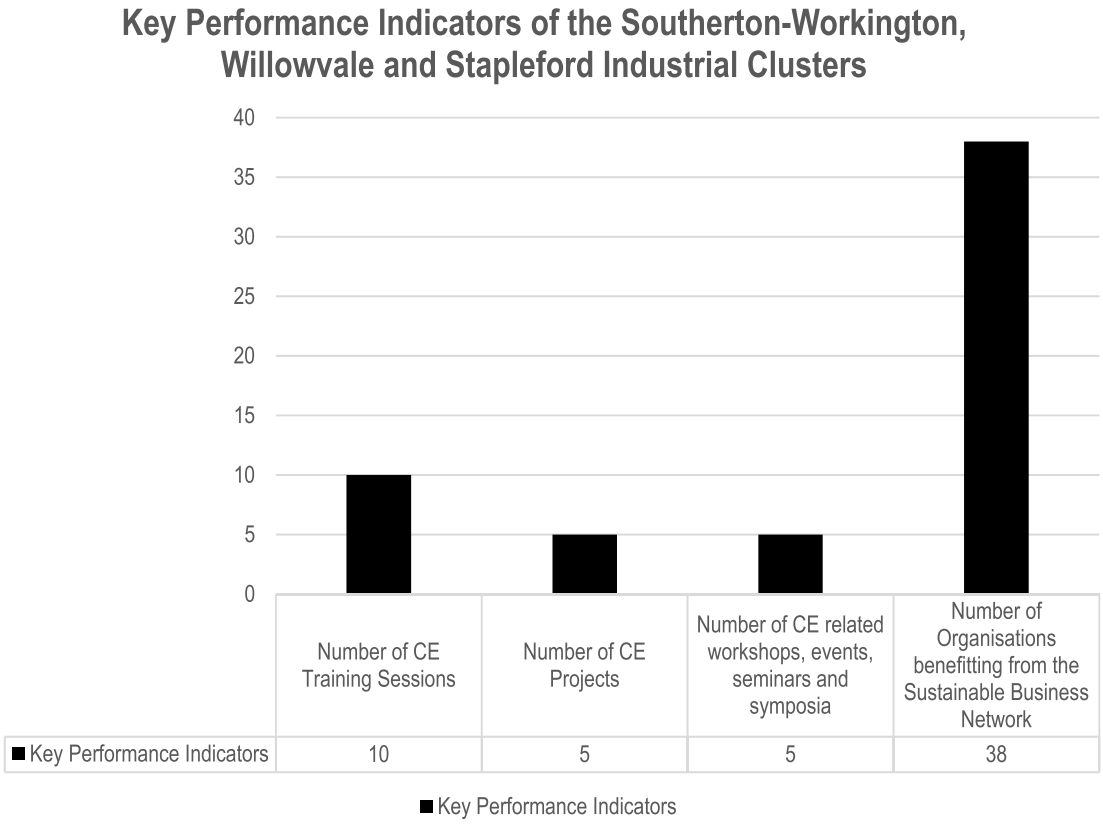

Fig. 8. Key performance indicators of the southerton-workington, willowvale and stapleford industrial clusters.

type which was recyclable, was identified as paper. In assessing the proportion of waste recycled and organisations implementing CE measures arithmetic computations were undertaken based on the responses from cluster members. These metrics were calculated based on the number of recyclable materials divided by the number of total waste streams and expressed as a percentage, in order to determine the recycling potential of the clusters. The proportion of organisations implementing waste reductions was calculated by number of organisations implementing waste reduction measures suggested by the cluster and divided by the total number of organisations and expressed as percentage.

Due to network participation, there were significant gains in energy management and renewable energy. Energy efficiency programmes at companies that were audited through the Industrial Waste Audit Programme (IWAP) were successfully implemented. A total of 2 companies managed to install 1 MW roof top solar and 5 MW solar field, soon to be connected to the national grid. This has contributed to emissions reduction and creation of green jobs within and outside the industrial clusters.

Due to the involvement in the industrial cluster, there were opportunities for industrial symbiosis in Zimbabwean industrial clusters. Table 1 shows different types of waste existing in the industrial cluster and Table 2 presents some of which had the opportunity for industrial symbiosis. A total of six types of waste were currently being used for industrial symbiosis where waste from one organisation became a raw material to another organisation. The industrial symbiosis opportunities were still in their infancy and require further development in terms of technical design and business models for their promulgation.

Table 1
Waste types from selected industrial clusters in Zimbabwe which should be assessed for Circular Economy potential.

Waste Types from selected industrial clusters in Zimbabwe (72 waste types exist in Zimbabwean industrial clusters, but some of them can be classified and merged in some major 49 waste groups illustrated in this table.		
Waste poly-woven bags	Chemical waste	Empty chemical containers
Scrap metal and scrapped machinery	Waste rubble	Expired chemicals
Used transformer oil	Broken glass	Fertiliser bags
Broken asbestos	Seed chaff	Old equipment
Used HFO oil	Scrap bricks	Contaminated soil
Used hydraulic oil	Reel cores	Laboratory effluent
Oil filters	Sugar bags	Oil separator sludge
Air filters	Boiler ash	Waste building rubble
Used paint tins	Old belts	Used printer ink cartridges
Broken fluorescent light	Laboratory waste	Household waste
Used paper	Shrink wrap material	Medical waste
Used plastic	Refrigerant gases	Food waste from the canteens
Used mutton cloth	Sanitary waste	Empty beverage bottles
Waste plastic bag	Diapers	Used kaylite
Waste coal rubble		Electronic waste
Waste conveyor belts		Chicken feathers
Run-off effluent		Garden waste
		Other

Table 2
Existing cases of industrial symbiosis in Zimbabwean industrial clusters.

Waste stream	Industrial symbiosis source	Industrial symbiosis target
1) Waste Plastic	Plastic waste from brick moulding	Community organisations involved in plastic recycling
2) Waste Bones	Waste bone material from abattoir	Sugar processing organisations in other industrial clusters
3) Waste Bricks	Solid waste from brick manufacturers	Road rehabilitation by cooperative groups and individuals involved in road rehabilitations
4) Food waste	Beverage companies canteens	Farmers involved in livestock production
5) Spent grain	Beverage companies	Farmers involved in livestock production
6) Chemical waste	Waste from material from fertiliser industries	Wall finishing plaster manufacturing company

The clusters varied in their membership numbers. Southerton-Workington industrial cluster had the most number of members (25) in comparison with the other industrial clusters such as Stapleford (9) and Willowvale (4). Southerton-Workington industrial cluster showed higher activity in the area of cluster meetings as shown in Fig. 9. All the clusters were affected by the Covid-19 pandemic and their activities were greatly reduced during that time. Recently, the clusters have also adopted virtual meetings.

It should be noted that the numbers of cluster members active in each industrial cluster varies regularly due to the fact that some organisations operate and close operations at different stages of their life cycle. It can also be noted that not all organisations in the same geographic location are automatically active members of the industrial cluster. Some organisations are not involved in cluster activities even if they reside in close precincts and proximity with others of the same geographic cluster. In this case, it is not possible to attribute circular Economy improvements in those organisations to cluster network activities.

4.8. Challenges and barriers

The major challenges of industrial cluster networks in Zimbabwe is that they were conceptualised based on geographical proximity and not necessarily based on CE or Eco-Industrial Parks (EIP) models. Zimbabwean industrial clusters are not Eco-Industrial Parks. The primary determining factor of their formation was the zoning of industries, away from residential and commercial properties. Therefore, the major challenge is to convert these industrial clusters into havens of a Circular Economy. This process is an arduous task which requires organisational cultural transformation.

The diversity of organisations and sectors of companies which are in the clusters is a major obstacle in standardising approaches and facilitating a CE transition. The few companies leading on CE as well as industrial symbiosis, include fertiliser, food and beverages companies. Some members in the identified industrial zones of the clusters do not cooperate with those coordinating the industrial clusters in areas of CE.

Financing is a major obstacle for implementation of initiatives suggested by the network. This barrier is common with previous research in other jurisdictions by (Hina et al., 2022). The research observed that network members undertook environmental audits and site visits at each other's industrial facilities. Whilst these audits and visits were very well organised by the network committees, not every network member was implementing these CE measures due to lack of financial resources to finance green technologies. The audits from Southerton-Workington industrial cluster included those with environmental management,

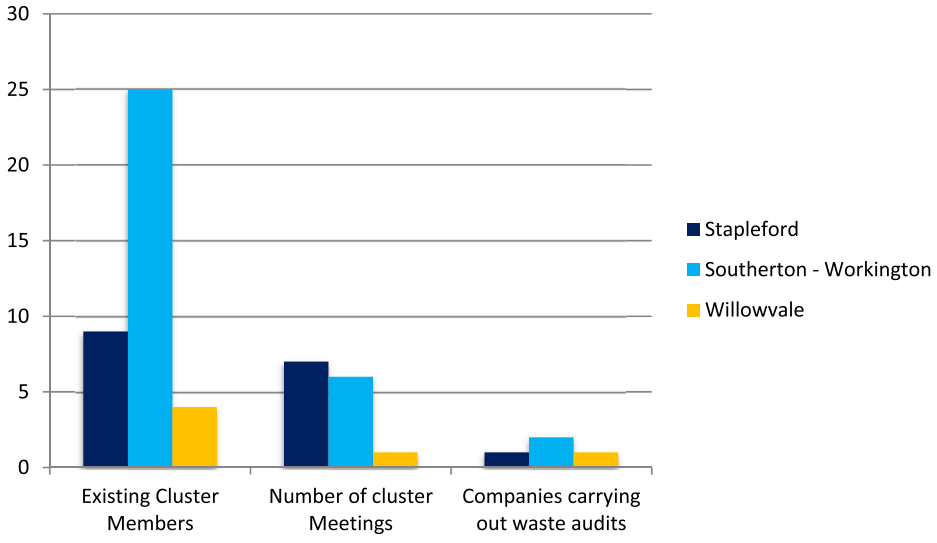

Fig. 9. Comparative analysis of industrial clusters.

legal compliance and waste audits. Under the support of the Climate Technology Centre and Network (CTCN), some of the cluster network members benefitted from energy and water audits which were organised in collaboration with the Business Council for Sustainable Development Zimbabwe.[1] In order to overcome the barrier of financing, the need to further collaborate with external partners, government and other partners to fund these CE initiatives is necessary. The involvement of local banks in the CE discourse at national level is also considered as a strategy for overcoming barriers.

Policy barriers were also cited as a hindrance to the success of the network due to limited financial incentives for undertaking CE activities at company level. The lack of incentives made it difficult to convince top management within organisations about the importance of Circular Economy. Those organisations which overcame barriers related to resistance by management included those which were part of Multinational Corporations (MNCs). The MNCs had robust measures to manage environmental and social risk through the supply chain. The sharing of standards was possible from developed countries to developing countries such as Zimbabwe. As a result, the research observed that there were other factors beyond network participation which were responsible for an organisation's CE performance.

Due to the fact that CE is a complex concept requiring clear elucidating and explanation within clusters, there was lack of adequate technical capacity to implement CE. A number of activities such as *"waste auditing initiatives", "chemical management training", "industrial symbiosis" and "chemical leasing"* were undertaken as a way of bridging the gap between theory and practices. (Hart, 1995) already elaborated the fact that implementation of sustainable development initiatives requires *"tacit knowledge"*. (Mbohwa et al., 2010) confirms the capacity challenges especially in the areas of wastewater management in Zimbabwean industrial clusters. The results also are in agreement with (Mudavanhu et al., 2013) who cite capacity to implement chemical management practices in SMEs still persist. In this regard the findings of this research coincide with the assertion of the aforementioned researchers.

Ownership of the industrial cluster was a challenge as there was low ownership amongst cluster members. There were also views that the organisations which supported industrial clusters needed to take greater ownership of the industrial clusters and CE activities. However, this strategy is not effective as there is need to have ownership by the members of the industrial clusters themselves.

The effectiveness of CE cluster activities related to waste management was affected by lack of continuity at organisational level of selected cluster members when SHEQ[2] practitioners changed organisations and at times relocated to other countries. The feedback from the cluster members also pointed to the need for more ownership of the clusters, including the provision of resources for cluster meetings by partner organisations. However, sustainability of networks cannot be scaled up by external forces.

There is need to establish a new strategy and ownership of the cluster concept. The incentivising of the clusters, especially the host organisation or the industries carrying out major coordination of the cluster must be considered. However, looking at the experiences and other global networks such as the Global Resource Efficient and Cleaner Production Network (RECP-Net), overdependence on external support, such as from donors may be good in the interim, but in the long-run is not sustainable and the network may collapse without programme funding. The fact that some industrial cluster activities for Southerton-Workington, Stapleford and Willowvale were anchored on an external agent supporting them, when the support is limited or discontinued, the network dynamics and effectiveness are greatly affected.

Lack of cooperation was one of the barriers that affected the scaling up of CE in all industrial clusters. Implementation of CE was concentrated in companies that were following cluster activities and those that were focused on network cluster activities. Some organisations still exist in the clusters but were inactive on cluster activities. The main challenge is how to convince them to participate in cluster activities including those related to CE.

The lack of adequate training opportunities on CE was cited as one of the major hindrances to the attainment of sustainable development in Zimbabwe. There were different training needs within the clusters, including limited knowledge on.

- Accurate waste measurement and recording
- Identification of waste
- Waste reduction methods
- Waste separation and recycling options
- Collection of baseline data
- Establishing the impact of waste reduction measures
- Definition of the whole scope of waste auditing as well as profit generating practices from waste management.

Through network participation, some of these activities were beginning to improve greatly. In some organisations, there was low priority of industrial cluster activities and also restrictions by members of top management to send representatives to cluster activities. Such organisations lagged behind in the adoption of CE and hindered network growth.

4.9. Drivers

In Zimbabwean industrial clusters, there were a range of drivers to network participation ranging from legal compliance, market pressures and organisational culture. Some of the cluster members were part of international organisations which had a strong blueprint on waste management. As a result, there was a high level of compliance with the international standards of the organisations that had international parent companies. Some of the organisations were producing products such as beverages under licenses from MNCs and therefore were required to follow the sustainability requirements of these parent organisations.

The need to export goods and services compelled many organisations from the industrial clusters to start adoption of CE measures. Within the Southerton-Workington, Stapleford and Willowvale industrial cluster networks; most organisations were focused on promoting the export of their products and services. In order to do that, the organisations were required to be sustainable. Within the Southerton-Workington, Willowvale and Stapleford clusters, there were activities related to management systems such as ISO 14001:2015, ISO 9001:2015 and ISO 45001:2018. Due to network participation, a number of organisations were working on developing ISO certification in order to protect environmental resources. Some of the drivers noticed in Zimbabwean industries were similar to research by (Hina et al., 2022). Differences in the priorities of network actors despite geographical proximity were also observed and draw similar experiences from (Tura et al., 2019).

The other major driver of industrial clusters was the proximity benefits on transportation of waste from one organisation to another. Due to the fact that the clusters were located in one city, it was possible to establish linkages for industrial symbiosis. Evidence was noted through the provision of waste streams such as PET to recycling firms located in the city. Further examples included the transportation of chemical waste from fertiliser companies to organisations involved in the manufacturing of wall finishing plasters. Brick waste and used

[1] The Business Council for Sustainable Development Zimbabwe (BCSDZ) is a Sustainable Business Network consisting or over 100 members. It is a Global Networking partner of the World Business Council for Sustainable Development (BCSDZ). It was formed in 1993 by a group of CEOs focused on sustainability.

[2] Safety, Health, Environment and Quality Management practitioners are mostly tasked with activities related to waste management and Circular Economy Initiatives.

plastic were also transferred for road rehabilitation and recycling respectively. The realisation of the proximal advantages of industrial clusters also acted as a driving and motivating factor for geographically induced networks of collaboration. The resultant cost reduction for recipient organisations and the time saving benefit were also of higher level significance. This facilitated greater opportunities for attaining Circular Economy.

4.10. Effect of governance, ownership and technical capacity on the success of industrial clusters

From the empirical information drawn from the industrial clusters, all the three industrial clusters had network leadership to govern the operations of the cluster. However, there were no oversight bodies such as boards which could provide direction to the industrial cluster. Therefore, executive committees were the ones driving the network. In some cases, failing to arrange industrial cluster activities resulted in apathy and limited participation. Due to the lack of subscription in some of the networks such as the Willowvale, Workington-Southerton and Stapleford clusters, the financing of cluster activities was a common challenge. Therefore, effective programmes of pollution prevention were not possible, unless under the financing of external institutions such as Environment Africa. This depicted limited ownership by the network actors. Cluster members have to some extent sustained networking activities beyond Environment Africa and development partners, albeit lower consistency and lower financing regimes. This research proposes subscriptions and innovative financing models even in geographically associated industrial clusters to deal with the issue of resource mobilisation for CE activities. Due to varying multiple country contexts, the effectiveness of such measures will vary significantly from one country to another.

4.11. Evaluation of industrial clusters based on the OECD DAC Evaluation Framework

Through the document review, key informant interviews and observation of industrial clusters, several aspects were evaluated. The five evaluation criteria were analysed based on the network activities and impact. There were many conclusions and deductions derived from the evaluation of the clusters. Table 3 presents the rating of the industrial clusters based on the empirical results drawn from the different clusters.

Table 4, presents a comparative analysis of the industrial clusters and analysis of some of their composition, governance models, CE activities, barriers and business models. Comparing the clusters, shows that Workington-Southerton and Southerton clusters are predominantly dominated by industry, whereas Stapleford cluster is a bit different as it is a hybrid of industry and the community. The combination of industrial and community stakeholders presented both opportunities and challenges to the cluster and the need to consider multiple stakeholder needs in implementing Circular Economy activities. All the three clusters face financial challenges to support CE project implementation and this is occasionally alleviated through partnerships with organisations such as Environment Africa and Climate Technology Centre and Network (CTCN). Other barriers include the technical capacity on implementing advanced concepts such as industrial symbiosis and Circular Economy. There are challenges related to the management of fluorescent tubes, which is prevalent across all the industrial clusters as indicated in Table 5. Furthermore, the ability to implement wastewater management remains a perennial challenge amongst the industrial cluster members. Some of these challenges could be as a result of financial barriers facing cluster members. The attainment of CE and industrial symbiosis is also greatly hindered by low institutional capacity within the cluster members and therefore, the emerging usage of waste management contractors for waste recycling activities and waste collection in order to close the loop. As illustrated in Table 5, within the studies industrial clusters, a total of 10 contractors were identified. This demonstrates that when industrial clusters have limited capacity for Circular Economy, they can transfer this responsibility too external providers.

Table 3
Evaluation of Zimbabwean Industrial Clusters using the OECD DAC Framework.

Evaluation Criteria	Assessment	Reasons for the classification
Effectiveness: The ability to attain set objectives	Moderately High	The effectiveness of the industrial clusters is moderately high due to the evidence shown in waste reductions and identifying recycling options.
Efficiency: Ability to properly use allocated resources	Very High	Clusters in Zimbabwe are able to undertake their networking activities with minimal or no financial resources spent. Where resources are allocated for technical assistance, there is an ability to support members.
Relevance: Appropriateness of the intervention to the beneficiary needs	Very High	The thematic topics addressed by the clusters, including waste management, industrial symbiosis and Circular Economy are relevant to the developmental and industrial needs of Zimbabwe
Sustainability: The ability to continue with the benefits beyond external support.	Very Low	The sustainability of Zimbabwean industrial clusters is very low. This is due to the fact that without financing from development partners, most of them are not able to implement significant circular economy activities. The lack of a financing model for the clusters limits their ability to implement high cost initiatives. Some of the benefits related to circular economy capabilities may not last beyond projects initiated by external stakeholders. Ability to convene beyond external actors is also very limited.
Impact: The changes that the intervention can make	Moderate	In selected areas, they succeeded, such as waste reduction and identification of industrial symbiosis measures. However, on high cost waste prevention and management measures, implementation was low.

5. Discussion

The highest number of cluster members is noticed in Workington-Southerton cluster (25) followed by Stapleford (9) and Willowvale (4). With regard to the activities of the cluster meetings, Stapleford had seven cluster meetings annually, whereas Workington Southerton had six cluster meetings and Willowvale had one cluster meeting. Convening cluster meetings is an essential building block of ensuring that the cluster remained active. Different constraints were cited as responsible for the existing pattern including, availability of time, availability of hosting facilities and ability of the network leadership to convene members. These factors varied from one cluster to the other. From the results, Workington-Southerton and Stapleford, show greater activity as compared to the Willowvale cluster. Waste streams varied from recyclable to non-recyclable materials depending on the type of industry. Some organisations took advantage of geographical proximity to forge partnerships for industrial symbiosis.

The results show 15% reduction in waste due to implementation of waste reduction measures from the Industrial Waste Audit Project. The

Table 4
Comparative analysis of industrial clusters.

	Workington-Southerton	Stapleford	Willowvale
Number of active members assessed	25	9	4
Composition	• Industry	• Industry and Community *(Hybrid industrial cluster)*	• Industry
Leadership and Governance	•Chairperson and Committee •No oversight bodies	•Chairperson and Committee •No oversight bodies	•Chairperson and Committee •No oversight bodies
Business model	•No subscription •Self-financing of CE measures •External financing from development partners such as Environment Africa and CTCN •Support from civil society organisations such as Environment Africa	•No subscription •Self-financing of CE measures •External financing from development partners such as CTCN •Support from civil society organisations such as Environment Africa	•No subscription •Self-financing of CE Measures •External financing from development partners such as CTCN •Support from civil society organisations such as Environment Africa
Level of CE cluster activity	•High	•Moderate	•Low
Approaches to promote CE	•Audits •Training and awareness •Cluster meetings •Cluster meetings	•Audits Training and Awareness •Community and Industry exchange activities •Waste exchange e. g. bone char and sugar processing industries exchange	•Audits •Training and Awareness •Cluster meetings
Barriers	•Financing •Technical capacity on CE •Diversity of industries and different priorities on CE Interventions •Dependence on external support	•Financing Geographical proximity of the cluster from other industries makes it difficult to facilitate waste exchange and industrial symbiosis as it is located out of the industrial zones of Harare •Dependence on external support •Demands of the community, which may not align with priorities of industry	•Financing •Technical capacity on CE •Diversity of industries and different priorities on CE interventions

number of organisations participating in the industrial clusters does not include all the organisations which are in the industrial cluster. This leaves other organisations located in the same industrial zone not getting access to circular economy technical assistance. It can be observed that geographical proximity alone does not determine the success of networks for sustainability.

The results show that Workington-Southerton, Stapleford and Willowvale clusters are self-financing. Without external support, the industrial clusters are failing to implement advanced circular economy measures. Previous studies on industrial clusters in Zimbabwe (Mahuni and Bonga, 2016; Mbohwa et al., 2010) failed to explain the effect of business models of industrial clusters on the ability to deliver CE improvements at company level. The self-financing business model of the industrial clusters is not yielding significant results as many organisations are affected by financial barriers and macro-economic pressures as a result of lack of resources.

The involvement of external organisations such as Environment Africa and the Climate Technology Centre and Network (CTCN) supporting network members via the Business Council for Sustainable Development Zimbabwe (BCSDZ) acts as a stimulating factor to the network actors. Projects such as the Industrial Waste Auditing Project supported by Environment Africa act as catalyst to the organisations involved in the clusters. However, the external support by development partners is not sustainable in the long run if the network actors do not take ownership of the activities of the network and industrial clusters.

It terms of undertaking activities, the Workington-Southerton industrial cluster seems to be the most active in comparison to other clusters, whilst industrial clusters like Stapleford have active CE initiatives with both industry and the community. However, the Willowvale industrial cluster seems to have very low activity and requires enhanced support and resuscitation if networking is to be effective.

All industrial clusters in Zimbabwe require governance regimes, technical capacity, ownership, communication and documentation of case studies in order to stimulate a sustainable business case. Consistent execution of CE network activities is also a key strategy in recruiting, maintaining and developing a cohort of organisations with active participation.

Whilst many stakeholders are attempting to convert the industrial clusters of Zimbabwe into Eco-Industrial Parks (EIPs), this will not be an easy task as they were designed as industries in geographical proximity to each other. A combination of factors to stimulate collaboration will be required such as financing, legal, policy, communication and technical assistance.

6. Conclusions

6.1. Final remarks

The research concludes that industrial clusters have a role to play in promoting Circular Economy transition in developing countries such as Zimbabwe. Through awareness activities, capacity building and waste audit projects, there was concrete effort towards attaining a CE. However, the results of networking in industrial clusters is not significantly higher than those which organisations network in a dispersed manner away from each other. Implementation of Circular Economy initiatives is greatly influenced by network governance, corporate strategy, financing, leadership, communication and knowledge management.

Based on empirical evidence from the research, it can be concluded that industrial clusters can facilitate uptake of industrial symbiosis and waste exchange as evidenced in Zimbabwean industrial clusters. We conclude that there is an opportunity for recycling 24% of waste generated from industrial clusters in Zimbabwe. We conclude that 15% of cluster members implement CE measures from cluster activities and the effect of the Industrial Waste Capacity Building Project. Similar studies in Zimbabwe industrial clusters estimate a range of 15%–25% (Madanhire and Mupaso, 2018) who had estimated waste reduction in industrial clusters but however, had not explained the business models under which these were attained and the appropriate governance regimes deployed. Whilst this performance is encouraging, it needs to be scaled up if Zimbabwe is to accelerate towards CE transition.

We conclude that six (6) waste products are already being used for industrial symbiosis, but more waste could be enrolled to harness industrial symbiosis. Future research should focus on assessing factors which may stimulate network participation in industrial clusters beyond geographical proximity. It is also essential to research on the factors that improve network participation and increase adoption of CE measures.

The most popular business models of industrial clusters include self-financing of CE activities in combination with external support from development partners. There was more impact of externally financing initiatives in comparison to self-initiated activities by the network

Table 5
Empirical information about Zimbabwean Industrial cluster networks.

Empirical information about Zimbabwean industrial cluster networks
1) Industrial clusters generated more than 72 different types of waste materials
2) Ten (10) contractors were involved in managing waste on behalf of cluster members
3) Proportion of waste recycled is approximately 24%
4) Paper is the leading waste stream in industrial clusters.
5) In currently sampled industrial clusters, an average of 1500 people; are employed per every 5 members at full capacity, but this varies due to operational challenges facing organisations.
6) The most common challenge affecting industrial cluster networks is the issue of managing waste fluorescent tubes.
7) Capacity for Wastewater management is currently still very limited and also affected by availability of financial resources to invest in advanced wastewater treatment technologies
8) Currently the average number of cluster members is 13 members per cluster.
9) Safety Health and Environmental practitioners are normally tasked with the responsibility of carrying waste management activities including waste audits and participating in cluster networking activities.
10) At least 6 waste materials are being utilised for waste exchange as raw materials to other industrial processes and this presents a model of industrial symbiosis.

members themselves as shown by the evaluation of the Industrial Waste Audit Programme.

The ownership of the clusters is debatable, as stakeholders consider the members to own the clusters, whereas other stakeholders still perceive partner organisations that financed network activities as owners of the clusters. Without subscriptions, the clusters cannot build resources to finance activities and at the same time if that was to happen, there is no mechanism to exclude other organisations which are in the same geographical proximity.

The barriers faced by industrial clusters in promoting CE are mainly financial related, due to lack of monetary resources to implement CE. In addition, clusters are also faced with governance and structural issues such as lack of goals that identify members and also lack of oversight bodies. Limited awareness of CE concepts also calls for greater focus on awareness and technical assistance.

As a networking model, the industrial cluster concept in Zimbabwe is gaining good ground for success, but it does not outperform other networks which are geographically dispersed. Industrial clusters must take advantage of their geographical proximity to scale up the Circular Economy. They also need to develop strategies and financing models to ensure that they attain sustained impact. Furthermore, industrial clusters in Zimbabwe are not Eco-industrial parks as they were designed with geographical proximity in mind, rather than with a consideration of ecological possibilities such as those inspiring CE transition and industrial symbiosis.

6.2. Theoretical contributions

Theoretical contributions of the research pertain to the conclusion that effective and viable business models are required to ensure industrial clusters are well resourced and can finance their CE activities. Further theoretical contributions pertain to the need for stronger and robust governance regimes beyond the secretariats in order to develop strategic CE initiatives and oversight.

6.3. Practical contributions

Practical contributions of the research pertain to new approaches of overcoming barriers and challenges as well as emerging business models of running industrial clusters. New governance regimes associated for coordinating the industrial cluster networks are brought to the fore by the research. Practical applications of evaluation criteria such as OECD DAC, has demonstrated that networks can be evaluated in the same manner that projects and programmes can be evaluated. Superimposing project and programme evaluation criteria onto organisation performance criteria is a key practical contribution that is not very common in developing African countries such as Zimbabwe.

6.4. Limitations

The limitation of the research pertains to the fact that the research was based on a specific number of Case Studies, namely Workington-Southerton, Willowvale and Stapleford Industrial Clusters. The findings from the research of the aforementioned case studies may not be exactly the same in different country contexts under different policy, legal, monetary and geographic conditions. Furthermore, due to the fact that the research is based on geographically associated network, the results may vary in the case of different networking modalities. The limitations of the research include the fact that the research was limited to the specific geographic case studies and in the context of Zimbabwe. These findings may be different in other countries with different policy, governance and financing regimes. The other limitation is that there were not many industrial clusters in Zimbabwe, apart from the capital city of Harare and other parts of the country which are rural do not have industrial clusters. In some enterprises, there was a general insecurity and suspicion of what the intentions of the study were and how information of their environmental performance would be utilised. In various enterprises, there was limited quantification of waste streams, thereby reducing the level of accuracy of the data that was presented by some enterprises. This also made it difficult to benchmark the performance of selected enterprises in line with international levels of performance. The diversity of activities within the various clusters makes it generally difficult to compare different industries due to the differences in the raw materials and processes. There was also limited data on waste, as various organisations are at different levels of development in their waste quantification, waste management and knowledge management systems. However, despite the limitations, the study was carried out effectively and derived a lot of practice oriented findings in the field of waste auditing and waste management and hence managed to address some of the limitations.

6.5. Opportunities for further research

There are opportunities for further research with respect to industrial symbiosis in industrial companies in Zimbabwe. Furthermore, there is need for more case studies on the geographic proximity and Circular Economy implementation and to prove or disapprove this aspect in multiple contexts. There is an opportunity for researching on product development in industrial clusters especially those that generate a significant amount of waste streams. Research must focus on how these products can be brought to viability and sustainability through network collaboration. There is also scope for further research on the effect of geographical proximity and uptake of Circular Economy practices. The business case of geographically clustered networks warrants further research in multiple country contexts.

6.6. Scientific value

This research has extended knowledge on business models for inter-organisational collaboration and business models for networks. The research has extended the knowledge on how to make industrial clusters more financially viable and how to enhance the impact of their programmes. Contrasting previous research, the main advancement is that industrial clusters should have financing models beyond merely relying on members to finance their own CE activities and occasional donor financing of cluster activities. Robust financing models such as subscriptions and building a reserve fund for CE innovation is necessary. Previous studies have not focused on how the industrial clusters can be viable and self-sustaining. In addition, previous research has not focused on governance and leadership of industrial clusters. Therefore, the main advancement in research demonstrates the need for improved organisational structures of the industrial clusters, including oversight bodies such as cluster boards. In order to strengthen CE practices, we propose improved capacity building of cluster members, Public Private Partnerships, establishment of a mechanism to pool cluster financial resources for CE, establishment of cluster Boards and improving ownership of the industrial clusters through facilitating participation by cluster members. The scientific value of the research lies in the identification of proven effects of network collaboration on the waste management practices of industrial clusters and characterisation of an emerging business case. Further scientific insights relate to the need for networks to grow their financing models beyond financing organisations and developing partners; in order to attain long term viability. In extending knowledge, this research affirms the notion that success of network collaboration si influenced by other factors beyond mere, convenience of geographical location. Governance regimes, business models, network structure and cognitions also play a leading role in determining network success. Whilst geographical location can facilitate reduction in transport costs for industrial symbiosis and transfer of waste from organisation to another, it is more important to nurture the relationships amongst organisations, in order to develop a sustained impact. Most research on industrial clusters has been focusing on the benefits of clustering, whilst missing the point in literature that there are other factors which influence network success. This research extents research by delving into the factors that facilitate network success beyond mere geographical proximity.

CRediT authorship contribution statement

Tawanda Collins Muzamwese: Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Laura Franco-Garcia:** Writing – review & editing. **Michiel Heldeweg:** Writing – review & editing.

Declaration of competing interest

The authors declare that there are no competing interests with regard the research, that could influence the outcomes of this paper.

Data availability

Data will be made available on request.

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Appendix A. Supplementary data

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