Herath, P., Dissanayake, P. and Thisakya, G., 2023. The potential of industrial symbiosis: An analysis of barriers to its implementation for better waste management in industrial zones in Sri Lanka. In: Sandanayake, Y.G., Waidyasekara, K.G.A.S., Ramachandra, T. and Ranadewa, K.A.T.O. (eds). *Proceedings of the 11th World Construction Symposium*, 21-22 July 2023, Sri Lanka. [Online]. pp. 1064-1078. DOI: https://doi.org/10.31705/WCS.2023.85. Available from: https://ciobwcs.com/papers/

THE POTENTIAL OF INDUSTRIAL SYMBIOSIS: AN ANALYSIS OF BARRIERS TO ITS IMPLEMENTATION FOR BETTER WASTE MANAGEMENT IN INDUSTRIAL ZONES IN SRI LANKA

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ABSTRACT

Industrialisation has led to a massive increment in resource consumption and waste generation, which demands improved management strategies for Waste Management (WM), especially in Industrial Zones (IZ). Thus, the application of Industrial Symbiosis (IS) in an IZ is demanded as a solution. It is a collaborative approach in which different industries and organisations work together to create a closed-loop system that maximises resource efficiency, reduces waste, and improves environmental sustainability. Sri Lankan IZs still have not yet established a proper method to manage industrial waste, which has led to heaps of waste. Since IS is an effective and timely solution for this issue, this paper was intended to analyse barriers to the potential implementation of IS for better WM of IZs in Sri Lanka. A qualitative research approach with two case studies were used in this study. A total of 12 interviews were conducted and collected data was analysed using code-based content analysis. The barriers were extracted through the analysis of case findings using an abductive analysis. The empirical findings revealed 34 barriers under six categories, namely economic, organisational, regulatory, technological, risk and information. The higher initial cost, lack of financial ability, competition among participants, unavailability of institutional support, and lack of regulatory incentives for IS initiations were some of the key barriers identified in this study. The knowledge generated through this research can be used by respective industry practitioners to take informed decisions in addressing these barriers, which will be crucial to unlocking the potential of IS in IZ.

Keywords: *Barriers; Industrial Symbiosis (IS); Industrial Waste (IW); Industrial Zone (IZ); Waste Management (WM).*

1. INTRODUCTION

There is an emerging need for a system to recover waste for secondary uses where it lowers the cost of manufacturing, enables efficient use of resources, encourages eco-friendly product designs and ultimately it minimises the environmental and human health issues (Mohamed, 2009). In this context, Industrial Symbiosis (IS) concept is raised as a

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suggestion for waste management (WM) in Industrial Zones (IZs) through resource optimisation. IS enables industries to shift to a circular model where waste generated from one organisation is transformed into another organisation as its feedstock and vice versa (Bocken et al., 2016). IS engages a variety of organisations in different sectors in a network to bring up long-term culture change and eco-innovation through facilitating the creation and sharing of knowledge for novel sourcing of inputs, value adding usage of non-product outputs, and enhancing the efficiency and effectiveness of business and technical processes (Lombardi & Laybourn, 2012).

In the process of facilitating and developing a robust IS network, it is increasingly important to have a greater understanding of barriers applicable to the development as it plays a critical role in the context (Domenech et al., 2019; Paquin & Howard-Grenville, 2012; Södergren & Palm, 2021). The previous research studies identified that the reason for most of the catastrophes in IS projects is due to the inability in identifying the barriers that could arise during the implementation. Hence, despite the abundance of research on IS networks, a gap in the literature could be identified, when it comes to exploring the barriers of implementation of IS networks. This has become a timely requirement in bridging this knowledge gap to boost the successful implementation of IS networks in Sri Lanka. Therefore, this paper aimed at analysing the barriers to the successful implementation of IS networks in IZs of Sri Lanka.

2. LITERATURE REVIEW

2.1 WASTE MANAGEMENT DEFICIENCIES IN INDUSTRIAL ZONES

The phrase "IZ" refers to a vast tract of land that has been subdivided and constructed for the simultaneous use of numerous enterprises, distinguished by shared infrastructure and close proximity of organisations (Chertow, 2000). Rather than solely providing products to consumers, IZs enable a large percentage of employment, community presence, and economic strength (Duflou et al., 2012). Even though, being recognised as most visible morphological form of manufacturing facilities (Sacirovic et al., 2019), IZs also pose challenges due to rapid development including excessive use of resources and increased pollution from industrial activity in the zones.

In IZs, improper and isolated WM procedures cause more environmental problems and spread diseases (Karunasena & Kannangara, 2012). Bandara and Hettiarachchi (2010) have identified environmental consequences of improper waste disposal as unpleasant surroundings, loss of property values, increased flooding possibilities, creating health and safety issues to public, spreading diseases, soil pollution and degradation of other natural resources. Lack of WM knowledge, high transportation cost, negative attitudes, unsatisfactory service from facilitators, lack of labour, communication inefficiencies, poor monitoring of responsible parties, financial issues, outdated strategies, poor legal enforcement for WM, and insufficient investment from government on WM initiatives are identified as main causes for prevailing WM issues in IZs (Karunasena & Kannangara, 2012).

2.2 APPLICATION OF THE CONCEPT OF INDUSTRIAL SYMBIOSIS IN INDUSTRIAL ZONE

IS seems to have found a renewed impetus in the framework of the Circular Economy (CE), a novel approach to sustainability and Sustainable Development (SD) that has been

rapidly gaining momentum worldwide (Cecchin et al., 2020). It deliberately engineered the items to be modular, robust, and recyclable, allowing for closed loop metabolism while maintaining the highest possible added value proportion (Fischer & Pascucci, 2017). CE appears to prioritise the economic system while giving direct advantages to the environment and indirect benefits to social aspects (Geissdoerfer et al., 2017). When organisations form part of a metabolism, they collaborate to create IS in which materials and energy withdrawn from one process or organisation can be used for another (Ashton, 2008). In this perspective, IS concept is utilised as the main instrument that assist in reducing industrial reliance on natural resources by expanding waste recovery (Geng et al., 2007; Mohamed, 2009). The same finding was further confirmed in a study by Islam et al. (2016) where they mentioned that IS concept is a key tool, which is used in industrial system which enhance sustainability. Several researchers such as Geng et al. (2007), Van Berkel et al (2009), Chertow et al. (2019) and Shi (2020) highlighted the efforts, which have been taken to develop IS networks in IZs to identify untapped potential of IS. For example, IZs, which are currently practicing IS are visible in Europe, Australia, North America, and Singapore, and planning for new initiatives are taken place in emerging economies like Cambodia, Colombia, China, Egypt, Costa Rika, El Salvador, Morocco, India, South Africa, Peru, Vietnam, and Tunisia as stated by Shi (2020). IZ managers of China have been adopted this concept as an innovative tool for management of industries (Geng et al., 2007). IS networks have been developed by national initiatives in Japan with the aim of revitalising industries (Van Berkel et al., 2009). According to Chertow et al. (2019), an analysis based on 1000 enterprises concludes that 84,000 tons of annual industrial waste (IW), 74,000 tons of annual carbon dioxide emissions, and 22 million litres of daily wastewater have been reduced as a result of IS applications. A vast range of benefits can be acquired by applying IS concept to IZs (Domenéch, 2010). Hence, there is an evidential background for applying IS concept to gain prospect of IW within the IZ.

2.3 BARRIERS TO THE APPLICATION OF THE CONCEPT OF INDUSTRIAL SYMBIOSIS CONCEPT

Barriers can be considered an important attribute of IS networks, which directly affect the success of developing the networks (Islam et al., 2016). Hence, it is important to have considerable concern for barriers in the application of IS concept for WM of IZs. The barriers identified through the literature review are presented in terms of six perspectives, namely, Economic, Technology, Organisational, Regulatory, Risk and Information (Refer to Table 1). According to many authors such as Paquin and Howard-Grenville (2009), Walls and Paquin (2015), Domenech et al. (2019) and Sodergren and Palm (2021), the economic, organisational and information barriers play a vital role in preventing firms from engaging in IS application. As shown in Table 1, higher initial cost and financial incapability were discovered as major economic barriers. When paying attention to the technological aspect, a lack of technical capacity and expertise was identified as the most persistent barrier over other factors by the authors. Diversified and competitive participants and a lack of institutional supports were the critical factors identified as organisational barriers in IS applications. Referring to the regulatory barriers, the main concern raised by the authors was the lack of regulatory incentives for IS initiations (Islam et al., 2016). The summary of the barriers derived from the previous studies is presented in Table 1.

Table 1: Summary of barriers of initiating IS concept

Barrier category	Barrier factor	Reference
Economic barrier	Initiation cost, transport, and logistical cost Adaptation cost to procedures, transaction cost Lack of financial ability Unknown cost-benefit ratio	[1] [2] [3] [4] [5] [6]
Technology barrier	Lack of technical capacity and expertise Rapid technological change Issues relating to waste quality Lacking infrastructure and logistical integration	[2] [3] [5] [6]
Organisational barrier	Power, status, lack of trust of participants Lack of time and spatial facilities Competition among participants Lack of environment concerns and management support Resistant to change Lack of collaboration due to isolation Lack of institutional support	[1] [2] [3] [6] [7]
Regulatory barriers	Restrictive regulations for establishment and operation Lack of regulatory incentives Difficult approval processes Conflicting regulations	[1] [6] [7]
Risk barriers	Risk and uncertainty of investments, system performance, and outcomes Risk of inter-dependency	[1] [2] [7]
Information barriers	Poor awareness on the concept Lack of information on synergistic possibilities Lack of trainings and technical information Lack of management of operational information Lack of information sharing mechanisms Lack of information of job roles and responsibilities	[2] [6] [7] [8]

[1] Walls & Paquin, 2015; [2] Domenech et al., 2019; [3] Paquin & Howard-Grenville, 2009; [4] Islam et al., 2016; [5] Bossilkov et al., 2005; [6] Södergren & Palm, 2021; [7] Domenéch, 2010; [8] Chertow, 2007

However, when it comes to the Sri Lankan context, barriers of IS network development have not been discussed in literature yet. Thus, in bridging this knowledge gap, this paper intends to discuss the barriers to the IS network development in IZs. The next section discusses the research process adapted in bridging this knowledge gap.

3. METHODOLOGY

This study intends to analyse barriers to the successful implementation of IS networks in IZs of Sri Lanka. Accordingly, the research question was developed as follows.

> ***RQ:*** *"How could barriers influence the successful implementation of IS networks in industrial zones?*

Yin (2009) suggested that a research approach has to be selected based on the type of research question, the extent of control an investigator has over actual behavioural events and the degree of focus on contemporary or historical events. Since, this research followed an in-depth exploration of the contemporary phenomenon within its real-world

context, with a "How" type of research question, a case study research strategy could be justified. A multiple-case design was selected as this research area is broad and not limited to a certain industry as it focuses on IZs where variety of industries are operated with "application of IS concept for WM in IZs" as the unit of analysis.

Yin (2009) recommended that the number of cases should be decided based on literal replications and theoretical replications expected through the study. Following such argument and the robustness of the data collection techniques used with proper data triangulation, similar two IZs were selected as the cases expecting literal replications. Further, the high data saturation experienced during data analysis justified the adequacy of the number of cases selected. The profile of selected cases is given in Table 2.

Table 2: Profile of case studies

Case	Area (in acres)	Number of Factories	Number of workers	Main categories of factories operated	Estimated waste generated per year
A	531	86	39,000	Hi-end apparel, rubber production, electronic production	21,328 tonnes
B	450	77	26,000	Fabric production, rubber productions, chemical production, printing services, and ceramics	38,487 tonnes

Referring to both cases, "handing over to scavengers" and "co-disposal" are commonly used WM strategies where the ultimate disposal mechanism is questionable. Moreover, "landfilling" and "incineration" are practiced as waste management strategies, which have a huge effect on biodiversity. In addition to that, "3R strategy", "life cycle assessment", and "green purchasing" are used as WM strategies, which cover only a small portion of waste generated at IZs. Only a few organisations adhere to advanced strategies such as "cleaner products", "eco-designs" and "extended producer's responsibility" for WM. A higher portion of waste generated at IZs is being open dumping, open burning, or incinerated. These inappropriate WM practices at IZs are a huge threat to the environment and create public nuisance and severe health issues.

A total of 12 semi-structured interviews were conducted, with six personnel from each case (Refer to Table 3). The number of interviews was limited by the fact that there are no experts on IS network development since practical applications have not been implemented yet in Sri Lanka. The interview guideline focused on 27 barriers identified through the literature review. Respondents were requested to elaborate their answers based on their current exposure to the barriers.

Table 3: Respondent's details

Case	Respondent Code	Years of experience	Designation
A	A1	6 years	Senior Manager - Environmental Sustainability
	A2	5 years	Assistant Manager - Sustainability
	A3	3 years	Executive - Sustainability
	A4	3 years	Executive - Compliance and Sustainability
	A5	3 years	Executive - Environmental Sustainability

Case	Respondent Code	Years of experience	Designation
	A6	4 years	Executive - Environmental Safety & Health
B	B1	4years	Executive - Compliance and Sustainability
	B2	5 years	Executive - Environmental Safety & Health
	B3	3 years	Executive - Compliance and Sustainability
	B4	5 years	Factory Engineer - Head of Engineering
	B5	4 years	Assistant Manager - In-charge of Operation
	B6	5 years	Manager - Facilities and Administration

Data analysis was conducted using code-based content analysis. It is vital to have an in-depth understanding of the barriers as it essential to mitigate them to ensure successful application of IS network in IZs. However, so far, there has been no systematic academic analysis of the application of IS in IZs in Sri Lanka. Thus, to investigate barriers in depth, this paper applies the categorisations identified through literature review (Refer to Section 2.3). Similar categorisations have been widely used in previous studies (Domenech et al., 2019; Paquin & Howard-Grenville, 2009; Södergren & Palm, 2021; Walls & Paquin, 2015). According to Sodergren and Palm (2021), the use of such categorisations provides a multifaceted approach to assess big-picture forces for a better understanding of the barriers in a broader view. The barriers were extracted through an analysis of case findings using an abductive analysis. Furthermore, the findings unveiled an inter-relationship among certain barriers, resulting in synergistic effects. To illustrate this relationship, a cognitive map was developed.

4. CASE STUDY FINDINGS

Case study findings are discussed and presented under the five subsections: technological barriers (Section 4.1), economic barriers (Section 4.2), organisational barriers (Section 4.3), regulatory barriers (Section 4.4), risk barriers (Section 4.5), and information barriers (Section 4.6).

4.1 TECHNOLOGICAL BARRIERS

Findings generated through the case study analysis revealed that IS initiatives demand extensive technological knowledge and applications for their operations. Table 4 shows the technological barriers of IS network development.

Table 4: Summary of technological barriers

Code	Barrier
T/B1	Lack of technical knowledge and expertise
T/B2	Rapid technological change
T/B3	Issues relating to the quality of the waste
T/B4	Lacking infrastructure and logistical integration
T/B5	**Lack of utilising advanced equipment and machineries***

T/B – '**T**echnological/**B**arrier'
**Note: ***Findings that are identified only from the analysis of cases

Hence, lack of technical knowledge and expertise (T/B1) can limit the involvement of participation in the network. Further, rapid technological change (T/B2) is a common barrier where the technological applications tend to be outdated soon with innovative technologies. Thus, organisations may struggle to keep up with the latest technologies, hindering their ability to participate effectively in the IS network. Issues related to the quality of the waste (T/B3) can be emphasised as another devastating barrier in technological aspect. It was witnessed by A6 by asserting that *"inputs of organisations need to be in expected level of quality where unsatisfactory quality conditions* function *as a barrierwithin IS network"*. Moreover, lacking infrastructure and logistical integration (T/B4) exerts limitations on capacity of the IS network, which is a barrier for operations and expansion of the network. More interestingly, with the application of IS, the process required the advanced equipment and machineries to be used. Unfortunately, it was proved that IZs and the participant are lack of utilising advanced equipment and machineries (T/B5). It has been proven that organisations with limited financial resources are unable to allocate funds for technological advancements, which include provisions for infrastructure, equipment, machinery, and hiring expertise to manage the processes (refer Code E/B3 and E/B4).

4.2 ECONOMIC BARRIERS

A summary of economics barriers of IS network development is listed in Table 5.

Table 5: Summary of economic barriers

Code	Barrier
E/B1	Initial cost, transport, and logistic cost
E/B2	Adaptation cost to new procedures or transition
E/B3	Lack of financial ability
E/B4	**Lack of fund allocation***
E/B5	Cost-benefit ratio

E/B – '**E**conomic/**B**arrier'

**Note: ***Findings that are identified only from the analysis of cases.

Since all the required resources should be planned for new initiatives and transition to newly established set up to match the IS network operations including required infrastructure, transportation, equipment, and machineries (refer Code T/B4 and T/B5), it incurs huge cost to organisations. It entitles to considerable amount of initial cost, transport, and logistic cost (E/B1), cost of adaptation to new procedures or transition (E/B2) at once which prevents the entry of organisations to IS network. Collaboration of above both barriers may not only lead to limited resources available for investment in IS initiatives but also strain the financial resources of organisations, making it challenging for them to undergo the necessary changes and participate in the IS network. As expressed by A1 and B4, lack of financial ability (E/B3) and lack of fund allocation (E/B4) are similar economic barriers of IS in which organisations with lower financial position would not participate in this type of massive initiation. Further, organisations would like to have a demonstrable return on their project investments, which is also completely similar for IS initiatives. Thus, not having clearly defined cost-benefit ratio (E/B5) may restrict organisation from accessing the IS network.

4.3 ORGANISATIONAL BARRIERS

Since the concept of IS is novel to Sri Lanka, institutional support must be at its maximum to ensure the initiation and operation of the network. However, such kind of an assurance cannot be expected in Sri Lanka as stressed by respondents.

A summary of the organisational barriers of IS network development is listed in Table 6.

Table 6: Summary of organisational barriers

Code	Barrier
O/B1	Lack of institutional support
O/B2	Power, status, lack of trust of participants
O/B3	Competition among participant
O/B4	Lack of collaboration due to isolation
O/B5	**Conflicting participant***
O/B6	Lack of time
O/B7	**Lack of knowledge on IS concept ***
O/B8	Lack of environment concerns and management support
O/B9	Resistant to change
O/B10	**Lack of employee engagement on new processes***

O/B – '**O**rganisational/**B**arrier'

**Note: ***Findings that are identified only from the analysis of cases.

According to the findings, unavailability of institutional support (O/B1) can be proclaimed as a major barrier to IS network development where it limits the progress and sustainability of the network, making it difficult to gain momentum and secure resources. Moreover, the lack of institutional support may stem from inadequate regulatory incentives (refer Code R/B2) and a lack of proper attention to IS-oriented regulations (refer Code R/B3), which in turn limits the encouragement for initiation. Power, status, lack of trust of participants (O/B2), competition among participants (O/B3), lack of collaboration due to isolation (O/B4), and conflicting participants (O/B5) were identified as few of other organisational barriers which limit the formation of strong relationship among participants in an IS network. Competitiveness and a preference for isolation may prevent the effective exchange of resources and limit the overall efficiency and effectiveness of the network. On the other hand, the presence of conflicting participants, who have diverging interests or incompatible objectives, can disrupt the smooth functioning of the IS network by interrupting decision-making, resource sharing, and the achievement of collective goals. B6 highlighted that *"individual concerns of participants such as status, power, competition and trust may affect the formation of linkages in an IS network where it limits the formation of linkages, and it affects the operation of the network".* Lack of time (O/B6) is another organisational barrier to IS network development. B1 stated that *"higher workload on organisations may not spare time to manage operations of IS network, which reduces their involvement in the network"*. Lack of knowledge on IS concept (O/B7) was pointed by the respondents as an organisational barrier where A2 stated that *"lack of knowledge on benefits of the application and possibilities of the application prevents the participants from obtaining maximum output*

of the IS network". It was proved that without a clear understanding of the concept and its advantages, organisations may miss opportunities for resource optimisation and waste management. When examining the factors contributing to a lack of knowledge, it was discovered that insufficient training and technical expertise (refer Code I/B3) as well as a deficient knowledge sharing mechanism (refer Code I/B5) could be highlighted. Addition to those barriers, lack of environment concerns and management support (O/B8), resistant to change (O/B9) and lack of employee engagement on new processes (O/B10) were also identified as other organisational barriers. However, as believed by A1 and B4, both the barriers; O/B8 and O/B9 cannot be accepted as barriers where prevailing industrial system forces to consider on environmental facts as well it keeps on adapting to rapid changes.

4.4 REGULATORY BARRIERS

A summary of regulatory barriers of IS initiation are listed in Table 7.

Table 7: Summary of Regulatory Barriers

Code	Barrier
R/B1	Restrictive regulations for establishment and operation
R/B2	Lack of regulatory incentives
R/B3	**Not having proper concern on IS oriented regulations***
R/B4	Difficult and delayed approval processes
R/B5	Conflicting regulations

R/B – '**R**egulatory/**B**arrier'

**Note: ***Findings that are identified only from the analysis of cases

Restrictive regulations for establishment and operation (R/B1) of IS network prevent facilitators from involving in IS initiatives. This fact was further emphasised by A4 where he stated that *"there are restrictions to the initiation of IZs where several requirements should be adhered".* It became evident that such regulatory restrictions may limit the opportunities for organisations to engage in IS activities. Lack of regulatory incentives (R/B2) and not having proper concern on IS oriented regulations (R/B3) are co-related barriers of IS network development where no encouragement is made for initiations. The opinion became sustain through the empirical study where A1 who has 6 years of experience in environmental sustainability emphasised that *"unavailability of IS oriented regulations and guidelines is a major barrier for initiations".* The absence of specific regulations and guidelines related to IS initiatives hinders the clarity and guidance required for organisations to navigate and comply with relevant standards and practices. Difficult and delayed approval processes (R/B4) in Sri Lankan government is another barrier to initiations of IS that vital to be made a discussion. It made sense where B3 specified that *"government institution's processes are much complex and not timely where it discourages people to hands in to it".* Furthermore, it can be argued that the initiation process may experience delays and difficulties due to the restrictive regulations governing establishment and operation (R/B1). Addition to those, conflicting regulations (R/B5) was identified as regulatory barrier where B1 stated that *"IZs are govern by BOI where regulations of other related institutions are overrun by BOI regulations which may arise conflictions in IS application".*

4.5 RISK BARRIERS

A summary of risk barriers of IS network development is listed in Table 8.

Table 8: Summary of Risk Barriers

Code	Barrier
Ri/B1	Risk on uncertainty of investment, system performance and outcomes
Ri/B2	Risk of inter-dependency
Ri/B3	**Risk of changes in demand and supply by participants***

Ri/B – '**Ri**sk/**B**arrier'

**Note: ***Findings that are identified only from the analysis of cases.

Risk and uncertainty of investments, system performance, and outcomes (Ri/B1) was identified as a major barrier where participants refuse to involve in IS projects. A3 stated that *"there are not any IS initiated IZs in Sri Lanka where the return on investment is not visible and also the performance of the application is not clear, which negatively affects the mindset of organisations"*. Hence, participants in IS projects may hesitate to get involved due to the perceived risks and uncertainties associated with investments, system performance, and expected outcomes. Risk of inter-dependency (Ri/B2) and risk of changes in demand and supply by participants (Ri/B3) are co-related barriers as identified through the study. This risk can hinder collaboration and resource sharing, as organisations may be hesitant to depend on others for their business operations. This barrier limits the formation of strong partnerships and inhibits the smooth functioning of the IS network. On the other hand, the risk of changes in demand and supply by participants can create uncertainties and challenges within the IS network. Organisational behaviour and shifts in market demand can impact the availability and reliability of resources exchanged within the network. These changes may disrupt the balance and effectiveness of resource utilisation, affecting the operational stability and efficiency of the IS network. It became apparent through the findings that organisations refuse to rely on other organisations where the behavioural changes of organisations may interrupt the business operations of dependent organisations.

4.6 INFORMATION BARRIERS

A summary of information barriers of IS network development is listed in Table 9.

Table 9: Summary of Information Barriers

Code	Barrier
I/B1	Poor awareness on the IS concept
I/B2	Lack of information on synergistic possibilities
I/B3	Lack of training and technical information
I/B4	Lack of management of operational information
I/B5	Lack of information sharing mechanisms
I/B6	Lack of information of job roles and responsibilities

I/B – '**I**nformation/**B**arrier'

Note: *Findings that are identified only from the analysis of cases

Poor awareness on the IS concept (I/B1) is identified as a barrier where optimum output of application may not be obtained as a result. B5 specified that *"poor awareness on the scope, applicable possibilities and areas of applications of IS concept may lead to ineffective performance of the network".* Lack of information on synergistic possibilities (I/B2) prevent formation of exchange links. Organisations may not be aware of the potential synergies and resource-sharing opportunities, limiting their engagement and collaboration in the network. Lack of training and technical information (I/B3) leads to outdated processes within the network. This situation can occur due to a lack of technical knowledge and expertise (refer Code T/B1). On the other hand, organisations may face challenges in initiating training programs or improving the relevant expertise within their organisation, primarily due to limited financial resources (refer Code E/B3) and inadequate fund allocation (refer Code E/B4). Lack of management of operational information (I/B4) affects the smooth operation of the network. B2 stated that *"lack of management information creates handling difficulties and interruptions to operations".* It indicates that clear and effective information management systems are essential for facilitating collaboration and knowledge sharing among participants. Lack of information sharing mechanisms (I/B5) leads to the isolation of participants knowledge. B4 stated that *"isolation of knowledge negatively affects the main purpose of IS initiation".* It prevents the exchange of valuable insights and experiences impeding the collective learning and development of the network. Lack of information of job roles and responsibilities (I/B6) is another information barrier to IS network development, which leads to deficient performance of the network due to unclear expectations and responsibilities that can create confusion and inefficiencies in the coordination and execution of tasks.

5. DISCUSSION

By reviewing the existing literature, a total of 27 barriers were identified. However, these findings were in general and not specific to the Sri Lanka. These barriers seem to be possible for Sri Lanka as per case study findings. Paquin and Howard-Grenville (2012) stressed that higher initial cost and financial incapability are major barriers that hinder the successful application of the IS network, falling under the economic category. The same finding was discovered through the analysis of case study findings. Diversified and competitive participants and lack of institutional supports are some of the main barriers identified as the organisational barriers in IS application (Domenech et al., 2019; Paquin & Howard-Grenville, 2009; Walls & Paquin, 2015). It became apparent through the analysis of case findings that though there is an impact from competitive participant, unavailability of institutional support can be highlighted as most pressing barriers to IS initiation in Sri Lanka. Referring to the regulatory barriers, the main concern was given by the authors on lack of regulatory incentives for IS initiations. Precisely, the same finding was derived within the case study.

Additionally, seven barriers including one technological (refer code T/B5), one economical (refer code E/B4), three organisational (refer codes O/B5, O/B7 and O/B10), one regulatory (refer code R/B3) and one risk barrier. These barriers were specific to the context of Sri Lanka. The lack of interest and involvement from various stakeholders, including the government and institutional support in the IS concept in Sri Lanka, has contributed to the emergence of these barriers, as evidenced by the case study findings. Unfortunately, it may cause lack of awareness or enforcement of IS-oriented regulations in Sri Lanka. Thus, organisations may not feel compelled or obligated to embrace IS

practices. Moreover, the uncertain market conditions and changes in demand and supply patterns in Sri Lanka, coupled with limited funding, may make participants hesitant to engage in IS arrangements. These factors may hinder industries from implementing such novel processes, despite their potential to provide valuable inputs to the organisation. Further, the results of data analysis reflect to determine the inter-relationship among few barriers itself (Refer to Figure 1). It was observed that not all barriers are interconnected; however, a meaningful relationship can be observed among certain barriers, which mutually influence each other, leading to a synergistic output. (refer code Ri/B3) barriers were solely identified through the case studies.

6. CONCLUSIONS

IS has gained increasing attention in recent years as a promising solution to address the challenges of resource depletion and environmental degradation. While IS has the potential to deliver significant economic, environmental, and social benefits, there are several barriers that may hinder its adaptation. However, a better knowledge of barriers is vital to have a wide range of identification about the negative influence which leads to restricting the IS initiation in the IZ. Thus, this paper aimed to explore barriers to the successful implementation of IS networks in IZs of Sri Lanka. Altogether, 34 barriers, including 05 technological, 05 economic, 10 organisational, 05 regulatory, 03 risk, and 06 information barriers were identified throughout the study. All barriers were discussed with reference to the Sri Lankan context. The higher initial cost, lack of financial ability, competition among participants, unavailability of institutional support, and lack of regulatory incentives for IS initiations were some of the key barriers identified in this study. Overall, addressing these barriers will be crucial to unlocking the potential of IS in IZ and realising its economic, environmental, and social benefits.

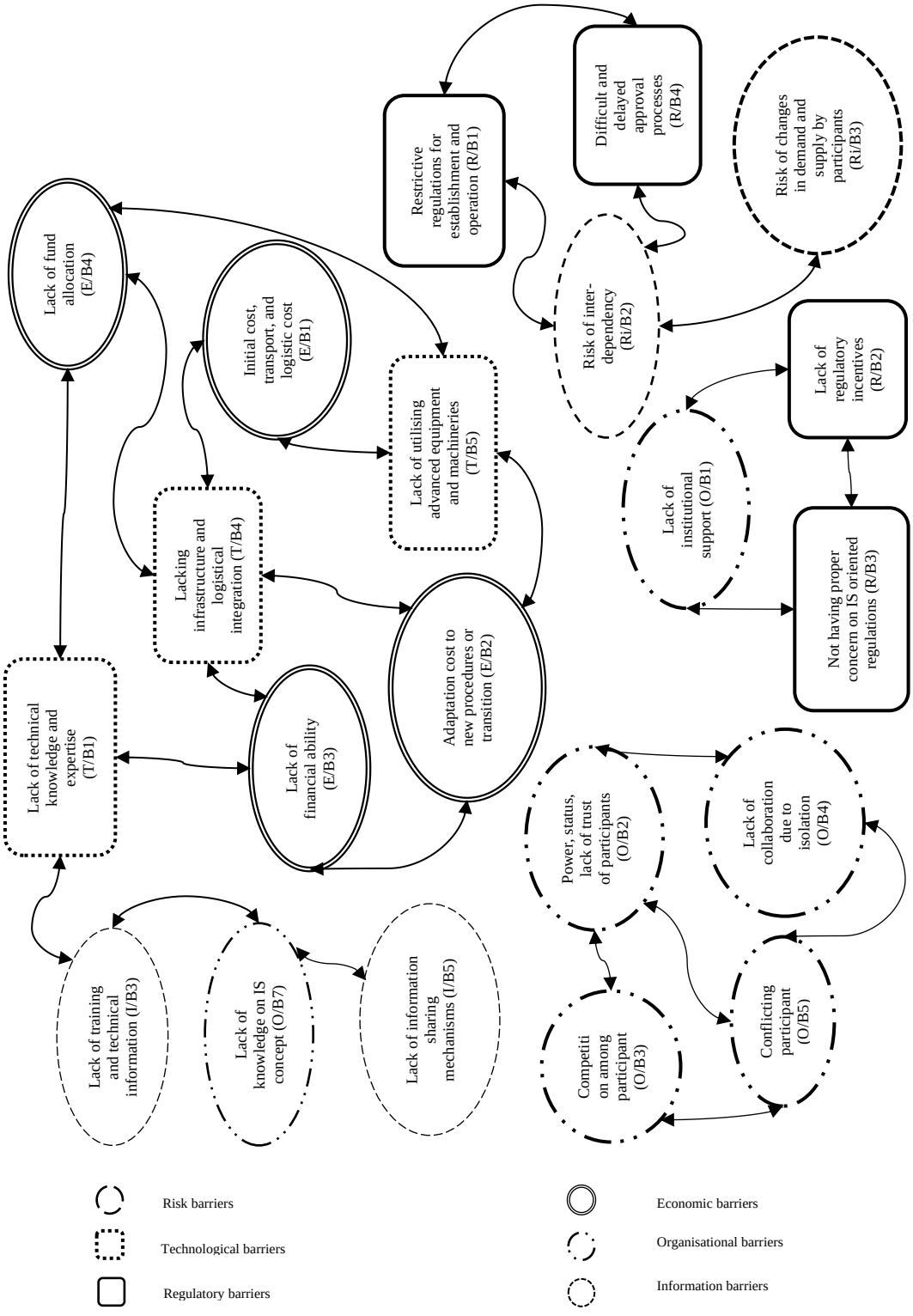

Figure 1: Inter-relationship among barriers

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