Journal of Sustainability Science and Management
Volume 20 Number 1, January 2025: 101-121
eISSN: 2672-7226

FOSTERING ECONOMIC SUSTAINABILITY THROUGH THE PICK-UP AND DROP-OFF (PUDO) POINT SUITABILITY INDEX: OPTIMISING LAST-MILE DELIVERY EFFICIENCY

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http://doi.org/10.46754/jssm.2025.01.006
Received: 26 December 2023 Revised: 27 August 2024 Accepted: 6 September 2024 Published: 15 January 2025

Abstract: The Pick-Up and Drop-Off (PUDO) system has emerged as a viable solution for managing missed deliveries and enhancing sustainability in the e-commerce industry. However, the absence of a comprehensive tool for identifying suitable PUDO locations in Malaysia poses a challenge. This research aims to develop a PUDO Point Suitability Index specifically tailored to identify prospective PUDO service deployment, particularly in rural communities and address the needs of communities not covered by the existing courier service network. Data collection was conducted at all *Pusat Ekonomi Digital* (PEDi) in the Kuching and Serian divisions of Sarawak, Malaysia. The instrument development process uses a multiphase approach that includes observations, in-depth interviews, document analysis, and quantitative surveys. To calculate the suitability index, factors such as local product availability, competition, prospective users, readiness, facilities, accessibility, and security were considered and weighted accordingly. The identification of suitable PUDO points could improve the delivery network, thereby improving last-mile delivery efficiency and stimulating local trade. It also acts as an enabler for a wider market reach; thus, promoting entrepreneurship in rural communities. The outcome of this study offers the relevant authorities, valuable knowledge that will enable strategic planning, and organised efforts in the implementation of PUDO services.

Keywords: Supply chain, assessment, logistic planning, economic sustainability.

Introduction

Last-mile delivery is a critical component that cannot be disregarded in the fast-paced world of e-commerce and logistics. The establishment of the Pick-Up and Drop-Off (PUDO) parcel point networks is a critical step towards e-commerce sustainability (Kawa & Pieranski, 2021). In the courier sector, these services have grown in popularity as a simple and effective way to satisfy the demands of clients in both urban and rural locations. Globally, it has emerged as a major trend in last-mile logistics (Kawa, 2020). Customers can use this service to pick up their products at a time that is convenient for them, even if they are not present to receive them at home. This is predicted to expand the use of e-commerce as well as the necessity for courier services in both markets. The issue for logistics providers is to build effective Pick-Up and Drop-Off (PUDO) sites that act as key hubs for linking clients with the delivery network (Lozzi *et al*., 2022). However, the deployment of PUDO stations in rural areas, where the existing courier services network may be limited, remains a major challenge. This gives logistic providers an opportunity to positively influence these communities by bringing logistics services directly to them. Currently, there are 119 PUDO points in the Kuching and Serian divisions (MCMC, 2024).

The goal of this study is to develop a PUDO Point Suitability Index that is specifically designed to identify locations for PUDO service deployment, particularly in remote communities to address the needs of the population that are not currently served by the courier service network in Sarawak. This research aims to improve service accessibility, convenience, and the creation of

a sustainable logistics ecosystems that benefits the entire community by optimising last-mile delivery efficiency. This study has the potential to contribute significantly to the field of logistics and last-mile delivery. Logistics providers and authorities can better identify acceptable locations for PUDO points in rural areas by building a comprehensive and customised PUDO Point Suitability Index, bridging the gap between underserved populations and efficient e-commerce services. Hence, this study hopes to contribute to the improvement of last-mile delivery efficiency, promote inclusive economic growth, and improve overall consumer experience in the field of e-commerce logistics.

Several studies have been conducted in developed countries to identify the location of PUDO points and build a PUDO network (Morganti *et al*., 2014; Kawa, 2020; Gunawan & Susilawati, 2021; Corejova *et al*., 2022). According to Morganti *et al*. (2014), the location of a PUDO point can be determined by considering the characteristics of pick-up points such as the ability to reduce delivery delays and provide competitive prices, as well as ensuring that service coverage was not only restricted to dense areas such as urban areas but also in less dense areas such as suburban and rural areas with varying delivery volumes. A successful PUDO service from the standpoint of the courier service operator may address several issues associated with traditional home delivery such as missed delivery, complex route planning, and traffic delivery (Zenezini *et al*., 2018). Aside from that, Internet penetration levels should be examined when determining acceptable places (Morganti *et al*., 2014).

Marketing Mix and PUDO@PEDi Suitability Index

From the perspective of both courier service providers and consumers, the framework of this study was constructed based on the marketing theory created by E. Jerome McCarthy (1960), as cited in Kotler and Keller (2016), which consists of four elements which are product, price, promotion, and place, and further extended by Booms and Bitner (1981), who added three more elements which are people, physical evidence, and process to suit the service industry. The framework provides a comprehensive approach to marketing by considering other variables critical for creating effective marketing strategies. In the context of PUDO services, the "place" component of the 7Ps approach is particularly important for evaluating potential PUDO locations. The component focuses on the distribution and accessibility of goods or services to clients, necessitating an understanding of the target market's geography, preferences, and convenience.

The relevance of the extended marketing mix by Booms and Bitner (1981) to the service industry is supported by various studies. For instance, a study by Savitri *et al*. (2020) revealed that the marketing mix has a direct impact on the brand image and people's decision to use a service. This is also supported by the findings of Bastaman and Mufti (2017), who found that the marketing mix can directly affect the image of a brand and lead to a person's decision to be loyal to a service. Therefore, PUDO services need to understand and apply the marketing strategy to ensure the sustainability of the service. The PUDO@PEDi Suitability Index instrument was constructed based on this strategy. Table 1 shows how the PUDO@PEDi Suitability Assessment constructs are determined based on the marketing mix.

Towards Economic Sustainability: Optimising Last-mile Delivery Efficiency

Enhancing last-mile delivery efficiency faces several issues such as infrastructure issues, rural tech adoption rates, and customer approvals which are still prominent in rural areas. PUDO services must resolve these issues in order to grow. Technological and physical infrastructure constraints such as inadequate PUDO points and the lack of security, storage, and last-mile delivery infrastructure hinder PUDO service deployment (Tiwapat *et al*., 2018). Apart from that, poor Internet connectivity and subpar smart tracking systems also interrupt smooth operations.

Table 1: Marketing Mix and PUDO@PEDi Suitability Assessment Constructs

Marketing Mix Elements	Implication for PUDO@PEDi		PUDO@PEDi Suitability Assessment Construct
Product	Services are offered tailored to fulfil the needs of the potential users. Customisation of the service to include value-added features	Sadq *et al*. (2016); Rathod (2016)	PUDO@PEDi serves as a local centre that can provide services to market local products outside the community. Availability, popularity, and profitability of the local product can increase the potential of PUDO service deployment
Price	The cost of the service and the total cost of using the service, which includes time and effort	Kotler and Armstrong (2013)	Accessibility to the location (distance to the PEDi centre) and the accessibility and proximity to the nearest courier service will provide information on whether there will be a reduction of cost when using PUDO@PEDi service as compared to other courier services
Promotion	The extent to which the local community can get information about the services provided at the centre and how the information is delivered in a way that can encourage the community members to use the service	Caliskan *et al*. (2020)	Promotional activities under prospective users focus on the promotional activities and marketing approaches used by the PEDi centre's operator to attract and retain users
Place	Ease of access to the location and facilities for the service	Abdullah *et al*. (2019)	Accessibility to the location and business space
People	The PUDO operator's relationship with the customer. Quick response to users' inquiries and issues. Staff training to enable them to operate PUDO effectively and promote the service to the local community	Sallloum and Ajaka (2013); Gupta and Dev (2012); Amin *et al*. (2013)	Staff readiness to operate PUDO services, which includes: (i) Willingness (ii) Attitude (iii) Knowledge
Physical evidence	A comfortable and convenient facility, as well as a business space, can affect users' loyalty to the service. Availability and condition of equipment and hardware. Network connectivity performance. Security system	Miles *et al*. (2012); Agrawal *et al*. (2014); Huang *et al*. (2019)	Business space Security
Process	Ensuring that the process is simple and convenient. Ensuring timely delivery of core service with prompt response	Amin *et al*. (2013)	Facilities (Network, Equipment, Hardware) Readiness to operate the service in terms of: (i) Willingness of the staff (ii) Knowledge about the service (iii) Attitude towards customer, which will affect the quality of service

Last-mile delivery efficiency also suffers from low rural Information and Communication Technologies (ICT) adoption rates, which make overcoming technological constraints more difficult, but increases the possibility of enhancing last-mile delivery efficiency. Other than that, rural PUDO demand is lower in rural areas following poor Internet connections and limited digital literacy rates. Additionally, urban locations have better last-mile delivery networks, although the low number of customers can negatively affect last-mile efficacy in urban areas (Zhang *et al*., 2022). Internet connectivity and advanced tracking systems can help overcome technological limitations in underserved areas. PUDO service providers, government agencies, and telecommunication corporations must work together to improve technology and implement training and awareness initiatives that can boost the rate of tech adoption and use.

Low ICT adoption rates negatively affect the acceptability to PUDO services. It was noted that customers, notably in rural areas, prefer traditional house delivery, otherwise they worry about package security (Vani *et al*., 2013). In Sarawak, PUDO services are often e-services as a result of the emergence of digital economics. However, e-services must be trusted and familiar to gain customer approval (Mou *et al*., 2017). In addition, convenience, security, and cost-effectiveness campaigns help allay worries. PUDO services' flexibility and control will foster trust and acceptance.

Moreover, identifying rural high-potential PUDO locations is essential to overcome the last-mile delivery efficiency gap between urban and rural areas. In the Malaysian context, community Internet centres, namely the *Pusat Ekonomi Digital* (PEDi) can act as accessible PUDO locations for the local community. Strategically expanding PUDO locations in rural areas will boost technological adoption and equalise delivery options for urban and rural customers. However, these newly identified PUDO points will not be sustainable without collaborations between PUDO service providers, e-commerce platforms, logistics companies, and local authorities. These collaborations can overcome infrastructure limits, improve coverage, and integrate online retail platforms and PUDO services (Araújo *et al*., 2020).

Methodology

The main objective of this study is to develop the PUDO Point Suitability Index (PPSI) instrument. To achieve this objective, a multi-phase approach has been adopted, integrating various research methods. The reliability and utility of composite indicators are highly dependent on the selection of variables. To ensure the utmost accuracy and precision, the PPSI tool's indicators and sub-indicators were meticulously chosen under the guidance of esteemed experts, employing the Best-Worst Method (BWM). BWM is a technique for determining the weights of a criteria by identifying the most and least important criteria from a given set. The level of importance for each criterion is varied to determine the appropriate weights in the context of the deployment of PUDO service in a rural area, BWM is employed. The procedure is as follows:

Step 1: Selection of Experts to Develop the Index Instrument

In this phase, expert panels were chosen through purposive sampling. Eight experts were selected. A proper selection of experts is vital as it affects the quality of the results of the study. The panels were selected based on these four criteria: Knowledge and experience with the issues under investigation, capacity and willingness to participate, sufficient time to participate in the study, and effective communication skills (Adler & Ziglio, 1996). Purposively for this study, the panels of experts consisted of various stakeholder whose backgrounds include: PUDO operators, courier service providers, and academicians with a background in e-commerce, marketing, knowledge management, and consumer behaviour which is further specified as shown in Table 2.

Table 2: Expert panels selection

Expert Panel Background	Number
Professor in economics	1
Professor in knowledge management	1
Academician in e-commerce and marketing	2
Manager of PUDO@PEDi	1
Courier service providers' representative	2
Manager of PEDi	1

Step 2: Determine a Set of Decision Criteria

This phase entails observing existing PUDO locations and their operating dynamics in order to gain a thorough grasp of the current obstacles and opportunities in last-mile delivery. To gain useful insights and perspectives on PUDO point deployment in rural areas, in-depth interviews were performed with the experts. A document analysis was also conducted to analyse relevant literature and industry reports to provide a full understanding of the existing infrastructure and best practices for PUDO service deployment. This analysis was used to build a solid basis for the PUDO Point Suitability Index.

After that, the expert panel met to discuss the criteria for the identification of PUDO point locations. At this stage, 15 indicators were identified: (1) Adequacy of human resources, (2) business space availability and condition, (3) storage availability and conditions, (4) security systems, (5) occurrences of vandalism, (6) marketing approaches, (7) number of residents in the community, (8) number of digital and other entrepreneurs, (9) availability of direct parcel delivery services to the consumer, (10) availability of other PUDO points in the community, (11) the distance to the nearest courier service, (12) Internet service availability, (13) telecommunication network availability, (14) availability of local products, and (15) accessibility of the location. These indicators were further discussed and eight main indicators were identified: Local product, competition, prospective users, readiness, facilities, business space, accessibility, and security.

Step 3: Survey Using Best-Worst Method Survey

The Best-Worst Method (BWM) decision-making strategy was used in this investigation. The BWM (Razaei, 2020) is a reliable strategy for identifying the importance or preference of criteria in decision making processes. It has found widespread application in various sectors, including market research, healthcare, and social sciences. Participants can express their preferences by selecting the best and worst possibilities from a list of criteria, providing significant insights into the relative relevance of each criterion. The process ensures that the selected indicators accurately reflect the collective wisdom and knowledge of people with a thorough understanding of the subject area by enlisting an expert panel. Based on the eight criteria agreed upon in the discussion, each expert panel was asked to fill in a questionnaire, which included determining the most important criteria, the least important criteria, making a comparison between the most important criteria with another criterion, as well as between other criteria with the least important criterion.

Step 4: Determine the Relative Rankings and Weights for Each Criterion

This study employed Bayesian analysis to estimate the weights or importance of each attribute. Bayesian BWM is used in this research to discover the aggregated final weights of criteria for a group of experts all at once. In contrast to the classic Bayesian BWM, which cannot combine the preferences of several

evaluators in the group decision-making issue (Mohammadi & Rezaei, 2020). This Bayesian BWM incorporates the statistical rigor of Bayesian analysis in the development of the index instrument. This approach provides more robust estimates of attribute importance and allows for the calculation of weighted index scores, enabling better decision-making and evaluation of PUDO Points.

Step 5: Validation of the Instrument

The instrument was then validated through a pilot test to test its adequacy, validity, and reliability (Edwin & Vanora, 2001). For each criterion, sub-indicators were defined. Each sub-indicator has its own evaluation rubric. The pilot test was conducted in all PEDi's in Kuching and Serian division, Sarawak. To evaluate the suitability of the location to deploy PUDO services, the assessor observes and conducts an interview with the PEDi operator. The score for each sub-indicator was given based on the rubric (Appendix).

Data Analysis and Findings

Observation

The observations revealed that most everyday consumers at PEDi centres were young teenagers. However, adult users visit the centres on weekends to attend PEDi-organised ICT and entrepreneurial courses. Despite a decrease in the overall number of users at PEDi centres, the number of entrepreneurs who have registered with them has increased. The increase in entrepreneurial activity indicates a need for effective logistical solutions. PUDO services can assist local entrepreneurs by providing dependable parcel PUDO locations, simplifying their business operations.

PEDi centres, established in 2018 and later are smaller than those developed earlier. The limited space and storage will make deploying PUDO services difficult. Due to the limited space, the placement and size of PUDO lockers or storage rooms must be carefully considered. Modular or small storage options could be considered to maximise space utilisation while maintaining present services. Furthermore, some PEDi locations are in areas with poor road conditions, which may impede parcel delivery by courier services.

On a positive note, all PEDi centres had robust Internet connectivity, communications networks, and ICT gear, which will help with the deployment of PUDO services. The strong technological backbone enables the deployment of advanced PUDO technologies like real-time tracking, which improves user experience and operational efficiency. Furthermore, PEDi centres have become well-known community facilities with all residents aware of their presence. This widespread recognition provides an additional advantage when promoting the service. Leveraging the community's experience with PEDi centres can significantly help promote PUDO services. Marketing initiatives can leverage this existing trust and exposure to attract new service usage.

Vandalism has been reported at several PEDi centres. Security measures must be prioritised to safeguard PUDO services from vandalism. This may include working with the local community to ensure the centres' safety. Furthermore, creating secure access mechanisms and providing appropriate lighting will help deter potential vandals.

Document Analysis

Based on the Malaysian Communication and Multimedia Commission's report on postal and courier, the courier traffic data from the third quarter of 2023 showed an increase in parcel deliveries (MCMC, 2023). The number of parcels per capita rose to 7.1 as compared with previous years from 2021, which ranged between 5.3 parcels and 5.9 parcels per capita (MCMC, 2021; 2022). The upward trend continued into the fourth quarter of 2023 with parcel per capita reaching 8.0 and has recently increased to 8.6 in the first quarter 2024 (MCMC, 2024). These growths in trends can be attributed to several

factors such as the development of e-commerce and logistic infrastructures (Abdullah & Nawi, 2021; Ya'akub & Muharam, 2021; Qi, 2022).

Sarawak has a total of 91 national postal offices with only 18 located in urban areas while the rest are in rural areas (MCMC, 2024). This distribution underscores efforts to provide postal services across diverse geographical locations, ensuring accessibility for both urban and rural populations. The presence of a higher number of postal offices in rural areas highlights the commitment to bridging the service gap between urban and rural communities.

However, when it comes to PUDO@PEDi services deployed in Sarawak, the use of the services is still lacking. According to the report provided by one of the PUDO@PEDi, it has managed only two parcels since its inception in early 2022 with 20 individuals reported to have intended to use the service (PEDi A, 2023). This PUDO@PEDi does not provide any inbound service which is a significant inconvenience for consumers looking to collect their parcels. If they use J&T service, for instance, they need to travel to the neighbouring district, Kuching to collect their parcels. The only courier service in the community is Pos Laju, which is located 700 m away from the centre. Additionally, unstable Internet connections at the centre also affect the use of parcel scanning devices, which complicates the operation process (PEDi A, 2023).

In contrast, PUDO services deployed at PEDi centres in West Malaysia show a higher potential compared to Sarawak, despite facing several challenges. One of the PUDO@PEDi located in Selangor, for instance has managed 421 parcels between 2018 and 2022 with the nearest courier service provider located 200 m away, they face issues with limited space in PEDi centres, understaffing, damaged parcels, and non-compliance with schedules by couriers, which hinder the efficiency and reliability of PUDO services (PEDi B, 2023).

On the other hand, a PUDO@PEDi located in Negeri Sembilan has managed 2,705 parcels until 2022 since its inception in 2021. The PUDO@PEDi reported that there have been instances of returned items or uncollected items as users prefer parcels to be delivered directly to their addresses. Apart from that, the service is only for the use of e-commerce platform members with no walk-in customers allowed, which consequently restricts its accessibility and the utility of the PUDO service (PEDi C, 2023).

Interview with the Expert Panels

The final list of indicators and sub-indicators deliberated by the experts for PUDO point suitability instrument is shown in Table 3.

Based on the indicators and the sub-indicators in Table 3, each of the expert panels determined the most important criteria, the least important criteria, and the comparison between the most important criteria with the other criteria and between other criteria with the least important criteria. The result of this process is shown in Table 4.

The expert panel responses show that there are three critical criteria, namely local product, prospective users, and competition while the least important criteria among the criteria are accessibility, business space, and security. The Bayesian approach was then used to determine the average weight of each criterion. The average weight for each indicator is shown in Table 5.

Pilot Test

The assessments of the suitability of the 34 PEDi centres in the Kuching and Serian divisions to deploy PUDO points were conducted using the PUDO Point Suitability Index instrument. The researchers visited each PEDi to interview the PEDi staff and made some observations based on the assessment rubric (Appendix). The results are presented by the PUDO Point Suitability Index (PPSI) and Construct Acceptability Index (CAI) described in Table 6 and Table 7, respectively.

As shown in Table 6 and Table 7, the PPSI is colour-coded to make it intuitive, as colour effectively conveys subtle differences

Table 3: Indicators and sub-indicators for PUDO Point Suitability Index (PPSI)

Item	Indicators	Sub-indicators
1	Business Space (BS)	Business space availability
2		Layout and organisation
3		Security measures
4	Security (S)	CCTV coverage
5		Physical security
6		Vandalism control
7	Prospective Users (PU)	Population size
8		Daily customer
9		Entrepreneurs
10		Usage patterns
11		Marketing channels
12	Competition (C)	Presence of competing courier services
13		The proximity of the nearest courier services
14		Accessibility of the nearest courier services
15	Facilities (F)	Internet speed
16		Reliability
17		Equipment and hardware
18		Telecommunication speed
19	Local Product (LP)	Availability of local products
20		Popularity of local products
21		Profitability of local products
22		Accessibility of local products
23	Accessibility (A)	Distance to the suggested PUDO point
24		Road condition
25		Transportation access
26	Readiness (R)	Willingness to operate PUDO points
27		Attitude towards customer
28		Knowledge of PUDO services

in PUDO suitability, improving accessibility, and facilitating interpretation for non-technical stakeholders. Hue carries psychologically relevant meaning (Moller *et al*., 2009). At the extreme ends, green and red are selected because green is the chromatic contrast to red (Elliot & Maier, 2014). Green is positively associated with words of success while red is positively associated with words of failure and negativity (Moller *et al*., 2009).

Based on the indexes, PEDis' are then classified into four categories (highly suitable, suitable, less suitable, and not suitable) based on their suitability for PUDO services. This suitability is measured by considering eight enabling or hindering factors: Business Space (BS), Security (S), Prospective Users (PU), Competition (C), Facilities (F), Local Product (LP), Accessibility (A), and Readiness (R). The results are summarised as shown in Figure 1.

Table 4: Best-Worst Method survey findings

Expert Panel	Most Important Criteria	Least Important Criteria		LP	C	PU	R	F	BS	A	S
Panel A	Prospective user	Accessibility	Best to others	1	2	1	4	3	7	5	6
			Others to worst	7	6	7	5	4	2	1	3
Panel B	Prospective user	Accessibility	Best to others	2	2	1	3	2	5	4	5
			Others to worst	6	6	7	5	5	2	1	4
Panel C	Prospective user	Accessibility	Best to others	1	1	1	3	3	5	4	5
			Others to worst	7	7	7	4	4	2	1	3
Panel D	Competition	Business space	Best to others	2	1	1	3	3	4	5	4
			Others to worst	6	7	7	4	4	1	3	2
Panel E	Local product	Accessibility	Best to others	1	2	1	3	3	4	5	4
			Others to worst	7	6	6	4	4	3	1	2
Panel F	Competition	Security	Best to others	3	1	2	4	3	6	5	5
			Others to worst	6	7	7	4	4	2	1	1
Panel G	Local product	Business space	Best to others	1	2	1	3	4	5	5	5
			Others to worst	6	6	6	4	3	1	3	2
Panel H	Local product	Business space	Best to others	1	2	1	4	3	6	5	5
			Others to worst	7	6	7	4	5	1	2	3

Table 5: Average weights for each criterion

Criterion	Average Weight
Local product	0.1930
Competition	0.1863
Prospective users	0.2078
Readiness	0.1097
Facilities	0.1139
Business space	0.0580
Accessibility	0.0630
Security	0.0683

Table 6: PUDO Point Suitability Index (PPSI) indicator

PPSI Category	Colour Indicator
High suitable	
Suitable	
Less suitable	
Not suitable	

Table 7: Construct Acceptability Index (CAI)* indicator

CAI Category	Colour Indicator
Excellent	
Good	
Fair	
Poor	

*Construct Acceptability Index consists of Business Space (BS), Security (S), Prospective Users (PU), Competition (C), Facilities (F), Local Product (LP), Accessibility (A), and Readiness (R).

Figure 1 shows the suitability evaluation result summary, which resulted in the identification of five suitable PEDi centres to deploy PUDO services from a total of 34 PEDi centres assessed. The PEDi centres, which falls under less suitable criteria, improvements can be made based on the construct acceptability index presented in the detailed PEDi evaluation findings in Table 8 to ensure sustainable and effective deployment of PUDO services.

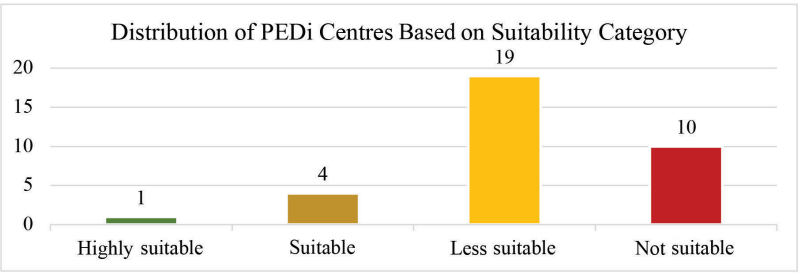

Figure 1: Result summary

Table 8: PEDi evaluation findings

No.	District	PEDi Name	PPSI	Construct Acceptability Index (CAI)								Conclusion
				LP	C	PU	R	F	BS	A	S	
1	Serian	Serian A	84.6	90.0	80.0	83.3	100.0	80.0	76.7	82.5	93.3	Highly suitable for PUDO deployment
2	Serian	Serian B	76.8	100.0	40.0	90.0	66.7	57.5	80.0	82.5	86.7	Suitable for PUDO deployment
3	Serian	Serian C	73.7	80.0	30.0	73.3	93.3	70.0	80.0	72.5	86.7	
4	Lundu	Lundu A	72.7	63.3	73.3	73.3	76.7	72.5	73.3	75.0	86.7	
5	Bau	Bau A	72.2	80.0	40.0	73.3	93.3	80.0	73.3	72.5	86.7	
6	Serian	Serian D	69.4	43.3	80.0	56.7	86.7	62.5	73.3	67.5	80.0	Less suitable for PUDO deployment
7	Lundu	Lundu B	69.0	66.7	63.3	60.0	83.3	62.5	80.0	80.0	86.7	
8	Serian	Serian E	68.8	73.3	10.0	53.3	56.7	87.5	90.0	80.0	86.7	
9	Lundu	Lundu C	68.3	76.7	60.0	60.0	70.0	72.5	53.3	77.5	86.7	
10	Bau	Bau B	68.2	80.0	60.0	66.7	73.3	32.5	86.7	80.0	86.7	
11	Bau	Bau C	68.0	70.0	56.7	63.3	73.3	72.5	76.7	65.0	86.7	
12	Kuching	Kuching A	67.9	53.3	80.0	60.0	70.0	80.0	70.0	55.0	86.7	
13	Kuching	Kuching B	67.4	60.0	70.0	63.3	83.3	50.0	80.0	67.5	86.7	
14	Bau	Bau D	66.5	63.3	53.3	70.0	60.0	65.0	86.7	70.0	93.3	
15	Lundu	Lundu D	66.4	66.7	23.3	80.0	80.0	82.5	66.7	72.5	86.7	
16	Bau	Bau E	66.1	63.3	56.7	73.3	73.3	40.0	80.0	77.5	86.7	
17	Serian	Serian F	65.9	60.0	40.0	66.7	40.0	87.5	53.3	80.0	86.7	
18	Serian	Serian G	65.8	83.3	10.0	73.3	80.0	27.5	83.3	80.0	80.0	
19	Bau	Bau F	65.7	76.7	30.0	56.7	90.0	60.0	90.0	82.5	93.3	
20	Serian	Serian H	64.8	46.7	36.7	56.7	93.3	42.5	80.0	75.0	80.0	
21	Kuching	Kuching C	63.6	66.7	80.0	26.7	63.3	72.5	73.3	77.5	86.7	
22	Serian	Serian I	63.1	23.3	36.7	46.7	80.0	80.0	73.3	80.0	76.7	
23	Lundu	Lundu E	62.8	63.3	13.3	76.7	70.0	75.0	86.7	80.0	86.7	
24	Kuching	Kuching D	60.6	76.7	20.0	63.3	60.0	62.5	73.3	80.0	86.7	

No.	District	PEDi Name	PPSI	Construct Acceptability Index (CAI)							Conclusion
				LP	C	PU	R	F	BS	A	S	
25	Kuching	Kuching E	57.3	10.0	56.7	66.7	70.0	77.5	80.0	62.5	86.7	Not suitable for PUDO deployment
26	Kuching	Kuching F	57.0	43.3	83.3	43.3	16.7	67.5	80.0	75.0	76.7	
27	Kuching	Kuching G	56.2	66.7	10.0	50.0	60.0	80.0	76.7	87.5	80.0	
28	Bau	Bau G	55.1	23.3	80.0	26.7	66.7	67.5	80.0	72.5	86.7	
29	Serian	Serian J	54.4	46.7	10.0	40.0	76.7	50.0	53.3	77.5	86.7	
30	Serian	Serian K	53.7	0.0	80.0	20.0	43.3	57.5	66.7	55.0	80.0	
31	Kuching	Kuching H	53.0	10.0	63.3	60.0	60.0	50.0	80.0	62.5	86.7	
32	Kuching	Kuching I	52.2	33.3	46.7	46.7	56.7	65.0	56.7	72.5	86.7	
33	Kuching	Kuching J	51.8	10.0	53.3	66.7	63.3	62.5	80.0	62.5	50.0	
34	Lundu	Lundu F	41.7	30.0	23.3	26.7	60.0	55.0	80.0	70.0	60.0	

Discussion

The experts' input during the development of the index instrument was all supported by the works of literature related to last-mile delivery issues. In ensuring that PUDO services can be deployed effectively, several factors need to be considered. According to Ainin *et al*. (2018), the main forces driving the introduction of PUDO services are the provision of a robust and dependable logistics network, improved accessibility to PUDO points, and practical PUDO options, all of which will improve courier services' overall effectiveness. Before implementing this service, the service provider must study the consumer's profile and match the implementation approaches to the consumer's tailored wants since customer demand and expanding e-commerce activities have also encouraged the adoption of PUDO services. Furthermore, Chen *et al*. (2018) stated that location convenience, innovation, and people's service expectations all influence the desire for self-service package delivery services.

A study in Sabah, Malaysia used the service quality gap (SERVQUAL) model to assess success factors of PUDO's implementation at PEDi centres in Sabah (Ahmad *et al*., 2023). Originally developed by Parasuraman *et al*. (1988), the SERVQUAL model only focused on the customer's perception on service quality and is therefore not the best tool to measure or determine success factors of implementation of PUDO in PEDi. The SERVQUAL model includes promptness, accuracy, safety, convenience, and tangibles is very limited at assessing the suitability of a location to deploy PUDO services. To bridge this gap, this research has eight main indicators for assessing the suitability of a location to deploy PUDO services. These indicators were based on a more recent marketing theory by Kotler and Keller (2016) in the context of the marketing mix and customer value. Product, place, promotion, and people are among the components of effective marketing strategies (Kotler & Keller, 2016). Selecting a service location requires careful considerations on customer convenience, closeness to target

customers, accessibility, and the reach of the distribution network (Lin *et al*., 2019). The objective is to choose locations that maximise operational effectiveness for the service provider while making it simple for customers to get to them. Hence, considering these factors, the suitable PUDO locations can be identified objectively based on this evaluation.

According to Kotler and Keller (2016), understanding customer needs and wants is crucial in developing and delivering a value proposition that meets their requirements. Apart from that, assessing the competitive landscape helps in understanding the market dynamics and identifying opportunities for differentiation. Kotler and Keller (2016) emphasise the significance of positioning and creating a unique selling proposition to stand out from competitors.

Furthermore, understanding the target market and its characteristics is fundamental in marketing. Kotler and Keller (2016) emphasise the importance of segmenting the market and developing customer profiles to effectively target and communicate with the desired audience. For a PUDO point to be deployed successfully, customer service plays a vital role. According to Gulc (2021), positive customer relationships and experiences, communication between courier services employees and clients, and cultured and courteous behaviour of employees are among the factors affecting the effectiveness and quality of courier services. Evaluating the availability and suitability of facilities for PUDO services is also essential. In the marketing theory, Kotler and Keller (2016) discuss the importance of the physical evidence or the tangible elements that customers interact with when engaging with a service, which includes facilities and infrastructure. They also highlight the importance of assessing the marketing environment, including the technological and regulatory aspects to ensure the feasibility and successful implementation of marketing strategies.

Assessing the accessibility of the location in terms of transportation networks, proximity to target customers, and ease of reaching the PUDO centres aligns with Kotler and Keller's concept of place or distribution (Kotler & Keller, 2016). They highlight the significance of choosing appropriate channels to make products or services accessible to customers. Other than that, they also discussed the importance of customer trust and satisfaction in marketing. Ensuring the security of customer packages and personal information is crucial for building and maintaining customer relationships.

Conclusions

This article presented the expert panel's results on the chosen indicators and sub-indicators of PUDO point appropriateness in creating the index instrument using the BWM. Experts agreed on the necessary and important indications to include in the index instrument to assess the eligibility of a place to deploy PUDO services such as in this study, PEDi centres located in Sarawak. Prospective users, according to expert panels have been the major factor in establishing the viability of a site to implement PUDO services. The availability of local products and competition held similar importance in this case. The results revealed a mix of functionality, potentiality, and consumer behaviour indicators to be incorporated in the practical evaluation of PUDO point appropriateness via the indicators and sub-indicators. As a result, this study not only recommended indicators and sub-indicators for the index instrument but also provided insights into the manipulation of key informants in creating major indicators for the building of the PUDO Point Suitability Index (PPSI) instrument contextually in Malaysia. This study provides new insights into the strategic selection of PUDO points which enhance the validity and contextual relevance of the application of PPSI in Malaysia. The methodological approach, on the other hand, contributes to the field by demonstrating how local context can shape the development of a tailored assessment tools, paving the way for a more effective urban planning.

Acknowledgements

This research is funded by the Malaysian Communications and Multimedia Commission through the Digital Society Research Grant.

Conflict of Interest Statement

The authors declare that they have no conflict of interest.

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Appendix

Evaluation Rubric for Each Construct

Local Product

Criteria	8-10 Excellent	5-7 Good	2-4 Fair	0-1 Poor
Availability of local products	A wide variety of high-quality, locally made products are available.	A good selection of locally made products is available.	A limited selection of locally made products is available.	Only a few locally-made products are available.
The popularity of local products	Local products are in high demand and have a strong following among consumers.	Local products are moderately popular and have some consumer demand.	Local products have a limited following among consumers.	Local products are not in demand among consumers.
Profitability of local products	Local products have a high profit margin and can generate significant revenue.	Local products have a moderate profit margin and can generate some revenue.	Local products have a low profit margin and may generate little revenue.	Local products have a very low profit margin and may not generate any revenue.
Accessibility of local products	Local products are easily accessible and readily available to consumers.	Local products are somewhat accessible and may require additional effort to obtain.	Local products are less accessible and may require significant effort to obtain.	Local products are not easily accessible and may require significant time and resources to obtain.

Competition

Criteria	8-10 Excellent	5-7 Good	2-4 Fair	0-1 Poor
Presence of competing courier services	There are no competing courier services in the area.	There are few competing courier services in the area.	There are several competing courier services in the area.	There are many competing courier services in the area.
Proximity of nearest courier services	The nearest courier services are located further than 5 km.	The nearest courier services are located within a 3-5 km radius.	The nearest courier services are located within a 2 km radius.	The nearest courier services are located within a 1 km radius.
Accessibility of nearest courier services	The nearest courier services are not easily accessible and require long travel time or significant effort to reach.	The nearest courier services are less accessible and require significant travel time to reach.	The nearest courier services are accessible with some difficulty and may require longer travel time.	The nearest courier services are easily accessible and reachable within a few minutes of travel time.

Prospective Users

Criteria	8-10 Excellent	5-7 Good	2-4 Fair	0-1 Poor
Daily users	The centre has a high number of daily users and the number is consistently increasing.	The centre has a good number of daily users and the number is stable or increasing over time.	The centre has a moderate number of daily users and the number is stable or slightly decreasing over time.	The centre has a low number of daily users and the number is consistently decreasing.
Entrepreneurs	The centre has a high number of entrepreneurs and they are actively using the centre's resources to grow their businesses.	The centre has a good number of entrepreneurs and they are using the centre's resources to grow their businesses.	The centre has a moderate number of entrepreneurs and they are somewhat using the centre's resources to grow their businesses.	The centre has a low number of entrepreneurs and they need to use the centre's resources to grow their businesses.
Usage patterns	The centre has a diverse set of users, including individuals, small business owners, and students, all of whom use the centre's resources effectively.	The centre has a varied set of users, including individuals, small business owners, and students, who use the centre's resources effectively.	The centre has a limited set of users, primarily consisting of individuals, small business owners, or students, who may only sometimes use the centre's resources effectively.	The centre has a very limited set of users and they may only sometimes use the centre's resources effectively.
Marketing channels	Comprehensive use of diverse and cutting-edge marketing channels. Exceptional online presence, including interactive website, active social media, and email campaigns.	A variety of effective marketing channels are employed. Consistent online presence with regular updates.	Basic marketing channels in use. Limited online presence with sporadic updates.	Limited or outdated marketing channels are used. Minimal online presence.

Readiness

Criteria	8-10 Excellent	5-7 Good	2-4 Fair	0-1 Poor
Willingness	Staff demonstrate a strong willingness to provide drop-off and pick-up services for customers and are proactive in offering the service when appropriate.	Staff are generally willing to provide drop-off and pick-up services for customers and are responsive when asked to do so.	Staff are willing to provide drop-off and pick-up services but may not always be proactive in offering the service.	Staff are unwilling or resistant to provide drop-off and pick-up services for customers or may provide poor service when asked to do so.
Attitude	Staff have a positive and friendly attitude towards customers and are happy to assist with drop-off and pick-up services.	Staff have a generally positive attitude towards customers but may not always be enthusiastic about providing drop-off and pick-up services.	Staff have a neutral or mixed attitude towards customers and drop-off and pick-up services.	Staff have a negative or unfriendly attitude towards customers and drop-off and pick-up services.
Knowledge	Staff are knowledgeable about the process of accepting and releasing goods for delivery and can provide accurate information to customers.	Staff have a good understanding of the process of accepting and releasing goods for delivery but may need additional training or support to answer some customer questions.	Staff have some understanding of the process of accepting and releasing goods for delivery but may not be able to answer all customer questions.	Staff have little understanding of the process of accepting and releasing goods for delivery and cannot provide accurate information to customers.

Facilities

Criteria	8-10 Excellent	5-7 Good	2-4 Fair	0-1 Poor
Internet speed	Consistently high speeds of 25 Mbps or more with low latency times.	Average speeds of 10-25 Mbps with occasional lagging.	Inconsistent speeds below 10 Mbps with frequent lagging.	Unusable speeds with constant lagging and connectivity issues.
Reliability	No downtime or connectivity issues.	Minimal downtime with occasional connectivity issues.	Frequent downtime with intermittent connectivity issues.	Regular downtime with consistent connectivity issues.
Equipment and hardware	Up-to-date equipment and hardware with minimal technical issues.	Mostly up-to-date equipment with occasional issues.	Outdated equipment with frequent technical issues.	Old and non-functioning equipment with major technical issues.
Telecommunication speed	High-quality voice and video calls with no connectivity issues.	Adequate quality voice and video calls with minor issues.	Frequent connectivity issues and poor call quality.	Unable to make voice and video calls due to poor connectivity.

Business Space

Criteria	8-10 Excellent	5-7 Good	2-4 Fair	0-1 Poor
Space availability	Sufficient space for conducting business activities and storage.	Adequate space for most business activities and storage.	Limited space for some business activities and storage.	Inadequate space for any business activities or storage.
Layout and organisation	Efficiently designed and organised to maximise space utilisation.	Well-designed and organised for effective use of space.	Some areas may be cluttered or disorganised.	Poorly designed and organised, making space difficult to use.
Security measures	Strong security measures in place to protect goods and equipment.	Adequate security measures in place for goods and equipment.	Basic security measures in place for goods and equipment.	No security measures in place for goods and equipment.

Accessibility

Criteria	8-10 Excellent	5-7 Good	2-4 Fair	0-1 Poor
Distance to PEDi centre	Less than 1 km or within walking distance.	1-5 km or accessible by bicycle or public transport.	5-10 km or requires private transportation or a longer walking distance.	More than 10 km or not accessible by public or private transport.
Road condition	Well-maintained, paved roads with good signage and lighting.	Mostly well-maintained roads with adequate signage.	Partially maintained roads with poor signage and lighting or partially unpaved.	Poorly maintained roads, unpaved, or inaccessible due to natural disasters or construction.
Transportation access	Multiple options for transportation, including ride-sharing services.	Adequate options for transportation.	Limited options for transportation or with longer wait times or high cost.	No options for transportation or with excessively high cost or limited availability.

Security

Criteria	8-10 Excellent	5-7 Good	2-4 Fair	0-1 Poor
CCTV coverage	CCTV cameras cover all areas of the PEDi centre with clear visibility.	CCTV cameras cover most areas of the PEDi centre with clear visibility.	CCTV cameras cover some areas of the PEDi centre with some blind spots.	No CCTV cameras are installed in the PEDi centre and poor-quality camera footage.
Physical security	Strong physical barriers such as grilles and reinforced doors, secure the premises.	Adequate physical barriers secure the premises.	Some physical barriers are in place but may not be strong enough or may have vulnerabilities.	Little to no physical barriers in place to secure the premises.
Vandalism control	No vandalism case.	Vandalism rarely happens.	Frequent cases of vandalism.	Highly frequent cases of vandalism.