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INTERMODAL TRANSPORT OF GOODS AND PASSENGERS IN RURAL COASTAL AREAS

Master's thesis in Maritime Management

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Cover: Passenger vessel used for intermodal transport of passengers in rural coastal areas

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ABSTRACT

Within last two decades of research regarding intermodal transportation of goods and passengers in rural areas was done separately. Statistics and research methods of two subjects has to be combined as intermodal transportation of goods as well as passengers and subject of rural areas are becoming more intertwined due to increased growth of rural areas and their need of almost constant flow of goods (Jones et al., 2000). The purpose of this thesis is to explore options to combine goods transportation with passenger transportation in rural coastal areas of Sweden.

The following research takes into consideration the rural areas inhabitant´s and passenger´s opinions, needs and points of view regarding combined transportation, handling of goods and passengers in rural coastal areas. The project was conducted by collecting quantitative and qualitative data of travellers' and inhabitants' opinions and attitudes about combined transport of people and goods on passenger ferries in the Swedish archipelago. This was conducted by analysing the results and by constructing a recommendation.

The research is limited to maritime transportation in the archipelago of the Swedish west coast and municipalities of Orust, Lysekil and city of Gothenburg. The information was gathered from relevant academic literature sources as well as interviews and questionnaires. Flow of goods is limited to parcels, goods aimed for construction, hazardous goods, palletized goods and recyclable waste. Logistical transport mode – boats/ferries.

Keywords: Intermodal transport, rural coastal areas, combined transportation, flow of goods, IMDG, passenger transportation policy, marine vessels, transport logistics nodes.

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1 INTRODUCTION

This section presents the background of the transportation of goods and passengers in rural areas and the need for it as urbanization continues to grow, which results in more people living in these areas. The academic need for the study is to explore options for combining transportation methods and analyse the acceptance of the inhabitants for detected methods. Furthermore, it introduces research purpose, research objectives and limitations.

1.1 Background

The trend of urbanization continues to grow, as people find it more comfortable to work and live in city areas (Birch & Wachter, 2011). According to OECD (2019), 24 % of Swedish population have registered residency in rural areas. The definition "rural" refers to a habitat outside an urban area with a population of minimum 3000 inhabitants (Gurría, 2019). Majority of these people live in more accessible rural areas, with exception of approximately 200 000 people, that live in sparsely populated areas (less than 8 people per square kilometre), located more than 45 minutes' drive by car from an urban area, where at least 3000 inhabitants are registered (Hall, 2009). Most of the rural areas are accessible by waterways or roads. The population in these areas varies largely during different seasons, mainly effected by holiday residents and tourists (Hall, 2009). Regarding the factor of population volatility during different seasons, the public transportation service between rural areas has not been reliable. The responsibility for this act has been taken by the Swedish transportation authority, which covers the overall responsibility for the commercial transport, such as on waterways and roads (Transportstyrelsen, 2021).

During the last decade, the demand for delivery services of postal goods has increased, due to the worldwide healthcare crisis, which increased the e-commerce consuming (di Crosta et al., 2021). The PostNord's Swedish E-barometer shows that Swedish e-commerce grew by 49 % during the second quarter of 2020 compared with the previous year (PostNord, 2020). The e-commerce parcel-goods transportation is being conducted by logistics companies, which are in contact with delivery service operators and goods owners. For cost effective delivery during intermodal transportation, the cargo unit, such as a container or a pallet must arrive to the destination point without intermediate distribution processes (Han Zhang, 2011). The transportation of recyclable materials is being conducted by utilization companies or involved

logistics contractors. Regarding this fact, the continuously increasing population sets up an increased demand for commercial delivery services for parcel-goods, construction materials, utilization equities and basic consumer goods in the rural areas of Sweden, which has so far been performed by the inhabitants themselves.

To meet sustainability requirements with inhabitants/tourists' mobility, a solution would be to combine passenger transportation with goods delivery services. Despite the number of published/conducted studies there is still a lack of it that needs to be improved regarding the combination of passenger transportation with goods transportation in rural areas using waterways.

1.2 Research purpose

The main purpose of this MSc thesis is to explore options to combine marine transportation of goods with passenger transportation in rural coastal areas of Sweden. This is influenced by inhabitants` and travellers` opinion of the matter.

A secondary purpose was also to analyse the possibilities to use existing marine waterway operators for transportation of parcel goods and passengers as well as to do a brief analysis of most common risks involving passengers and marine vessels.

1.3 Research questions

In compliance with the two stated purposes the following three research questions have been formulated:

1. How can passenger transportation be combined with goods transportation in rural coastal areas of Sweden?
2. What are the possibilities for combining, using existing transportation methods?
3. What are the legal barriers regarding the combination of goods and passenger transportation using maritime transportation?

1.4 Limitations

Considering the research questions stated, the answers to them are specifically regarding maritime transportation methods, such as passenger ferries and deploy the answers into real life scenarios. The project mainly researched permanent inhabitants of the selected rural areas

because of the timeline of the thesis and the season, which the data was collected, also including tourist season. Specifically, the quantitative data was collected at municipalities of Orust and Lysekil by question sheets and internet questionaries. The information given out by the transportation operating companies was narrow and informative, mostly referred by the contact person to competition regulations inside the organization. The location of the research area demanded several hour travels, which limited the visits to the area. Considering relevant academic literature, it had shortcomings and there was a lack of previous research studies on the topic. Time constraints were also affecting this thesis, as the authors had limited time for data collection.

2 FRAME OF REFERENCE

Thesis starts with literature review of intermodal transportation and transportation methods. In addition, a review of regulations and sustainable policies of urban maritime transportation methods is also presented.

2.1 Intermodal transport

Intermodal transport is beneficial to rail, truck or maritime companies, but there is no single consensus definition for intermodal transport (Agamez-Arias & Moyano-Fuentes, 2017; Crainic & Kim, 2007). This definition depends on the viewpoint of the perspective. Maritime companies define this as cargo loading and unloading between marine vessels, rail companies define it as function of rail carts, trucking parties define it in terms of trailers, semi-trailers (Agamez-Arias & Moyano-Fuentes, 2017). Definition had to be chosen representing the most accurate use of all intermodal transport parameters, such as the use of different transport means and no change of the freight itself (Agamez-Arias & Moyano-Fuentes, 2017, p 6)

"Intermodal freight transport is movement of goods in a single freight unit through two or more successive modes of transport, with no handling of the freight during transportation."

Intermodal transportation according to chosen definition would mean that a container of 1 TEU would be unloaded in port of a country and then the same container, without changing any content in it would be loaded on a rail cart or semi-truck and then transported to its final destination which would be accessible via land transport (Figure 1). This operational mean would be considered intermodal transportation since two or more types of vehicles (in this case marine and truck vehicle) were used to transport the same container without changing its content (Crainic & Kim, 2007).

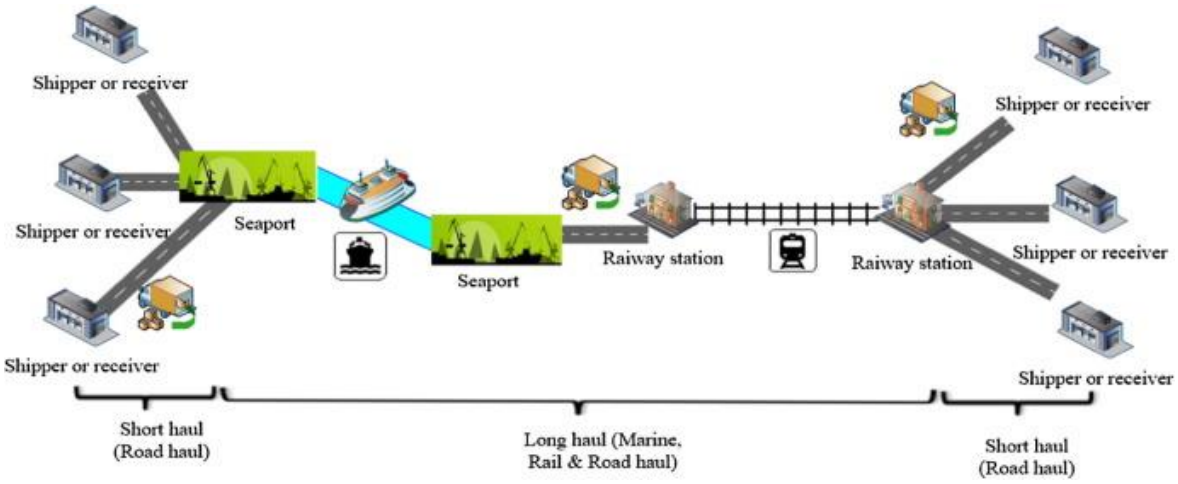

Figure 1 The intermodal process scheme (Baykasoğlu & Subulan, 2016, p 208)

Agamez-Arias & Moyano-Fuentes (2017) and Crainic & Kim (2007) discusses that:

Advantages of intermodal transport:

- Time and cost in transhipment of goods
- Cost, environmental impact of packaging
- Time handling insurance issues

Disadvantages:

- Customization of transport modes
- Heavy initial investments/unit loads
- Difficulties in relocation of empty unit loads
- Long lead-time
- Very in-depth co-ordination between operational companies and other parties such as warehouses, storage yards and assurance that those places will have necessary equipment to handle goods, would it be containers, cisterns, swap bodies or other matter of goods storage unit

Using intermodal transport scheme as shown in Figure 1, comprise barriers such as long lead-time, very in-depth co-ordination is needed between operational companies and other parties such as warehouses, storage yards and assurance that those places will have necessary equipment to handle goods, would it be containers, cisterns, swap bodies or other matter of goods storage unit. Nordic roads are known for their complexity in navigating and driving during cold season, thus when hauling goods, it especially needs regional and international co-ordination that all journey steps would be fluent as well as the operation itself, meaning intermodal transportation could reach economic profitability (Bärthel & Woxenius, 2004). Most of the barriers can be summarized as followed: network connectability, organizational power, uncertainty regarding market situation, technology, transport policy (Bergqvist & Monios, 2016).

Network connectability: haulage distance, shippers around the terminals, volumes of freight handling per shipper or shipping area, what kind of transportation type of handling freight the area has (Bergqvist & Monios, 2016).

Organizational power: as mentioned previously freight transportation can be complex, thus it needs regional co-ordination for precise navigation and preparation as well as international co-ordination between different transportation organizations. Preparing and executing all steps for successful freight delivery is complex, thus requiring co-ordination between multiple companies, in addition if organization is not thorough, transportation vehicle may be coming back empty, thus lowering profitability of the haulage (Bergqvist & Monios, 2016).

Uncertainty regarding market situation: some freight haulage may take a month or more to complete, within that time market situation may change, the freight value might drop or cost of transportation may increase, resulting in loss of profit (Bergqvist & Monios, 2016; Crainic & Kim, 2007).

Technology: does the handling area have necessary operational equipment to handle and store the freight unit, is the operational technology safe to use to assure product handling will not harm freight itself (Bergqvist & Monios, 2016).

Transport policy: is freight allowed to be transported on all roads within the country or it may only be transported in certain roads, is LHV (longer heavier vehicles) allowed in the country for maximum profit. What restrictions applies for the type of freight in the country (Bergqvist & Monios, 2016).

If the barriers are overcome, the sustainable aspect of the operations comes in light as well. Intermodal transport is generally more sustainable in matter of GHG (greenhouse gasses), case study focusing about sustainability of intermodal transport found that nitrogen oxides (NOx), sulfur oxides (SOx) and CO2 are lower than conventional transportation (Ramalho & Santos, 2021).

In addition, to being sustainable as well as profitable, shipper has to plan and co-operate with other companies or customers to fill the container unit with freight on the way back. An empty container unit being transported is a profit loss. (Bergqvist & Monios, 2016). To achieve this an evaluation of the area is needed: location of all operators in the area around delivery terminal, freight volumes per shipper or area, productivity of resource, such as fuel cost,

amount of trips per load unit and times it is going to be loaded or unloaded (Macharis & Bontekoning, 2004). Every mentioned logistical chain step is fragmented as almost every warehouse, storage yard or facility is owned or serviced by different company, if co-ordination fails at any step it may result in empty container trip back (Bergqvist & Monios, 2016).

2.2 Transport of goods in coastal rural areas

Transport of goods in coastal rural areas depend on available transport infrastructure and maritime transport modes.

2.2.1 Transport infrastructure

Economic prerequisites tend to push towards to unification of trading, industrial, handling and forwarding parties that are operating closely with the infrastructure of trade routes into logistical alliances, logistical centres and certain networks (Basova & Nechaev, 2013a). This in correlation with time proven technologies, parties will deliver goods to buyers or consumers with as little lead time as possible with minimum costs (Basova & Nechaev, 2013a). Trend is leaning towards more complicated trading routes which involves more shippers and receivers, as well as forwarding agencies, ship owners and other vehicle carriers, would it be rail, truck or aviation. Logistics centres and warehouse or storage territories, insurance companies, certain authorities and many other parties involved into successful cargo flow (Basova & Nechaev, 2013b; Roso, 2013). This is raising the need for more complex infrastructure and that it would withstand ever-increasing cargo inflow of goods to be delivered in larger quantities and bigger variety as more people choose to live in a decentralized manner, meaning more communities outside the main cities are getting more populated (Roso, 2013; Walsh et al., 2019).

Rural Transport Infrastructure (RTI) should meet four levels of development or “Level of service” (Lebo & Schelling, 2001):

1. **No (motorized) access** - no access for motorized vehicles within one or two kilometres from/to a household or village;

2. **Partial access** – motorized vehicle access during majority of the year but with interruptions;

3. **Basic access** – reliable all-year round for prevailing means of transport, with limited periods of accessibility;

4. **Full access** – uninterrupted throughout the year access to destination village or household, high quality surface and low-roughness.

For efficient transportation activities, such as delivery services, logistics and everyday use in rural area, it has to have a developed road connection between city, this connection should consist of gravel or better yet asphalt road above sea level with drainage on each side and a slope on few degrees that rain water would not accumulate in the middle of the road and would run-off into drainage (Barrios, 2008; Gharehbaghi et al., 2020). Community RTI mainly consists of paths and footbridges, sideroads and should be at a sufficient length and complexity that the community would be able to maintain it (Lebo & Schelling, 2001). Intermodal transport in rural areas depend on infrastructure which is developed, meaning that costs, difficulty and time needed to handle goods depends on three access levels (Barrios, 2008; Gharehbaghi et al., 2020; Lebo & Schelling, 2001):

No access or **partial access**: this level of service is most of the time applies to very low-density accumulation of populous in the area, usually one or two households. To upgrade access to main road or city to basic access service level take enormous number of resources and usually if even it is done, inhabitants cannot maintain the stretch of the newly built road (Lebo & Schelling, 2001).

Full access: a fully engineered road with consistent cross-sections throughout its alignment and water crossing of high standard (Lebo & Schelling, 2001).

Basic access: this level of service has to meet atleast minimum requirements and standards of the following – passability and reliability regarding that the stretch of the connection would it be road or a bridge, would be passable all times or if it is not, the situation would be resolved as fast as possible, adequate access to higher-levels networks regarding access to educational establishments, non-agricultural job opportunities, health facilities such as hospitals and treatment facilities, markets and national roadways, adequate access to domestic activities, such as wood collection, access to nature land, ponds and other small water entities and trafficability of industry, this includes but not limits access for trucks and semi-trucks to haul goods, logistical distribution points, ports and terminals, docks and ferries if mainland is separated with a body of water between the rural area (Lebo & Schelling, 2001).

Transport nodes are selected by taking into consideration geographical transportation paths, such as railway, airway, roadway or waterway (Figure 2) (Wang & Fu, 2022).

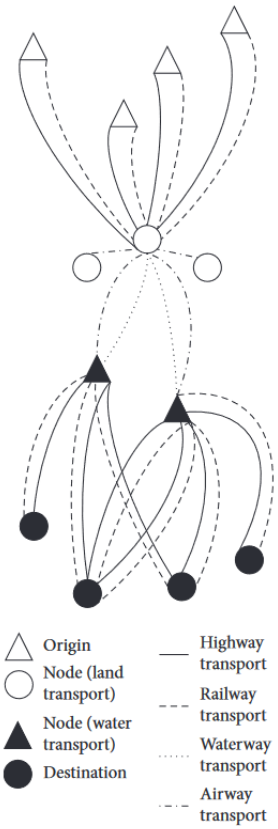

Figure 2. Freight paths of multimodal transport network (Wang & Fu, 2022, p 2)

Geographical location of nodes dictates a critical role in statistical prediction of freight volume, optimization of transportation routes and the selection of nodes themselves on site (Wang & Fu, 2022).

Any node that is selected to accommodate transportation route is selected with understanding that it will be able to support freight at any given time or at specified given time to become operational to support the transportation (Rodrigue, 2020; Wang & Fu, 2022):

1. Port terminal – it is a territory with enough place for maritime cargo handling services such as loading/unloading, customs, storage and similar services. The territory is accessible by maritime vehicle so it has to be alongside body of water deep enough big enough length and wide wise to be able to facilitate a vessel (Roso, 2013; Wang & Fu, 2022).
2. Storage/warehouse – a territory where shippers, receivers or other parties may leave their goods for storage and future handling. This territory may be accessible but not limited by rail, air, or marine vehicles (Roso, 2013; Wang & Fu, 2022).

3. Distribution point – a designated territory within port territory where fright is prepared to be loaded on vehicle and transported to end customer (Roso, 2013; Wang & Fu, 2022).

2.3 Maritime transport

Maritime transport is one of the best ways to transport freight as it can store large quantities in one trip and is flexible because different types of ships and different sizes can be selected to accommodate target port (Tapaninen, 2020). Ro-ro and double-ended ferries are capable to carrying transport vehicles between ports along with passengers, while coastal- and passenger ferries are suitable for short to medium length routes and they can operate in shallow waters.

Ferries

The market for maritime ferry is one of the most promising and one of the most rapidly developing markets (Krile & Maiorov, 2020). The demand of ferry use is growing as it allows for passengers to be mobile, using any transportation mean, would it be a bus, car, bicycle or on foot. This is achieved by using short to medium routes which were determined by publicly accessible schedule and the demand of the region established by passenger flow (Krile & Maiorov, 2020).
Car ferries are used mainly for transportation of goods or passengers using their vehicles (Edinbourgh, 2009). Often there are different alterations of the tame type of ship, some of them accommodate rail cars which are loaded using tracks which can be attached or detached at will (Edinbourgh, 2009; Molland, 2008).

- **Ro-Ro (roll-on/roll-off) ferries**: these ferries used widely because it is very useful when hauling goods using trucks or other similar transport modes. Example of these ferries are shown in Figure 3, along with operations in hauling goods and transport of passengers (Edinbourgh, 2009).

Figure 3. Ro-ro ship "Sirena Seaways" (Personal gallery).

Double-ended ferries: front and back of this type of ship can be altered, while its making journey between ports it does not need to rotate to let out vehicles thus making port operation simpler (Edinbourgh, 2009). For example, ferry which is going regularly to transport passengers on foot and in their cars between mainland of Gothenburg and Hono island is double-ended ferry (Figure 4).

Figure 4 Double ended ferry "SATURNUS" (personal gallery).

Coastal trading ships

Coastal trading ships or coasters is a ship type which distinctive feature that it is shallow-hulled, meaning that it can get through reefs, shallow waterways, where deeper-hulled ships cannot (Edinbourgh, 2009). It is especially used to load and unload cargo between the islands where ports are not deep enough to accommodate bigger vessels (Molland, 2008).

Passenger ferries

When some car ferries may accommodate cars and passengers at the same time, there are ferries which solely transport only passengers on foot or bicycle (Figure 5). These ferries are small, fast going, usually even fully electric. It may be used to transport passengers to islands or across the river to the other side of town (Edinbourgh, 2009; Molland, 2008).

Figure 5 Passenger ferries "YLVA" and "VALÖ" (personal gallery).

2.4 Goods transport

The literature review shows that consumer packaged goods handled in everyday bases, hazardous goods under regulations control and heavy goods which includes construction materials and waste.

Package goods

Consumer packaged goods (CPG) are items used on everyday basis by average consumers that require replenishment or routine replacement, items such as household products, beverages, food, clothes, tobacco and makeup (Brierley, 2002). Consumers in rural areas typically purchase goods from nearby towns and villages (Crank, 1995). During the last decade there has been a shift in consumer purchase behaviour toward purchasing package goods via e-commerce (Shengyu, 2021). Packaged non-hazardous goods do not require special permits for stowage onboard a vessel and can be transported using commercial usage vehicles (Thiess, 2017). The operating company of the carrying vessel in compliance with the maritime authority

specifies the locations authorized for stowage of the packaged goods on board the vessel (Organization, Focus on IMO - IMO and ro-ro safety, 1997).

Hazardous goods

The Swedish Transport Agency is in control of regulations of dangerous cargo regarding air and maritime transportation (Witzell, 2019). The Swedish Agency for Civil Protection and Emergency Preparedness (MSB) is in control of regulations regarding the transportation of dangerous cargo by rail and road (Ekwall & Torstensson, 2011). The MSB's regulations differ on safety advisors, by that it applies to all types of transportation methods (Ekwall & Torstensson, 2011). The law that regulates all modes of transportation (rail, road, air and sea), aims to prevent damage to environment, health, life and property that dangerous cargo could cause, while the regulation specifies the authorities in charge and their tasks (Witzell, 2019).

Heavy goods

Oversize/heavy cargo includes heavy and non-standard large pieces of cargo, such as construction materials, metal constructions, electric transformers, wind turbine spares, etc., which are usually part of advanced infrastructural high priority energy and technology projects (Petru & Krivda, 2021). As Petrov (2013) highlighted, the carriage of oversize/heavy cargo is a prioritized link of each infrastructural project; therefore, it must be organized without miscommunications, extra investments in infrastructure or redundant formalities. Handling of this kind of unusual type of cargo requires a supportive port infrastructure, as well as professionals to conduct cargo operations (Petrov, 2013). Hence, its main focus relies on the assurance of the safety of navigation for vessels carrying oversized/heavy cargo, even more in restricted waters (Petrov, 2013). Currently, heavy lifts are operated in ports that possess professional experience and appropriate equipment needed (Petru & Krivda, 2021). The port location is one of the main aspects for the port capability of handling oversize/heavy cargo (Petrov, 2013). Over short distances such as inland rural areas connected by waterways, such cargo may be towed to the destination or transported over longer distances by heavy lift carriers, which are designed for the carriage of oversize/heavy cargo (Petrov, 2013).

Waste

Commercial transports of several types of waste, including hazardous waste, always require a permit, which can be issued via local government structures responsible for environmental services (Liddick, 2010). For an individual or company to be able to apply for a transportation permit for all types of hazardous waste, it is required for the responsible handler to have an ADR certificate (a permit to drive hazardous goods) (Varhelyi et al., 2018). If the individual or entrepreneurship does not possess an ADR certificate, it is instead possible to apply for an ADR-S permit for transportation of other types of hazardous waste, which do not qualify as hazardous goods under the hazardous goods regulations (Varhelyi et al., 2018). The person or entrepreneurship engaged in a professional activity in which hazardous waste arises, is obliged to keep records for each type of hazardous waste, the amount of waste generated annually, origin, and to whom the waste is left for further handling (Varhelyi et al., 2018). It is also mandatory to keep record of the amount of waste collected annually and how often collection of the waste takes place (Varhelyi et al., 2018). The notes must be kept in chronological order and stored for at least three years (Varhelyi et al., 2018). The Individual/official responsible for the waste pursuant registration, is obliged to provide the supervisory authority and former waste owners the opportunity to access the contents of the notes, in case of requests (Varhelyi et al., 2018). According to Bereikienė (2020), a permit is always needed to transport waste if a subject/company is transporting waste containing any of these substances:

- Mercury, other than waste containing whole (undamaged) fluorescent lamps or other light sources
- Cyanide
- Cadmium
- PCB-products

Certain types of waste are exempt from the permit requirement (Bereikienė, 2020). If the waste has been generated through an individual's own professional activities, the person must to submit a notification to the County Administrative Board in order to transport these types of waste using waterways, which applies regardless of the quantity (Bereikienė, 2020). For entrepreneurs or companies, that transport waste professionally, do not have to submit an application or notification (Bereikienė, 2020). The following types of waste are exempt from the permit requirement:

- waste containing hazardous agricultural chemicals
- fly ashes and boiler dust from oil combustion
- infectious waste
- waste containing asbestos
- waste from combustion or pyrolysis of household waste and similar commercial, industrial and institutional waste (Bereikienė, 2020).

2.5 Regulative guidelines on maritime transport

2.5.1 Safety in transport of goods

Using inland waterways, it is mainly regarded as a transport mode with high safety (Hendrickx, 2012). This fact is also supported by Caris and Limbourg (2014), who mention that using waterways for transportation is considered secure, which is enhanced by using barges for hazardous cargo transport, which ensures safety both for the cargo operator and the passengers (Caris, 2014). According to the International Maritime Dangerous Goods (IMDG) code (IMO, 2020), the dangerous goods transport document may be issued in accordance with section 5.4.1 of ADR/RID provided the following additional requirements are met:

a. When liquid dangerous goods with a flashpoint of 60°C or below (closed cup (c.c.)) are to be transported, it shall be indicated whether the flashpoint is < 23°C or ≥ 23°C to ensure appropriate stowage.

b. Marine pollutants shall be identified within the documentation as „Marine pollutant“ or „Marine pollutant/environmentally hazardous" if required by paragraph 5.4.1.4.3.5 of the IMDG Code (IMO, Memorandum of understanding - Transport of dangerous goods, 2018).

The emergency response information in accordance with the IMDG Code shall include the Emergency Procedures for Ships Carrying Dangerous Goods (EmS) and the Medical First Aid Guide for Use in Accidents Involving Dangerous Goods (MFAG), these convention publications must be implemented and be physically present onboard a vessel carrying dangerous goods (IMO, 2020). According to the Dangerous Goods List of the IMDG Code, dangerous goods of classes two to nine may be transported onboard (Table 1).

Description and class as specified in IMDG Code/RID/ADR		Cargo ships or passenger ships carrying either not more than 25 passengers or 1 passenger per 3 metres of overall length*)		Other passenger ships	
Description	Class	On deck	Under deck	On deck	Under deck
Gases	2				
-flammable gases.	2.1	Permitted	Prohibited	Prohibited	Prohibited
-non-flammable non-toxic gases.	2.2	Permitted	Permitted[1)]	Permitted[1)]	Permitted[1)]
-toxic gases	2.3	Permitted	Prohibited	Prohibited	Prohibited
Flammable liquids	3				
- packing group I or II		Permitted	Permitted	Permitted	Prohibited
- packing group III		Permitted	Permitted	Permitted	Permitted
Flammable solids	4.1				
- UN No.1944, 1945, 2254, 2623		Permitted	Permitted	Permitted	Permitted
- other UN numbers		Permitted	Prohibited	Permitted	Prohibited
Substances liable to spontaneous combustion	4.2	Permitted	Prohibited	Permitted	Prohibited
Substances which give off flammable gases in contact with water	4.3	Permitted	Prohibited	Permitted	Prohibited
Oxidizing substances	5.1	Permitted	Permitted	Permitted	Prohibited
Organic peroxides	5.2	Permitted	Prohibited	Prohibited	Prohibited
Toxic substances	6.1				
- packing group I or II		Permitted	Prohibited	Permitted	Prohibited
- packing group III		Permitted	Permitted	Permitted	Permitted
Infectious substances	6.2	Permitted	Permitted	Prohibited	Prohibited
Radioactive material	7	Permitted	Permitted	Permitted	Permitted
Corrosive substances	8				
- packing group I or II		Permitted	Prohibited	Prohibited	Prohibited
- liquids packing group III		Permitted	Permitted	Permitted	Prohibited
- solids packing group III		Permitted	Permitted	Permitted	Permitted
Miscellaneous dangerous substances and articles	9	Permitted	Permitted	Permitted	Permitted

1) Refrigerated gases of ADR or of stowage category "D" of the IMDG Code are prohibited.

*) For the purpose of this MoU, the total number of passengers may be extended to not more than 1 person per 1 metre of the overall length of the ship.

Table 1 Dangerous Goods List of the IMDG Code transportation regulation (Güner-Özbek, 2008, p 189)

Table 1 describes the transportable substance (gases, liquids, solid substances), divides them into packing groups (I, II, III) and specifies their location onboard according to the type of the ship.

Safety of waterway transportation is also regulated by Directive 1999/63/EC, which implements the International Labour Organization's (ILO) Convention, to regulate the hours of work of waterway transportation workers to minimize risk of accidents (Thomas & Turnbull, 2018). The larger responsibility lies within the operating company (Fafaliou et al., 2006). The master of the waterway transportation unit must use all measures necessary to make sure that the circumstances relating to hours of rest and work are in proportion (Thomas & Turnbull, 2018). The master is also responsible of keeping a record of the daily hours of work and rest of the workers onboard, which must be documented and handed on to the national authorities if requested (Thomas & Turnbull, 2018). Possible risk of accidents is most likely to occur during working night time, caused mostly by higher levels of fatigue among the crew (Oldenburg, 2012). The number of accidents has decreased during the years mostly because of the improved safety measures taken into consider, but still the most predominant reasons of accident cases with inland waterways transportation are passenger overloading, storm conditions and collisions (Oldenburg, 2012; COLREG, 2020). To avoid these accidents, several systems can be used for inland waterway carriers, they are referred to as automatic identification systems (AIS), which detect overloading and collision risks onboard (Organization, 2022). The system improves safety in waterway operations and makes them more reliable compared to human operations with continuously running an built-in integrity test (BIIT) at appropriate intervals, monitoring the availability of the data collected from sensors and systems of the transportation unit, running an error detection mechanism of the transmitted data and error check on the received data (Goudosis & Katsikas, 2020).

2.5.2 Security in transport of goods

The theft of goods/deliverables is a worldwide problem. Product thefts from supply chains in Europe, the Middle East and Africa in 2019 produced losses of more than €172 million (Ekwall & Lantz, 2020). This number only reflects the value of the items and, moreover, majority of deliverables thefts remain unreported because of limited reporting by the transportation companies and the incompetency of law enforcement system to ensure tracking and reporting consistency (Ekwall & Torstensson, 2011). Ekwall (2020) highlighted that if the potential risk for disruption is considered very high for a supply chain or logistic setup, the design of the

system must be modified to reach neutral levels for the risk of disruption (Ekwall & Lantz, 2020). Enhanced risk management should be used as response to supply chain vulnerability and disruption (Ekwall & Lantz, 2020). The two main risk dimensions regarding goods theft are the value of the cargo and probability of the theft occurrence (Ekwall & Torstensson, 2011). Furthermore, risk management is a process of prioritization, in which the higher risk potential and the largest probability of occurrence are handled with a high priority manner, and lower risk potential and smaller likelihood of occurrence are handled as secondary in the list (Choi, 2021). To handle the financial impact in case of cargo theft, several insurance policies are being used (Wu et al., 2017). The main feature for a product to be theft endangered is its demand on the black market. If there is a high demand, theft cases of that unit are more likely to take place. Hence, these products require greater surveillance (Ekwall, 2009). A decent security level can be established by designing a security system based on the analyzation of the localized risk structure (Wu et al., 2017). Another way to enhance security is by meeting customer demands for security standards at either during the whole transportation journey or only in single locations (Wu et al., 2017). It is reasonable that the required security level at different destinations and for various products vary from security programs due to the threats that may occur regarding locational features (Closs, 2004).

2.5.3 Competition regulations in transport of goods

The policies regarding competition in inland waterways transportation, should take into consideration the specific nature of the transportation area (Fafaliou et al., 2006). The current provisions of the competition regulations will apply to all concerted practices, decisions and agreements which effect the fixing of transport conditions and prices, the control or limitation of transportation supply, the sharing of transportation markets or technical improvements (Pan & Liu, 2021). Joint financing or cooperation, purchase of transport accessories or equipment, where this kind of activities are directly involved to the provision of transport services and are needed for transport activities run jointly by road and inland waterway small or medium-sized transportation enterprises for prevention of the abuse of a dominant position in the transport market (Pan & Liu, 2021). These provisions apply also to the operations carried out by parties, that provide transport-related services and which have the pre-mentioned results or purpose (Fafaliou et al., 2006). Regarding the Official Journal of the European Union (2009) report, the following shall be forbidden as incompatible with the internal market: all agreements between undertakings, concerted practices and decisions by associations of undertakings

which could affect commerce operations between Member States and which have as their object or effect the distortion, restriction or prevention of competition within the internal market.

2.5.4 Maritime transport of people

The regulations apply to a potential marine carrier as a passenger ship, when it is capable to carry at least 12 passengers (Branch, 2015). The construction and maintenance of the hull, main and auxiliary machinery, electrical and automatic plants of a vessel used for public transportation, shall comply with the standards specified for classification by the rules of a recognized organization, or equivalent rules used by an Administration in accordance with Article 14(2) of Directive 94/57/EC, which states that: "*The recognized organizations shall provide to all Member States administrations all relevant information about their classed fleet, transfers, changes, suspensions and withdrawals of class. Information on transfers, changes, suspensions, and withdrawals of class, including information on all overdue surveys, overdue recommendations, conditions of class, operating conditions or operating restrictions issued against their classed vessels shall also be communicated to the Sirenac information system for port State control"* (SOLAS, 1974). The IMO ro-ro safety regulation convention (1997), states that every ferry that is being used for passenger transportation, must issue a Passenger Ship Safety Certificate, for a period not exceeding 12 months and must pass a periodical survey after this period (Organization, Focus on IMO - IMO and ro-ro safety, 1997). The main accessories that aim directly to the safety of the passengers on waterway carriers are the lifesaving appliances (Brakocevir, 2013). Every vessel classed as passenger vessel must carry lifesaving equipment such as immersion suites, life jackets, life boats, etc. according to the maximum number of passengers it is allowed to carry and the master of the vessel shall be responsible for complying with this figure (SOLAS, 1974).

3 METHODOLOGY

The objective of this section was to collect relevant academic literature on conducted research aim. In addition, following sub-section presents the structure for conducting questionnaire and interviews which is crucial for thesis as it is one of the requirements presented in thesis purpose.

3.1 Data collection

3.1.1 Literature review

Systematic literature review was chosen due to its accordance to the pre-defined research questions and to tackle the major literature gap of the topic (Booth Andrew et al., 2021). The review was written by identifying keywords which would be relevant for thesis such as intermodal, multimodal, rural, maritime, transport, infrastructure and dangerous goods, Swedish policy. Using these keywords, peer-reviewed sources were found which would be usable for supporting thesis. Search engines such as Chalmers library, Google scholar, Scoupus and Web of Science were used.

Scholarly papers were identified using keywords such as “intermodal transportation”, “coastal rural areas transportation”, “maritime vessels”, “rural development”, “IMDG”, “maritime transportation policy of goods in EU” and “passenger transportation”. Most of the sources that were selected, weren’t older than year 2000. For academic source to be chosen for citation in thesis it had to be as mentioned peer-reviewed and relevant for thesis as well as to have comprehensive explanation of the matter and be cited by other authors previously. In summary the final literature which was selected had to be in line with the right keyword, no more than two decades older, had to be peer-reviewed and cited previously and has to have comprehensive explanation of the matter (Booth Andrew et al., 2021; Neuman, 2014).

Literature review is a secondary data used to construct and support thesis results. This will provide similar researches and practical real-life implications of similar projects and their remarks. In addition, literature will provide theory needed to develop a hypothesis.

3.1.2 Case study

In this research, rural areas inhabitants' behavioural habits were the scope, which is consistent with the characteristics of a case study (Bryman& Bell, 2015). According to Bryman & Bell (2015), a case study differs from other studies from its focus aimed towards a bounded situation or system, an entity with functioning parts and a purpose. This fits well with the papers' in-depth focus on Orust and Lysekil municipality inhabitants travelling habits to grasp the size of the existing traffic flow. The route Kolhättan - Svanesund (Figure 6) is a waterway which connects the Orust municipality to the mainland, using a double ended ferry. The route between Finnsbo - Skår (Figure 8), is a waterway which connects the Lysekil municipality to the Orust municipality, using also a similar type of double-ended ferry. Using these two routes to reach destinations such as Orust and Lysekil from Trollhättan was analysed. The starting point was chosen due to its similar distance from both destinations. The infrastructure of the prementioned waterways was also analysed.

A case study of investigational characteristics is used for situations survey, where the circumstances under evaluation have several outcome options (Yin, 2014). A multiple case study was conducted aiming towards two cases, with the focus on potential to combine passenger transportation with intermodal transportation. Maritime transportation services in the archipelago on the Swedish west coast were selected as the case, aiming focus on municipalities of Orust and Lysekil in connection with the city of Gothenburg. A mixed method approach will be carried out, meaning that both qualitative and quantitative data collection approach will used as it is more superior than monomethod research (Stephan Felix & Smith, 2019). Primary data from qualitative interviews and quantitative questionnaire. Mixed data collection was chosen, because questionnaire which will be sent out to Respondents of the study which is considered to be objective thus giving better accuracy when constructing statistical part of results. Interviews is part of qualitative part of data collection. Questions will be conducted face to face. This will gain deeper, more subjective knowledge of the matter, I addition data collection will be conducted in three distinct stages (Neuman, 2014; Stephan Felix & Smith, 2019).

First stage, before constructing and gathering qualitative and quantitative data, a clear definition and measurement of task at hand has to be made (Neuman, 2014). Then conducting a quantitative approach for data collection, a questionnaire has to be made. Ofcourse this

empirical data has to be clearly connected with the abstract idea thus the need for idea bridging between the two rises (Neuman, 2014).

Second stage, select the population of Respondents by constructing a sampling strategy. During this phase two common mistakes has to be avoided. First common mistake when sampling is conducted in a sloppy or improper manner, second mistake is to choose the type of sample inappropriate of the study`s purpose. There are different techniques for sampling, some of them such as ,,*Gold standard*,, technique of probability sampling is very precise, offers very little space for error to make an impact, but very difficult to conduct, has its own vocabulary of language that has to be followed and takes a long time (Sharlene & Burke, 2015; Neuman, 2014). Easier sampling such as Quota sampling is not as good, but quite trustworthy. It offers not as precise information but still Respondents are split and identified, such as male or female, age of 20, 40, 60, family member, single and many other similar indicators. Another technique is considered lesser of the three – convenience sampling, when no identifications or categorization is made. This takes the least time to conduct but offers most errors. Using the right technique, a generalization may be done (Sharlene & Burke, 2015; Neuman, 2014).

Third stage is to define target population. This works in correlation with sampling strategy. If for example quota sampling is chosen, target population has to be defined in it. This allows to describe specific elements of the study, such as age, gender, residence and similar criteria. After definition, boundaries for targets have to be set, since population is in constant motion (Neuman, 2014). Respondents might move to another home, some of them die and others are born, new families move in, thus a temporal boundary has to be set, such as family which is living in area of X longer than 15 years, members of community who are older than 18 but younger than 50.

Addition to these three stages, sampling frame has to be set. This is an actual set of units where sample has been drawn. It may be sources such as taxing records, driver license list of records, municipality administration data base and so on. Because populous is in constant motion, multiple sources have to be chosen to achieve maximum precision as well as the parameters have to be replicable for future study continuation.

Thereafter, sample size, because if target population has more parameters, the yield of accuracy is higher, since a chance of same result decrease due to more choices included in a form of parameters (Neuman, 2014).

Moreover, according to Table 1 (SOLAS chapter VII) of the IMDG code, majority of dangerous goods are permitted to be transported on deck alongside passenger ferries with no more than one passenger per three meters of overall length or 25 passengers per ferry.

3.1.3 Quantitative questionnaire

The questionnaire was divided into two sections based on the municipalities included in the study. Same nine questions were asked in both municipalities, to facilitate a cross-case analysis. Questions will be constructed in a way that it could be answered by pre-set answers (Neuman, 2014).

Measurement: overall distribution between negative questions and positive to create a construct of the respondent's satisfaction regarding the topic under study. Questions included in questionnaire comprised current happiness and satisfaction of inhabitants regarding their delivery situation and need to either improve it or not and about their attitude towards goods being transported alongside them in a ferry.

According to Neuman, (2014) many techniques exist and they have to be chosen in accordance to what the purpose of the research, what information may be gathered and by what means. Taking into consideration, quota sampling was chosen. Prior to general questions, Respondents will be asked if they are male or female, what age they are and from which are they are Lysekil or Orust.

Sample size: 370 for both Orust and Lysekil. Calculated with 95% confidence level, 5% margin of error (Sharlene & Burke, 2015; Neuman, 2014).

The following parameters were used in constructing the questionnaire:

1. Socio economic background;
2. Education level;
3. Occupation: student, full time worker, service personnel, etc.
4. Male or female, other;
5. Age (18-30; 31-40; 41-60; 61-90);
6. Are they from Lysekil or Orust area.

Sampling frame: Orust and Lysekil garbage collection companies, logistics companies and administration. Orust and Lysekil inhabitants. See appendix 1 for the full questionnaire.

3.1.4 Qualitative interviews

Fowler and Floyd, (2014) stated that the main way of collecting information is by asking people questions, their answers constitute the data to be analysed.

During qualitative data collection phase, the sample size was different than in quantitative data collection. This is because the interviews were conducted when answers to questions start to show a clear pattern, meaning that foundation of an answer is beginning to be almost the same. When that happens generalization of the population might be achieved (Weller et al., 2018). As the interview had only 5 questions it took approximately 15-20 minutes per person to answer them. 23 people were interviewed, 11 in Orust and 12 in Lysekil. As 23 people were interviewed a clear answer pattern was noticed, which allowed generalization to be done.

Data collected from interviews were not as in-depth as data collected from questionnaire, interviews are to gather information about the opinions, reactions and emotions of inhabitants of Orust and Lysekil about the topic, that when generalization of population will be done using quantitative data, it can be double-backed up by interviews and what was found during that phase. In addition, questionnaire was anonymous, which means that people who participated in it were not subjected to an interview too.

The following parameters were used to construct questionnaire:

1. Male of female;
2. Age (18-30; 31-40; 41-60; 61-90);
3. Are they from Lysekil or Orust area.

Technique used: open-ended, one-on-one interviews (Weller et al., 2018). For further details see Appendix 2.

3.2 Data analysis

Relying on theoretical propositions is parallel with the main approach for analysing the case study (Yin, 2014). The current research begun with the plan to investigate how cargo transportation can be combined with passenger transportation. However, after the authors had performed a large-scale review, investigating every existing waterway or transportation method between mainland and the islands was seen as too comprehensive to be examined. Hence, the authors determined to limit the scope of the study and aim the focus on an in-depth analysis of the selected rural areas inhabitants' behavioural habits as well. During the analysis, the opinions of the rural coastal area's inhabitants to use public transportation, that also carries cargo, is being measured. The measuring also involves the prementioned people's e-commerce activity. Regarding the analysis and discussion section, the objective was to gather more information about the existing infrastructure and current situation about the existing waterways in operation, connecting the city of Gothenburg to Orust and Lysekil municipalities.

As Yin (2014) highlighted, analysing stands for categorizing, testing, calculating, examining and recombining existing information to reach factual findings. The information analysis of case study is difficult, since it hasn't been defined very clearly, resulting in the analysis being the least developed aspect of case study research (Pruzan, 2016). Several people that conduct research begin case studies without a clear view about the technique to analyse the collected information (Pruzan, 2016).

As Yin (2014) mentioned, there are five methods to analyse case study data, these will be described as follows. The first method presented by Yin (2014) is pattern matching which compares a real-life based pattern to an expected pattern, which was created before collecting the data. When these prementioned patterns are similar, it can strengthen internal validity of the case study. The second method presented by Yin (2014) is building of explanations which is mainly used for explanatory case studies. The aim of this analysis technique is to create an explanation regarding the case. This technique is a unique type of pattern matching including several advanced courses of actions to define constructive links that explain "why" and "how" things happen, which could be difficult to precisely measure. The third method presented by Yin (2014) is based on time-series analysis, that aims to answer questions such as "why" and "how" regarding the relationships between events during a time of period. Yin (2014)

highlights that in addition long-term sequences must include constructive statements. There are three principal types of time series analysis which can be determined: chronological sequence, complex time series and simple times series. The logic models stated by Yin (2014) is the fourth technique. These models have gained popularity during the last decade, affected by the theories of change studies. The method was developed to operate a complex chain of events during a time of period, which is divided into stimulus-response-stimulus-response relative communications. The outcome for this stage is that the dependent variable for previous stage transforms into the independent variable for the upcoming stage. For this method, Yin (2014) created three types of logic models: program-level-; individual-level-; and organizational-level logic models. The fifth method stated by Yin (2014) is only applicable for multiple case studies, which is the cross-case synthesis. Highlighted by Yin (2014), the findings are likely to be more robust in multiple case studies compared to single case studies, which makes the analysis of multiple cases likely to be easier. This method handles every case study individually to obtain cross-case findings. Pruzan,w (2016) highlights the necessity of generating word tables for categorization of findings from the individual cases. The prementioned activity creates a fundamental to qualitatively analyse differences and similarities regarding the individual cases (Pruzan, 2016).

The current study will employ explanation building, which is aligned with the research questions that seek to answer the questions. Hence, this study is a multiple case study, so a cross-case analysis will be conducted to collaborate the individual cases and to find differences as well as similarities regarding them. The units used in the cross-case analysis between the two municipalities were:

- Economic impact (Pruzan, 2016);
- Social impact (Pruzan, 2016);
- Environmental risk (Pruzan, 2016);
- Financial risk (Pruzan, 2016);
- Feasibility risk (Pruzan, 2016);
- Social risk (Pruzan, 2016).

The targeted risks grasp the details of an intermodal transportation chain, which are further on matched with mitigating actions as a response to reduce the effects of the factor.

4 RESULTS AND ANALYSIS

In this chapter, the results and analysis of the quantitative questionnaires and the qualitative interviews are presented to answer stated research questions.

4.1 Transport infrastructure

Infrastructure is vital for the transportation network and consists of port facilities, waterways and road networks. The goods flow consists of the demand to transport goods from and to the municipalities of Lysekil and Orust. The transport network consists of the vehicles and vessels used for transportation of passengers, such as passenger ferries.

The infrastructure system is vital for transportation of people and goods in rural areas, but it also sets limits to the type of routes, vessels, vehicles that can be utilized. Regarding the combination of transport modes utilized for the transport chain, two routes between mainland and the islands have been identified and targeted using Google Maps application.

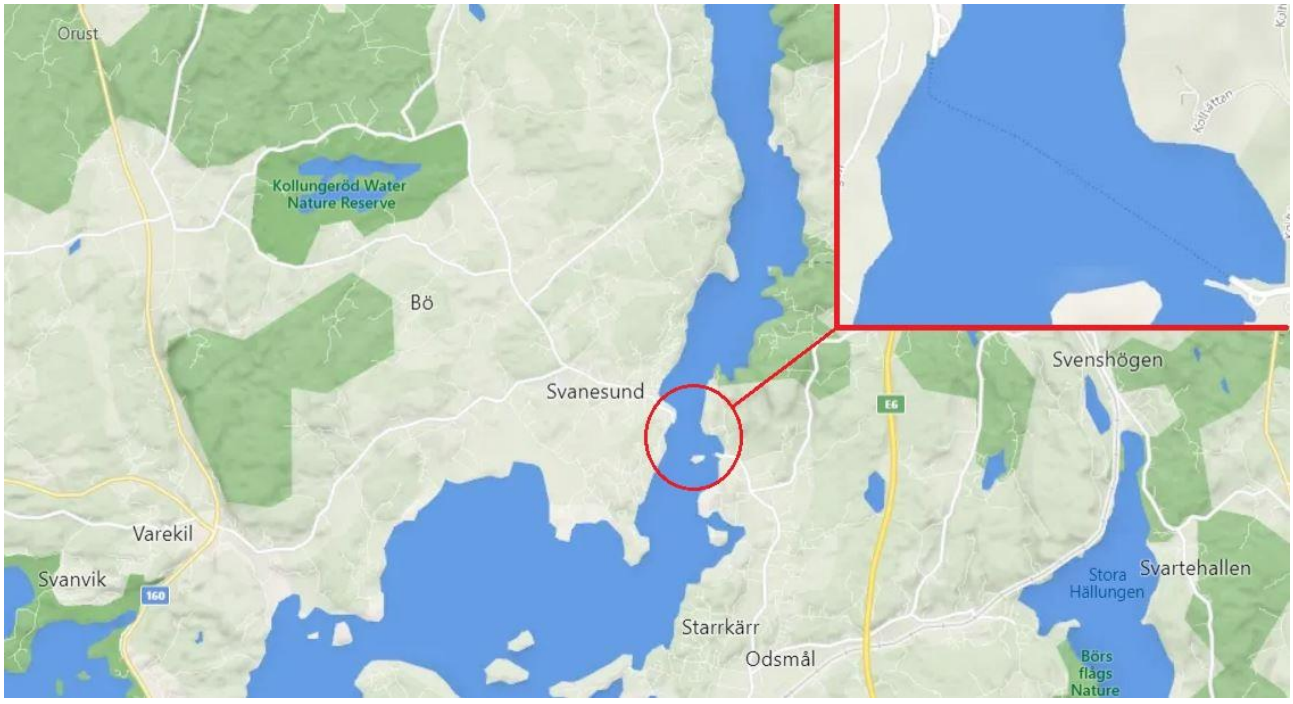

Figure 6 Waterway route Kolhättan – Svanesund (Source: Google maps).

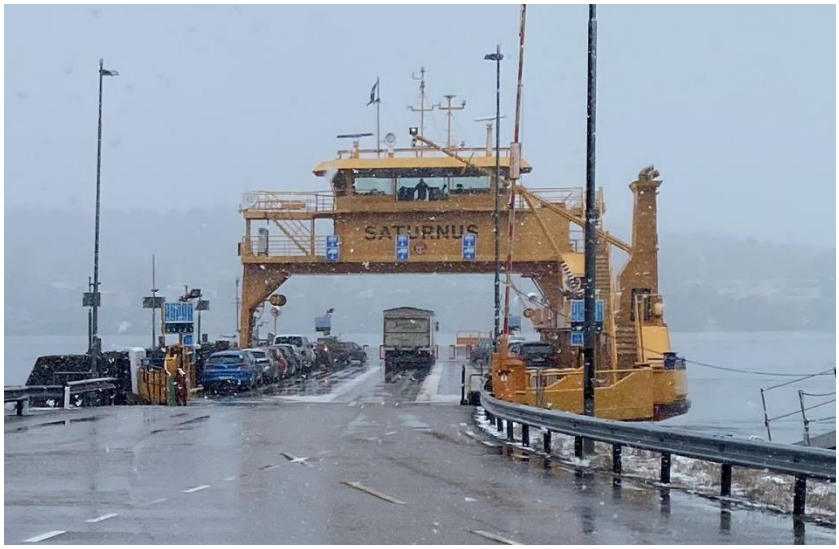

Figure 7 Double-ended ferry "Saturnus" operating on route Kolhättan – Svanesund (Personal gallery).

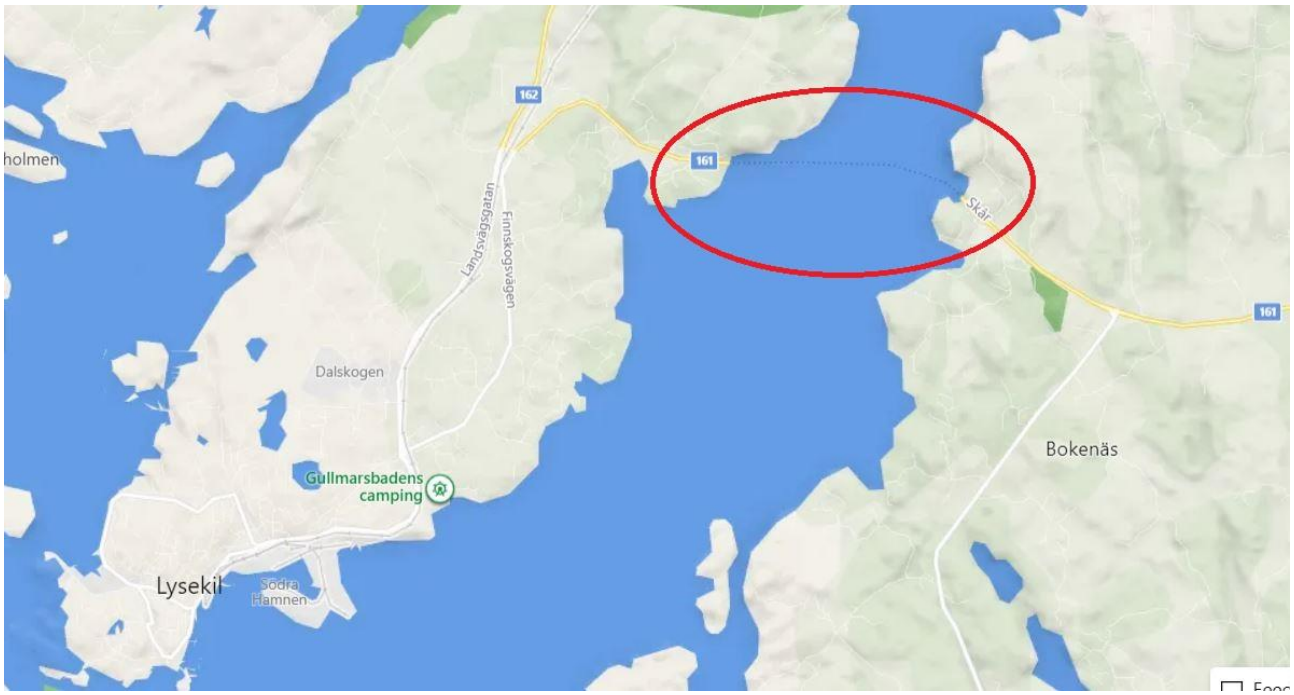

Figure 8 Waterway route Finnsbo – Skår (Source: Google Maps).

Figure 9 Double-ended ferry "Tellus" operating on route Finnsbo – Skår (Personal gallery).

The waterways currently used for passenger transportation between the mainland and the municipalities are justified as the road network differ largely from the distances on waterways. Inland shipping routes are considered to be rather limited with regards to the existing road network. However, in the current two cases it is rather preferable as passenger vehicles would need to drive a long distance on the road to reach the municipalities whereas the vessels just need to sail several minutes and a short distance.

4.2 Economic Impact

The literature review showed that the cost of transportation is the one most important criteria, when it comes to shippers to choose transportation solutions. This means that more cost-effective trading routes would decrease the price of shipping. Definitely this will also affect making transportation decisions in case of the Orust and Lysekil municipalities, as well as other coastal rural areas of Sweden. Inland vessel operators consider the price of transportation as their advantage. This advantage stands for a much shorter distance travelled compared to road transportation. Route from Trollhättan to Orust center using road transportation is 67.8 kilometres (Table 2).

Route	**Consumed time**	**Distance**
Trollhättan-Orust (via roads)	54 min	67.8 km
Trollhättan-Kolhättan-Svanesund-Orust (via waterway and roads)	55 min	53.1 km
Orust-Lysekil (via roads)	1 h 4 min	81.6 km
Orust-Finnsbo-Skar-Lysekil (via waterway and roads)	58 min	40 km

Table 2 Route distances and consumed time.

Using road routes combined with waterway transportation, the distance can be shortened by 14.7 kilometres. The route from Trollhättan to Orust using the Kolhättan – Svanesund waterway is 53.1 kilometres (Table 2).

By using road and waterway combination route, the distance is 41.6 kilometres shorter. The route from Orust to Lysekil using the Finnsbo - Skår waterway is 40 kilometres (Table 2).

The comparison of the compared routes justifies the usage of waterways, as it shortens the distance between destinations. Regarding this fact, the price for transportation of goods could be lowered when combined to the passenger transportation using waterways.

4.3 Social Impact

Regarding social situation of the matter a survey was done which is considered one of the primary sources for the thesis. Literature review showed that the need for intermodal transportation depends on the needs of the inhabitants. If they are satisfied or not with their current delivery price and time, if they think intermodal transportation is needed and if it would help.
Results regarding the matter have been acquired using survey where a basic background of the Respondents were gathered, and in addition interviews were done as well, which were described in methodology part of the thesis. The results showed:

32% of the Respondents were within age of 26 to 30 years old, 23% were from age of 31 to 40, 18% were from 21 to 25 years of age and of all of the Respondents 99% were university or high school graduates (Figure 14). Lastly regarding their socio background, 17% of all Respondents were working in business administration and 13% in Law enforcement and armed forces sector, 17% were students and only 3% were retired people.

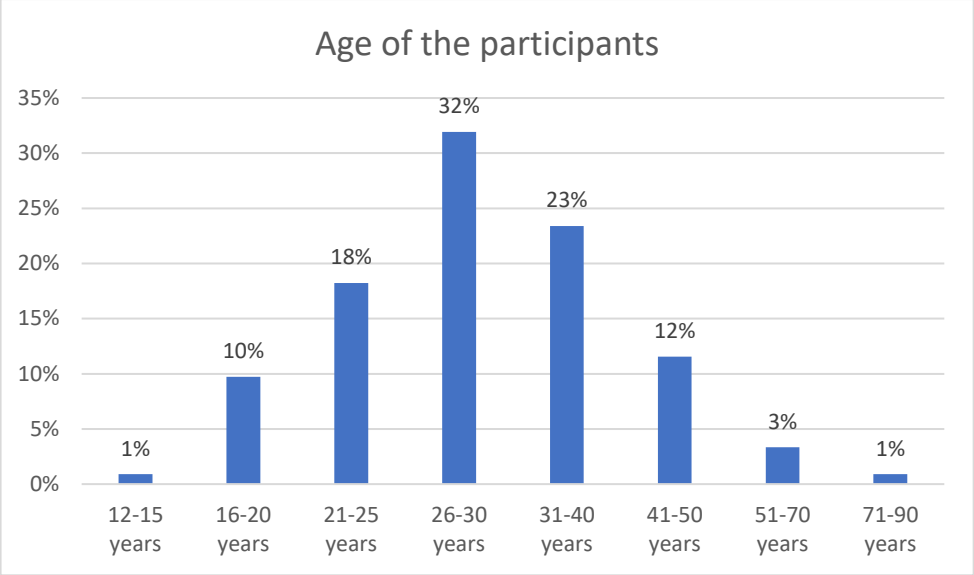

Figure 10 Age of the participants.

After socio background was established the respondents were asked if they want to improve current situation regarding package sending and receiving, its prices and lead time, current situation of public transportation and most important if they are comfortable or not to travel in the same ferry besides various goods, such as recyclable, construction or dangerous goods.

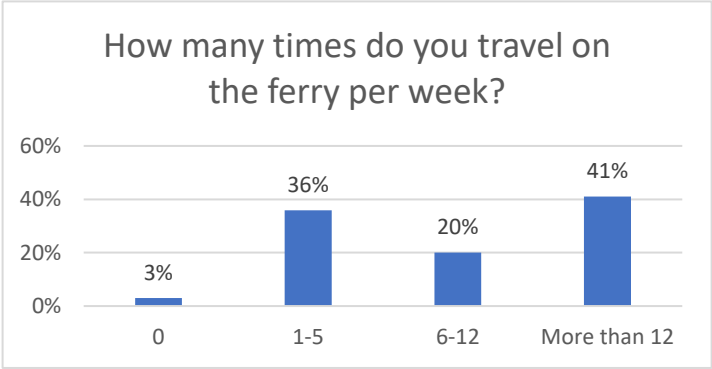

Figure 11 Ferry usage by inhabitants.

Figure 11 showed that 41% of respondents said, that they use the ferry more than 12 times per week, but it is worth mentioning that Lysekil inhabitants are using the ferry less than Orust since they have access to highway and chose to commune using it rather than the ferry line and the ones which do 37% do it using own cars and 24% using public transportation.

Furthermore, a question about number of times do they transport construction goods on their own per week were asked (Figure 12). The results showed that both of the municipalities have their own local goods industry, but it is only limited to wood production, but heavier materials

such as cement and/or metal industry is not there or on a very small scale. So, inhabitants are transporting or ordering them.

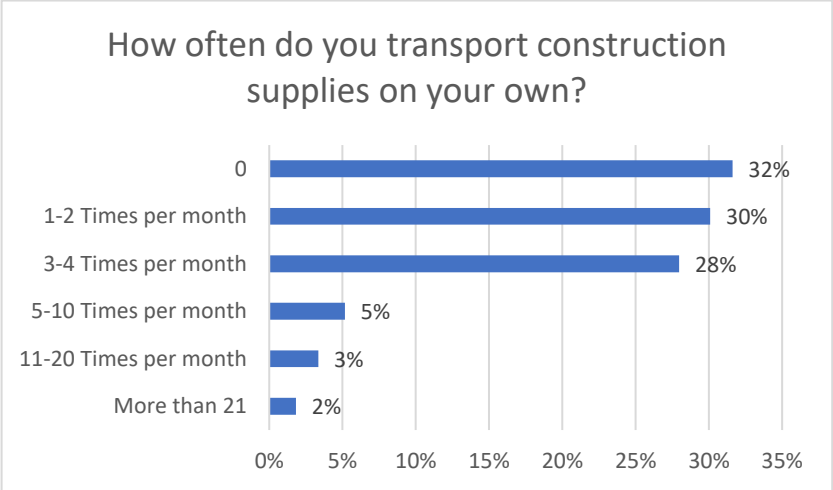

Figure 12 Construction material transportation.

In addition to transportation of construction goods, transport of parcel goods related to e-commerce packages were included into the survey and interviews. Results from the questionnaire shows that 33% of the respondent's order between 7 to 10 packages per week (Figure 13).

There is potential to increase the numbers as there are businesses which frequently order bigger amounts of parcels. In addition, most of the people during the interview said that the situation regarding lead time and price could be improved as 72% of respondents said that they are not happy with the delivery time and 79% said it is too expensive.

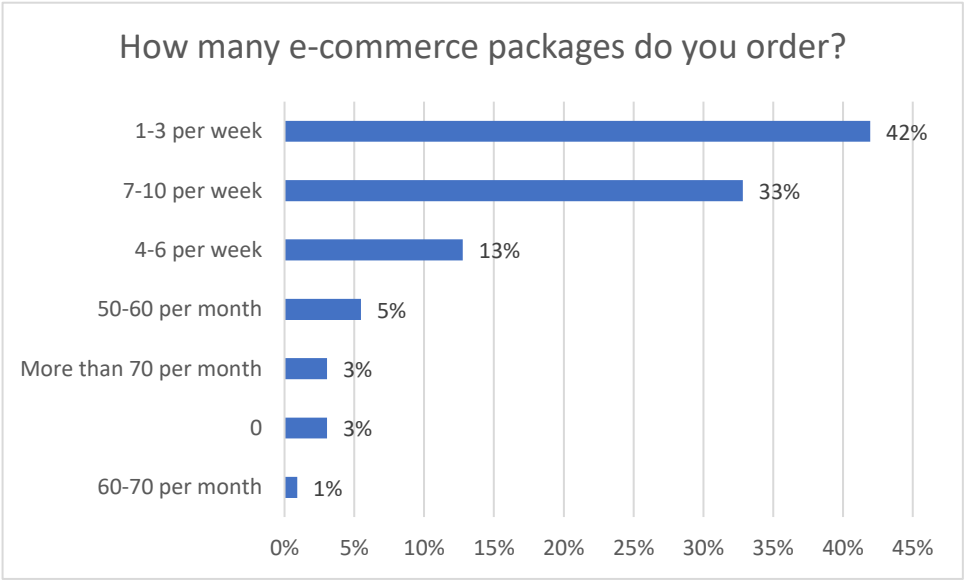

Figure 13 E-shopping habits.

The results shows that respondents in Lysekil tend to e-shop more and have the packages delivered to them, whilst Respondents in Orust tend to e-shop less and if they do, they pick up the packages themselves. When asked why they mention that the delivery is too expensive and takes too much time and gets lost time to time, so they chose to pick it up themselves. Most of the time on the way or from work. Clearly Orust has more delivery related problems than Lysekil, due to Respondents being scattered more all over the island when compared with Lysekil, where the city is developed and Respondents live more compact. But in both cases with some people being happy with their delivery services (those Respondents order less per month), but most of them would like an improvement and feel like intermodal transportation can be the solution.

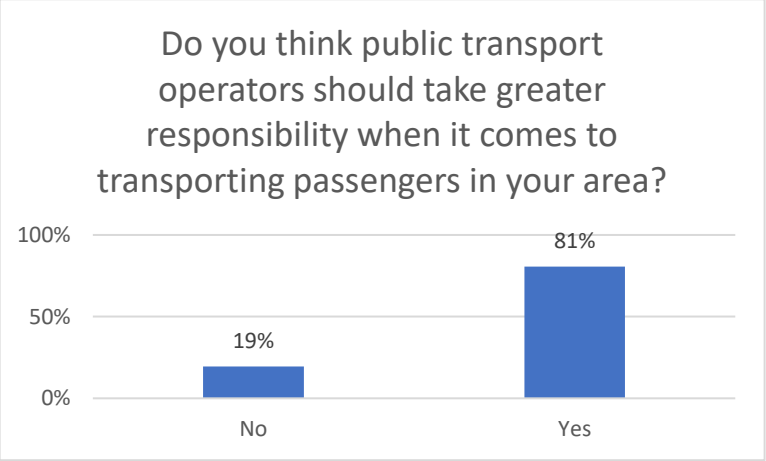

Figure 14 Current state of public transportation.

Moving on to public transportation. 81% of respondents said that they are unhappy with the current public transportation and it has to be improved (Figure 14). In the case of Orust, this fact was supported even more when using public transportation, it was noticed that the busses are going not as frequent as required. For example, during rush hour of 13.00-16.00 when school kids finish their classes, the busses are going not frequent enough and when bus transfer is needed, it can sometimes take up to 1 hour. During cold season this is unacceptable said most of the kids.

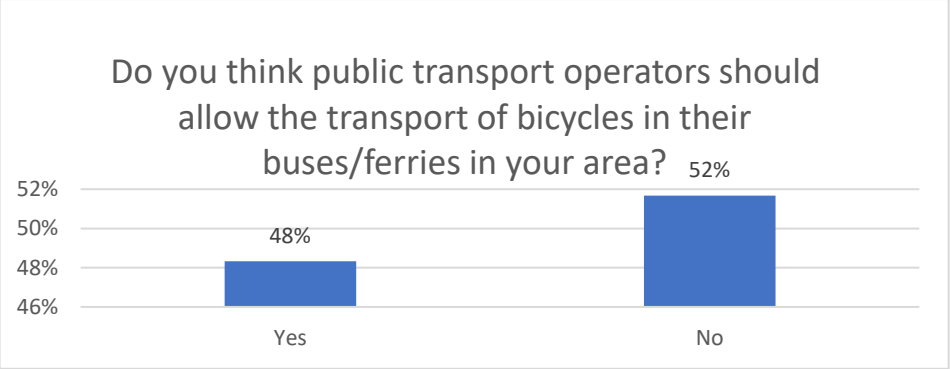

Figure 15 Transportation of bicycles on the buses/ferries.

But when Respondents encountered the question regarding if public transportation should allow bicycles on the bus 52% said No (Figure 15). The results from analysed interviews showed that this is due to them feeling uncomfortable when cyclists would bring their bikes onto the bus and in result there would be less space for passengers and some people feel uncomfortable due to bikes being dirty.

In addition, regarding intermodal transportation, the biggest barrier to implementing it are the inhabitants themselves. It is important to know if they would mind or not if the ferry would transport goods alongside them, goods such as heavy construction material (cement, heavy metal, detergents and so on), dangerous goods, such as oil, paint, even fuel. The results from interviews and questionnaires show that most of the people are in favour of traveling alongside such goods, with few exceptions when people said they do not like the idea as shown in figure 16,17 and 18. The difference between mentioned figures is the type of goods transported which is generally considered dangerous or unpleasant.

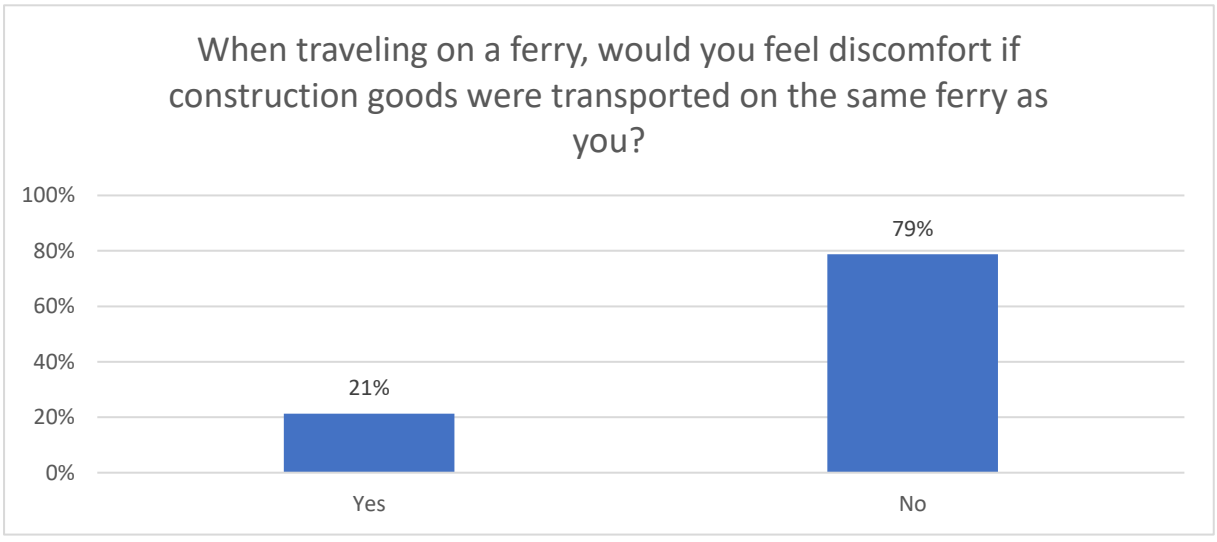

Figure 16 Discomfort towards construction goods.

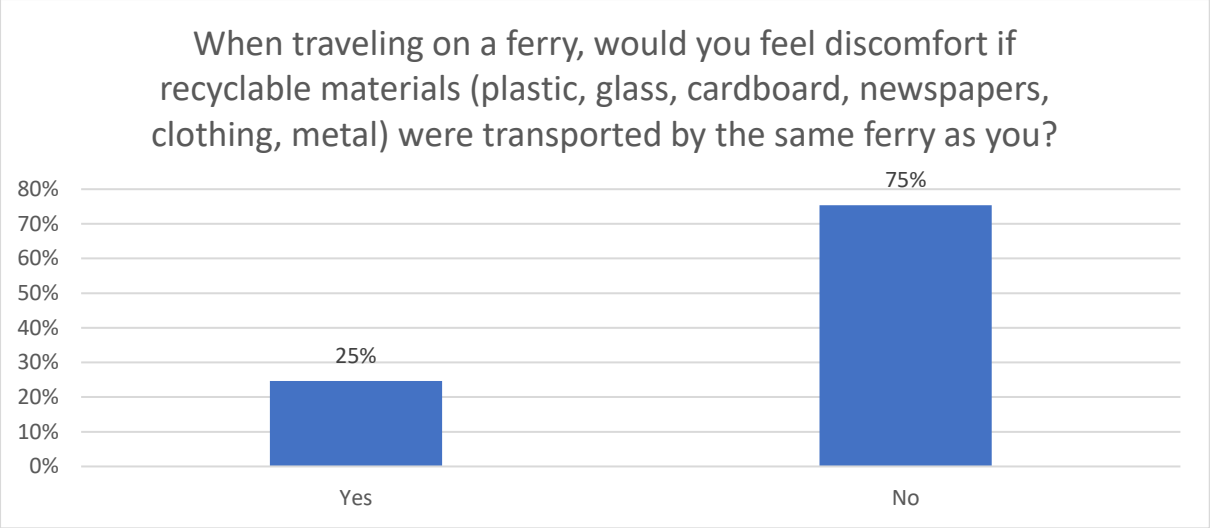

Figure 17 Discomfort towards recyclable goods.

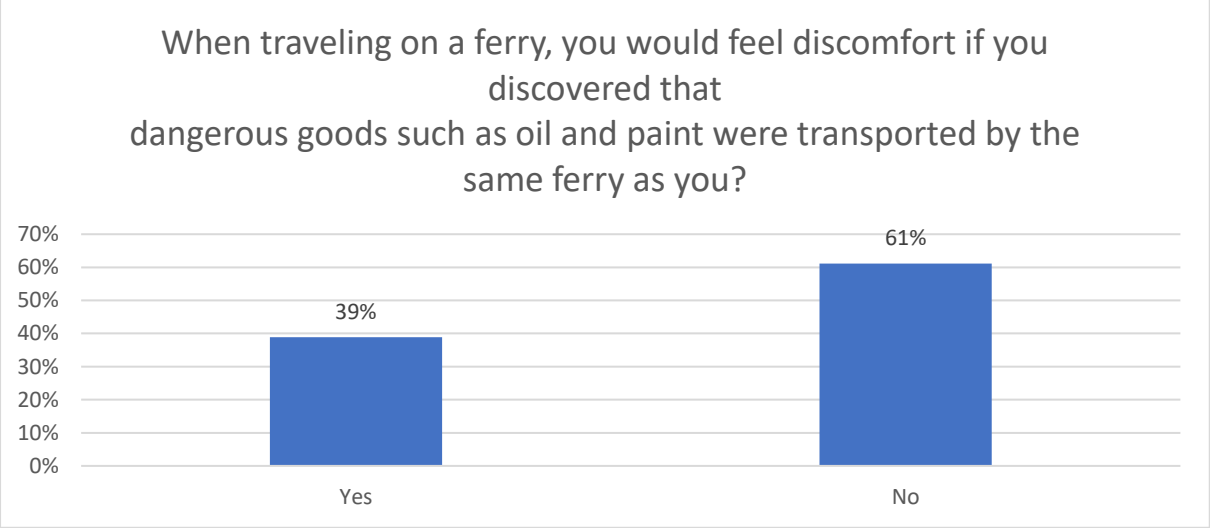

Figure 18 Discomfort towards dangerous goods.

The results indicate that people do not mid these goods being transported alongside such goods, if they are secured properly and especially if this would lower the price of municipality administration and increase the frequency and reliability of deliveries.

When asked how much more should the tourists pay for the tickets in comparison with the residents, 14% answered it should be 30% more, 43% answered it should be 20% more, 8% of the Respondents said it should be 10% more. This would help keep the prices down or even lower it as residents were asked what price they are willing to pay for the ticket themselves, it varied the most between 31 and 40 Kr. (Figure 19).

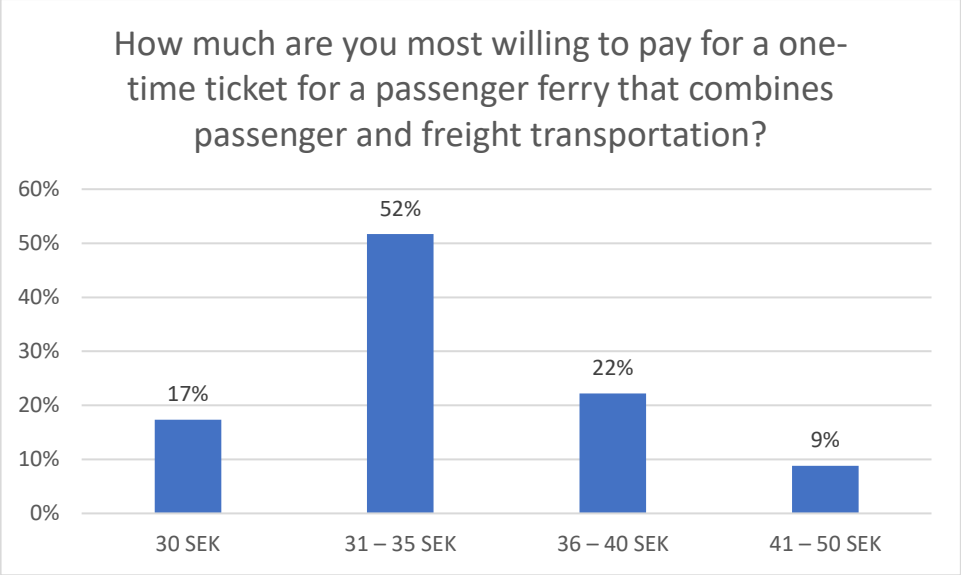

Figure 19 Price of the ticket for the inhabitants.

The infrastructure investigated in this thesis resulted in shorter distances when using a ferry. This is important for rural areas as they are in continuously changing due to the spread of urbanization, which demands for the distances and routes likely to be changed. To be able to use and develop more efficient transportation solutions, it is also essential to understand the opportunity to adjust the infrastructure. In case of changes being made for roads or routes, using the ferry as a transportation method would however indicate higher efficiency in combination of transporting passengers and cargo. As both goods and passengers will be transported, the traffic flow and the operating schedule for the ferries will also be a variable subject. The size of the ferry needed and how many departures per day it should perform should further be discussed. So far it is only been allowed for the ferries to load passengers and passenger transportation onboard. However, it could be in the interest of third parties and cargo companies, that the ferry operator would also carry goods onboard. This would result in increased efficiency for the ferries. Thus, requirements of the shipowner and the loading capacity of the ferry will have the deciding role in the final decision. While several transportation routes have been compared in this thesis, the available solutions have been considered. In case of change in the rules and regulations, or certain permits that allow vehicles that carry goods onboard would be implemented, it could also improve the intermodal transport solution. In conclusion, considering the current situation preview of this thesis, the goods and passengers combined transportation solution using waterways seems to have a higher efficiency rate than serving only as passenger transportation. Furthermore, a risk analysis is also performed to completely grasp the details of an intermodal transportation chain.

4.4 Risk Analysis

Combined transportation of people and goods includes risks regarding environmental impact, economic impact, feasibility risk and social impact of the chosen method. A risk analysis is performed in this section, where the most common risks are targeted and analysed. Mitigation actions are proposed accordingly in the risk evaluation section.

4.4.1 Environmental risks

This chapter is analysing the environmental risks regarding safety in transport of goods. The risk regarding the increased environmental impact is directly involved with the increased consumption of fuel by the ferries. As the ferries are more loaded, the load of the engine of the ferry increases and also the fuel consumption. This risk is higher for transportation vehicles that carry heavy goods and construction materials, which have evident environmental consequences and is directly related to the environmental impact.

4.4.2 Financial risks

This chapter is analysing the financial risks regarding competition regulations in transportation of goods. The financial risk regarding higher tensity of traffic, such as passenger vehicles and goods delivery vehicles is major when looking at the intermodal transport chain. Increased amount of traffic can lead to larger fuel consumption and increased delays in departures. There are also costs related to unexpected weather conditions, which will result in increased waiting times for the transportation units and larger infrastructure costs. However, if using the combination of goods and passenger transportation with a ferry, this risk can be mitigated. In this case the infrastructure cost can be split between both modes of transport. In conclusion, these risks are minor and can be foreseen

4.4.3 Feasibility risk

This chapter is further analysing the feasibility risks regarding goods carried by ferry or by truck, which are both regarded as feasible solutions. Although, risks when combining goods with passenger transportation using a ferry, that has not been used in the area before, will obviously increase. Intermodal transportation solutions for the ferries will need to be adapted to the specific conditions in other ways than those that they are settled currently for, which is

only passenger transportation. The risk of space limitations onboard the ferries might also lead to difficulties for the intermodal transport to both passengers and goods delivery vehicles. This risk is furthermore highlighted if a ferry is being utilized as the only transport solution. Thus, the passenger transport using a ferry is more flexible, and could simply be rerouted. In that case, the loading of the ferry has a shorter loading time, which results in a higher feasibility in operation, as it could have more departures per day.

4.4.4 Social risks

Current chapter is analysing the social risks. It is clear that the safety risk increases when combining goods transportation with passenger transportation. An increased tensity of traffic will factually increase the risk of accidents including cargo, vehicles and passengers. Considering the risk of leakage of dangerous goods, it is one of the largest of the possible events. The seriousness of the event depends on where the leakage will occur; either in the water or on the deck of the ferry, which can potentially result in a risk of damage on health and the environment. A large risk is also the danger of capsizing the ferry due to overloading or misplacement of heavy goods onboard, which could have fatal results. In conclusion, these risks have a large impact.

4.4.5 Risk evaluation and mitigating actions

The current section suggests mitigating actions for the prementioned risks such as recommendations for feasibility, environment, financial and social aspects, which are presented accordingly in Table 3.

Risk type	**Mitigating actions**
Environmental risk	• Keep the fleet well maintained and use clean fuels • Implement MARPOL safety and prevention guidelines onboard the ferry • Implement a weight tax regulation for very heavy vehicles
Financial risk	• Use the intermodal transportation mode to split the infrastructure cost • Implement cost analysis strategy • Support constant flow of goods and passengers • Regular maintenance of the fleet
Feasibility risk	• Combine passengers and goods transportation • Contact the goods delivery companies to inform about the solution • Start a pilot route to investigate the process and make decisions accordingly

	• Involve project managers of ongoing constructions of the area to the project
Social risk	• Constantly be in an open dialogue with passengers and goods delivery • Invest in safety systems and equipment • Conduct safety trainings regularly

Table 3 Mitigating actions of identified risks in intermodal transport of goods and people.

5 DISCUSSION

The purpose of this research is to explore options to combine goods transportation with passenger transportation in rural coastal areas of Sweden. For this purpose, it is important to investigate travelers' and inhabitants' opinions and attitudes about combined transport of people and goods on passenger ferries in the Swedish archipelago as well as analyse the possibilities for using existing waterway operators for this kind of transportation method.
This chapter the results which were found during research phase are discussed. In addition, this section will answer three research questions regarding how passengers and goods can be combined, what are the combination possibilities and what the legal barriers for this.

The results suggest that the current transportation used in the archipelago, such as ferries and vehicles using land access differ a lot in a manner of time and distance it takes to travel to the same destination. In the case of both municipalities of Orust and Lysekil, they both have the option to use either ferries or land access to the mainland to travel, which helps to ease the congestion of vehicles during the rush hours in the morning, evenings of work days and during holidays and when using ferries in certain cases the trip has shorter distance. In addition, using surveys and interviews to investigate if inhabitants of the municipalities are satisfied with their current delivery services and what do they think about combined transport of people and goods on passenger ferries it was found that the services in their opinion have to be improved due to price which is too high and the waiting time of the delivery which is too long as well. This can be solved or atleast improved using combination of passengers and goods. Questionnaire results and interviews showed that the residents feel comfortable traveling alongside various goods such as recyclable goods, medicine, oil, paint, construction goods such as cement, more than 85% in all cases said they are fine with the idea. The Respondents of the research varied from teenagers up to senior residents who are retired.
It is worth mentioning the limitations of the research as it does not contain all of the answers to successfully explain step-by-step how to improve the situation stated above. It is just a stepping stone of the matter to explain and conduct a plan of action to improve price, time and difficulty of the matter. The results presented a strong basis for further research, the inhabitants are in need of change and as presented, they are willing to meet the demands and feel comfortable with the base solutions as enough Respondents were questioned to make a strong generalization, but further research has to be done looking more into legal barriers, economics of the matter and most importantly the logistical situation, and how it can be improved.

6 Conclusions

Combined transportation of passengers and goods using waterways outclasses all other transport solutions both regarding feasibility and sustainability. It is shown that using waterways to carry passengers and goods together is the most efficient combination for the total flow of traffic. The solution has a potential to lead to the lower price of ferry ticket and lower infrastructure costs. All of this would help to develop the municipalities even more and attract tourism and lower the prices of the tickets for the residents themselves.

In this chapter the conclusions of the conducted research are presented along with the risk of uncertainties while implementing new combined methods of transport is always certain, but the risk should also be compared to the benefits perceived from the method. The goods and passenger transportation method using waterways can be beneficial for all parties, while the effort to mitigate risks is motivated. Before implementation of the method, mitigating actions and further research is thus recommended.

The answer to the first research question of how can passenger transportation be combined with goods transportation in rural coastal areas of Sweden stands largely behind bureaucracy. The final decision of allowing this method of transportation to be implemented must firstly be motivated by the positive will of the area's residents, which later on must be confirmed by the authorities.

The answer to the second research question of what are the possibilities for combining, using existing transportation methods. The solution would be to use the existing ferries and waterway routes also for goods carrier vehicles transportation. For beginning, the process would need to start with a pilot project for a successful implementation process further on.

The answer to third research question of what are the legal barriers regarding the combination of goods and passenger transportation using maritime transportation, would be that currently it is not allowed by the regional authorities to use the ferries, which are utilized for public transportation, to carry goods or transport goods carriers. The legal barriers also stand behind the international maritime organization conventions. These conventions regulate strictly certain types of goods, that need special conditions for transportation onboard vessels.

6.1 Managerial implications

This thesis concludes that a ferry is a sustainable and competitive mode of transport, which delivers flexible transportation solutions in rural areas.
The research takes into consideration the opinions of residents and transport operators, which are shown to be positive towards the use of rural waterways in goods transportation. Although this study has been conducted focusing on the multiple case study of Orust and Lysekil municipalities, the results are transferable to similar researches for rural coastal areas of Sweden, if the context is being adapted. This study draws the attention to the beneficial aspects and importance of using ferries in rural coastal areas goods transportation, which intense the demand for further research within the subject.

6.2 Future areas of research

This thesis has a narrow logistical perspective, investigating feasible ways for intermodal transportation of goods and passengers combined, but has mainly focused on the opinions of the parties involved and the social impact of the subject. The narrow approach has definitely strengthened the quality of the result in this research.
Intermodal transportation using waterways has proven to be essential to maintain and develop sustainable and efficient transport chains for goods and passengers. Regarding this, an important future area of research would be the optimization of the intermodal transport considering the total flow of the units. The feasibility levels of the transportation routes can also vary, depending on the start and finish point of the route, which is considered as a geographical feature and would be a very interesting area for further investigation.
A future area of research could further improve and optimize the suggested transportation solution for the intermodal transport of goods and passengers, investigate new options for alternative fuels and propulsion systems for the ferries.

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8 APPENDICES

8.1 Questionnaire

No.	Question	Answer							
1.	How many times do you travel by ferry per week?	0		1-5		6-12		More than 12	
2.	In which city is your primary residence?	Lysekil Municipality		Orust Municipality		Other municipality			
3.	Please indicate where (name of geographical location, e.g. Käringön)								
4.	What is the purpose of your trip to and from the municipality?	Tourism, pleasure	Shopping	Temporary visit	Work commute	Other reason, usually			
5.	What kind of transport do you use to/ from the ferry?	Transport own car	Transport leased/ borrowed car	Bicycle/ electric bike	Moped/ scooter	Bus public transport	Other, please enter		
6.	How often do you transport construction goods on your own?	0	1-2 times/ month	3-4 times/ month	5-10 times/ month	11-20 times/ month	More than 21		
7.	How many e-commerce packages do you order?	0	1-3/ week	4-6/ week	7-10/ week	50-60/ month	60-70/ month	More than 70 / month	
8.	Are you satisfied with the current situation regarding delivery time of the peket?	YES				NO (e.g. too uncertain)			
9.	Are you satisfied with the current situation regarding	YES				NO (too expensive)			

	the delivery cost of packages?						
10.	Do you think that a combined freight transport of goods and passengers on the same ferry is a good idea?	YES			NO		
11.	If YES to question 10, please indicate the reason why	Lower transport costs for passengers	Lower transport cost of freight transport	Reduced delivery time, freight transport	Increased transport service, passengers	Increased transport service, freight transport	Other
12.	If NO to question 10, please state the reason why	Safety risk	Risk of congestion due to limited space		Unnecessarily, transport of goods and passengers works well		Other reason, please indicate
13.	Do you think that you and your municipality would benefit from combined transport of goods and passengers?	YES			NO		
14.	If your answer was YES to question 13, specify the type of benefit that could be created	Improved quality of life of residents (especially on the islands)	Improved conditions for companies (especially on the islands)	Improved municipal service retrieval of return materials (plastic, glass, cardboard, newspapers, clothing, metal)	Increased income from tourism	Increased marketing of the municipality as a tourist-friendly municipality	
15.	If your answer was NO to question 13, please state the reason why	Combined has no impact on me or others	Combined transport won't benefit me enough	Combined transportation will not significant	Combined transport is the wrong approach to increasing service in the	Other reason, please indicate	

				ly benefit others.	transport of goods and people	
16.	Do you think public transport companies should take greater responsibility when it comes to transporting passengers in your area?	YES			NO	
17.	Do you think public transport companies should allow freight transport in their buses/ferries in your area?	YES			NO	
18.	Do you think public transport companies should allow the transport of bicycles in their buses/ferries in your area?	YES			NO	
19.	When traveling on a ferry, would you feel discomfort if construction goods were transported on the same ferry as you?	YES			NO	
20.	When traveling on a ferry, would you feel discomfort if returned materials (plastic, glass, cardboard, newspapers, clothing, metal) were transported by the same ferry as you?	YES			NO	

21.	When traveling on a ferry, you would feel discomfort if you discovered that dangerous goods such as oil and paint were transported by the same ferry as you?	YES			NO		
22.	If combined transportation were to be used in parcel transport, what impact would this have on your e-commerce orders?	Very little impact (= 1)	Small impact (= 2)	No impact (= 3)	Big impact (= 4)	Very big impact (= 5)	
23.	How much more should tourists pay for the ticket than the residents?	0% more	<10% more	<20% more	<30% more	<40% more	<50% more	100% more
24.	How much are you most willing to pay for a one-time ticket for a passenger ferry that combines passenger and freight transport?	30 kr.	31 - 35 Kr.	36 - 40 Kr.	41 - 50 Kr.		

8.2 Interview questions

Nr.	Question
1.	How often do you use e-shop and do you choose them being delivered to you?
2.	What biggest difficulties do you face when getting your parcel? Delays, parcel not being delivered, damaged parcel…
3.	Do you feel that delivery services are lacking in your area? Why?
4.	Would you feel safe if a ferry which you use to get to work or go home would transport recyclable goods, heavy construction material and other goods?
5.	Would you use e-shop more often if delivery to your home would be faster, cheaper and easier?