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Sustainable FLM transport based on IPF transport by ferry in coastal rural areas: A case from Sweden

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ABSTRACT

With the increased emission requirements in Europe over the past century the role of Integrated Passenger and Freight (IPF) transport for sustainable first- and last mile (FLM) transport have increased. IPF transport by ferry has the potential to increase sustainability in FLM transport in coastal rural areas. A literature review followed by a single case study was conducted to examine six core elements of IPF transport by ferry for improvement of environmental, economic, and social- sustainable FLM transport in a Swedish coastal rural areas. In addition to the literature review, empirical data was collected from a total of 346 semi-structured interviews with passengers (i.e., visitors, tourists, residents), goods owners and policymakers, observations (at ferries, piers) and a hackathon. The study show that environmental sustainable FLM transport could be improved by increasing usage of free capacity in ferries, and improved planning of the IPF transport by ferry. The study indicate improved environmental sustainable FLM transport linked to introduction of electrical ferries for IPF transport. Economic sustainable FLM transport related to the long-term viability of IPF transport by ferry could be improved by enhanced compliance between traffic planning programs and the execution of FLM transport in coastal rural areas, and adjustment of passengers' one-way ticket fare of IPF transport. The study suggest introduction of modul-based ferries to improve economic sustainability of FLM transport based on IPF transport by ferry. To improve social sustainability of FLM transport, safety risks in IPF transport of bicycles, management of freight and passengers at piers, accessibility of passengers and goods owners at piers should be considered. The study indicate improvement of social sustainabiltility related to accessibility of passengers and goods owners at piers.

1. Introduction

First- and Last Mile (FLM) transport comprises mobility and logistics challenges in urban, semi-dense and rural areas (Eurostat, 2021) but also issues on the protection of the environment, preservation of safety and quality of life of citizens (European Commission, 2019). This study focuses on environmental, economic, and social sustainable FLM transport based on Integrated Passenger and Freight (IPF) transport by ferry in rural areas. This differs from FLM transport by other transport modes (bus, tram, sub-way etc.) in urban areas due to regulatory requirements on safety, and planning of IPF transport. Mobility and logistics challenges in rural areas are affected by a lack of a common definition (Eurostat, 2021), since rural areas are defined according to national policy objectives or a combination of multiple criteria (e.g. population size and density, the presence of agriculture, distance to urban areas and lack of

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infrastructure and/or social services) (Eurostat, 2021; Glesbygdsverket, 2008). In this study, rural areas are defined by the one-kilometre grid cell method used by Eurostat (2021), where a grid cell is deemed rural if it has less than 300 inhabitants. This definition incorporates population density and size and the size of grid cells to facilitate comparisons between European countries (Eurostat, 2021). It may, however, differ from that used by authorities in the provision of financial support (Tillväxtanalys, 2014).

Rural areas are characterised by agriculture productivity, income inequality and volatility, depopulation as an effect of urbanisation, a lack of efficient information technology, a lack of transport infrastructure, difficulties to access public transport services, and high costs of public and private services (OECD and European Commission, 2020). This creates challenges to FLM transport in rural areas regarding accessibility, funding and available infrastructure (Eurostat, 2021; Henning-Smith et al., 2017; Makkonen et al., 2013); political support (Henning-Smith et al., 2017; Makkonen et al., 2013) at local, regional and national government levels (Wear, 2009).

Many studies have been published addressing IPF transport to improve FLM transport (see Cavallaro & Nocera, 2021) and trunk line transport (e.g., Fielbaum et al., 2021; Gschwender et al., 2016) in urban areas. Most papers present studies conducted in urban areas (Behiri et al., 2018), few papers address IPF transport using ferries (Bruzzone et al., 2021; Mazzarino & Rubini, 2019) and implementation in rural areas (Van Duin et al., 2019; Makkonen et al., 2013). Examples of IPF transport in European rural coastal areas include Hurtigruten in Norway (Hurtigruten, 2023), ferries in Croatia (Croatia Traveller, 2023), and in Italy (Bruzzone et al., 2021; Cavallaro & Nocera, 2023). Studies on IPF-based FLM transport in rural areas are still needed that consider the interactions between stakeholders to support policymakers in integration of passenger and freight transport systems (Cavallaro & Nocera, 2021).

This study focuses on sustainable FLM transport in coastal rural areas based on IPF transport by ferry. It extends previously published studies on IPF transport (e.g. Cavallaro & Nocera, 2021; Bruzzone et al., 2021), and FLM transport in rural coastal areas by ferry (Bruzzone et al., 2021; Wear, 2009). The purpose of the study is to identify and examine core elements in IPF transport by ferry for the improvement of sustainable FLM transport in coastal rural areas. The following research question (RQ) is employed:

RQ: How can core elements in IPF transport by ferry contribute to improved sustainable FLM transport in coastal rural areas?

According to the stated purpose and research question, this study aims to support regional policymakers, public transport operators and shipping companies in their improvement of sustainable FLM transport in rural coastal areas that is based on IPF transport by ferry. The need to support policymakers in planning of IPF transport has been addressed by Crainic et al., (2016). The study extends recently published research conducted by Bruzzone et al., (2021) and Cavallaro & Nocera, (2023) on IPF transport in rural coastal areas by ferry.

Following this introduction, Section 2 comprises a literature review on IPF transport, FLM transport and sustainable business models. Then, the applied methodology is presented (Section 3); this includes a case study for examining sustainable FLM transport based on IPF transport. Section 4 provides the results and a discussion and finally, some conclusions are drawn (Section 5).

2. Literature review

2.1. IPF transport

IPF transport has been widely discussed in academia during the last decade (Cavallaro & Nocera, 2021; Van Duin et al., 2019). Published research suggests opportunities to increase the efficiency and reliability of transport systems, and the sustainability in operations compared to if passenger transport and freight transport systems are separated (Arvidsson et al., 2016; Monios, 2019). A lack of integration between the two systems reduces the utility of shared mobility and overcapacity in FLM transport in public transport systems (Shaheen & Chan, 2016).

Several studies have been published on the integration of passengers and freight in long-haul (Ghilas et al., 2013) and short-haul airfreight, using public transport to improve mobility and FLM transport in urban areas (Coenegrachts et al., 2021; Ghilas et al., 2016; Lindkvist & Melander, 2022; Trentini & Mahléné, 2010; Van Duin et al., 2019). Trentini & Mahléné (2010) present a summary of shared public transport services (tram, bus, subway and car) used for urban freight transport in the US, EU and Asia. Fatnassi et al. (2015) address the possibility of urban freight operators gaining sustainability advantages in terms of improved service time and energy reduction in an integrated passenger-freight transport network. Ghilas et al. (2016) present a solution to the time-window problem of scheduled lanes in routing a given set of busses based on requests for freight transport. They conclude that transport requests can be used in the scheduling of mobility services.

The scheduling of mobility services based on an integration of passenger and freight transport in urban areas has been the subject of various recently published studies (Elbert & Rentschler, 2021; Le Pira et al., 2021; Lindkvist & Melander, 2022). Le Pira et al. (2021) present a conceptual model for integration between mobility-as-a-service (MaaS) and urban freight. They conclude that this may increase the utilisation of passenger transport vehicles and will reduce freight transport. However, passengers' choice of public transport may be affected by costs of travel, travel time (Hagenauer & Helbich, 2017), long waiting times, security (Lois et al., 2018) and safety during transshipment (Abenoza, et al., 2018) and maritime transport services (Márquez, et al., 2014). Lindkvist & Melander (2022) present a literature review on the sustainability advantages and disadvantages of MaaS and urban consolidation centres. Their findings support research presented by Elbert & Rentschler (2021) which show that urban freight transport stakeholders using public transport may gain advantages in meeting social and environmental sustainability goals. They further address that public transport operators need to develop information and communication technology (ICT) tools to facilitate IPF transport in urban areas.

Studies on IPF transport show that public transport operators may gain social sustainability advantages by creating opportunities for people with poor job prospects, as well as providing general delivery and passenger services despite poor economic feasibility (Van Duin et al., 2019). Published research shows that multimodal IPF transport that uses the free capacity in public transport vehicles for freight transport is environmentally and economically viable for urban freight stakeholders (Bruzzone et al., 2021; Ghilas et al., 2016).

Their findings align with Zhu et al. (2023) who show that IPF transport using trams for middle-mile distribution can reduce costs and provide environmental benefits. To meet transport policies, multi-agent transport simulation models for passenger transport have been shown to be applicable to freight transport (Schröder & Liedtke, 2017).

Few studies on IPF transport in rural (or peripheral) areas have been published (Bruzzone et al., 2021; Cascetta et al., 2009; Huang et al., 2019; Namgung et al., 2019; Pernkopf & Gronalt., 2021; Wear, 2009). IPF transport in rural areas may improve passengers' perception of service due to that cost reductions in integration of passenger and freight transport would create additional, more frequent transit or delivery services. (Bruzzone et al., 2021). However, due to low frequencies in passenger and freight transport services supplied in rural areas, users are obliged to adapt their trip schedules to possible effectiveness, which differs from transport services in urban areas (Cascetta et al., 2009). Wear (2009) mentions that IPF transport in rural areas is affected by the long-term viability of public transportation. Namgung et al. (2019) explore passengers' preferences with regard to the time value (for walking, in-vehicle, maximum delay and waiting times) of IPF transport by bus in a Japanese rural area. They found that passengers choice of transport is affected by waiting time and maximum delaytime at the bus stop, as well as time for walking to the bus stop. Their findings further address that IPF transport is preferred by elderly passengers, and conclude that IPF transport could be used to improve door to door service for passengers.

Huang et al. (2019) analyse the operational costs (marginal cost and total income related to decision-making) of IPF transport by rail in a rural Chinese area based on a mathematical separation model.Their findings show that passenger, operational freight, and total network costs are replaceable i.e., if the passenger transport volume increases, the freight transport cost will increase and vice versa. Because of this, they conclude that IPF transport by rail is inefficient and that passenger transport service, freight transport service should be separated. This differs from Bruzzone et al. (2021), who conclude that IPF transport by ferry is environmentally and economically viable for all supply chain stakeholders since it reduces the external costs of pollution of nitrous oxide and carbon dioxide from FLM transport in rural areas of the Venice lagoon. The external costs of pollution, in the mentioned paper, are estimated based on modelling emissions caused by freight and passenger transport in two areas followed by a multiplication of their unitary economic value published in reference manuals on on external costs of transport. Their conclusion complies with studies on IPF transport by aerial ropeway for FLM transport of freight, people, waste and empty load carriers in alpine rural areas (Pernkopf & Gronalt., 2021). Recent research on IPF transport by ferry shows economic viability with regard to costs of construction, energy and operations in using a electric ferry (Kortsari et al.,2022).

The literature review in this study reveals that further studies on IPF transport by ferry are needed that address usage of free capacity in the ferry (Bruzzone et al., 2021) and electric powered ferries (Kortsari et al.,2022) to reduce emissions. There are also a need for further studies that address 'long term viability' i.e. compliance with transport planning programs and European directives on public procurement of public transport (Wear, 2009; European Commission, 2014), and passengers' choice of IPF transport affected by costs of travel (Pernkopf & Gronalt., 2021) and operational costs of IPF transport by ferry (Bruzzone et al., 2021). Finally, there is a need of studies on IPF transport by ferry that includes safety of passengers and crewmembers in management of freight (IMO, 1974; Márquez, et al., 2014) and accessibility of passengers' and goods owners to piers (Tsoi & Loo, 2021).

2.2. FLM transport

FLM transport includes the first and the last leg of each transport operation of both passengers and freight (Nocera et al., 2020; Tight et al., 2016). In public transportation, FLM transport is directly linked to accessibility and, thus, to passenger choice of transport mode (Zellner et al., 2016). Ahern and Hine (2012) address lack of elderly peoples' access to FLM transport in rural areas and mention the long-term costs of reducing such FLM services linked to social isolation and mental health problems. Boarnet et al. (2017) analyse FLM transport based on accessibility to low-wage jobs in an urban area. They found that changing the distance to stations in low-income neighbourhoods improves transit access low-wage jobs more efficiently compared to policies on reduced transit waiting time.

Referring to FLM transport of freight, several studies report system inefficiencies and poor operational performance contributing to high transport costs (e.g. Ambra et al., 2018; Bergqvist & Monios, 2016). To reduce operational costs in last mile transport of goods in urban areas, published research suggests improved consolidation (e.g., Hagberg & Hulthén, 2022; Abbasi et al., 2021) and implementation of consolidation centres (e.g., Anand et al. 2021, Isa et al., 2021). In the maritime sector, consolidation of goods into containers reduces transportation cost and emissions of hinterland transport (Fan et al., 2019). Published studies suggest the use of crowdshipping in the public transport network as an approach to reduce the environmental and economic impact of the last-mile transport of e-commerce goods in urban areas (Gatta et al., 2019). In rural areas, carriers may experience higher costs due to low and sparse demand, which adversely affects the provisions of service for FLM transport (Boyer et al., 2009).

The FLM transport of passengers and freight in urban or rural areas often uses the same infrastructure, leading to conflicts. For example, studies have shown conflicts among the interests of trucks, trams used for FLM transport and cyclists, as well as between carriers and retailers' economic interests in the use of space in urban areas (Pitera et al., 2017; Ringsberg et al., 2023). Due to diverging interests of stakeholders, aspects of land use, population density and diversity, multimodal transfer, service quality, operational management strategies and access to pier infrastructure should be considered in development of sustainable passenger FLM transport by ferry in urban areas (Tsoi & Loo, 2021; Cavallaro & Nocera, 2023).

In addition, FLM transport of passengers and of freight is not only considered as two separate transport systems in transport planning, policy-making and research (Arvidsson et al., 2016; Monios, 2019); they are also regulated differently by different authorities with regard to guidelines on responsibility, public procurement, safety and security. For example, in Sweden public transport operators must comply with national acts and ordinances on public transport (e.g. The Swedish Act 2010:1065 and Swedish Ordinance 2011:1126 [Swedish Parliament, 2010; 2011]) and public procurement (e.g. Swedish ordinance 2016:1162 [Swedish Parliament,

2016]). They should further observe European strategies on mobility and sustainable transport (European Commission, 2020). Similarly, shipping companies involved in FLM transport in coastal rural areas based on IPF transport by ferry must comply with international guidelines supervised by the International Maritime Organization (IMO), such as the International Maritime Dangerous Goods (IMDG) code on the transport of hazardous and dangerous goods (IMO, 2020) and the SOLAS and MARPOL conventions (on safety [IMO, 1974] and protection of the environment [IMO, 1983], respectively). Additionally, they must also comply with Regulation (EU) No 1177/2010, Directive 1999/63/EC on the working time of seafarers and with national ordinances on maritime transport to minimise the risk of accidents (Thomas & Turnbull, 2018). Integrated maritime transport on in-land waterways must also be considered to be safe for both passengers and the shipping company (Caris et al., 2014). Thus, published literature on FLM transport reveals that this could be facilitated by IPF transport by ferry.

2.3. Sustainable business models

The development of sustainable business models has received attention both in the academic literature and in society since the adoption of the 'triple bottom line' concept into business (Geissdoerfer et al., 2018; Evans et al., 2017). This concept emphasises co-creation and a balance among benefits based on an integration of environmental, economic and social values in the development of a sustainable planet (Evans et al., 2017; Stubbs & Cocklin, 2008). A sustainable business model thus includes performance measures based on the triple bottom line concept and a wide range of societal stakeholders (Stubbs & Cocklin, 2008). Boons and Lüdeke-Freund (2013) further argue that a sustainable business model should equally measure environmental, economic, and social values. The model should measure suppliers' responsibilities against stakeholders, customer consumption towards the distribution of economic costs and benefits among stakeholders based on the company's ecological and social impact. A business model for sustainable FLM transport based on IPF transport by ferry must consider different stakeholders' benefits and long-term viability, defined in this study according to Geissdoerfer et al., (2018) as 'a business model that incorporates proactive multi-stakeholder management, the creation of monetary and non-monetary value for a broad range of stakeholders, and which holds a long-term perspective' (Geissdoerfer et al., 2018, p. 409).

Many papers have been published on business models for sustainable IPF transport in urban areas. For example, a five-blueprint business innovation model for sustainable IPF transport in the Antwerp (Coenegrachts et al., 2021) offers a high integration with public transport, which increases the catchment area and attractiveness of public transport. Likewise, business models for sustainable FLM transport based on IPF transport in urban (Mazzarino and Rubini, 2021; Van Duin et al., 2019) and rural areas (Bruzzone et al., 2021) have been published. Van Duin et al. (2019) present a business model for cargo-hitching showing positive impacts on social sustainability and service quality, while Mazzarino and Rubini (2021) propose a framework for assessment of the feasibility of IPF transport using ferries to improve sustainability and urban logistics in the Venice lagoon. Based on their proposed framework, a business model for sustainable FLM transport and IPF transport by ferry has been presented by Bruzzone et al. (2021).The business model addresses positive impacts on operational efficiency (variation traffic flow, travel distance, load factor and frequency in freight deliveries) and the environmental (variations of energy used and external costs of air pollution) and social sustainability (costs of labour) of IPF transport by ferry. Recently a business model for FLM transport that combines IPF transport with demand-responsive transport (i.e., I-DRT transport) by ferry in rural areas was presented by Cavallaro & Nocera, (2023). The model evaluates performance of I-DRT transport based on financial, operational, environmental, and social key performance indicators (KPIs). Presented business models and frameworks on IPF transport by ferry does not address usage of electrically powered ferries to reduce emissions (environmental sustainability), transport planning of IPF transport, passengers' choice affected by costs of travel (economic

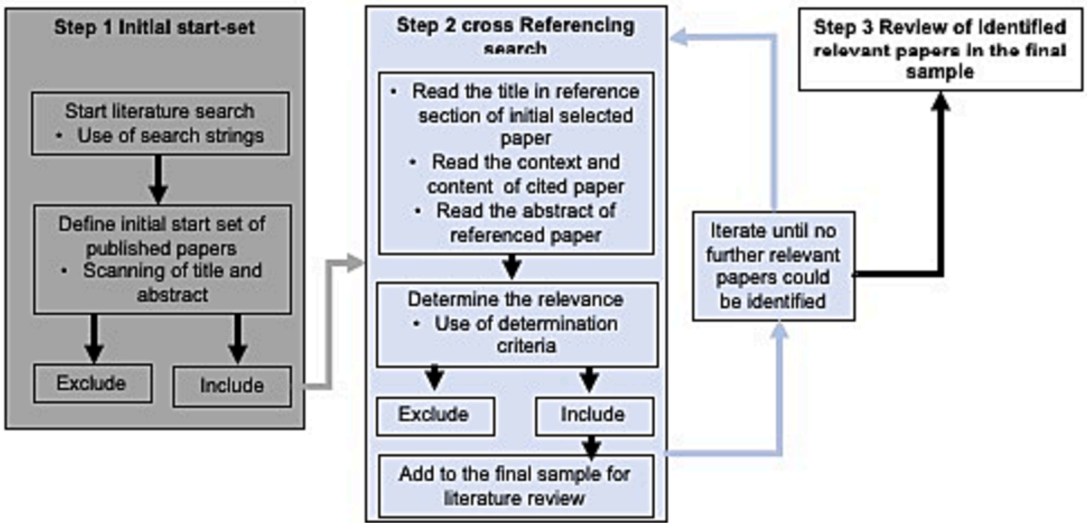

Fig. 1. The cross-referencing procedure (Geissdoerfer et al., 2018).

sustainability), safety of passengers and crewmembers in management of freight, and accessibility of passengers and goods owners to piers within IPF transport (social sustainability).

3. Material and methods

First, a literature review (Easterby-Smith et al., 2015; Geissdoerfer et al., 2018) was conducted. The results from this were used in development of interview questions for data collection and in the analysis of collected empirical data. The empirical data were collected in a case study (Yin, 2009) of an IPF transport by ferry in a Swedish coastal rural area.

3.1. Literature review

The literature review was conducted as a three-step cross-reference (Geissdoerfer et al., 2018) process (Fig. 1). According to Geissdoerfer et al. (2018), cross-reference snowballing creates advantages by looking at the reference lists and citations for additional references in the papers found in the literature search, which complements the literature review.

Step 1 included a literature search of published papers between 2007 and 2023 to define an initial set of papers relevant to this study. The date for the initial search of relevant papers was set based on the release of the 'Green Paper on Urban Mobility' (Cavallaro & Nocera, 2021). The final date was set to January 2023 (end of the project). The search strings and databases, Web-of-Science (WoS) and Scopus, are presented in Table 1. In addition, to determine the relevance of an identified paper, the following inclusion criteria were used:

- Scientific study/studies
- Peer-reviewed papers
- Matches the purpose of this study
- Published in English

The abstracts and titles of identified papers gained in Step 1 were scanned to acquire an initial set of relevant papers for this study.

In Step 2, additional relevant papers were identified by cross-referencing. The reference section of the initial selected papers (Step 1) was analysed by reading each papers' title, its context, contents, citations and reference list. The abstracts of additional identified papers were then read to determine if those papers should be included or excluded in the sample of relevant papers according to the inclusion criteria. Through this process, relevant papers were subsequently added to the sample and for further review. This process was repeated until no further relevant papers could be identified. The final sample for a full review in Step 3 contained 52 papers (marked with a "*" in the reference list of this paper). These were used as references in the literature review section, in the development of interview questions, in the discussion and conclusion sections, as well as in the analysis of data (Section 3.4, Table 5). In addition to published papers, relevant international, European and national regulations on public transportation and maritime transport were identified in EUR-lex, IMO and Swedish parliament databases. In total, 10 relevant regulations (three international, six European and three national) were identified and used as references.

3.2. Case study design and context area

According to Yin (2009) case studies should be used if the objective is to clarify a particular and a complex situation by investigation of a contemporary phenomenon within its real-life context and when the boundaries between phenomenon and context are not clear. Bruzzone et al. (2021) state that IPF transport is complex. An IPF ferry line used for FLM transport between a multimodal transport node (Tuvesvik) in the Swedish municipality of Orust and two islands (Gullholmen and Käringön) was selected for the case study (Fig. 2).

The municipality of Orust is defined as a rural area according to Eurostat (2021) since it comprises 386.5 square kilometres of land and had a population of 15,444 inhabitants as of 30 September 2022 (Statistics Sweden, 2019; 2022), which provides a population density of 39.96 inhabitants/km^2. The municipality is also an island itself with a road connection to the mainland, characterised by agriculture, volatility of income, long travelling times for commuting to urban areas (at least 45 min) (Region Västra Götaland, 2019), increasing depopulation and difficulties for residents to access public transport services (Statistics Sweden, 2021; Statistics Sweden,

Table 1
Databases, literature search strings and fields used in the literature review.

Search strings	Search field	Number of identified papers		
		Scopus Step 1	WoS Step 1	Step 2
'sustainable business model' AND 'transport*'	Title, abstract	4	3	8
'business model*' FOR 'sustainable transport'	Title, abstract,	4	3	4
'passenger' AND 'rural transport'	Title, abstract, keywords	5	4	5
'passengers' AND 'freight'	Title, abstract, keywords	32	16	26
'first' and 'last' and 'transport'	Title, abstract, keywords	5	7	9
Total number of selected papers		29	25	52

Fig. 2. The ferry line between the multimodal transport node and the two islands (Gullholmen and Käringön).

2022a). Moreover, from April to October, the population increases to approximately 40,000 inhabitants because of tourism and the 6,113 registered holiday homes (Statistics Sweden, 2022b; Orust, 2023).

Based on the literature on IPF transport in rural areas and sustainable business models (Bruzzone et al., 2021; Donaldson & Preston, 1995; Makkonen et al., 2013; Van Duin et al., 2019; Wear, 2009), the case included the following stakeholders.

Public authorities, comprise a regional authority with the main responsibility for the development of public transport services in the region that includes the case study area. These were represented by regional policymakers in the hackathon. The regional authority establishes agreements with a public transport operator in compliance with national regulations on public transport (set by parliament policymakers). The regional authority also establishes traffic planning programs and policies for the development of public transport based on requirements on the accessibility and safety of passengers, safety and low environmental impact (Region Västra Götaland, 2021). The regional public authority is funded by taxes under the governance of the Swedish government. In this study parliament policymakers represented by the three socialist, two liberal and three conservative parties were included in the interviews.

Public transport operator, comprises a limited company owned by the regional public authority responsible for the procurement,

planning and development of public transportation services by tram, bus, train and ferries in the region (Västtrafik, 2023). However, the public transport company does not in practice execute public transport, but it is operated by transporters (e.g. shipping companies) based on established contracts. Since the public operator is owned by a regional public authority, public transport services in the region are financed by taxes. Therefore, the transport operator must comply with Directive 2014/25/EU on the public procurement of public transport services (European Commission, 2014). For the planning of public transport services, the operator uses the ICT tool Remix, which was also developed for the planning of IPF transport (Remix, 2023). To provide passengers with information (about departure/arrival times, ticket fares, stops, time schedules, travelling times, congestion, etc.), the operator uses a specially developed web interface and a cell phone app (ToGo).

According to the time schedules for the two ferries, one departs from the multimodal node bound for the island of Gullholmen between 06.45 a.m. and 8.30p.m. every 40–45 min during the winter season (11th December to 14th May) and every 15–20 min during the summer. The travel time between the node and Gullholmen is five minutes, and the journey costs of 35 SEK (approx. 3.5 Euros). Likewise, one ferry departs from the node bound for the island of Käringön between 07.00 a.m. and 08.30p.m. every 1–1.5 h during the winter season and every 25–30 min during the summer. The ferry between the node and Käringön makes a stop at Gullholmen and has a total travelling time of 40 min, at a cost of 35 SEK (approx. 3.5 Euros) (Västtrafik, 2023). The public transport operator also operates a passenger transport terminal at the multimodal transport node with a bus line for further travel.

Shipping company (i.e. transporter), comprises of a private company that operates a freight terminal at the multimodal transport node (in Tuvesvik) and a ferry line of two vessels (Table 2) based on a three-year contract for IPF transport by ferry with the public transport operator. The contract regulates economic compensation from the regional authority in the execution of public transport services and usage of the public transport operators' web interface and mobile app (ToGo) in communicating travel information to customers. For the execution of freight transport, the shipping company has contractual agreements with transporters for the long-haul freight of goods with goods owners on the two islands and with the municipality for renting the freight terminal (Käringötrafiken, 2023). At the terminal, received long-haul freight shipments are consolidated and placed into transport units (roller cages, cabinets and pallets) for further IPF transport by ferry. The IPF transport of freight is performed based on prioritisation of FLM transport of passengers. Because of this and seasonal variations between the summer and winter, needs for the FLM transport of freight, the number of transport units during FLM transport varies between 1 and 14 units/travel.

The two ferries used for IPF transport are designed for passenger transport under deck and the free space on the weather deck in the stern and/or bow is also used for FLM freight transport. Both ferries are equipped with cranes in the stern for the lifting of heavier transport units and portal ramps that are put out by the crew for the movement of lighter transport units between the deck and pier. For the communication of freight arrival times with goods owners and freight transport, a Facebook group is used.

Passengers (visitors, tourists, residents), are customers using the IPF transport by ferry for FLM transport in the coastal rural area. Passengers are not a homogenous group due to different needs for accessibility (e.g., disabled, elderly), and time efficiency (e.g., commuters, leisure passengers) when using IPF transport services by ferry. Because the case study is situated in a popular tourism area, the number of passengers increases during April-October.

Goods owners, are customers using the IPF transport by ferry for FLM transport of goods in the coastal rural area. In addition, goods owners do not constitute a homogeneous group due to differences in transport needs (e.g. on demand) and requirements (e.g. safety, preservation of temperature) during freight transport. Due to tourism the number of transport units increases during April-October.

Society.

This refers to community associations and companies with common interests to preserve a viable society and an environment attractive for residents, goods owners, visitors and tourists.

3.3. Case study data collection

Following the guidelines on case study research, empirical data were collected from different sources (Yin, 2009); semi-structured interviews and observations, and a hackathon was held (Rys, 2022).

Semi-structured interviews

In total, 346 semi-structured interviews were conducted with passengers, goods owners and policymakers at regional and parliament level in Sweden (Table 3). All respondents were purposively selected by convenience sampling (Creswell, 2014). The interviews with passengers were conducted on-site during a period of three months (March-June 2022) to include the impact of tourism on FLM transport. The goods owners were interviewed on-site during October 2022. Interviews with policymakers were conducted in August 2022 at their offices. The policymakers represented seven out of eight of the political parties (representatives from one of the socialist parties declined to participate).

All the interviews were conducted face-to-face, lasted 10–15 min and were transcribed. The respondents were all asked six initial questions about their age, gender, occupation, place of residence, educational level and opinions about IPF transport by ferry in coastal

Table 2
The two ferries used for IPF transport (Skärgårdsbåtar, 2023).

Ferry	Total carrying capacity (passengers)	Top speed (knots)	Length above water (m)	Width above water (m)	Draft (m)	Fuel
Strömcrona	148	12	24.38	6.59	1.93	Diesel
Strömstjärna	198	12	28.38	6.53	1.7	Diesel

Table 3
Respondents' socio-demographic characteristics (N = 346).

	Passengers (n = 330)		Goods owners (n = 9)		Public authority policymakers (n = 7)	
	No.	Percentage	No.	Percentage	No.	Percentage
Gender						
Male	163	49	6	67	5	71
Female	167	51	3	33	2	29
Age						
>19	36	11				
20–29	165	50				
30–39	77	23	3	33	2	29,
40–49	38	12			2	29
50–59	11	3	2	23	3	42
65<	3	1	4	44		
Highest Educational level						
Elementary school	3	1				
Upper secondary school	142	43	5	56	1	14
University/ college	185	56	4	44	6	86
Occupation						
Student	56	17				
Culture employed	20	6				
Business, sales manager	56	17				
Industry, production employed	53	16				
Law enforcement employed	43	13				
Researcher teacher academia	40	12				
Service hotel/ restaurant employed	51	15				
Retired	11	3				
Place of residence						
Orust municipality.	168	51	9	100	0	0
Another municipality	162	49	0	0	7	100

rural areas. In addition to the six initial questions, interviews with passengers and goods owners included 11 closed and five open-ended questions (see A**ppendix). The questions focused on the following:

- Frequency and aim of travel on the ferry during the week
- Satisfaction with time efficiency of the transport service (passenger and freight transport)
- Transport of different types of freight; bicycles, hazardous goods (petrol, paint, oil, corrosive substances, etc.) and construction goods (bricks, lumber, cement, etc.), recyclable goods (plastic, cardboard, newspapers, clothes, metal, glass)
- Safety in FLM transport of different types of freight (as above)
- Use of a differentiated fare of a one-way-ticket by ferry for residents and tourists/visitors
- Responsibility in IPF transport by ferry
- Fare of a one-way ferry ticket
- Safety, economic, and logistic challenges in IPF transport by ferry.

Likewise, in addition to the six initial questions, interview questions with policymakers included three closed and three open-ended questions about the following (see A**ppendix):

- Political party affiliation due to the relationship with environmental concern (Cruz, 2017)
- Level of political engagement (regional or parliament)
- Responsibility for IPF transport by ferry
- Safety, economic and logistic challenges in IPF transport by ferry.

For the data collection during interviews, standardised interview templates were used (Yin, 2009).
Observations.
Observations were conducted at piers at the multimodal node, on the islands, and on the two ferries. During the observations, notes and photos were taken focusing on the following:

- Pier infrastructure to ensure accessibility for passengers and goods owners
- Pier infrastructure to ensure the safety of passengers during FLM transport and management of freight at the piers
- The safety of crew members in the management of freight at the piers.

4. Hackathon

A hackathon is a short-term intensive event that gathers different groups of participants to solve a defined problem, a challenge, or

create a joint project, which meets a specific need determined by the event organiser (Heller et al., 2023). According to Rys (2023), hackathons differ from brainstorming, in that the method includes free transfer of knowledge, lack of problems in people presenting their work to competitive teams and complete strangers, and encourages mutual trust. Recent published research addresses that hackathons have been conducted in disciplines such as Information Technology, Higher Education, Medicine, social science and sustainability (for a review see Heller et al., 2023). In this study, a two-day hackathon was arranged with the aim of identifying innovative solutions (Rys, 2022) to challenges in sustainable FLM transport in coastal rural areas based on IPF transport by ferry. In total, 22 persons represented by 19 stakeholders with an interest in FLM transport participated in the hackathon (Table 4).

In order to facilitate the identification of innovative solutions, the three categories of challenges (i.e., infrastructure, logistic operations and business models) previously identified through analysed interviews were presented for the participants (see the analysis section 3.4). The hackathon ended with short (10–15 min) presentations and assessment of innovative solutions conducted orally and in writing.

4.1. Data analysis

Few studies have been published focusing on IPF transport by ferry to improve FLM transport in rural coastal areas (e.g., Bruzzone et al., 2021; Makkonen et al., 2013). Ad-hoc key KPIs for evaluation of FLM transport in rural coastal areas based on IPF transport by ferry have been presented (Bruzzone et al., 2021; Cavallaro & Nocera, 2023), as well as in the development of a sustainable business model for ferries (Tsoi et al., 2021).

For the analysis of sustainable FLM transport in coastal rural areas based on IPF transport by ferry, this study combines the three sustainability dimensions (environmental, economic and social) described by Evans et al. (2017) and the six core elements of IPF transport by ferry found in the literature review (Section 2.1) (Table 5).

Closed questions included in the interviews were statistically analysed (number and percentage) (Sharlene & Johnson, 2015). Open-ended questions on challenges and opinions about IPF transport by ferry included in the interviews were analysed by directed content analysis (Hsieh & Shannon, 2005), and the analysis was based on the sustainabilty dimensions and the six core elements of IPF transport by ferry (Table 5). The open-ended questions were also analysed for challenges and categorised into 1) infrastructure, 2) logistic operations (including environmental sustainability) and 3) business models. These categories were used during the hackathon. Collected written presentations and notes from the hackathon were analysed with directed content analysis (Hsieh & Shannon, 2005).

The analysed results from the literature review and empirical data from the three sources (semi-structured interviews, observations, hackathon) were continuously compared for triangulation and validation of the results (Yin, 2009; Denzin & Lincoln, 2011).

5. Results and discussion

The results from the conducted literature review (Section 2.2) showed that FLM transport of passengers and freight in coastal rural areas could be facilitated by IPF transport by ferry. This was confirmed during the interviews by 84 % (277) of the passengers and by all the policymakers (100 %) and goods owners (100 %). In addition, 80 % (264) of the passengers, all the policymakers (100 %) and goods owners (100 %) indicated that the public transport operator should allow freight transport into the ferries to increase sustainability in FLM transport.

This aligns with the Swedish National Act (2010:1065) on public transportation. The Act does not mention transport by ferry (compared to other public transport modes) but states that public transport operators are allowed to freely procure commercial public transport and freight transport. The lack of focus on transport by ferry in the Swedish Act indicates that public transport operators do not need to take responsibilities for IPF transport in coastal rural areas by ferry. The lack of focus was confirmed by the 81 % (267) of passengers and 67 % (6) of goods owners and aligns with the findings of Bruzzone et al. (2021) and Cavallaro and Nocera (2021). The interpretation of responsibilities included national acts on public transportation may however vary among Swedish stakeholders. This was confirmed in the interviews with policymakers and goods owners; all policymakers addressed that the public transport operator should be responsible for the transport of passengers and the shipping company should be responsible for FLM transport of freight, while all goods owners stated that the public transport operator should be responsible for IPF transport by ferry. Thus, further studies may be needed to explore public transport operators' responsibilities in IPF transport by ferry related to National Acts on public transport.

Published studies included in the literature review and the interview results presented in this study indicate that the impact of national acts on the procurement of public transport to improve sustainable FLM transport in coastal rural areas based on IPF transport by ferry needs to be further investigated.

Table 4
Stakeholders participating in the hackathon.

Stakeholder	No. participating organisations
Shipping company	1
Goods owners	7
Public authority	2
Society	9

Table 5
Sustainabilty dimensions and the six core elements of IPF transport by ferry.

Sustainability dimension	Core elements of IPF transport by ferry	Source
Environmental	Usage of free capacity in ferries	Bruzzone et al. (2021)
	Usage of electriccally powered ferries	Kortsari et al. (2022)
Economic	Long term viability of IPF transport by ferry	Wear, (2009); European Commission, (2014)
	Ferry transport costs of passengers and goods owners	Pernkopf & Gronalt.(2021)
		Bruzzone et al. (2021)
Social	Safety of passengers and crewmembers IPF transport by ferry	IMO, (1974); Márquez, et al. (2014)
	Accessibility of passengers and goods owners on ferries and piers	Tsoi & Loo, (2021)

5.1. Sustainable FLM transport in coastal rural areas based on IPF transport by ferry

In this section, the results from the interviews, observations and the hackathon on sustainable FLM transport in coastal rural areas based on IPF transport by ferry are presented and discussed (Fig. 3). According to Fig. 3 sustainable FLM transport is examined based on the identified six core elements of IPF transport by ferry (Section 2.1) and the three dimensions of sustainability (Section 2.3) (See also Section 3.4, Table 5).

Due to the stated purpose of this paper improvement of sustainable FLM transport in coastal rural areas have been examined based on the intersections between the three dimensions (i.e., environmental, economic, and social sustainability), leaving the intersections between two dimensions for future studies (i.e., between environmental- and social sustainability; between social- and environmental sustainability, as well as between economic- and environmental sustainability).

5.1.1. Environmental sustainability

Usage of free capacity in ferries.

Three of the regional policymakers stated during the interviews that increased capacity requirements should be placed on public transport operators. This was also addressed by all the goods owners and highlighted during the hackathon. In addition, most passengers (52 %), and goods owners (88 %) addressed capacity problems in ferries related to the de-prioritisation of freight in favour of

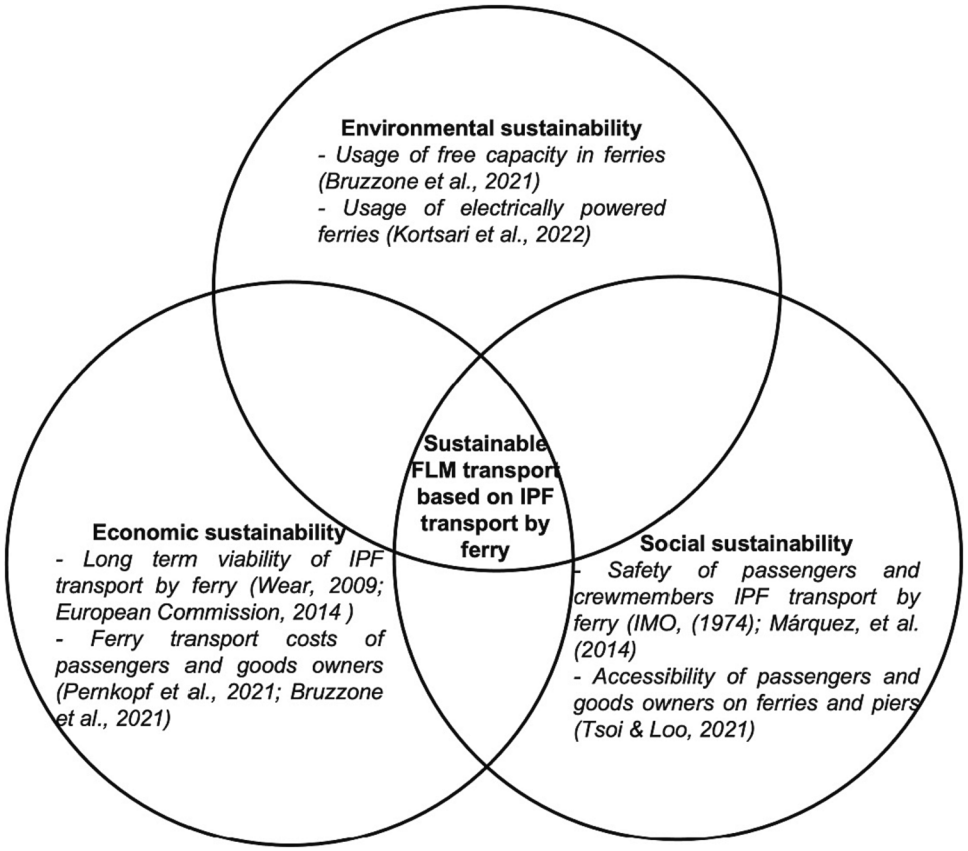

Fig. 3. Sustainable FLM transport in coastal rural areas based on IPF transport by ferry.

passenger transport during the summer season. They stated that passengers and goods are left on the pier at the multimodal transport node. Referring to the lack of capacity, 44 % (4) goods owners of food products especially addressed problems with increased product damages and a lack in the supply of products to the two islands due to that the goods have been left on the pier.

With regard to usage of free capacity in the ferries used for IPF transport, the results from the hackathon emphasised a need for improved transport planning. In order to increase the use of free capacity, 67 % (6) of the goods owners suggested during the interviews that ferry planning during the summer season should include a prioritisation among the number of passengers, freight volume and times of departure. Referring to IPF transport, they also suggested that the FLM transport of freight should be prioritised in the morning (06.30–10.00 a.m.) and in the evening (after 4p.m.), when the number of passengers is limited, while the FLM transport of passengers should be prioritised during the day (10 a.m.-4p.m.), when the number of passengers is high. They also proposed that, during the winter, IPF transport by ferry should be planned based on the fixed arrival times of goods and statistics about passengers' travel frequency and goods owners' freight transport demands. The need to improve the planning of FLM transport based on IPF by ferry was confirmed in the passenger interviews on travel frequency and travel aims. These results indicate that most passengers use the ferry more than 12 times a week, followed by 1–5 times per week (Fig. 4).

The interviews with passengers and goods owners revealed that the IPF transport by ferry is mostly used for commuting to and from work (Fig. 5).

The results from the hackathon suggested that the usage of free capacity in ferries could be increased by allowing the transport of recyclable goods. Further studies are, however, needed that focus on the FLM transport of recyclable goods or food products in rural coastal areas by ferry, as well as the planning of IPF transport by ferry based on passenger demands on travel time.

Usage of electrically powered ferries.

All the goods owners addressed during interviews concerns about increased air and water emissions of FLM transport due to the two diesel-powered ferries presently used for IPF transport by ferry. In order to reduce FLM transport emissions, goods owner interviews and the hackathon presentations suggested introduction of electrically powered ferries in two separate ferry lines: one line with higher departure frequency with a smaller ferry only going to Gullholmen, and the other with a larger ferry going to Käringön via Gullholmen.

The hackathon results also addressed the charging infrastructure for ferries. The opinion was that this could be used for the charging of other types of transport vehicles (trucks, cars, etc.) at the multimodal node and for balancing the electricity supply on the two islands during the day. These results align with Kortsari et al. (2022), who state that introduction of electrically powered ferries is economically feasible due to decreased operational costs of energy and sharing of charging infrastructure. However to ensure environmental sustainablity by using electrically powered ferries, further studies are needed that include energy consumption (Paladugula et al., 2018) and impact on costs of one-way tickets for passengers (i.e. as an impact of infrastructure challenges) (Sæther & Moe, 2021). To ensure reliability such studies should be based on detailed dataset on transportation service and consumed energy (Paladugula et al., 2018).

5.1.2. *Economic sustainability*

Long term viability of IPF transport by ferry.

The literature review (Section 2.1) showed that IPF transport is affected by transport planning programs and European directives on public procurement on the execution of public transport services. This was supported by the interviews, with three of the policymakers on parliament level who stated that rural coastal municipalities should receive increased governmental support for development of viable IPF transport to improve FLM transport. The results from analysed hackathon presentations, addressed the importance of a long term viable IPF transport by ferry of freight to the grocerystore as an important node in the provision of services (e.g. post, pharmacy) for residents, visitors and tourists on the two islands.

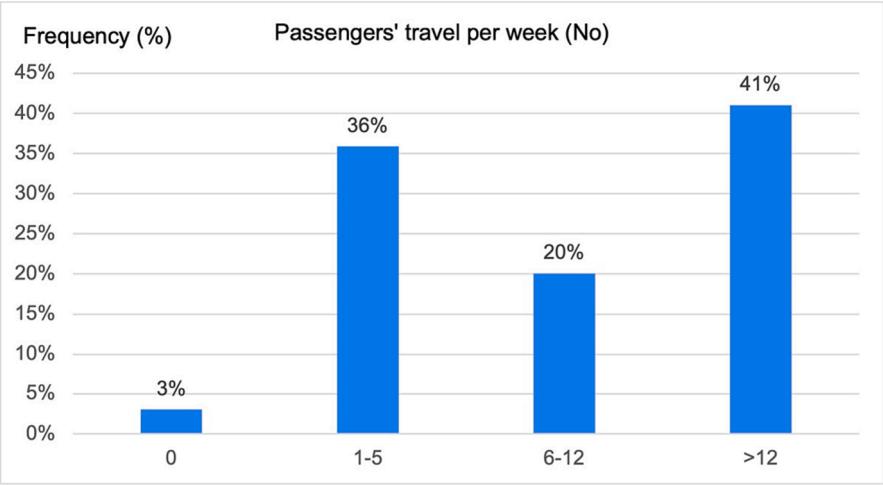

Fig. 4. Passengers' travel frequency per week with the ferry (N = 330).

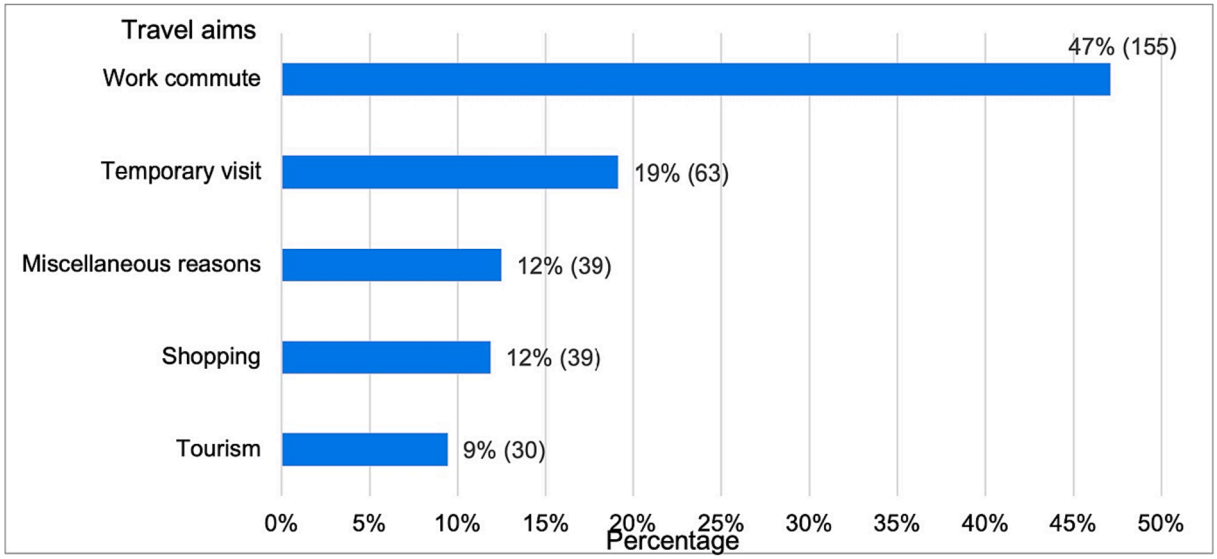

Fig. 5. Passengers' travel aims when using the ferry for FLM transport (N = 330).

It emerged from the interviews that 67 % (6) of the goods owners and from the hackathon presentations, that there is lack of compliance between the traffic planning programmes set by regional authorities and the planning of FLM transport based on IPF transport by ferry at the public transport operator. During the interviews goods owners especially addressed lack in planning of the IPF transport due to cancelletion of ferry trips with short notice, usage of the free capacity, and in transport of passengers with different needs. To improve the viability of IPF transport by ferry in compliance with regional traffic planning programmes, the public transport operator, should look further into the use of simulation models such as Schröder & Liedtke, (2017).

Some 88 % (8) of the goods owners interviewed addressed that the shipping company and the public transport operator should improve communication about free capacity, departure/ arrival times, and cancelled ferries with stakeholders and passengers in their execution of FLM transport basd on IPF transport by ferry. They emphasized that the communication should be based on statistics on goods owners' and passengers' needs. This was also confirmed by hackathon presentations, which suggested arrangements of common meetings and development of an ICT tool (a cell phone app) for improved communication in planning of FLM transport of passengers and goods to the islands.

These result are consistent with Elbert and Rentschler (2021) and Lindkvist and Melander (2022), who both suggest that public transport operators develop ICT tools to improve the FLM transport service for passengers. It ought, however, to be noted that the ICT tool Remix used by the public transport operator included in this study, comprises tools for the planning of FLM transport of passengers integrated with freight (Remix, 2023). One explanation for not using the tool Remix could be that the public transport operator lacks

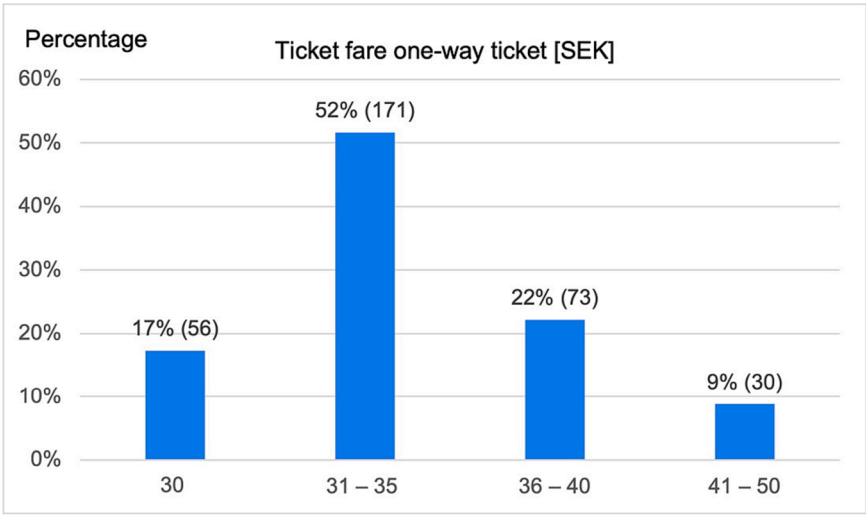

Fig. 6. Passengers' accepted fare of a one-way ferry ticket in FLM transport (N = 330).

access to statistics about freight volumes and passengers transported by the shipping company operating the IPF transport.

5.2. Ferry transport costs of passengers and good sowners

Published studies on IPF transport show that passengers' choices of public transport are affected by the costs of travel and that freight costs are affected by efficiency in operations. Interviews with three policymakers on parliament level addressed that a reduced ticket fare for passengers' travels implies that the operational costs of FLM transport based on IPF transport by ferry would have to be covered by the costs of freight paid by goods owners or by financial support from the authorities. Analysed passenger interviews shows that most passengers (69 %) would choose the IPF transport by ferry for FLM transport if the fare of an one-way ticket was less than 35 SEK (approx. 3.5 Euros), while 31 % would choose the ferry if the fare was higher than 36 SEK (approx. 3.6 Euros) (Fig. 6).

Most (95 %) of the passengers addressed that there should be a difference in the fare of a one-way ticket between visitors and tourists, on the one hand, and residents, on the other (Fig. 7). Thus, the result indicates that the operational costs of FLM transport based on IPF transport by ferry might be covered by visitors and tourists especially during the tourist season.

According to hackathon presentations, the introduction of a smaller ferry with a higher departure frequency between Gullholmen and the multimodal transport node (Tuvesvik) would increase the shipping company's opportunities to share the FLM transport costs of passengers' travels and goods owners' costs of freight transport during the day.

To reduce freight operational costs in FLM transport, the hackathon presentations suggested the introduction of module ferries in IPF transport. According to the presentations, these ferries would consist of a cabin, a flat deck and transport modules specifically developed for FLM transport of passengers and different types of goods. The transport modules would be placed onto and locked into the deck of the ferry. The number of transport modules placed on the ferry would be adjusted based on the demand of FLM transport of passengers and/or freight. The use of modular vehicles may create sustainable economic advantages in terms of reduced operational costs in combination of modules and reduction of trip duration (Hatzenbühler et al., 2023). The hackathon presentations further suggested opportunities to reduce costs of safety incidents of passengers, and crew members in FLM transport based on IPF transport by ferry, since transport modules adapted to passenger or freight transport are separated. It ought to be noted, however, that the introduction of module ferries increases the costs of infrastructure investments, such as in lifts to move freight from the transport module onto the pier and in the rebuilding of IPF ferries used for FLM transport. Thus, the result addresses that further research is needed on development of modular ferries for FLM transport in rural coastal areas.

The interviews with all (100 %) policymakers showed that IPF transport by ferry used for FLM transport in rural coastal areas could be economically viable for all stakeholders as this creates opportunities to reduce operational costs of freight and passengers' travel costs. This is consistent with the results reported in the literature review (Section 2.1), which showed that IPF transport could be economically viable for all stakeholders in FLM transport due to an increased usage of the free capacity in transport vehicles and efficiency in operations (Bruzzone et al., 2021; Pernkopf & Gronalt, 2021). Likewise, the results align with recently published studies on mobility on demand services with opportunities to decrease operational costs at producers by integrating passenger and freight transport (Fehn et al. 2023). Further studies are still needed that consider cost factors of passenger and freight transport in evaluation of sustainable FLM transport based on IPF transport by ferry in rural areas. However estimation of such factors are expensive and complex and must carefully be measured (Cappelli & Nocera, 2006).

5.2.1. Social sustainability

5.3 Safety of passengers and crewmembers IPF transport by ferry.

The interviews with passengers revealed that many felt unsafe in FLM transport by ferry of bicycles compared to the transport of

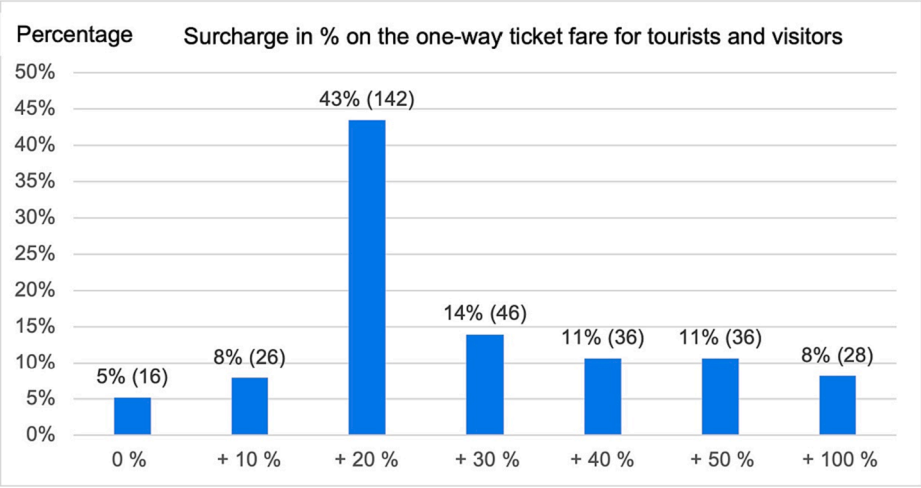

Fig. 7. Surcharge on the fare of an one-way ticket for visitors and tourists in percentage (N = 330).

construction, hazardous and recyclable goods (Table 6). This was also stated in the interviews with three (30 %) of the goods owners, who also mentioned safety issues linked to bicycles on the piers during the summer season.

The high percentage of passengers feeling safe when transporting construction recyclable and hazardous goods indicates opportunities for the shipping company to increase the transport of various freight in IPF transport by ferry. This was confirmed by the observations on ferries at piers, which showed that transport units used in FLM transport must be secured and given separate areas to ensure safety during transportation. However, this requires a rebuilding of ferries based on IPF transport needs with regard to regulations on the safety of passengers and freight, such as the IMDG-code (IMO, 2020). In order to ensure safety in FLM transport, the hackathon results further suggested development of modular ferries for IPF transport (as described above).

The hackathon presentations and observations on piers indicated a deficiency in the safety of passengers and crewmembers in their management of freight between the ferry and the piers. According to observations a metal portable ramp is manually placed out by the crewmember between the ferry's deck and the pier for disembarkation of passengers and unloading of freight. It was observed that there was a lack of safety in placing out the ramp, since the ramp is heavy (approx. 60 kg) and not adaptable to water-level differences. Deficiencies in passengers safety was also observed when using the crane during unload of freight. In order to ensure safety of passengers during unloading/ loading of freight 44 % (4) of the goods owners stated during interviews that the shipping company should assign non-accessible passenger areas on the piers to ensure the safety of passengers, which was also confirmed by the hackathon presentations.

5.3. Accessibility of passengers and goods owners at ferries and piers

With regard to a high number of passengers and freight volumes during the tourist season, the hackathon presentations and observations on the ferries suggested that the shipping company should widen doors and introduce areas for wheelchair parking under the deck to improve accessibility for disabled and elderly passengers. The latter has also been found in studies of MaaS, which show the exclusion of certain groups of passengers in public transportation (Lindkvist & Melander, 2021). In addition, 56 % (5) of the goods owners mentioned a lack of accessibility due to some piers being narrow, which causes accessibility problems when there are both passengers and freight. The piers should therefore be rebuilt. The results indicate a need for further studies on accessibility for passengers and goods owners at piers, and development of ferries based on IPF transport by ferry.

6. Conclusions

According to the literature review there is growing interest in sustainable FLM transport in urban and rural areas. This study examined sustainable FLM transport in coastal rural areas based on IPF transport by ferry. Results obtained from the literature review suggest that sustainable FLM transport could be improved based on six identified core elements of IPF transport by ferry. The review also shows that few studies have been published on sustainable FLM transport in coastal rural areas based on IPF transport by ferry. To extend and complement published research, this study presents a single case study of a sustainable FLM transport based on IPF transport by ferry in a Swedish coastal rural area.

The case study shows that the *environmental sustainability* could be improved by usage of the free capacity in ferries which is also confirmed by previously published studies. The results address that increased capacity requirements should be placed on the public transport operators, as well as improved planning of FLM transport to improve usage of free capacity in ferries. The results further suggests that planning of IPF transport by ferry of freight should include a prioritisation among the passenger numbers, freight volumes and times of departure, while passengers' travels should include travelfrequency and aim of travel. The case study also confirm that environmental sustainability in FLM transport could be improved by the introduction of electrically powered ferries for IPF transport.

It emerged from the case study that *economic sustainability* related to long term viability of IPF transport by ferry might be improved by providing financial support to rural coastal municipalities. The results especially address a need to enhance the compliance between traffic planning programs set by regional authorities and the execution of FLM transport to improve the long-term viability of IPF transport by ferry. This could be done by regional authorities establishment of guidelines on development and planning of IPF transport by ferry. The results further suggest that the public transport operator should improve communication with passengers by using existing ICT tools for planning of IPF transport by, was also is confirmed in other published studies. For balancing cost of travel of passengers with transport costs of freight the results show that passengers would choose the IPF transport by ferry if the fare of an one-way ticket is lower than the existing fare, and that there should be a difference in the fare between visitors, tourists and residents especially during the tourist season. The case study also indicates that economic sustainability in terms of reduced operational costs by the introduction of modular ferries in IPF transport.

The case study shows that *social sustainability* in FLM transport in coastal rural areas based on IPF transport by ferry could be improved if the shipping company considers safety risks in IPF transport of bicycles and in management of freight and passengers at piers. The result also suggest implementation of modular ferries to improve safety during FLM transport and at piers. The case study also addresses that the shipping company needs to improve accessibility to passengers and goods owners for an improved social sustainable FLM transport in rural coastal areas based on IPF transport by ferry.

Further, the case study addresses divergent interests between stakeholders in improvement of sustainable FLM transport based on IPF transport by ferry. To ensure the liveability of communities in coastal rural areas the stakeholders and regional policymakers should collaborate and consider divergent interests. It is important that regional policymakers also involve local stakeholders (e.g., residents and goods owners) in the improvement of sustainable FLM transport in coastal rural areas based on IPF transport by ferry.

The study extends published research on sustainable FLM transport as one of the few studies which focuses on IPF transport by

Table 6
Passengers' feelings of safety in FLM transport of freight based on IPF transport by ferry (N = 330).

Goods type	Passengers' feelings of safety	
	No % (n)	Yes % (n)
Bicycles	52 (172)	48 (158)
Construction goods (bricks, lumber, cement, etc.)	21 (69)	79 (261)
Hazardous (petrol, paint, oil, corrosive substances, etc.)	39 (129)	61 (201)
Recyclable goods (plastic, cardboard, newspapers, clothes, metal, glass)	25 (82)	75 (248)

ferry. It further extends published studies on IPF transport by examining possible improvements of sustainable FLM transport in coastal rural areas based on six core elements of IPF transport by ferry. By using a case study design with data collection from multiple sources the results have provided added validity (Yin, 2009). The search process of the literature review, the case study context, the participants included in the study and the six core elements of IPF transport by ferry identified in literature review have been carefully described to ensure validity. The case study is limited to a single case study of a Swedish, spatially coastal rural area defined according to Eurostat (2021). As with all qualitative case studies, and case studies, the results obtained from the study cannot be generalised in a statistical sense (Yin, 2009). This is a possible weakness of the study whose utility however is prevalently ascribable to obtain deeper knowledge on how to improveme sustainable FLM transport in coastal rural areas based on IPF transport by ferry rather than to generalise the presented results. For generalisation of results further studies that explore sustainable FLM transport in coastal rural areas based on IPF by ferry in other countries/ regions are needed. Such studies could explore sustainable FLM transport based on energy consumption of ferries and impact on one-way ticket fares for passengers in using electrically powered ferries for IPF transport. Further studies are also needed that evaluate transport costs of IPF transport-based cost factors (Cappelli & Nocera, 2006) and the introduction of modular ferries. Lastly, further studies are needed on development of the IPF transport ferries, and the piers to improve accessibility of passengers and goods owners.

Authorship contributions.

Please indicate the specific contributions made by each author. The name of each author must appear at least once in each of the three categories below.

Conception and design of study: Henrik Ringsberg.

Acquisition of data: Henrik Ringsberg, Ayton Hüüs, Tomas Kaktavičius.

Analysis and/or interpretation of data: Henrik Ringsberg.

Drafting the manuscript: Henrik Ringsberg.

Revising the manuscript critically for important intellectual content: Henrik Ringsberg.

Approval of the version of the manuscript to be published (the names of all authors must be listed): Henrik Ringsberg.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A

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Initial inquires during all interviews

1. **What is your age (in years)?**

2. **I am**
   - ☐ Male
   - ☐ Female

3. **What is your main occupation?**
   - ☐ Student
   - ☐ Culture, employed
   - ☐ Business, sales manager
   - ☐ Industry, production employed
   - ☐ Law enforcement, employed
   - ☐ Researcher/teacher, academia
   - ☐ Service hotel/restaurant, employed
   - ☐ Retired

4. **What is your main place of residence?**

   - ☐ Orust municipality
   - ☐ Another municipality

5. **What is your level of education?**

   - ☐ Elementary school
   - ☐ Upper secondary school
   - ☐ University/college

6. **Do you think a combination (integration) of passenger transport and freight transport is a good idea? Please explain why or why not.**

Inquires used during interviews with passengers and goods owners

1. **How many times do you travel by ferry each week?**

0	1-5	6-12	More than 12

2. **Are you satisfied with the current situation regarding the delivery times of freight? Please explain why or why not.**

3. **Are you satisfied with the current situation regarding public transport for traveling by ferry? Please explain why or why not.**

4. **Do you think public transport operators should allow freight transport in their ferries? If YES please explain why.**

5. **Do you think public transport companies should allow the transport of bicycles on their ferries?**
   - ☐ YES
   - ☐ NO

6. **Do you think public transport companies should allow the transport of hazardous goods (petrol, paint, oil or corrosive substances, etc.) on their ferries?**
   - ☐ YES
   - ☐ NO

7. **Do you think public transport companies should allow the transport of construction goods (bricks, lumber, cement, etc.) on their ferries?**
   - ☐ YES
   - ☐ NO

8. **Do you think public transport companies should allow the transport of recyclable goods (plastic, cardboard, newspapers, clothes, metal, glass) on their ferries?**
   - ☐ YES
   - ☐ NO

9. **Due to safety, when traveling with the ferry, would you feel discomfort if bicycles were transported on the same ferry as you?**
   - ☐ YES
   - ☐ NO

10. **Due to safety, when traveling with the ferry, would you feel discomfort if hazardous goods (petrol, paint, oil, corrosive substances, etc.) were transported on the same ferry as you?**
    - ☐ YES
    - ☐ NO

11. **Due to safety, when traveling with the ferry, would you feel discomfort if construction goods (brick, lumber, cement, etc.) were transported on the same ferry as you?**
    - ☐ YES
    - ☐ NO

12. **Due to safety, when traveling with the ferry, would you feel discomfort if recyclable goods (plastic, cardboard, newspapers, clothes, metal, glass) were transported on the same ferry as you?**
    - ☐ YES
    - ☐ NO

13. **In your opinion, what is the least acceptable fare for a one-way ticket (in Kr) for a ferry that combines passenger and freight transport?**

30	31-35	36-40	40-50

14. **In your opinion, how much more should tourists and visitors pay for a one-way ticket than residents?**

0% more	<10% more	<20% more	<30% more	<40% more	<50% more	100% more

15. Do you think public transport operators should take responsibility for transport of passengers and freight with the ferry? If YES, please explain your answer.

16. Do you see any safety, economic or logistic challenges in combined/ integrated transport by ferry? If YES, please explain your answer.

Section 3 Inquires used during interviews with politicians.

1. What is your political party affiliation?

- ☐ V
- ☐ S
- ☐ MP
- ☐ C
- ☐ L
- ☐ M
- ☐ KD
- ☐ SD

2. At what level are you politically active?

- ☐ Regional
- ☐ Parliament

3. In your opinion, which stakeholder is responsible for the transport of freight and passengers in costal rural areas by ferry? (Please select the most appropriate option.)

- ☐ The public transport operator is responsible for passenger transport; transport operators are responsible for freight transport.
- ☐ The municipality is responsible for passenger transport; transport operators are responsible for freight transport.
- ☐ Goods owners are responsible for freight transport; public transport operators is responsible for passenger transport.
- ☐ The public transport operator is responsible for passenger transport and freight transport.
- ☐ The municipality is responsible for passenger transport and freight transport.
- ☐ Goods owners are responsible for passenger transport and freight transport.
- ☐ Residents and are responsible for their own freight transport.

4. What are the main challenges and opportunities do you see in combining public transport and freight transport by ferry? In your answer, please consider:

a) Safety in combined transport
b) Costs of passenger travel and freight transport
c) Environmental requirements linked to combined transport

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