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EMISSION-FREE LOGISTICS IN REMOTE RURAL AREAS

ABSTRACT

Purpose: The EU Green Deal aims at making the continent climate-neutral by 2050. This heavily impacts the logistics sector, which currently predominantly relies on carbon-emitting ground, sea and air transports. While there are economic incentives to implement innovative emission-free alternatives in urban regions, rural areas can barely even hope for economical transportation services and thus are often supplied by traditional, emission-intense, means of transport. In particular, Remote Rural Areas (RRAs) provide a challenge to this goal: A combination of factors hinders the application of modern sustainable transport solutions in this context. The purpose of this paper is to define and analyse emission-free transportation in RRAs, providing an overview of current approaches to the issue and aiming to synthesize an opportunity to improve current concepts.

Methodology: It provides an overview of existing literature on supplying remote rural regions, with a special focus on emission-free transportation. It relies on quantitative methods, exemplary comparison and analysis of current good practices.

Results: The research results in the proposal for an implementation process for associated transportation concepts in RRAs, based on a detailed discussion of literature and practice. This combined logistical concept supports decision makers in their task of supplying their regions sustainably.

Conclusion: The paper concludes that freedom from emission is claimed more often than it is realised. Nevertheless, often independent RRA systems provide favourable conditions for achieving the Green Deal objective, assuming that funding and interest in the issue are given.

Keywords: Rural, remote, logistics, green deal, emission-free

1. Introduction

1.1 Problem definition

The long-running tendency for urbanization in Europe and beyond has political, economic and structural consequences for supply chains and the infrastructures they operate on. With the centralization of people in agglomerations, demands and

final destinations of many supply chains are also being centralized. This, in turn, transforms many serial supply chains into less divergent supply chains. Last mile logistics is consequently becoming increasingly short-distance intra-city transport rather than long-distance delivery transport (see Bretzke, 2013). These divergent supply chains are increasingly becoming economically and ecologically

sustainable, as transport to the agglomeration can be bundled and short-distance last-mile deliveries can be operated by emission-free transport modes, such as cargo bikes or electric delivery cars. Seto et al. (2010) even argue that we cannot afford not to urbanize to become increasingly sustainable as a global society. While these transformations are ongoing, a future featuring largely emission-free transports starts to look increasingly feasible for urban populations.

In contrast, rural areas do not profit as much from the described transformation of supply chains, since both demands and supplies of businesses and industries in rural areas are more dispersed. Given the smaller volume of transport to and from rural areas, logistic services and the infrastructure they operate on are often underused, overpriced and thus deteriorate over time. As Porru et al. (2020) argue for public transport, this in turn accelerates the urbanization and widens the urban-rural gap even further. In many remote rural areas, deteriorating infrastructure forces inhabitants to migrate, as life in isolation is becoming increasingly risky (see Marino & Lazrus, 2015). Finally, improving the transport offer in rural areas is one facet of making rural areas more accessible, which, according to Brovarone and Cotella (2020), is a prerequisite for an ongoing sustainable development of rural areas.

The urban-rural divide seems to be even wider when it comes to sustainable transport (and mobility). As Wappelhorst et al. (2014) argue, the potential for electric car sharing e.g. is “too low to guarantee the economic viability” in non-urban regions. Last-mile deliveries, which are carried out in both urban and rural areas, are three times as expensive in rural areas, as Gevaers et al. (2014) determined, which leads to a trend that delivery companies are increasingly reducing their delivery frequencies to rural areas or raising their prices. As Kokorsch and Küpper (2019) conclude, possible ways out of the growing urban-rural divide seem to be either (semi-)autonomous transport technologies or social innovations. This study will examine efforts to maintain rural areas in an - economically and ecologically - sustainable way.

It will further focus on remote rural areas, a subcategory of rural areas, which are far from urban agglomerations. Remote rural areas are typically inhabited by few people and often possess insufficient or outdated transport infrastructure due to the challenging terrain or climate conditions. This

geographical area of research is further defined in the following chapter, accompanied by framework definitions of unique challenges of transportation in this setting and two levels of freedom from emission. Subsequently, good practices of remote rural areas, which strive to become emission-free, are presented and classified. A derived strategic supply chain concept for promoting emission-free transportation in remote rural areas is the focus of this study. It is followed by a comprehensive conclusion, critically discussing current efforts and recommending further research.

1.2 Methodology

To realise the outline above in a scientific way, a qualitative methodology establishes a structured framework of relevant sources.

An extensive review of available literature on the topics of emissions in transportation and remote rural areas allows for multidimensional and fact-based definitions of the required nomenclature. Coexisting definitions are analysed, discussed and combined. On this basis, significant good practices could be identified through an increasingly targeted literature review process. As this section represents a dynamic status quo, current digital sources were used to ensure the topicality of the introduced states. The synthesis of these two method applications, first in theory, then in practice, is conducted by the identification of a strategic supply chain concept for the observed areas, presentable in a meaningful process flow chart.

As a result, the paper summarises the current state of emission-free transport in remote rural areas and proposes an approach to increasing its share.

2. Definitions

2.1 Remote rural areas

Remote rural areas are geographical regions that are both rural in nature and remote. They are thus far from neighbouring regions, cities or settlements. Both terminologies, rural and remote, are used to define a wide range of concepts and therefore require a definition to clarify how they will be understood in the following text.

Rural is usually defined in opposition to urban, a definition that is often disputed, e.g. by the Thünen Institute in Germany, as it suggests that all non-urban regions can be considered similar, which barely

is the case (see Küpper, 2016). For the remainder of this study, however, an understanding of rural as non-urban is sufficient, as the study will focus on a narrower concept of remote rural areas.

Remote areas are areas that are far away from any other area. What distance this characterisation requires is often left unclear. For the sake of defining a distinct threshold, this study considers only areas that are hard to access as remote. Hard to access, in turn, shall imply that there is no individual means of transport or at least hourly operating scheduled public transport that could bring people and goods to and out of the area and to another area within less than an hour during daytime. This threshold is consistent with the OECD's definition of PRR (Predominantly Rural - remote) areas, as recorded by Dijkstra and Ruiz (2010), which requires a driving time of over an hour to a population centre over 50,000 inhabitants for more than 50% of inhabitants.

Remote rural areas (RRAs), subsequently, are regions that are both rural in nature, and thus non-urban, and remote, therefore hard to access.

The European Union understands the development of such regions as the main political aim to reach cohesion, it furthers the equality of life in remote rural areas to other parts of the continent. As part of these cohesion policies, the Commission identified so-called "regions with specific geographical features" that can rightly be called the remote rural areas of Europe. According to ADE (2012), these can be grouped into:

1. Remote rural islands, in particular in Scotland, Croatia, Greece, and the Baltic and the Arctic Sea.
2. Remote mountainous areas, as those found in the Alps, the Balkans, the Pyrenees, and, depending on the geographical definition of Europe, the Caucasus and the Ural Mountains.
3. Sparsely populated areas, which are predominantly found in the Arctic regions of Europe and in some parts of Spain, Romania and Bulgaria.

This grouping indicates that RRAs are neither limited to a region nor to a country of the European Union. Even though this paper is focused on the EU and its RRAs as outlined above, all regions of the

world include hard to reach communities of this nature. Supplying them with goods poses multiple logistics challenges.

2.2 Unique characteristics of logistics and mobility in RRAs

Remote rural areas constitute a challenge to logistical means. As a result of their remoteness and thus isolated position, the areas defined above require reliable logistic connections to other areas to sustain themselves. Resilient supply chains for supplies, such as food or medicine, are a necessity for the local population. Likewise, local businesses depend on reliable supply chains leading from the rural remote areas to sell their goods (Brown et al., 2008).

While many non-remote rural areas are connected by conventional modes of transport, maintaining any earthbound infrastructure is very cost-intense given the often small population targeted (Morgenroth, 2014). This favours the use of modes of transport which do not rely on continuous infrastructures, like aeroplanes, helicopters or, where applicable, ships (see Mikkala & Tervo, 2013). Provision of logistics services is therefore more demand driven, bundled and expensive in remote areas. Transport-related access to the area can be obstructed by geography (e.g. insular or mountainous) or climate factors (especially in the Arctic region). Specialised supply chains, for example cold chains for medical resources or fresh food, involve legal requirements which further complicate the provision.

At the same time, as mentioned above, the EU (EU, 2021) recognises the necessity of appropriate provision of transportation for people and goods as "a critical aspect of social and economic development and cohesion," while emphasising that this is to be "implemented in close alignment with the energy and ecological transitions". This implies that sustainable transportation is to be provided to all Europeans, regardless of their place of residence - including those who inhabit the RRAs defined above, to further the emphasis on an equal collective of states and their regions. Likewise, many national laws demand that all citizens of their respective countries benefit from the same level of state services, such as the healthcare system, which is only feasible if a resilient logistics solution is in place (see Wilson et al., 2009).

It becomes evident that the provision of logistics and mobility to RRAs is a more vital topic than is often presumed, both in the political sphere and as a challenge to related businesses. This mirrors the current state of sustainability in all aspects of life, i.e. the looming climate catastrophe. To sum up, preventing emissions in logistics, be it urban, rural or remote, has to be the top priority from a scientific point of view. The intersection of emission-free logistics and RRAs can therefore be considered an issue of importance to corporate and public organisations alike. In order to reliably promote this intersection, a reliable definition of what constitutes freedom from emission becomes necessary.

Logistics, the movement of goods, and mobility, the movement of people, are typically two different fields of research, which are sometimes linked, but only rarely intertwined. For the remainder of this paper, the feasibility and the status quo of emission-free logistics and mobility in remote rural areas are often, but not always, considered simultaneously. As all forms of transportation, whether of goods or people, rely heavily on the same earthbound infrastructure, the challenges of a transformation towards emission-free forms of logistics and mobility are often structurally very similar. Once an emission-free bus or train is developed to operate in a specific remote rural area, it is regularly also capable of transporting goods - or vice versa. The authors acknowledge that a more granular differentiation might be important or even crucial in some contexts.

2.3 Emission-free

All European and most non-European states are committed to reducing or stopping emissions of carbon dioxide, the main driver of man-made climate change. This goal was formulated in the adoption of the 2015 Paris Climate Agreement (see UNFCCC, 2016), which vows to limit global warming by drastically reducing emissions by the year 2030. However, a range of different concepts exist to reach that target. One such concept, and the easiest one to measure, is emission-free, which means that no greenhouse gas emissions are emitted at all. In particular, this concept does not include areas that still emit carbon dioxide but compensate for these emissions, e.g. by so-called 'tree banking' (see World Economic Forum, 2022).

When speaking about remote rural areas, a further differentiation in *internally emission-free areas*, i.e.

areas in which no emissions are emitted by transportation, but which are reached by carbon dioxide emitting means of transport, and *externally emission-free areas*, which are additionally exclusively served by emission-free means of transport, is required. In the latter case, a more comprehensive approach to freedom from emission is given, including the upstream (resp. downstream) leg of the supply chain.

In both cases, an exclusively internally and more comprehensively externally emission-free RRA, an already challenging logistical environment, is limited further in its options. The examples of good practice collected below reflect both concepts, before these findings from theory and practice result in a synthesised strategy to achieve emission-free RRAs.

3. Good practices

3.1 Internally emission-free remote rural areas

3.1.1 Remote rural islands: Porto Santo, Portugal

Porto Santo is a small Portuguese island in the Atlantic, measuring approx. 40 square kilometres. It is part of the Madeira archipelago, but its nearest neighbour island to the southwest is over 40 km away, isolating the island, not only but also in its production of energy. Even though the island is currently still relying on a TPP (thermal power plant) for most of its energy needs, ambitious plans are drawn up to increase the share of sustainable energy sources as high as possible. The potential to be internally emission-free is being researched and realised by a public private partnership including an automotive company. This includes the plan to switch to electrical vehicles for all the needs of Porto Santo's 5,500 inhabitants. As an RRA of manageable size, the limited range of these vehicles does not threaten the integrity of island-based supply chains. According to Torabi et al. (2017), the storage of energy to handle peaks in demand is a current challenge to these plans. Facilities acting as batteries or the involvement of vehicles to this end (bidirectional EVs) are possibilities proposed by Strobel et al. (2021) and Torabi et al. (2021).

The plan towards emission-free Porto Santo is further jeopardised by the biggest local economic factor and source of peak demand for energy, namely tourism. The vast majority of the 100,000 tourists a year arrive by plane, the most frequent but least

sustainable mobility option to reach the island. All plans to achieve zero emissions therefore exclude the airport and its use, the emission-heavy part of tourist mobility. Inhabitants are conflicted by the knowledge that their goal of eradicating emissions attracts an increasing number of tourists, hence aeroplanes, hence emissions. All intentions of Porto Santo to become emission-free thus currently merely focus on internal measures.

3.1.2 Remote mountainous regions: Zermatt, Switzerland

Zermatt is an RRA in southern Switzerland, located in the mountains of the Alps. Like Porto Santo, it supports a population of between five and six thousand, generously supplemented by winter sports tourists. The village itself is combustion engine free and - according to its own statements (see Zermatt Tourismus, 2023) - it reduces emissions wherever possible, only really causing emissions with snowcats used for slope preparations. Local energy production is based to a large extent on hydroelectric power (73% in 2021) (see Elektrizitätswerk Zermatt AG, 2022), ensuring a clean source for electricity demand in Zermatt. Electric vehicles, which serve the logistics and mobility needs of the city, are manufactured and designed specifically for this region and are exclusively owned by public actors and businesses, reducing the share of personal vehicles to zero. As this was democratically decided and the small inhabited village core is accessible on foot, the residents of this RRA are quoted as being satisfied without owning a personal vehicle.

However, Zermatt still encourages tourism and provides large parking lots for combustion engine cars outside of Zermatt to get there. This makes the area, just like the island of Porto Santo, only an internally and only mostly emission-free RRA.

3.1.3 Sparsely populated areas: Svalbard, Norway

The Norwegian archipelago of Svalbard is a secluded Arctic region. Its area includes the former coal mining town of Longyearbyen. Housing approx. half of the inhabitants of Porto Santo or Zermatt, but nearly all of Svalbard's population, its logistical needs are of manageable nature. Nevertheless, throughout its history and current focus on research regarding climate change, this RRA aims to be internally emission-free. This goal is emphasised by the multiple effects of global warming, which, according to Paddison (2021), are challenging the

town constantly. As a result, the closure of its current energy source, an old and expensive coal plant, is planned for 2023. It is to be replaced by multiple sources of renewable energy, reducing carbon emissions of the city by 80% by 2030. For now, the mayor encourages shared mobility solutions for immediate improvements in mobility emissions. A modelling study by Ringkjøb et al. (2020) examined the feasibility of this shift towards renewables with positive results, emphasising the need for power storage and back-up capacity. The purchase of a 'giant battery' in 2022 (see Jonassen, 2022) brings this proposed concept into motion.

As a result, Svalbard is close to becoming entirely emission-free, despite the harsh conditions of the Arctic. However, Longyearbyen sees a stark increase in flight traffic and moorings for cruise ships, becoming a hub for arctic tourism. As these modes of transport are not feasible in an emission-free way yet, Svalbard has to be considered on its way to becoming merely internally emission-free.

3.2 Externally emission-free remote rural areas

3.2.1 Remote rural islands: Samsø, Denmark

A small Danish island of Samsø is home to around 4,000 people who live in 22 villages spread over 112 km². Its geographic position favours renewable energy through wind turbines, which satisfy most of the island's energy needs, in a combination with solar panels and biomass plants.

Replacing coal-based electrical power from the mainland, this transition towards emission-free energy sources was conducted in just ten years. According to Sperling (2017), the shift was possible through the integration of and participation by the local community. Among other factors, Sperling attributes the success of this huge endeavour to a 'sense of locality and responsibility' and a 'community spirit', but also to various supportive actions by the government. He nevertheless describes the processes as intensive. Lewis (2017) identifies the resulting co-ownership of infrastructure by the community itself as a vital success factor for the transformation.

Surpassing this community-based effort in Samsø, the island aims to be completely emission-free by 2030, eliminating the last carbon-emitting sectors of heating and road transport by introducing wind power- and biomass-based alternatives (see UNFCCC, 2023). To achieve decarbonisation of the trans-

port of good and people to and from Samsø, the municipality had to start their own shipping company in 2013 to order new LNG powered ferries. The new shipping company immediately conducted a feasibility study to produce all the required LNG locally on Samsø (Mikkelsen, 2015). Today, the Samsø municipality-owned ferry is entirely fuelled by locally produced natural gas (Tybirk, 2018). In 2024, an electric ferry shall replace this LNG-powered ferry as a next step towards freedom from any emissions (see Danfoss A/S, 2023).

Emissions are about to be eliminated from Samsø - internally, in heating and mobility, just like externally, in transportation to and from the island.

3.2.2 Remote mountainous regions: Stoos, Switzerland

A small mountain village Stoos in Switzerland is on its way to become the first emission-free village in the Alps. It has only 150 inhabitants, but also additional 2,200 beds for tourists, as it is a winter sports resort. Like Zermatt, it has always been car-free, but started to invest heavily in reducing emissions that result from reaching the RRA. In 2017, it replaced its old cable car with an earthbound electric funicular (see Stoosbahnen AG, 2023). Later, it linked the funicular to the public transport network of Switzerland with an electric bus. Finally, the village started a project with an all-purpose vehicle company to design and build a vehicle that can transport goods to and from the village (see Hiller, 2022). This effort will potentially make Stoos' logistics and mobility internally and externally emission-free in the future.

3.2.3 Sparsely populated areas: Bulnes, Spain

Bulnes is a tiny hamlet in northern Spain. It is home to just approximately 40 people and until 2001 it could have been reached only by a two-hour hike from a neighbouring village. Since 2001, an electric funicular links the village to a neighbouring settlement and the national Spanish road network (see Basterra, 2011). As the funicular itself does not emit any carbon dioxide, it could thus technically be considered externally emission-free. Internally, Bulnes, similarly to Stoos, has teamed up with an all-purpose vehicle producer (Alke, 2023) to design an emission-free vehicle that can be transported via the funicular and do deliveries and transport within the village, making all transport internally emission-free.

4. Strategic RRA supply chain concept

The collection of good practices of RRAs, which seek freedom from emissions, and the included methods complementing these attempts show progress which remote areas are making and the tools they can use for this purpose. A discussion of existing efforts and achievements in internal and external emission freedom revealed a usually comprehensive wish to eliminate harmful energy consumption - the focus is seldom exclusively on the logistics sector and its 'footprint'. The authors found that there is a lack of coordinated application of methods in this sector until the end of the complete concept for logistics. In this section, therefore, they attempt to synthesise a strategic concept which considers knowledge of the findings so far.

It is usually trivial to define the geographical boundaries of RRAs due to their remoteness, which is one reason why it is often easier for RRAs to attempt to limit internal freedom from emission at all. The necessary transport of goods and people can thus easily be grouped into transport *within* the RRA, as well as *to and from the RRA* - or, in other words, internal and external transports. The first step towards any transport solution for RRAs, including emission-free ones, would be the ownership of transport demand data. This is not simple because public institutions typically do not measure the demand for logistics services fulfilled by third-party companies. Yet, it is required as a foundation to formulate a comprehensive strategy towards freedom from emission.

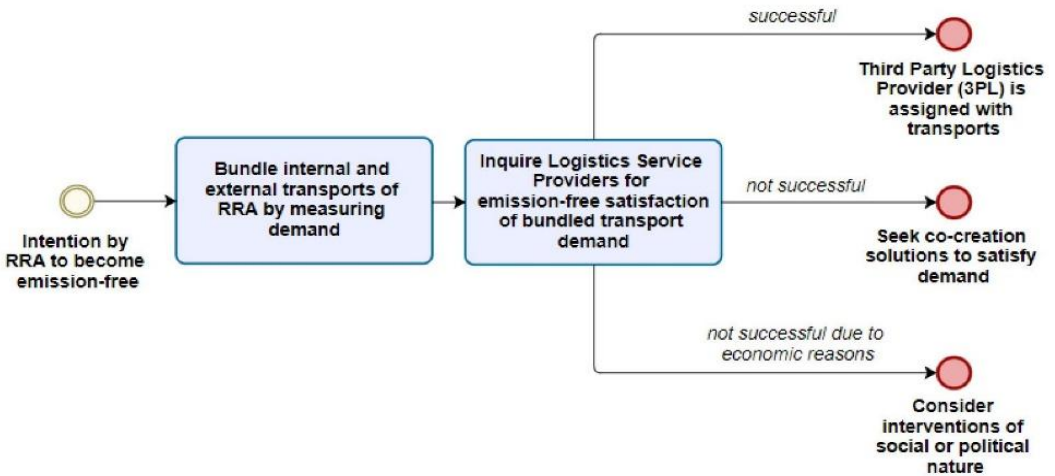
In the second step, the RRA could and should actively seek for possible service providers that can meet these bundled transport needs, while requesting these services to be provided without emitting any harmful emissions. The RRA has an advantage because it can define a clear demand for a service, e.g. "deliver X tons of goods daily from the island to the mainland and Y tons from the mainland to the island, without emitting any carbon dioxide". If no service provider is able or willing to provide such a service to the RRA and its citizens, the RRA should invest in finding a solution from within. This is exemplified by Samsø, which had to develop an ambitious community-based plan of public investments and co-ownership, or Bulnes and Stoos, which both had to design and construct vehicles fit for the purpose of operating in their respective RRA.

Should the procurement of a service provider fail solely and exclusively for economic reasons, meaning an unprofitable business case, the RRA community can also invest in social innovations from within. That such innovations from within have the potential to (re-)vitalise or sustain an entire RRA can be observed, e.g., in the Chatham Islands, which manages its entire internal and external transport infrastructure successfully since its parent state, New Zealand, failed to provide such services (Rennie, 2022). Crowd logistics, active involvement of community members and their resources in respec-

tive supply chains, could be one of the solutions to overcome the financial gap. Another solution could be a public subsidy of the required service to maintain the connectedness of the RRA, while reducing its emissions. These unconventional solutions to providing transport in, to and from RRAs require extensive involvement of the democratic entities of the region – mirroring the earlier clustering of demand as a community effort.

As a result, in all potential outcomes of this strategy, one of three clear paths can be pursued. Figure 1 provides an overview of this simple concept.

Figure 1 Model of strategic RRA supply chain concept



Source: Authors' own representation, by Bizagi Modeler

Looking at the discussed and many other good practices observed, taking these steps seems to be the best chance for RRAs to become emission-free, as they allow RRAs to autonomously reduce their emissions gradually to become emission-free. In particular, the proposed model grants the RRA the autonomy to act without having to trust, demand or ask for improvement of the infrastructures bridging the gap between the RRA and the larger markets outside of it. This is crucial, as infrastructures leading to and from RRAs are typically not owned by the RRA community and thus any infrastructural improvement has to be made by higher-level, often national, bodies. As Fox & Porca (2001) argue, national bodies will often conclude that infrastructural investment in RRAs is very unlikely to drastically

improve remote economies and thus avoid major investment in such infrastructure.

5. Conclusion

This overview of emission-free logistics options in RRAs provided various insights. In an established framework of clear definitions, existing efforts could be observed and evaluated. The resulting strategic supply chain concept in this context provides a synthesised and simplistic framework for RRAs, which aim to reach freedom from emission. This chapter includes final conclusions of this approach, followed by a summarising feasibility discussion of emission-free RRAs and an identified area for further research on this topic.

The strategic RRA supply chain concept of the previous chapter was structured to reflect the current state of research on the topic. As shown, many RRAs aim for emission-free transportation, with varying results. By generally following the described steps, a collective and purposeful course of action can be followed. By involving the public in a democratic way and with participation-based solutions (as demonstrated in numerous examples of good practice such as Zermatt and Samsø), population resources, innovative potential and, most importantly, cooperation in collective action are ensured in a way which could never be provided sustainably by a top-down approach. At the same time, the possibility of the concept of involving large logistics providers makes economic solutions possible: Externalisation of transport requirements through MaaS (Mobility as a Service) solutions provides access to economies of scale and can make the latest vehicles or platforms attainable in this way. A focus on renewable energy sources and electrification as opposed to internal combustion engines is a common factor in these logistical aspects. RRAs rely on this technology to reach their goal; efficient use of renewable resources, energy storage capabilities and corresponding innovations in logistics vehicles is ongoing and accelerating. In those RRAs, which nevertheless cannot be serviced economically without environmental emissions, the remaining options are of social (e.g. crowd logistics) and political (e.g. subsidies) nature. Especially in the European Union, growing cohesion in these two fields could prove the applicability of the concept.

As reasonably constrained areas, RRAs already offer great opportunities for the development and testing of emission-free options, whether by service providers or collective community efforts. Overall, they proved to be good laboratories for the application of emission-free transport and mobility methods, which can later be adopted on a larger scale. Distances within settlements are typically shorter than in urban centres and travel to and from remote rural areas is rare, as the accessibility of the area often makes it impossible for its citizens to commute. In some cases, as is the case with a number of Scottish islands, the transition towards sustainability is driven by state and public actors, such as the regions and islands concerned and the Scottish Government. In other cases, as is the case with the Greek island of Astypalea or the aforementioned

Porto Santo in Madeira, public-private partnerships drive the transition.

On the other hand, the adaption of emission-free modes of transport and mobility in RRAs is limited by multiple factors. Most notably, differences in the comprehensiveness of sustainability efforts are clearly visible, demonstrating a deeply rooted issue at hand: emission-free logistics concepts for RRAs are more often than not incomplete, shifting emissions to upstream processes in the supply chain, like bordering parking lots and planes. While this avoids the negative local effects of emissions, such as particulate matter emission in populated areas, the goal of preventing greenhouse gases in general is not sufficiently addressed. In this context, current technology does not yet provide emission-free long-distance or high-speed means of transport that can serve RRAs. The potential exception of high-speed trains is infrastructure-bound and requires extensive investment, even in less challenging environments. Additionally, stakeholders can also jeopardise the efforts. Public-private partnerships carry risks for the community, especially if it relies on the output, as in mobility and transportation. Greenwashing, building a sustainable appearance without actual progress, can be considered one of them. Its deceiving language is encountered repeatedly in this research since upon close inspection, none of the practices examined can claim to actually have no emissions as defined, internally or externally, at least when factors other than transportation are taken into account. Bulnes could serve as the exemption from this rule, as its extremely small size and population made the discussed solutions possible. Stoos emits no carbon dioxide from internal and external transport, while Samsø, Porto Santo, Zermatt and Svalbard are not yet internally or externally emission-free in terms of transport. Explaining this, many of the RRAs mentioned above are tourism-focused economies, which rely on their public image and can invest in expensive sustainable solutions to increase their appeal to environmentally conscious travellers. Of course, not all RRAs are tourism-focused and well-off enough to consider this trade-off. Alternatively, community-based approaches, as embodied in the strategic concept, can only succeed with an involved public, which invests time and resources in long-term shifts towards sustainability. Misinformation about climate change or lack of interest

in the topic can, for example, prevent constructive approaches by labelling them as unnecessary.

Finally, there are limitations to the analyses conducted, posed by the nature of available source material and authorship. As mentioned, the interest in being perceived as a sustainable RRA can spin any public-facing publication towards a distorted and therefore less scientific conclusion. On the other hand, internal and more reliable policy-related sources, such as scientific pre-studies, are seldom written for public use. Therefore, they are often composed in the local language and not retrievable by conventional research methods within the scope of this work. In relation to authorship, both authors of this study are scholars in the domain of business sciences. A linear point of view of the natural sciences is lacking in this discussion of topics, which are certainly related to this additional field. To handle this limitation, the authors have limited the presentation of natural sciences and related technologies to consensus in the respective field.

As evident from this long list of uncertainties and limitations, further research is needed in this important field. For the most part, sustainability continues to be a priority after economic KPIs. The authors see this as an opportunity to adapt current economic analyses. According to (Laird & Mackie 2014), current cost-benefit analyses do not include all the benefits of servicing remote rural areas. Future approaches to this topic should thus consider both all (indirect) economic aspects and the impact on emissions as beneficial. A comprehensive approach to the transport needs of remote rural areas can therefore produce adequate solutions for stakeholders in and outside of the regions in a sustainable way, economically and environmentally.

As the effects of climate change are immediate events, adequate action becomes increasingly urgent. RRAs could be at the forefront of setting an example, regardless of the small global impact of a single success in reducing emissions. Approximations like the Pareto principle show the great impact of small first steps - as long as there is a will to change.

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