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Island accessibility challenges: Rural transport in the Finnish archipelago

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A global trend in declining island populations is causing severe accessibility challenges for rural archipelago residents. Since waterways often provide the only viable connection between islands, the planning of ferry routes and capacities relative to prevailing population patterns is critical. In this paper, we present a case study of Pargas, a rural archipelago region in Southwestern Finland, which in many ways provides a typical example of current depopulation trends in archipelago regions. Owing to high maintenance costs, changing population patterns and transportation needs, the ferry network of Pargas has recently attracted attention in terms of planning and a perceived need to reduce costs. Still, compared to in-land transportation, few academic studies have explored this issue. Using methods adapted from urban and land-based transport studies and diverse datasets, we aim at identifying spatial discrepancies between population patterns and transport options in the peripheral archipelago and at determining how well the ferry network meets the needs of the permanent and seasonal population of the islands. Our results show that although the existing ferry network in general functions relatively well in relation to the population, spatial mismatches between transport opportunities and population patterns in some of the prominent islands are nevertheless evident. Because the economic vitality of the region depends on a well-functioning transportation network, this study offers suggestions for improving transportation services in the study area.

Keywords: Accessibility; Archipelago; Finland; Ferry; Rural population; Transportation

1. Introduction

Spatial patterns of accessibility – directed by transportation networks – are strongly associated with population distribution (Mun, 1997; Kotavaara et al., 2011a; 2011b). However, the link between population distribution patterns and transportation networks remains an issue that still requires scrutiny (Gastner and Newman, 2006). Transport options and accessibility to regional centres are also vital to the development and economic opportunities of rural areas world-wide (Hare and Barcus, 2007; Agarwal et al., 2009; Salonen et al., 2012). Transportation and economic

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geographers have studied the relationship between transportation networks and regional economic development and found a 'two-way symbiosis' (MacKinnon et al., 2008) between the two: economic development tends to foster the expansion of transportation networks and vice versa (Kansky, 1963; Taaffe et al., 1963; Hoyle and Smith, 1998).

Roads and railways – or land-based transportation in general – have drawn considerable attention in transportation and accessibility studies, whereas much less attention has been given to waterways in this field of research (Ducruet et al., 2010). Indeed, maritime transport and archipelagos form a special case when looking at transportation networks and accessibility: the situation in archipelagos is unique, as accessibility is dictated primarily by ferries (Hernández Luis, 2002; Kajander et al., 2008), whereas in continental and urban areas there are lots of different types of transport available. Islands depend heavily on maritime transport links, so the service of ferries plays a crucial role in influencing the islands' population levels and economic life (Cross and Nutley, 1999; Baird, 2012; Laird, 2012).

In this paper, we analyse the performance of the existing ferry network in relation to the current population distribution in our case study area Pargas (Southwestern Finland). We identify spatial discrepancies between population distribution and transport opportunities in the archipelago's islands with methods originally developed for urban land-based transport. As in many other parts of the world, the Finnish population's distribution has been analysed in relation to accessibility by rail and road networks (Kotavaara et al., 2011a; 2011b), but the Finnish archipelago and its ferry networks have received little academic attention until now.

Pargas is a rural archipelago region consisting of ca. 100 inhabited islands (Ministry of Employment and the Economy, 2010), and ferries are practically the only means of public transportation between the various islands themselves and between the islands and the mainland. Current transportation arrangements in the area have evolved out of long-established practices and experiences (Kajander et al., 2008), and involve a mixture of private (car) and public (ferry) transport. Given the high costs of ferry transport in Pargas in relation to its low population density and the resulting pressure to rationalise the transport arrangements, researchers, local authorities, entrepreneurs and the archipelago's residents have recognised the need to study and develop the ferry network (Viitanen et al., 2007; Kajander et al., 2008). With this intention in mind, our main research questions are:

(1) How well does the existing ferry network correspond to the current population distribution?

(2) Are there spatial discrepancies in the current transportation arrangements?

We approach the research questions with a diverse combination of regional- and transport-related data collected from a multitude of sources. This study is of particular interest to authorities in charge of the planning of ferry transportation, but also to researchers from various fields interested in the problems of rural transportation in general and island transportation in particular. The methods of analysis presented in this paper provide a tool for locating spatial mismatches between population distribution patterns and transport options, potentially helping in the allocation of public funds (cf. Vickerman, 1995).

2. A review of the relevant literature

2.1 Analysing population patterns and accessibility

The accessibility and concentration of any given population and any economic activities are closely linked to each other but the relationship between these is highly scale-dependent (Kotavaara et al. 2011a, 2011b; Spiekermann et al., 2011): on a regional scale, the availability of transport opportunities and the resulting accessibility tend to have a concentrating effect on both the population and on economic activities; on the other hand, within urban areas increasing accessibility is often reflected in urban sprawl. However, Moller-Jensen and Knudsen (2008) and Linard et al. (2012) for example have reported contradictory results on the link between accessibility and concentration, thus revealing the complexity of the relationship between the two.

When the relationship between population distribution patterns and accessibility is assessed, accessibility is often measured with gravity-based models (potential accessibility) that assume that the attraction of a destination increases with its size and decreases with the distance that has to be travelled to reach it (Moller-Jensen and Knudsen, 2008; Spiekermann et al., 2011). The concept of accessibility may nevertheless have various definitions and there is broad understanding that the optimal way of operationalizing it depends on the context (Geurs and van Wee, 2004; Martin and van Wee, 2011). Here, we understand accessibility as the extent to which (land-use solutions and) transport systems enable people to reach destinations by the travel modes available and we focus on a location's perspective instead of that of an individual (see Geurs and van Wee, 2004). We argue that analysing a location's accessibility from another location purely by using traditional methods of measuring distance (physical distances or travel times) might not adequately represent the situation in an archipelago.

In transport geographic literature, research on ferry transportation networks and accessibility still remains relatively scarce, as maritime transport studies have focused mainly on liner shipping and the logistics of freight transport (Rodrigue and Browne, 2008; Frémont, 2009). There are, however, some exceptions including works by Hernández Luis (2002) on inter-island shipping in the Canary Islands; Odeck (2008) on Norwegian ferries as part of the road network; Baird (2012) and Laird (2012) on ferry services in Scotland; and Lai and Lo (2004), Ceder (2006), and Wang and Lo (2008) on the ferry network of Hong Kong. Consequently, many methods for measuring accessibility have been developed for land-based transport and urban areas that may not be directly applicable when it comes to measuring transport opportunities in an archipelago, as a ferry-based transport system is, in many ways, a special case (see also Hernández Luis, 2002):

(1) Transport systems in archipelagos are often a combination of public and private transport, in that many people travel in their personal vehicles but are reliant on public ferries and their schedules and routes to complete their journey;

(2) In a peripheral region, headway times are often long and connections might not be regularly available. Thus, the frequency of a particular transport service might be even more critical a factor in an archipelago than in an urban public transport system; and finally

(3) Ferry capacity places additional restrictions on journey flexibility and transport opportunities.

Cross and Nutley (1999) introduced one of the few methods for measuring accessibility that was developed specifically for archipelago settings. Their index incorporates ferry service frequency and travel time as well as other factors reflecting the relative convenience of different types of island transport. Compared to more recent accessibility indicators, however, this rank-based assessment method gives a relatively coarse picture of accessibility. Given that a ferry-based transport system shares common features with other public transport systems (schedules, predefined routes and capacities being essential parts of it), some of the more recent methods developed for urban public transport accessibility analysis (Mamun et al., 2013) might provide interesting options for analysing island transport, if properly modified to take into account the specific characteristics unique to island transport.

2.2 Kansky´s model on the relationship between transportation networks and regional economic characteristics

Kansky (1963), one of the pioneers in applying concepts from graph theory to geography, introduced several methods for analysing network structures. The study of networks has increasingly employed new concepts including complex networks, scale-free networks and 'small worlds' (Schintler et al., 2007; De Montis et al., 2010; Ducruet et al., 2010), but Kansky's formulas, and formulas derived from them, continue to hold their relevance. They remain in active use in the study of transportation networks (Gattuso and Miriello, 2005; Graham, 2009; Derrible and Kennedy, 2010), especially in developing countries and in peripheral rural regions (Marr and Sutton, 2007; Aderamo and Magaji, 2010).

With his graph theory approach, Kansky (1963) sought to explore the relationship between transportation networks and regional economic characteristics. He developed a predictive model of transportation networks, with the aim of predicting the distribution of transportation routes in terms of the probability of the individual nodes (concentrations of economic activity) to be included in the network. Accordingly, the more economic activities in a given place, the higher is the probability that the place belongs to a transportation network. Although Kansky applied his model to predict the spatial patterns of rail and road networks, there is no apparent reason why maritime networks could not be analysed just like any other transportation network (Ducruet et al., 2010). In fact, compared to land transport, the spatial distribution of maritime transport lines is less constrained by strictly defined boundaries. Of course, in practice, coastal geography, icing and depth requirements for particular types of ships impose limitations on sea traffic, especially in the case of complex and shoal archipelagos such as Pargas (Bonsdorff et al., 1997).

3. Pargas

3.1 Rural settlement patterns in Pargas

As the previous chapter on population distribution patterns and accessibility suggested, population distribution on islands is also often related to remoteness and transportation opportunities, as improved transport services can not only persuade islanders to remain, but also attract newcomers to the islands (Begg et al., 1996). Our case study area, Pargas (Figure 1), provides a good example of a (global) trend described by Connell (2010) as 'the downward spiral' of outer islands: the trend in Pargas has long been the gradual depopulation of the more remote islands that have no fixed connection (bridges) to the main islands or to the mainland. Furthermore, the proportion of pensioners has increased steadily, while the proportion of children and youth has decreased dramatically. These drastic changes in the population of Pargas have coincided with a shift from traditional livelihoods, such as fishery and agriculture, to a service-oriented society engaged in the public welfare sector, tourism, recreational services and transport (Andersson and Eklund, 1999; Salmi, 2009). Consequently, the decrease in the permanent population has, at least partially, been counterbalanced in Pargas by a recent increase in the number of summer cottages and part-time residences on the islands, thereby creating additional demand for ferries. Moreover, especially during the summer season, tourists are an important group of users of the ferries, which also benefits the local economy (Andersson and Eklund, 1999; Bergbom and Bergbom, 2006; Salmi, 2009). However, despite the growing tourism sector, ferry traffic in Pargas aims primarily to meet the needs of people who actually live on the islands all year round.

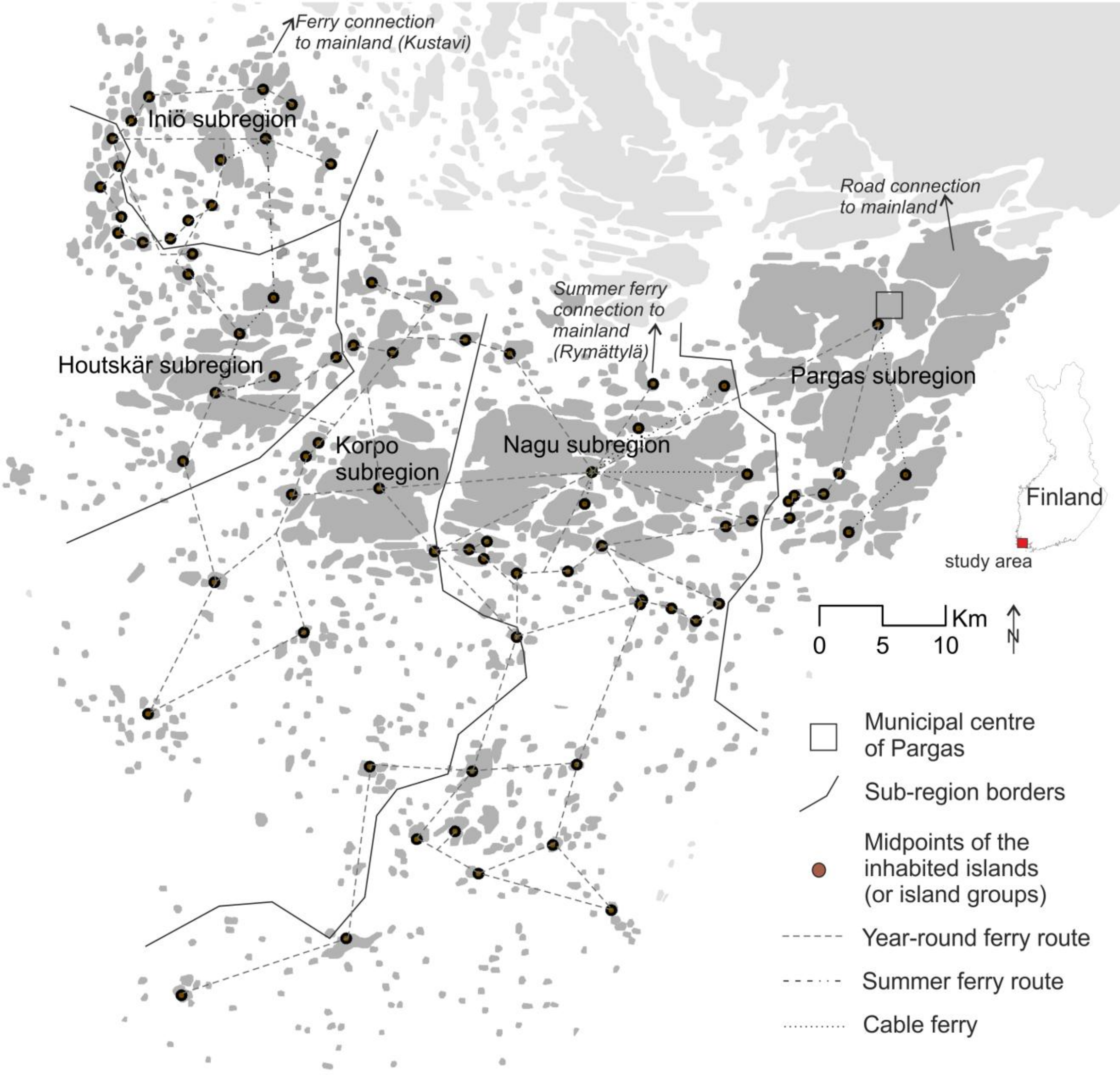

Figure 1. The Pargas archipelago, its five sub-regions (Pargas, Nagu, Korpo, Houtskär and Iniö) and a simplified scheme of the main ferry routes between the islands (only island midpoints have been taken into account, not true pier locations). For true geometries and more detailed ferry route descriptions, see Kajander et al. (2008) and the Centre for Economic Development, Transport and the Environment (2012).

Data sources: General map 1:1000000, 2010 © National Land Survey of Finland (background map); Kajander et al., 2008 and the Centre for Economic Development, Transport and the Environment, 2012 (main ferry networks); Grid database, Statistics Finland, 2009 (island midpoints)

Currently, the population of the whole Pargas archipelago is 15,300 persons, of which about 12,000 live in the main island of Pargas and over 3,000 on islands with no fixed land connection (Statistics Finland, 2009). The municipal centre of Pargas (see Figure 1) can be considered urban, but other parts of the region are predominantly rural. The smaller inhabited islands do not have a sufficient population base to justify and support the existence of services such as schools, health centres or shops. Therefore, efficient sea transport to the main islands that do provide these services is essential for the social and economic development of Pargas. Similarly, the geographical structure of the labour market is important when considering the commuting behaviour of sparsely populated regions (Sandow, 2008; Sandow and Westin, 2010). In Pargas, the major commuting flows are to the main islands and further on to the Finnish mainland, thus highlighting the importance of a well-functioning ferry network.

3.2 Finnish regional policy as a driver of transportation arrangements in Pargas

Regional policy forms an integral part of the economic development potential of remote regions. In short, regional policy in Finland has traditionally supported populating the entire country (Jauhiainen, 2008). This includes measures targeted at enhancing the employment opportunities and economic conditions of rural regions via the direct allocation of state funds, the relocation of state establishments from the capital region to more remote locations, the founding of provincial universities, large infrastructure endeavours (broadband, highways, railways etc.) and state owned or aided public transport for improving the accessibility of these rural regions (Tervo, 2005). Of course, such supportive actions performed under regional policy are not unique to Finland; rather they are quite common among many of the European welfare states (Shucksmith and Chapman, 1998; Farrington and Farrington, 2005). Therefore, lessons learned from the optimal organization of state funded traffic arrangements can be seen as a key issue for other countries seeking regionally balanced and inclusive growth paths.

As stated, in Finland the primary justification behind ferry traffic is not economic, but social and political. Therefore, in Finland, ferries are part of a public and statutory transport network that serves inhabited islands, even when this is financially unfeasible. Accordingly, the ferry network is heavily subsidized, and therefore, from the customers' point of view, pricing is not an acute problem in Finland compared, for example, to Greece (Pantouvakis, 2007) or Norway (Mathisen and Solvoll, 2010; Mathisen and Jørgensen, 2012), as the use of the ferries is free for all. Without this public support, the larger main islands would be the only ones with adequate transportation services, while the smaller outer islands would be serviced only during the peak tourist season. This would negatively impact the economy and society of Pargas in nearly all respects, leading, for example, to greater isolation and loss of employment opportunities (Andersson and Eklund, 1999).

4. Data and methods

4.1 Data and workflow

Analysing the functionality of the ferry network of Pargas requires some basic figures about the population distribution pattern and geographical accessibility of the islands. For clarity, islands connected to each other by bridges are counted as one island. In addition to the routes between the various islands of Pargas, ferry connections link Jumo (Iniö) to Kustavi, and Seili (Nagu) to Rymättylä (operated only during the summer), thus connecting these islands to the Finnish mainland (see Figure 1). However, because this study mainly examines the intra-municipal transportation network, these links fall outside the study area. In addition, the Seili-Rymättylä connection operates mainly as a part of a scenic tourist route. However, when discussing the interpretation of the results, we take into account the importance of the Jumo-Kustavi route to the population of Iniö.

The data cover 76 (mostly inhabited) islands belonging to the ferry network of Pargas. First, data on the population's distribution (number of inhabitants per island) and seasonal housing (number of summer cottages) were derived from the Grid Database of Statistics Finland (Statistics Finland, 2009). Second, data on transportation variables (distances, sailing frequencies, speeds and capacities of the vessels, and travel times) were gathered from existing reports (Kajander et al., 2008), timetable and data portals of the Centre for Economic Development, Transport and the Environment (2009), Finferries (2010) and the map service of Eniro, Finland (2010), as well as from correspondence with the authorities in charge of the archipelago ferry network in order to obtain figures for average daily frequencies of ferry connections, travel times and ferry capacities per island. In travel time and frequency calculations, we took the municipal centre of Pargas as the focal node of the analysis. The basic characteristics of the data are presented in Table 1. The following chapters describe each step of the analysis in detail.

Table 1.Basic characteristics of the data (per island) used in this study

	Min	Max	Sum	Average	Median
Population	0	12 013	15 235	200	4
Summer cottages	0	1 861	5 704	75	14
Average daily frequency of ferry connections (summer)	0.2	54	-	6.9	0.8
Average daily frequency of ferry connections (winter)	0.1	54	-	6.7	0.8
Travel time to the municipal centre of Pargas in minutes (summer)	19	389	-	129	107
Travel time to the municipal centre of Pargas in minutes (winter)	19	389	-	132	107
Car carrying capacity of the ferries	0	66	-	14	10

4.2 Assessment of each node´s relative weight in the ferry network

The first step of the analysis was to assess the relative weight (or importance) of each island in the Pargas archipelago – in other words, the relative weight of each node in the ferry network – by following the ideas proposed by Kansky (1963) in his predictive model of network structure. In this paper, the concept of 'relative probability of belonging to the network' (Kansky, 1963) is understood as the relative weight of a given island (i.e. the concentration of economic activity).

The regional characteristics of each island were quantified with two variables: the number of inhabitants and the number of summer cottages per island. We also tested other variables related to the mobility of the population and their need and preferences for transportation [see recent literature on travel behaviour (Næss, 2006; Susilo and Dijst, 2010; Haugen, 2011)], namely, the number of people of 'active age' (18–64 years), the number of workplaces and the annual income per island. However, these variables almost perfectly correlated with the number of inhabitants per island and were available on a much coarser resolution than the population data – and thus excluded from the analysis. The summer cottage variable was included because leisure housing creates additional demand for ferries, and the variable (although it correlates with) is not unambiguously tied to the size of the population per island.

The regional characteristics of each island were weighted as follows: first, the number of inhabitants on an island was divided by the total number of inhabitants in Pargas. The same figure was calculated for summer cottages, but the share of leisure housing was weighted by 0.25 in order to account for the seasonal use of summer cottages (0.25 stands for the 3 summer months of the year, that is, a quarter of the total number of months in a year). The Ministry of Transport and Communications (2009) in Finland used the same weighting for summer cottages in a study on service level definitions for archipelago transport. The sum of these percentages divided by 1.25 yields the total relative weight of a given node in the network of islands (Equation 1).

$$\text{Relative weight of node } i = \frac{\left(\left(\frac{a_i}{\sum a}\right)+0.25\left(\frac{b_i}{\sum b}\right)\right)}{1.25} \quad (1)$$

Where a is the number of inhabitants on island i and b is the number of summer cottages on island i.

4.3 Transport opportunity index (TOI)

In this analysis we quantify accessibility using a modified version of a recently developed Transit Opportunity Index (TOI) (Mamun et al., 2013). As the name suggests, the index was originally developed for analysing public transit in a 'more traditional public transport setting' – an urban region with a public transport system based on buses. Despite the different application setting, we chose to use this index because it fulfils the essential theoretical criteria we deemed necessary for quantifying transport opportunities in an archipelago: unlike many other accessibility measures, in addition to travel times (or distances) this index also accounts for transport frequencies, capacities and connectivity.

The original index (Mamun et al. 2013) is composed of transit access and transit connectivity measures. Transit access refers to the spatial and temporal coverage of the transit system: it measures the area that is close to the transport system and quantifies per capita service levels using data on daily vehicle departures and bus capacities. Transit connectivity is assessed jointly by a connectivity parameter (straight connections between origins and destinations vs. necessary transfers) and a travel time based connectivity decay function.

In order to adapt the index for our study setting and data, the Transport Opportunity Index applied here assumes the following form (Equation 2):

$$TOI_{ij} = \frac{A_{ij}C_{ij}}{\sum_i A_{ij}C_{ij}} \quad (2)$$

Where A_{ij} (Equations 3–5) describes access to the ferry transport system operating between origin island i and destination j (always the municipal centre of Pargas in this case) and C_{ij} (Equations 6-7) describes the degree of connectivity between island i and the municipal centre of Pargas. A_{ij} is further defined as follows:

$$A_{ij} = R_{if}S_{ijf} \quad (3)$$

where

$$R_{if} = \frac{Pr_i}{G_i} \quad (4)$$

and

$$S_{ijf} = F_{ij}U \quad (5)$$

R_{if} is the spatial coverage of the ferry network on island i; Pr_i is the number of relevant piers on island i (always 1) from where connections to the municipal centre of Pargas depart; and G_i is the number of inhabited grid squares on island i (describing the dispersal of the population in relation to the pier). S_{ijf} is the service frequency where F_{ij} stands for the average daily frequency of ferry connections between island i and the municipal centre of Pargas and U stands for the vehicle capacity on ferries on the respective route. The original index includes *per capita* service frequency which means that S_{ijf} is divided by the population of i. In our case, however, the population is part of the relative weight calculation and thus excluded from the TOI calculation. The car-carrying capacity (U) of the smallest ferries (i.e. boats) to the smallest islands is zero. However, on demand a (heavy transportation) ferry with a car-carrying capacity is available for these routes. Thus, for computational reasons the zero values were replaced with the value of one (half of the actual smallest car-carrying capacity).

C_{ij} (Equations 6-7) describes the connectivity between island i and the municipal centre of Pargas, offered by the ferry network.

$$C_{ij} = \delta_{ij}D_{ij} \quad (6)$$

Where δ_{ij} is a connectivity parameter that gets a value of 1 if the minimum number of ferry transfers required between island i and the municipal centre of Pargas is equal to or less than 2 (median in the data) and the value of 0.5 if the number of necessary transfers is equal to or exceeds 3. D_{ij} (Equation 7) is a distance coefficient based on travel times:

$$D_{ij} = \frac{1}{T_{ij}} \quad (7)$$

Where T_{ij} is travel time (in minutes) between island *i* and the municipal centre of Pargas.

This is where the operationalization of the original index differs the most from our use of it. Mamun et al. (2013) used a binary form of the connectivity parameters (1 = straight connection between *i* and *j*; 0 = transfers needed). In our case, the great majority of the connections include transfers from one ferry to another and, thus, this representation would have led to meaningless values in our analysis (the great majority of islands having zero connectivity). Furthermore, the original index uses empirical travel survey data (including travel times) to determine a logistic connectivity decay function that describes how the disutility of travel increases as a function of travel time. Given the lack of empirical data on travel patterns, we assumed that the disutility would grow linearly (a reasonable assumption in larger regions, as many other gravity-based accessibility studies have shown) and thus quantified this parameter directly as 1/travel time.

The seasonally varying parameter values (frequencies, capacities, transfers and travel times) were accounted for in the calculations so that values for the summer months were weighted by 0.25 and values for the rest of the year were weighted by 0.75. Harsh winter conditions may impose limitations on the ferries, and the more remote islands sometimes have to rely on hovercrafts instead of ferries. These limitations are difficult to predict and quantify. Therefore, we decided to simplify the model by leaving the possible constraints of extreme weather conditions out of the analysis.

In the analysis, the municipal centre of Pargas acts as the only destination (*j*) because it is the seat of important municipal- and other services for the whole of the archipelago's population, an important destination for the work force from other islands, and serves as the main gateway to the mainland (except for the population of Iniö, which may choose to use the route from Jumo to Kustavi). Travel time calculations included all necessary ferry connections and drive times through the islands, and the most optimal (fastest) route was selected for the analysis. More precisely, ferry travel times were calculated according to the inter-pier distances and the average speed of the ferries. The average ferry speed was adjusted to 80% of the maximum speed, as this fitted well with the ferry timetables we used for validation. The model also accounted for drive times through the larger islands (for example, from Iniö one needs to drive through Houtskär, Korpo and Nagu to reach the municipal centre of Pargas), but the smaller islands were treated as simple nodes to simplify the graph theory modelling of the archipelago.

We calculated the transport frequency for each island as the (weekly) average of daily ferry connections between each island and the municipal centre of Pargas and determined capacity by the maximum vehicle capacity of the ferries belonging to a particular route. We excluded passenger capacity from the analysis, because prior studies (Kajander et al., 2008) have shown that insufficient vehicle capacity (measured as the number of private cars) is more critical than passenger capacity in restricting the accessibility of outer islands.

Finally, we compared the relative weights and transport opportunity scores to assess how well the existing ferry network corresponds with the current population distribution pattern. For this, the islands were divided into three groups (good, average and low) of 25 islands each in both rankings (relative weights and TOI) according to their scores. This is significant, as the authorities in charge of ferry transport also classify the service standards of the routes by defining groups of high, mediocre and low demand and realised 'accessibility' (Ministry of Transport and Communications, 2009). The islands were grouped into these categories as follows: (1) demand, that is, relative weight (high > 0.13; average 0.05–0.13; low < 0.05) and (2) accessibility, that is, TOI (high > 0.150; average 0.035–0.150; low < 0.035).

5. Results

Table 2 summarises our main findings. Spearman's correlation coefficient (0.332; p-value = 0.004) shows that the relation between regional population characteristics and transportation opportunities is statistically significant and that, as a general rule, the islands with the highest relative weight (population base) are 'highly accessible' in terms of travel times, sailing frequencies and ferry capacities. Thus, answering our first research question, the existing ferry network corresponds reasonably well to the current population distribution pattern. The main and (in terms of population) larger islands (e.g. Nagu, Korpo and Mielisholm-Attu-Jermo) closest to the municipal centre of Pargas have high scores on both rankings due to their existing population base and the high frequency and capacity of the ferries connecting them to the municipal centre of Pargas (Tables 2–3, Figure 2). In particular, in Nagu and Korpo, the drive-through traffic towards the outer islands via additional ferry connections contributes to this need for a high 'score' in both sailing frequencies and ferry capacities.

However, the main interest here lies in the islands ranked in high-low categories to reveal the clearest contradictions in the rankings of islands between relative weights and transport opportunity scores; overall, as cross-tabulations suggests there is a 'modest' association between the categories (Figure 2 and Tables 2–3). Utö offers a contrasting example, with its relatively significant population and mediocre transport opportunity ranking (0.04, the limit of the lowest category being 0.035). This stems from the long travel time to the island, which is situated in the outer archipelago. The same holds true for Berghamn (Houtskär), but with a lower relative weight. The larger islands of the Iniö sub-region (Iniö, Jumo and Keistiö) are an exception due to their poor winter time accessibility, which resulted in a low transport opportunity score. A further discrepancy exists between the high transport opportunity score and low relative weight score of some smaller islands (Björkholm and Ramsholm; and to some extent Finnö, which is close to Korpo), with fortunate locations along frequently serviced ferry routes and with short travel times to the municipal centre of Pargas. Thus, answering our second research question, the current ferry network appears to have spatial discrepancies.

We also tested another index describing island accessibility. The modified version of a composite index proposed by Cross and Nutley (1999) gave very similar results compared to the TOI that we eventually used in our analysis. The TOI was chosen due to its more solid theoretical basis and formulation, but testing the alternative method confirmed the robustness of the applied measure.

Table 2.The relative weights and transport opportunity scores of selected islands in the Pargas archipelago

Island	Subregion	Regional characteristics Population	Summer cottages	Relative weight	Transportation Ferry access (A_{ij})	Connectivity (C_{ij})	Transport opportunity index
Pargas	Pargas	12,013	1,861	69.91 (-)			
Nagu	Nagu	1,254	1,045	10.25 (1)	13.87	0.040	3.59 (1)
Korpo	Korpo	673	610	5.67 (1)	11.10	0.019	1.33 (1)
Houtskär	Houtskär	339	235	2.60 (1)	3.19	0.006	0.11 (2)
Mielisholm-Attu-Jermo	Pargas	126	332	1.83 (1)	11.57	0.053	3.94 (1)
Norrskata	Korpo	67	192	1.03 (1)	13.00	0.007	0.56 (1)
Björkö-Kivimo	Houtskär	110	107	0.95 (1)	4.53	0.005	0.14 (2)
Iniö	Iniö	102	46	0.70 (1)	0.51	0.002	0.01 (3)
Mossala	Houtskär	71	21	0.45 (1)	14.00	0.004	0.38 (1)
Jumo	Iniö	59	37	0.44 (1)	0.76	0.002	0.01 (3)
Saverkeit	Houtskär	44	56	0.43 (1)	6.47	0.005	0.19 (1)
Käldö-Vallmo	Nagu	14	99	0.42 (1)	48.00	0.024	7.58 (1)
Keistiö	Iniö	37	55	0.39 (1)	0.61	0.002	0.01 (3)
Högsar-Ängholm	Nagu	16	68	0.32 (1)	67.50	0.020	8.92 (1)
Åvensor	Korpo	14	66	0.30 (1)	2.04	0.009	0.12 (2)
Sandö	Nagu	12	66	0.29 (1)	86.40	0.024	13.65 (1)
Haverö	Nagu	14	62	0.29 (1)	108.00	0.029	19.98 (1)
Maskinnamo	Korpo	7	66	0.27 (1)	3.68	0.008	0.19 (1)
Utö	Korpo	34	23	0.26 (1)	1.80	0.003	0.04 (2)
Nötö	Nagu	9	55	0.24 (1)	1.80	0.007	0.08 (2)
Kolko	Iniö	14	40	0.21 (1)	3.27	0.002	0.05 (2)
Pensar	Nagu	24	22	0.20 (1)	5.69	0.015	0.57 (1)
Heisala	Pargas	16	33	0.20 (1)	7.89	0.039	1.99 (1)
Åseholm	Iniö	15	24	0.16 (1)	3.84	0.002	0.06 (2)
Sorpo	Pargas	13	20	0.14 (1)	72.00	0.024	11.10 (1)
Berghamn	Houtskär	8	26	0.13 (1)	0.26	0.004	0.01 (3)
…				…			…
Finnö	Korpo	0	5	0.02 (3)	3.65	0.006	0.15 (1)
Ramsholm	Pargas	0	5	0.02 (3)	36.08	0.025	5.86 (1)
Björkholm	Pargas	2	1	0.01 (3)	55.25	0.028	10.18 (1)

Groupings of high, average and low transport opportunity and relative weight scores indicated in parenthesis 1 = high; 2 = average; 3 = low.
Rows where the relative weight and transport opportunity index scores do not match are highlighted in grey

Table 3.Cross-tabulations between the transport opportunity score (TOI) and the relative weights of the islands

TOI	Relative weight			
	High	Average	Low	Total
High	14	8	3[1]	25
Average	7	9	9	25
Low	4[2]	8	13	25
Total	25	25	25	75

[1]Björkholm, Finnö and Ramsholm (see Figure 2 for locations)

[2]Berghamn (Houtskär), Iniö, Jumo and Keistiö (see Figure 2 for locations)
Cells where the relative weight and TOI scores do not match are highlighted in grey

6. Discussion and conclusions

Our results show a close connection between island population distribution patterns and transport opportunities; as a general rule, the islands with the largest populations are the ones with the best ferry transport services. This result supports those of a previous study by Kajander et al. (2008), which found that the ferry network worked relatively well. Thus, generally speaking, Pargas provides a fairly good example of how accessibility challenges in a peripheral archipelago can be resolved. Therefore, these Finnish ferry transportation arrangements provide a good benchmark for other countries seeking to promote the accessibility of remote archipelago regions. The single most important factor in the development of this well-functioning ferry network has been the long-term and constant support provided by the state, fuelled by the political will to sustain the viability of remote regions. This has enabled the long-term planning of and investment in developing the ferry network of Pargas. Another key to successful planning, we believe, is the fact that the authorities in charge of the planning of Pargas's ferry transport service have been constantly interested in developing the tools required to monitor and assess the performance of the ferry network and have been keen to listen to the islands' inhabitants when developing the network. However, even though the general situation is positive, there are some clear spatial discrepancies between the existing population distribution pattern and accessibility via the ferry network.

In Iniö and its surrounding islands, with their relatively large population base, the transport opportunities to the municipal centre of Pargas in the winter season are exceptionally poor. A possible solution to this poor winter service could be to operate the already existing direct summer route from Mossala (belonging to the Houtskär subregion) to Iniö outside the peak tourist seasons. Accordingly, the low transport opportunity score for Utö, one of the most prominent outer archipelago islands, could be improved with the acquisition of a faster ferry. Moreover, the low vehicle-carrying capacity of many ferries is also an issue that deserves immediate attention. In any event, the mobility of people in the archipelago – whether permanent or seasonal residents or tourists – relies on the traditional regional policy (Ministry of the Interior, 2007) that has supported the ferry network thus far being continued. Well-functioning ferry connections are a prerequisite for the archipelago to remain viable, but without public subsidies for the ferry operators, it would not be feasible for the shipping companies to provide these transportation services.

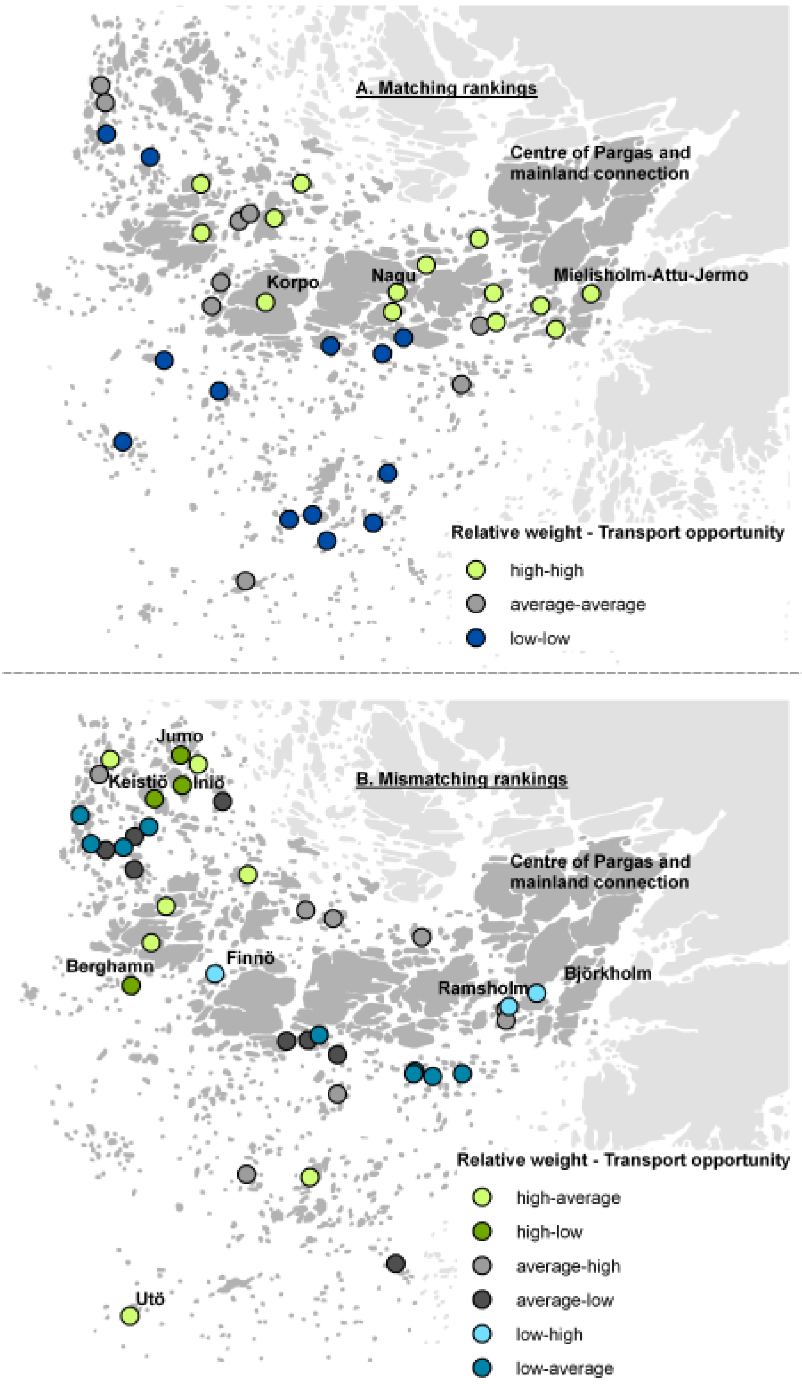

Figure 2. (A) Islands where the relative weight ranking and the transport opportunity ranking match. (B) Islands where the rankings do not match. Data sources: See caption in Figure 1.

We do not discuss the costs of ferry transportation – definitely an issue worth further study – but in our analysis we identified where the discrepancy between the population distribution pattern and current transport services is the greatest, and we offer suggestions for improving the transport arrangements. However, in relation to the role of costs, when applying the findings of our study, it is reasonable from a welfare perspective to maintain a high level of accessibility for the regions with a relatively low weight, given that the extra costs of providing these services are low. In other words, even though consumer surplus is low it derives positive social surplus if costs are also low. In contrast, the enhancement of accessibility to islands with a high relative weight at an unreasonably high cost is, in turn, unfeasible.

The Finnish example presented in this study confirms the theoretical and empirical propositions concerning the close link between accessibility and population concentration (MacKinnon et al., 2008; Spiekermann et al., 2011). Moreover, it is well in line with global trends concerning accessibility challenges in rural archipelago settings: the relative isolation of islands leads to more depopulation (Cross and Nutley, 1999; Connel, 2010), and with the lack of other modes of transport, the planning of ferry routes and capacities becomes critical (Hernández Luis, 2002). To support the social and economic development of the archipelago in the future, hard-pressed public funds must be allocated as efficiently as possible. Identifying areas where the spatial mismatch between population distribution patterns and transport options is at its most acute is important for accomplishing this task. This paper has provided some practical tools for the identification of such mismatches by adapting existing methods to an archipelago setting.

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