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Towards the introduction of elements that contribute to the LRT operation sustainability through technology-based ancillary revenue

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Abstract. Transportation and technology innovation is one of the Sustainable Development Goals (SDGs) elements, and it has been outlined in goal number nine. The high demand for LRT usage requires a large amount of electricity. It contributes to the increase in electricity costs that have to be borne by LRT operators, and it is one of the main contributors to the increase in LRT operating costs. Revenue from fares unable to offset the rising operating cost. Therefore, LRT operators need to explore ancillary revenue activities to cover LRT operating costs. This paper aims to identify the elements involved in generating ancillary income through technology-based businesses from fibre optic cable networks along LRT alignment for the LRT operation sustainability. This study adopted semi-structured interviews for data collection and thematic analysis to analyse the data collected to identify the elements involved in generating ancillary revenue. Eleven themes were identified from the thematic analysis using NVivo. The list of elements involved has been proposed in this study has the potential to be a driver in generating ancillary revenue for the sustainability of LRT operations and contribute to sustainable development in achieving one of the objectives outlined in the SDGs.

1. Introduction

Infrastructure systems such as energy, water, waste, transportation and telecommunications are essential needs of every society. All these infrastructures need to be sustainable to achieve the Sustainable Development Goals (SDGs) objectives. Infrastructure development of Public Transport is one of the critical and complicated issues for modern societies. Infrastructure investments are massive and expensive, and their impact can transform the landscape of cities and regions for decades, if not centuries [1]. To respond to this, transport planners and engineers have to implement the best strategy using knowledge, innovation, best practice and advanced technology to ensure all investment provides a good return. In recent years, the sustainability of a transportation system has become enormously important, mainly due to increasing environmental issues and climate change [2]. According to Hens, Melnyk [3], technology will reduce environmental risks while increasing energy and economic security and human capital. The LRT system in Malaysia uses full electrical power to contribute to the country's environmental sustainability. Powrie [4] states that Railway electrification offers benefits for both the environment (zero carbon dioxide (CO_2) and particulate emissions at the point of use) and traction operation (reduced complexity and cost) but requires investment in fixed infrastructure. However, the high demand for the use of the LRT system requires a large amount of electricity. It contributes to the

increase in electricity costs to the LRT operators. This cost is one of the main contributors to the increase in LRT operating costs. The energy consumption of urban rail transit systems increases rapidly with the expansion of transit networks and increased service frequency [5]. The development of sustainable infrastructure and promoting the economy of development can be realised in various ways. It is important since the operating costs of rail-based public transport are too high. The fare revenue is unable to offset the rising cost of operating the LRT. Therefore, it is important to explore the ancillary revenue in supporting the LRT operation sustainability. While new technology attributes to the growth of the global economy, the LRT operator faces the challenges of identifying the elements that can contribute to ancillary revenue increments in ensuring rail-based public transport becomes a sustainable infrastructure economically and financially. Therefore, this paper will focus on issues related to finance and economics in sustainable infrastructure through ancillary revenue. This paper aims to identify the elements involved in generating ancillary revenue through technology-based businesses from optical fibre cable networks deployed along with LRT Right of Way (ROW). This study adopted a business model canvas developed by Osterwalder and Pigneur [6] as the basis to identify other elements involve specifically to generate additional revenue through technology-based businesses for LRT operators.

2. Sustainable Development Infrastructure through Ancillary Revenue
One of the SDGs elements is transportation and technology innovation, and it has been outlined in goal number nine in the SDGs. There are three main components of sustainable development: environmental, economic, and social. Serebrisky, Watkins [7], Bhattacharya and Jeong [8] reported that the sustainable infrastructure framework encompasses four significant pillars: economic and financial, environmental, social, and institutional. Saghir [9] claims that the infrastructure development can be achieved by (i) improving access to key facilities; (ii) creating additional jobs and economic activities, (iii) expanding the overall production capacity; (iv) reducing production costs through improvements in transport and connectivity, and (v) connecting markets and other economic facilities. Therefore, sustainable infrastructure is economically sustainable if it generates a positive net economic return, considering all benefits and costs over the project lifecycle, including positive and negative externalities and spillovers. Considering that fare revenues are insufficient to cover operational and capital costs, some urban rail systems worldwide supplement their funding with non-fare commercial or ancillary revenues [10]. The fare revenue is income generated from fare ticket payments from users to board the LRT. In contrast, ancillary income is income generated from ancillary activities such as retail, parking, advertising, and technology-based business (telecommunications, mobile applications, smart transportation systems). The ancillary revenue is crucial to the financial viability of a mass transit railway without funding support from the Government – even one with high levels of patronage and excellent operating efficiency like MTR [11]. To date, various ancillary businesses have run along the rail-based public transport route. According to Chow [12], various streams can be envisaged to generate additional revenues to either compensate a deficit in the fare revenue or create additional investments resources: (i)Commercial & retail-related activities in stations, such as kiosks, shops and promotion space; (ii) Advertising in the station, on-board trains, on smartcards/token; (iii) Branding of infrastructure: a brand against a station; (iv)Infrastructure leasing: space, telecom assets; (v)Land value capture: TOD; and (vi)Others streams: Digital content, merchandising, Energy selling: solar, other ancillary revenue activities (e.g. in station events/filming, consultancy and parking).

3. Methodology
This study adopted semi-structured interviews to identify the LRT operator and technology provider's perspective on the elements involved. Respondents consisted of individuals involved in the railway and technology industries. The equation proposed by Galvin [13] will be used in this paper as a reference to determine the number of respondents involved will give the probability that the level of saturation will be achieved.

$$R = 1 - (1 - P)^{1/n} \tag{1}$$

In order to generate qualitative data through the use of open questions, semi-structured interviews were used in this study. The development phases of the semi-structured interview were prepared by adapting the procedure used by Kallio, Pietilä [14]. All interview questions developed are based on the nine main elements of the business model canvas by Osterwalder, A. and Y. Pigneur. The nine elements are customer segments, value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partnerships, and cost structure. The semi-structured interview began with a free association task by asking respondents about their understanding of the business model canvas element and their opinion about the business model. It was followed by questions about the respondent perspective on each business model canvas element—the interview questions based on the study main research topic. In order to get a fixed set of responses, the closed question was used, and an open question was used to allow the respondent to express the answer in their own words. Thematic analysis was used to analyse the interview data. NVivo version 12 (NVivo) software is used to facilitate the process of coding and data analysis. Time for analysis and tedious manual and clerical tasks such as transcribing, searching for themes and producing the report can be simplified using NVivo. The software is also capable of handling immense amounts of data with validity and audit functions. The advanced feature of the software, such as identifying themes, gleaning insight and developing conclusions, are required in the study [15].

4. Results and Discussion

The respondent demographic questionnaire from the semi-structured interview required respondents to provide their background information to understand the background and knowledge of the respondents. All respondents involved are individuals with work experience in the rail-based public transport industry or technology providers. A total of ten respondents were interviewed, consisting of workers from the telecommunications and rail industries. The minimum number of populations required as per equation (1) to have a belief or attitude so that 95% (P = 0.95) are confident that ten interviews (n = 10) will be used, answering R = 25.89%. Provided 25.89% of the population adheres to this belief, ten interviews will be enough to give 95% confidence to the researchers to discover it. According to Israel [16], in a normal distribution, approximately 95% of the sample values are within two standard deviations of the true population value (e.g., mean). 95% confidence level means 95 out of 100 samples will have actual population values within the specified accuracy range. According to Bernard and Bernard [17], 10 to 20 knowledgeable people are enough to uncover and understand the core categories in any well-defined cultural domain or study of lived experience. Therefore, Parse [18] recommends 2 to 10 participants to achieve redundancy or saturation. Table 1 shows the breakdown of the respondent profile obtained from the semi-structured interview.

Table 1. Summary of Respondent profile.

Respondent Code	Years of Experience	Position	Highest Education Level
R1	9	Associate	Bachelor's Degree in Technology Management
R2	13	Senior Associate	Bachelor's Degree in Business Computing
R3	2	Associate	Bachelor's Degree in Mathematics Technology
R4	13	Head of Planning	Master of Construction Contract
R5	15	Senior Associate	Master of Business Administration
R6	10	Project Manager	Bachelor's Degree in Controlling Instrumentation and Automation Engineering
R7	6	Network Engineer	Bachelor's Degree in Manufacturing Engineering
R8	16	Specialist	Master of Business Administration
R9	15	Senior Manager	Master of Business Administration
R10	18	Senior Engineer	Bachelor's Degree in Electrical Engineering

Eleven themes were identified as a result of the thematic analysis performed using NVivo. The findings obtained from the analysis conducted on all interview transcripts found that all nine elements created by

Osterwalder and Pignuer can contribute to the LRT operation sustainability with two additional elements identified, namely technology and risk. Table 2 shows the content analysis for all the themes involved that have been identified using NVivo. A code stating "yes" means that the respondent believes that the element is important for LRT operation sustainability, while "no" means that the respondent does not agree or has no opinion on the element not contributing to LRT operations' sustainability.

Table 2: The outcome from content analysis for all themes extracted from NVivo.

	R01	R02	R03	R04	R05	R06	R07	R08	R09	R10	Total
Activity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10
Resources	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10
Cost	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10
Customer	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10
Value Proposition	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10
Relationship	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	9
Revenue Streams	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	9
Technology	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	9
Key Partner	Yes	No	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	8
Channel	Yes	Yes	Yes	No	Yes	No	Yes	Yes	Yes	Yes	8
Risk	No	No	No	Yes	No	No	No	No	No	Yes	2

4.1. Key Activities

One significant finding is that marketing and sales are two main segments in key activities elements. These results match those observed in earlier studies. This finding was also reported by Silva and Maló [19], Štefan and Richard [20] and Dijkman, Sprenkels [21]. This study indicates that relevant data and sharing of views between marketing and sales teams might enhance performance and create a compelling experience for a prospective customer. Most respondents stated the use of technology to facilitate marketing and sales activities. The most widely coded for marketing components is online marketing. During R04 commented: *"With the internet, we can reach even more potential customers. By using marketing through the internet, we will be able to interact directly with users without time and space constraints. So, internet marketing is one of the effective ways nowadays to further expand the reach of the market."* Similarly, R05 argues that: *"In my opinion, an effective marketing strategy is an online marketing strategy. We also have a social media account that can be used by technology partners in introducing products or services that will be provided."* In ensuring the successful sales strategy, R09 argues that: *"Perform sales performance appraisals. Periodic performance appraisals can detect errors in existing sales methods."* R10 highlighted the important strategy to ensure the success of the sales strategy during the interview. R10 mentioned that: *"And what is important is the cooperation between the marketing and sales team."* In summary, the theme of the main activities is important to ensure that both parties have their respective responsibilities. As stated by R07: *"Through this main activity, all those involved in this collaboration can find out their respective roles in ensuring that the services provided to customers do not have any problems."* R08 also mentioned that: *"By identifying the main activities involved, the direction of the collaboration carried out will be clear."*

4.2. Resources

The results of this study agree with the statement made by Štefan and Richard [20], who points out that key resources consist of four major segments: physical resources, financial resources, intellectual resources, or human resources. There are several possible explanations for this result. Physical resources are critical to the organisation's success because it is challenging to operate a business without equipment, infrastructure, and inventory. R05 argues that: *"As one of the companies that operate rail-based public transport, our main physical resources are LRT tracks, LRT carriages, lands along the LRT line and the pillars that support the LRT line and station."* R10 stated in the interview session: *"The physical resources we need are telecommunications-related assets. Among the assets involved in this collaboration are such as active equipment, passive equipment, and CME structure."* Human

resources play an important role in observing the whole process and avoiding mistakes through available skills and knowledge. According to R10: *"Among the experts we need are Engineers, Technicians and other support workers such as Customer Service Officer, Auxiliary Police and others."* R07 argues that: *"In my opinion, the human resources we need the most are skilled and knowledgeable workers in the field of technology. Our company needs skilled workers in the field of telecommunications, IT or electrical and electronics."* This study shows that intellectual resources are needed in making strategic planning of an initiative and accelerate the implementation of projects that have been planned. According to R03: *"The type of intellectual resources involved in ensuring the business runs through this collaboration is successful by involving ridership and patent data as well as copyrighted drawings."* Similarly, R07 argues that: *"the most important intellectual resources we need are technical details and LRT user data."* Another significant result is that the source of financial resources might come from various sources, namely: 1) From business operations such as revenue from products or services, 2) Capital funding: share and capital contributions issuance, and 3) External sources: vendor financing, bank loans and corporate bonds issuance. R10 argues that: *"The financial resources involved in this collaboration can be obtained either through borrowing or selling the company's equity."* R10 also mentioned that: *"If start-up company, I think, the best strategy to get start-up capital to run a business is through a government's financial grant."*

4.3. Cost Structure

The cost structure consists of two main segments: fixed cost and variable cost. During the interview session, R09 stated: *"In my opinion, the highest fixed cost is the rental cost to use the LRT's right of way. So rental costs, whether monthly or annual, will be a major contributor to our fixed costs."* R08 summarise that: *"expenses for the operation of the services provided such as overhead, site rental, bandwidth rental and telecommunication structure rental are also categorised as fixed costs that will be involved in this collaboration."* R05 mentioned that: *"For variable costs, I think the costs involved in the maintenance of technology-related equipment—utility costs such as electricity and water."* According to R05: *"Even general labour costs on a contract basis, I think, can be included as one of the variable costs."* R01 stated that: *"Variable costs involved, employee salaries, utility costs, possible asset rental can increase, and other unexpected costs such as vandalism, which we cannot control."* The result of the thematic analysis matched the theorised dimensions of Priyadi and Prasetio [22], Suwandiman and Mukti [23] and Sutrisno [24], in which are cost is divided into two main segments, namely fixed cost and variable cost. Another important finding was that an additional segment had been identified through the analysis conducted, namely start-up cost to complete the cost elements. A possible explanation for the start-up cost might be that setting a reasonable budget, in general, is crucial for every collaboration. It assists the LRT operator and Technology Provider in the collaboration staying on track and focusing on the end target. If the budget involved is never followed correctly in this collaboration, it can lead to serious financial issues.

4.4. Customer

The most prominent finding to emerge from the analysis is that the primary customers for this collaboration are the telecommunications operator, LRT user, enterprise, individual customer, and LRT operator. According to R04, *"the main customers who will use this product or service are LRT users."* The same goes for the opinions expressed by R07. He mentioned that: *"LRT users and companies along the LRT line are our main customers if we collaborate with the LRT."* While R10 views that the customer: *"can be telecommunication companies, companies that provide data centres, LRT users and others."* R06 commented: *"Companies close to the LRT line that need internet service have the potential to become our customers."* R05 commented that: *"In my opinion, if the product or service is based on technology, the main customers may consist of our passengers, retailers inside and outside our station, as well as corporate companies such as telecommunications companies, IT companies and others."* This finding corroborates the ideas of Štefan and Richard [20], who argue that customer segment is defined by five types of market: mass, segmented, niche, diversified and multi-sided. The present study raises the possibility that the potential customers to use the products resulting from this collaboration are not only focused on LRT users, but the customers can reach beyond the LRT colony under the coverage of

the deployed technology services. Therefore, it can be assumed that knowing the customers better is crucial because their information can help the business earns more revenue and sustains the business.

4.5. Value Proposition

This study found that the value proposition element provides many benefits to the consumer. One interesting finding is that this collaboration provides more savings in cost, time, and assurance of customer equipment safety. Telecommunication operators will further expand their network if they collaborate with LRT operators, as stated by R04: *"The most significant advantage of the service carried out through this collaboration is in terms of coverage of the fibre optic cable network."* R03 argues that: *"The LRT line makes a ring loop in the Klang Valley in most of the development-intensive areas, which enables our partners to expand their business network throughout the Klang Valley."* The safety of telecommunication equipment will also be safer if working with LRT operators as LRT lines are safe and guarded corridors that prevent unnecessary access to the public. R06 stated that during the interview session: *"The advantage of the service offered by us in collaboration with the LRT is in terms of safety and guarantee no service interruption to customers. Our fibre optic cable will be installed inside via the LRT line duct."* This study confirms that value capture is associated with added value to the customer, as mentioned by Silva and Maló [19], Bilgeri, Brandt [25] and Joha and Janssen [26]. Therefore, it can be assumed that the value proposition element is an element involved in ensuring the LRT operation sustainability.

4.6. Relationship

Silva and Maló [19], Štefan and Richard [20], Tseng and Wu [27], Jocovic, Melovic [28], Chuang, Lin [29], Chan [30] and Haaker, Bouwman [31] showed that the relationship element is revolving around the relationship with the customer. It differs from the findings presented here, where relationships in collaboration involve relationships with customers and collaboration partners, stakeholders, and shareholders. Stakeholders and shareholders involved in this collaboration include the ministry, local authorities, utility providers and the surrounding population. R10 argues: *"Creating a collaboration contract is the most effective strategy in maintaining collaboration. So, having a complete and detailed contract will make it easier for both parties to resolve any disputes that may occur during the collaboration period."* In maintaining relationships with stakeholders and shareholders, R07 and R10 argue that communication is the most effective strategy. R07 argues that: *"Communication is the most important method in maintaining relationships with stakeholders and shareholders."* Each of these identified relationship segments is likely to have a positive relationship with the performance of the collaborations undertaken. This means that if there is an improvement in each segment in the relationship element, it will also improve the performance of the collaboration carried out.

4.7. Revenue Streams

This study found that there are various sources of revenue that can be generated through this collaboration. Among the revenue sources are site rental, bandwidth leasing, fibre leasing, revenue share, Wi-Fi, end-to-end services, and commission. R07 argues: *"We generate the revenue from dark core fibre rental, bandwidth and site structure. But bandwidth sales and structural rentals are the biggest sources of revenue that can be generated, in my view."* R04 argues that revenue can be generated through revenue sharing, where R04 states that: *"The main source of revenue that is likely to be generated is through revenue sharing with partners."* R10 argues that: *"If we collaborate with other companies, the revenue sharing is also one of our revenue sources."* This finding is consistent with that of Štefan and Richard [20], who mentioned that revenue streams are usually multi-source, and the type of revenue is affected by the kind of business. These results may be limited to collaboration between telecommunication operators with LRT operators. Hence, all revenue streams are based on the primary sources of revenue generated from the telecommunications business.

4.8. Technology

An unexpected result was the listing of technology-related elements resulting from an analysis conducted using the NVivo12 software. According to R09: *"Technology can facilitate activity and may*

make the business run can be done better and more effectively. Incorporating technological elements in the business venture makes it possible for the business venture to reach a broader global market." While R04 states that: *"In this age of technology, it is necessary that we need to incorporate this technological element into the framework to be built."* R05 argues that: *"Digital transformation needs to be one of the main components of the technological element."* There are several possible explanations for this result. The first possibility is that this collaboration is related to technology-based businesses. It makes technology an essential element so that successful collaboration remains sustainable in every technological evolution and progression. Another possible explanation for this is to ensure that both collaborating parties are better prepared for future development. These findings related to the technology element must be interpreted with caution. If there is no proper and robust business model used to deploy the latest technology, successful collaboration is unlikely to succeed. The lifespan of established business models is declining as technology disrupts industry after industry [32]. Beqiri [33] suggests that it was more necessary than ever to change the business model toward a model based on competitive advantage in the last decade with the explosion of technology.

4.9. Key Partners
The current study found that selecting key partners consisting of technology-neutral players will increase flexibility in penetrating the market. Another important finding was that key partners with such infrastructure RoW could reduce the deployment cost. R03 argues that: *"Neutral companies, companies that can cooperate with other telco companies and any company that is seen as potential in generating additional revenue to us."* R03 commented on his preferred business partner and his expectation from the partnership: *"In my opinion, the criteria for a business partnership that need to be in ensuring that a collaboration carried out can be successful are companies that have an NSP (Network Service Provider) and NFP (Network Facilities Provider) license from SKMM."* R09 argues that: *"The main criteria I will choose our business partners who have infrastructures such as railways, highways, utility routes such as water, electricity and gas."* This finding is consistent with that of Nakano [34], who argues that infrastructure plays a fundamental role as a basis for economic aspects of both domestic and international activities. As such, the LRT has excellent potential to be a key partner for any technology provider company due to its infrastructure that meets the criteria mentioned. These findings suggest that selecting legitimate licensees such as NSPs and NFPs as key partners can provide an advantage in exploiting new market opportunities due to their experience in technology-related industries.

4.10. Channels
The results of this study indicate that element of the channel shall be part of the framework. This study found that the built framework's channel element is divided into network-based distribution and physical-based distribution. According to RO8: *"The product that can be delivered to customer Network-related distribution is one way of delivering products to customers. It can be done using virtual, telecommunication spectrum, fibre optic cable network, online and any network-connected medium."* While R10 argues that: *"Technically, the service provided by us is channelled through the optical fibre cable."* As mentioned by R03: *"We will implement the type of product distribution strategy to deliver the products or services we provide by using Customer Service Officer as a middleman to deliver the services provided and open as many kiosks or outlets that can be held at LRT stations, especially in penetrating as many markets as we can."* In contrast, R02 thinks that opening kiosks at LRT stations may facilitate the distribution of products. As a person who works in public transport industries, R02 states*: "We will usually offer to open as many kiosks as possible near the outlets at the LRT station to penetrate as many markets as possible."* This finding is consistent with Verhoef, Kannan [35] and Piotrowicz and Cuthbertson [36], who suggested that channel elements can be done either online or offline. A possible explanation for network-based distribution might be that as technology advances, more and more solutions are emerging to streamline the distribution process. In contrast, physical distribution involves various product distribution activities associated with the supply of finished products from technology operators to consumers. Therefore, combining the two segments found in this channel element must be present in this collaboration.

4.11. Risks

Another important finding from the analysis is related to the risk elements. According to R05: *"Fibre optic cables installed on the track have less risk of fibre cutting compared to fibre-optic cables installed on the road."* R02 explained why the optical fibre cable is less risky when installed inside LRT track's via duct compare to outside of the station: *"I see with this existing business that the fibre cable service using via duct will be safer because the issue of fibre cutting outside of the station area is much higher compared to the fibre cable inside the station."* For business risk, R07 argues that: *"Business partners are important in minimising the risk of running a business."* Similarly, R09 states: *"This business partnership is important in ensuring that business risks can be reduced."* The evidence from this study suggests that the element of risk is related to business risk and operational risk. A possible explanation for this might be that identifying risks can prevent the business from taking such risks if they have the high potential to occur and could result in substantial losses to both parties. Therefore, effective risk management is essential in ensuring that this collaboration remains sustainable in generating maximum profits. As technology changes and continues to evolve, it is also a risk, especially for technology-based businesses, to ensure their offerings are current and relevant to the customer base. All type of technology risk has the potential to trigger financial, reputational, legislative or strategic risks. Finch [37] claims that a business plan helps the organisation think well to mitigate any risk anticipated by the business in the future and optimise business growth and development according to priorities. Serebrisky, Watkins [7] claim that for infrastructure to be financially sustainable, it must generate an adequate risk-adjusted rate of return for project investors.

5. Conclusion

This paper aims to identify the elements involved in generating ancillary revenue through technology-based businesses from optical fibre cable for LRT operation sustainability. The list of elements involved has been proposed in this study to generate ancillary income for the sustainability of LRT operations and contribute to sustainable development and indirectly may be the driver to achieving one of the objectives outlined in the SDGs. The identified elements may be useful to initiate an ancillary revenue framework through collaboration with technology provider so that the public transport industry remains sustainable with effective cost and operation. The validation process of the identified elements needs to be done to ensure that it can be implemented in the industry. Therefore, subsequent studies should focus on the validation process of the identified elements and the development of the ancillary revenue framework. The expert elicitation method may be suitable for the validation process because this method will involve the views of industry experts on the effectiveness of the elements in the framework developed and the improvements that need to be made so that it is in line with industry requirements to ensure sustainability.

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