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Addressing sustainability in mobility: a study on Finnish smart mobility innovation projects

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Abstract

This research studies how recent Finnish smart mobility innovation projects have addressed sustainability in their objectives. A framework and a coding scheme were built upon scientific literature and was used for analysing documented project materials. A truth table was generated that quantifies how the different aspects of sustainability have been addressed in the projects' objectives. The observed differences between the projects were analysed from two directions: in terms of funding sources (European Union vs. national) and project location (urban vs. rural areas). The results of qualitative comparative analysis showed that while sustainability was by and large present in the projects, some of the aspects of sustainability were more dominantly addressed than others. Also, there were differences in how sustainability was addressed between the projects in urban areas and the projects in rural areas.

Keywords Smart mobility, Sustainability, QCA, Innovation project

1 Introduction

In 1987 the Brundtland Commision's declaration "Our common future" [1] set the constitutions to the sustainable development. The United Nations' Agenda 2030 [2] continued the work by stating that all three dimensions of sustainability—environmental, social, and economic—need to be addressed in a balanced and integrated manner. Based on the Agenda, a list of 17 Sustainable Development Goals (SDGs) containing certain targets for each goal was set for long-term planning and measuring multidimensional sustainability in all United Nations member countries [3].

Transport and mobility is one of the target domains. SDG's target 11.2 defines sustainable transport as "to provide access to safe, affordable, accessible, and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities, and older persons" [3].

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Smart or *intelligent* mobility does not necessarily equal sustainable mobility or vice versa. In the study conducted by Leviäkangas and Ahonen [4], scientific literature and European Union's and Finland's policy documents considering smart and intelligent mobility were reviewed and analysed. The study concluded that smart and intelligent mobility driven by the automotive industry originally focused on using technology to provide safe, comfortable, and affordable transport to drivers and passengers. It also concluded that the technology-oriented approach has been since changed so that *smart* in mobility means also *smart* in terms of environmental sustainability.

Increased public awareness and realization of the effects of transport emissions on the climate have led to accelerated efforts in research, policymaking, and strategic planning in order to solve environmental issues with the help of smart mobility. In recent years, also the social dimension has emerged in the discussion, but it is still dominated by the environmental dimension in the public view [5].

The research on the different aspects of sustainability in smart mobility is not static but is constantly changing when new multidisciplinary challenges are discovered

and explored. Transport policies are also changing due to scientific consensus and new findings. Root-level research in smart mobility is guided forward by international and national policies and funding frameworks and is actualised by pilot projects funded by different innovation and research actions.

Project funders evaluate proposals with the criteria based on the priorities of the programme or horizontal principles that apply to all projects applying for funding (e.g. Horizon 2020 or Interreg Baltic Sea Region). The criteria used by the funders vary substantially. There are horizontal goals that exist in almost all funding sources such as *gender equality* or *non-discrimination* but they are loosely defined, not specifically operationalised, and last but not least, very often poorly confirmed. It is not possible to estimate how smart mobility projects address sustainability in detail, including different dimensions, by simply reviewing the programmes, but projects should be studied individually.

In academic literature, there exist several tools and indicator sets for evaluating the sustainability of transport. However, Karjalainen and Juhola [6] conclude in their systematic literature review that most of them are assessing sustainability at the city or neighbourhood level and the project level is less covered. The few papers focused on project level are assessing the sustainability of existing infrastructure (e.g. [7–9], policies and plans (e.g. [10], or service and system performance [11–13]. Assessing projects with these tools requires measurable data and substantial effort. Hence, a more straightforward approach is needed to be able to evaluate the sustainability of the project in its early phases, and also before the project actualisation, without measured impacts, performance, or results.

To fill this gap this paper proposes an approach for evaluating the sustainability of smart mobility projects based on their stated objectives. The approach consists of a framework that does not concentrate on three dimensions of sustainability, but on 10 categories of sustainability. With the help of the framework, quantified and comparable data on sustainability can be analysed by using qualitative comparative analysis (QCA) to observe how different categories of sustainability are covered.

This research studies whether smart mobility innovation projects conducted in Finland addressed sustainability in their objectives in a balanced manner. The paper aims to examine whether the funding source or urban–rural division affect how sustainability is addressed in innovation projects. There is a motivational background for this aim. First, there are currently multiple funding sources for sustainable mobility projects in Finland, and while the funding programmes have partly identical objectives, there are differences too, or at least supposedly there should be some. In addition to programme goals, project-level research should accomplish sustainability goals in a broader sense meaning that individual projects are aiming for achievable objectives that fulfill the sustainability goals in a co-creative manner. Second, research in smart mobility is currently urban-centered, and research is partly lacking in the rural context. Even if some of the projects are taking place in the rural context, it is not evident whether the projects are addressing issues related to rural areas.

In addition, the paper examines a representative sample of projects analysed for this study. In essence, all innovation projects on smart mobility in a certain time window were included in the analysis, provided that sufficient documentation (i.e. clearly stated project objectives) was available. The research approach can be considered as a multi-case study and taking into account the representativeness of the sample (case projects), it can be regarded as cross-section of the recent innovation projects. Therefore, the data represents quite well the root-level RDI (research, development and innovation) efforts of the studied period. The results show whether there are dimensions of sustainability that are dominating some sustainability aspects and if there are aspects that are neglected. Research findings paint a summarised picture of smart mobility research and its focus on different aspects of sustainability. The study can be replicated with a different sample of projects collected from a different country or a certain funding framework. The results of a such study could be used for example for balancing a project portfolio considering sustainability aspects.

The research questions are as follows:

- Do smart mobility innovation projects in Finland address sustainability in a balanced and integrated manner (RQ1)? The purpose is to identify how different aspects of sustainability are covered by the analysed projects.
- Are there differences in how sustainability is addressed between projects with funding from European Union actions and national/regional funding sources (RQ2)? If there are differences, as one would expect, the funding programs are nurturing different types of projects that in the best case supplement each other.
- Are there differences how sustainability is addresses between the projects that are located in rural areas and the projects in urban areas (RQ3)? The purpose is to identify if addressing sustainability differs in the rural–urban axle.

The structure of the paper is the following. First, the background section describes Finnish transport

policy and funding and illuminates the main challenges of smart mobility, focusing on rural areas. In the section that follows, data and methods used in the analysis are introduced, including the framework constructed on the basis of the literature as well the application of Qualitative Comparative Analsysi (QCA). After that, the results are reported and then discussed. Finally, in the conclusion section, the results are summarised, and some theoretical underpinnings are pointed out.

2 Background

In the following section, two main background issues are covered: the funding regimes of smart mobility innovation projects and the issue of differences between rural and urban contexts. The first mentioned is relevant to witness whether European-funded projects differ from nationally funded innovation projects in terms of sustainability dimension profile. Rural and urban comparison is relevant for two reasons. First, there is a political divide between rural and urban areas. This might affect what dimensions of sustainability are prioritised. Second, the environmental, social, and economic consciousness is different in rural and urban areas. This is not least the result of different demographics, education, and income levels, which obviously have something to do with political sidelines.

2.1 Transport policies and funding in Finland

In terms of sustainability, the Finnish transport politics mostly follow the directions set by the United Nations and the European Union. For the time analysed, the Programme of Prime Minister Sanna Marin's Government had set a goal to reach carbon neutrality by 2035 [14]. Both Sanna Marin's government [14] and its predecessor Juha Sipilä's government [15] had been working to reduce emissions of the transport sector, for example by promoting renewable fuels and offering tax incentives for low-emission vehicles. Marin's government was also promoting the use of non-motorized modes, public transport, and mobility services, particularly in urban areas. It further saw working transport system with well-functioning infrastructure as a key enabler for social sustainability. During Sipilä's preceding government term, the legislation for transport services was renewed [16]. One of the main ideas was to introduce smart mobility solutions to the existing transport system. This included changing regulations for data sharing to enable new business models such as the sharing economy and platform economy.

Public funding for research and development in Finland comes mostly from European Regional Development Fund (ERDF), European Social Fund (ESF), Interreg programs (e.g. Interreg Central Baltic and Interreg Baltic Sea Region), and framework programs (e.g. Horizon and FP7). All of these funding sources have different aims in their instruments. Some national actors such as The Finnish Innovation Fund Sitra and Business Finland fund also research and development work and these funds have their own aims. Funding from ERDF and ESF is distributed regionally by the Centres for Economic Development, Transport and the Environment (regional subsidiaries of state functions) based on national strategies defined by Structural Funds in Finland. Figure 1 summarises the main funders for innovation projects and governments in power during the research period.

The topics that emerge from all aforementioned funding instruments are underlining low-carbon technologies, exploiting digitalization, and supporting small and medium-sized enterprises (SMEs). Social aspects

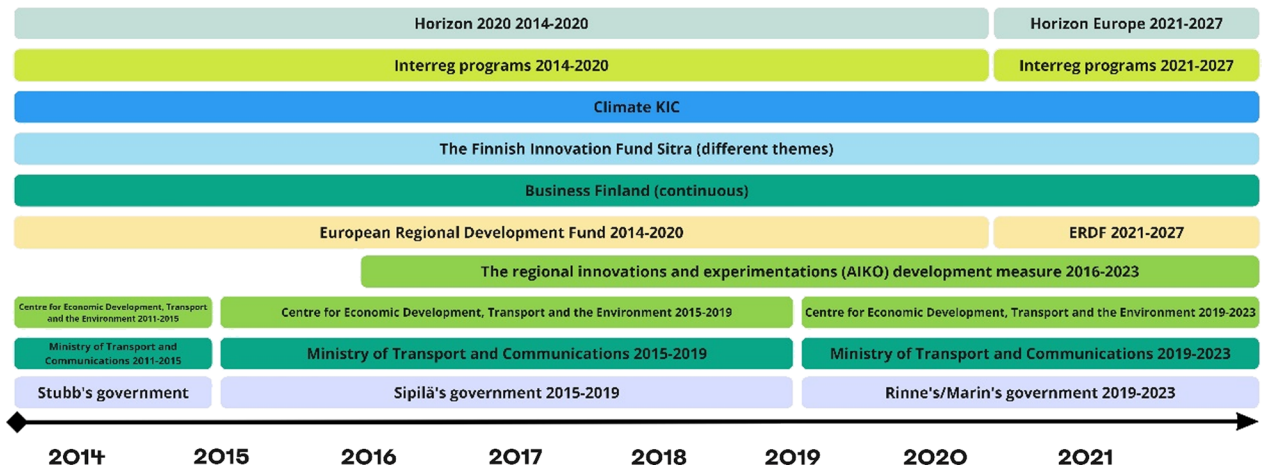

Fig. 1 Funders of innovation projects and governments in power during the research period

of sustainability are visible mainly in topics related to employment opportunities and job creation.

2.2 Challenges of smart mobility in rural areas

Almost 30% of the European Union's population lives in rural areas which represent 80% of the European Union's territory. Food production, forestry, and the use of other natural resources are located in rural areas. Rural areas are also popular for leisure and tourism activities. The characteristics of rural areas consist of population decline, aging, erosion of rural infrastructure, and limited transport and digital connectivity. Service provision is also diminishing in healthcare, education, and social services [17].

Conventional public transport is financially feasible with high passenger volumes which rural areas cannot offer. If public transport exists, it is lowly utilized and heavily subsidized which is not sustainable economically or environmentally. Rural dwellers are then relying their mobility mostly on private cars. Smart mobility solutions can be used to reduce the need for use of private cars and to balance the existing public transportation by supplementing it with new multimodal mobility services. Combining rides from other services such as postal service, school transport, and health and social transport might be done to furthermore supplement the availability and flexibility of transport services [18–20].

Challenges do exist. Firstly, in rural areas working transport system would need to adapt to the different needs of all types of user groups: children, working people, the elderly, and temporary residents such as tourists. Secondly, the resources in rural areas are typically limited compared to urban areas. The road network is in poor condition, the rail network usually does not exist, and the broadband network lacks behind in speed and has blind spots. The aging and decreasing population provides less workforce, especially competent and educated. Lastly, the financial feasibility of new smart mobility solutions is uncertain. Conditions are more challenging in rural areas because of restricted markets, thin flows, long distances, seasonal changes, and low occupancy rates [18–20].

Mobility in rural areas is currently based on private car use which makes it harder to construct the customer base for the new services. These issues make business models for smart mobility solutions in rural areas complicated. Working with public–private partnerships typically leads to a situation where cost sharing between different stakeholders is unclear and collaboration for that reason difficult. Collaboration with regional and national actors is important to be able to exploit the existing physical and digital infrastructure. Operative planning and long-term procurements should be made to be able to implement smart mobility services [18–20].

3 Methods

A framework (Fig. 3) and a coding scheme were built upon scientific literature and document material from the projects and were used for coding the data of the projects. As a product, a truth table was acquired that was used to compare how different categories of sustainability were addressed in the objectives of innovation projects (RQ1) with the help of QCA. In addition, addressing the categories was compared based on funding (RQ2) and the rurality (RQ3) of the projects. The coding process used was iterative, which means that the framework and the coding scheme were updated during the analysis of the material. The research process is visualized in Fig. 2.

The framework and coding scheme were constructued heuristically relying on research team's expertise and judgement. Strict rules for category building were considered to be too limiting and not leading to a credible result. In practice, there should have been many rules combined and then a synthesis (that in the end would have been somewhat heuristic again) should have been made. In many research problems, and some researchers claim that in fact in most problems, the starting point

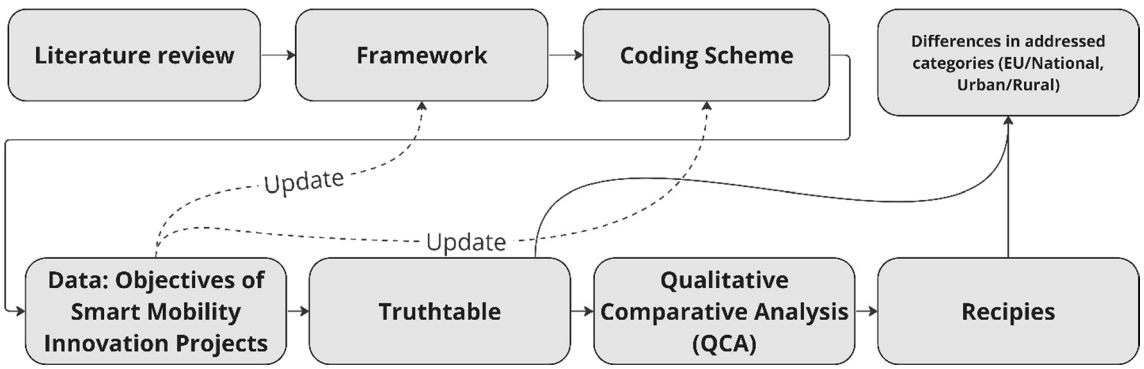

Fig. 2 Methods and data used in the study

is heuristical [21], and the next steps are analytical when the framework and scope of analysis have been decided.

3.1 Data

Data used in this study consists of publicly available documents of the innovation projects. The period of the projects was not limited when the data was collected. Based on the availability of recent projects the data consists projects from 2016 to 2021. The collection of the data was initiated using portals and websites of different funding sources such as Cordis, Interreg websites, and Finnish regional councils' websites. Data was then supplemented by searching data from the websites of other parties involved in the identified innovation projects. For this paper, only the objectives of the projects were evaluated. The period of the projects varied as well as the length of the projects (1–4 years). Some of the projects were ongoing during data collection and this was not seen as problematic as only the project goals were analysed. The type of material used in this study varied. The material consisted of final reports, project descriptions, project applications, project summaries, introductions, listed objectives, info pages, and news. All types of materials were used to evaluate the objectives of the projects if the source was deemed to be of adequate quality and reliability. Most of the material was in Finnish.

From over 60 projects identified, not all could be used in the analysis as such. Some of the projects were use-cases or demonstration sites for a larger project and were for that reason combined into one project. Additionally, a few projects did not have objectives publicly available and were for that reason discarded. The final set that is studied in this paper has 32 projects. The projects have been funded by European Union (Horizon and Interregs), nationally (e.g. Business Finland, SITRA, ministries e.g.), and regionally (Structural Funds). Most of the projects are related to passenger transport, but also a few logistics projects have been included. The lower representation of projects on the logistics side is due to the lack of projects available with a smart mobility focus and sufficient materials.

3.2 Framework for evaluating sustainability of smart mobility projects

Qualitative comparative analysis (QCA) needs a coding scheme on which the analysis is based. In this paper, a framework was created relying on the literature and then used as a coding scheme. The framework and coding scheme was defined based on the following literature sources: Bachok et al. [22], Buenk et al. [23], Bueno et al. [24], Castillo and Pitfield [25], de Oña et al. [26], Dobranskyte-Niskota and Perujo [27], Freitas [28], Haghenas and Vaziri [29], Jeon and Amekudzi [30], Karjalainen and Juhola [6], Klinger et al. [31], Litman [32], Macário [33], Moles et al. [34], Nicolas et al. [35], Santos and Ribeiro [36], Şimşek et al. [37], Toth-Szabo and Várhelyi [38], Ustaoglu et al. [39], and Zhao et al. [40]. These sources were collected by reviewing the scientific literature and listing out different indicators related to transport sustainability. After that, the authors categorised these indicators into ten different categories: *climate change, resource use, habitat protection, equity, safety & security, health, accessibility, efficiency, welfare, and affordability*. The categories were defined by the authors based on the literature reviewed and the project material under research. Table 1 summarises which of the sources addresses different categories. The framework presented in Fig. 3 has also example topics listed out for each category that tell which kind of indicators belong to each category. The coding scheme has the same structure as the framework but it has more example topics and additional notes that are not relevant to this paper, hence the coding scheme is not presented in this paper. A similar framework has been used in the authors' early works (see [41, 42] but for this paper, the framework has been extensively updated.

The process of building the framework and coding scheme was iterative and combined inductive and deductive approaches which is a commonly used approach in content analysis. This is a method called analytic induction [43]. In practice, this means that at the beginning of the process, a coding scheme exists (deductive) but it is updated during the analysis if new categories or topics emerge (inductive).

The coding scheme used defines the categories and lists different topics under the categories. An overview of the categories and topics for the coding scheme is in Fig. 3. The categories are defined as follows:

- *Climate change* (C) means that the project addresses climate change. This can be by addressing greenhouse gas emissions or some other way.
- *Resource use* (RU) means that the project addresses the use of fossil and renewable resources for example by decreasing the use of natural resources or land consumption. The project might also aim to increase the energy efficiency of transport and increase the use of recycled and recyclable materials.
- *Habitat protection* (HP) means that the project aims to reduce the effects that the transport system has on habitat, biodiversity, or nature. Effects concerning climate change are excluded and effects concerning only human health are excluded.
- *Equity* (Eq) means that the project aims to increase the equity and inclusion of different societies and groups.

Table 1 A list of sources used and categories they acknowledged

Dimension and Category	Environmental			Social				Economic			What is assessed?
Source	C	RU	HP	Eq	S	Ac	H	Ef	W	Af	
Bachok et al. [22]	X	X	X	X	X	X	X	X	X	X	Urban transport
Buenk et al. [23]	X	X	X	X	X	X	X	X	X	X	Micro-transit systems
Bueno et al. [24]	X	X	X		X		X	X	X		Infrastructure projects
Castillo and Pitfield [25]	X	X	X		X	X	X	X	X		Selecting sustainable transport indicators
de Oña et al. [26]					X	X		X		X	Transit service
Dobranskyte-Niskota and Perujo [27]	X	X	X	X	X	X	X	X	X	X	Transport activities
Freitas [28]				X	X	X		X		X	Intercity road transport
Haghenas and Vaziri29	X	X	X	X	X	X		X	X	X	Urban transport
Jeon and Amekudzi [30]	X	X	X	X	X	X	X	X	X	X	Transport planning
Karjalainen and Juhola [6]	X	X	X	X	X	X	X	X	X	X	Urban transport
Klinger et al. [31]						X		X	X	X	Urban mobility culture
Litman [32]	X	X	X	X	X	X	X	X	X	X	Transport planning
Macário [33]	X				X	X		X	X	X	Level/quality of mobility services
Moles et al. [34]	X	X				X	X	X	X	X	Settlements
Nicolas et al. [35]	X	X	X		X			X		X	Urban transport
Santos and Ribeiro [36]	X	X	X	X	X	X	X	X	X	X	Urban passenger transport
Şimşek, et al. [37]					X			X			Individual driver
Toth-Szabo and Várhelyi [38]	X	X			X			X	X		Urban transport
Ustaoglu et al. [39]	X	X	X		X	X		X	X	X	Rail investment
Zhao et al. [40]								X			Excess journey time

- *Safety & Security* (S) means that the project aims to increase the safety and security of the transport system. This can mean either studying the effects of different solutions on safety and security or developing solutions to increase safety and security.
- *Health* (H) means that the project aims to decrease the negative effects of the transport system on human health. It also means fostering healthy mobility choices that increase fitness.
- *Accessibility* (Ac) means that the project aims to increase access to transport services and other necessary services.
- *Efficiency* (Ef) means that the project aims to increase the efficiency of the transport system. It also considers reducing the cost of the transport system. User cost reduction is considered *affordability.*
- *Welfare* (W) means that the project aims to increase community and society welfare. It also concerns public participation to transport planning and politics.
- *Affordability* (Af) means that the project aims to decrease the end-user cost of the transport system. This concerns also household expenditure on transport.

3.3 Analysis of the project material

Every project was qualitatively analysed with a coding scheme that was constantly updated if new topics from the material emerged. Addressing different sustainability categories was evaluated and the information was then quantified by giving a value of 0 or 1 on the category whether it was addressed in the project or not. In addition, the part of the text mentioning the topic of the category in the project material was highlighted for reviewing the decisions made during the coding.

Furthermore, the funding source and rurality of the project were coded. ERDF and ESF funding is distributed by regional councils and were for that reason considered national funding. The principles of coding were as follows:

- European Union framework and Interreg projects were considered EU funded and were given a value of 1
- ERDF, ESF, and funding from national sources were considered national funding sources and were given a value of 0
- Projects focused in rural areas were considered rural projects and were given a value of 1
- Projects focused in urban areas were considered urban projects and were given a value of 0

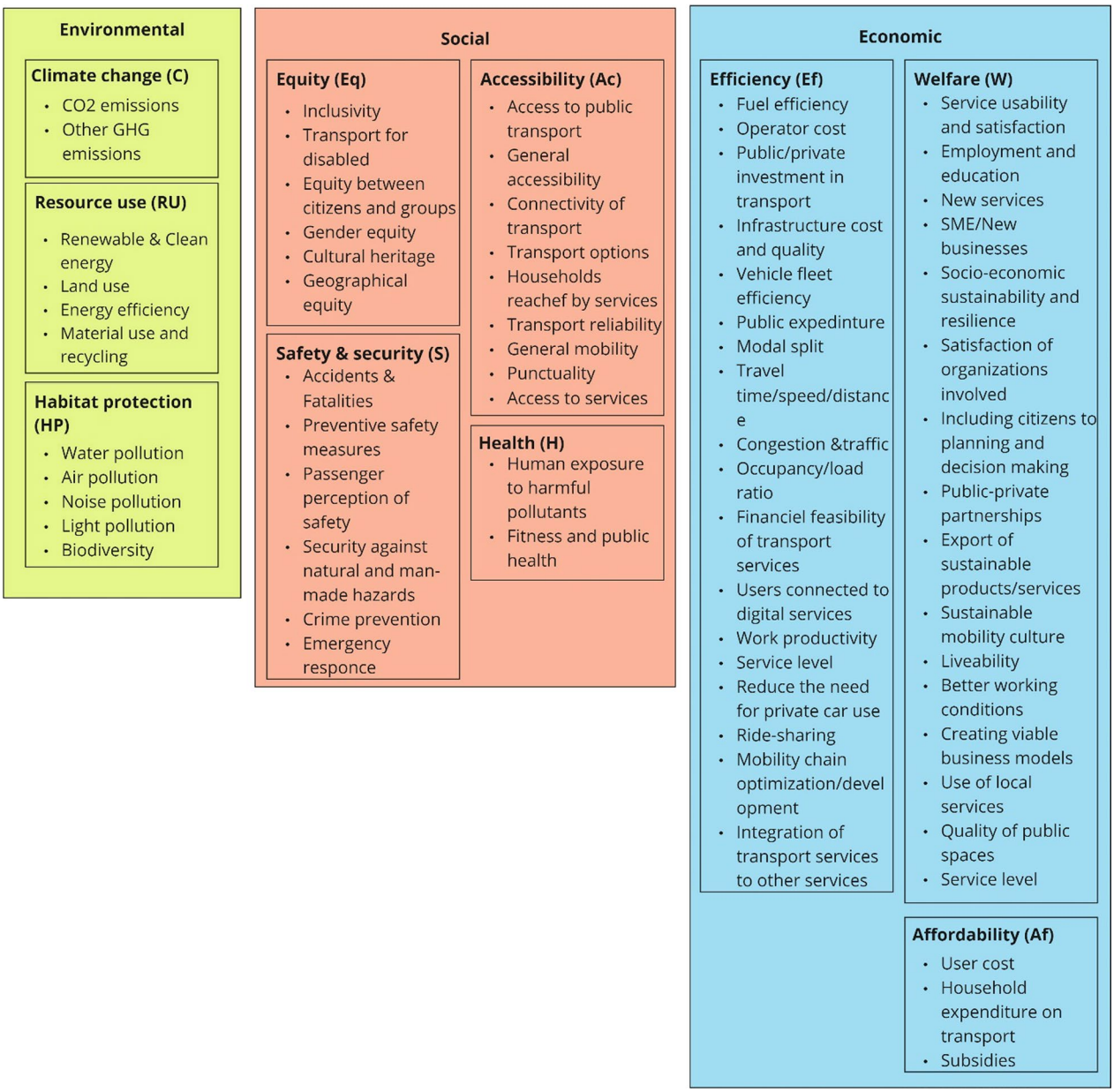

Fig. 3 The framework with categories and topic examples to the coding scheme

This coding of projects' funding source and rurality produces four subsets:

- Subset 1: EU-funded projects (9 projects)
- Subset 2: Nationally funded projects (23 projects)
- Subset 3: Projects with a rural focus (14)
- Subset 4: Projects with an urban focus (18)

As a result of the coding process, a truth table was obtained consisting of a binary code for every project regarding the addressing of the categories, funding source, and rurality of the project.

The analysis continued by first, calculating the frequency of the categories present in the different subsets and comparing them to find out the differences between the funding source (subsets 1 and 2) and the rurality (subsets 3 and 4) of the project. This was done by summing up the number of projects addressing the category in the subset and then dividing it by the number of projects in the subset. As a result, a value between 0 and 1

was obtained that represents how frequently a category has been addressed in the subset.

Secondly, qualitative comparative analysis (QCA) was used to evaluate the projects. QCA is a method initially introduced by Charles Ragin [44]. In this method, the coding scheme created is applied with the fsQCA tool, and the results are then interpreted according to the principle of complexity theory [45, 46]. There was a total of 32 projects with 10 causal conditions (i.e. categories). Every project had four possible outcomes, EU funded (1) or nationally funded (0), and rural (1) or urban (0). The fsQCA uses consistency and coverage as criteria for selecting sufficient and consistent causal models (recipes) leading to the outcome condition (e.g., rural focus). The Quine-McCluskey minimization algorithm was used for prime implicants to simplify the outcome solutions or recipes [45].

Finally, a more in-depth content analysis was made to the material, and mostly addressed coding scheme topics were extracted. Urban and rural projects were then compared to study whether the topics differed between urban and rural projects.

4 Results

The results of the analysis are represented in Fig. 4 and Table 2. Figure 4 illustrates the frequencies of addressed categories compared between the funding source and the urban/rural focus of the project. Table 2 represents four different recipes from the models of QCA analysis based on the outcomes in the truth table (EU funded, nationally funded, urban, and rural).

Figure 4 shows that *welfare* (W) and *efficiency* (Ef) are mostly represented within all the projects. *Accessibility* (Ac), *equity* (Eq), *climate change* (C), and *resource use* (RU) are also addressed in multiple projects. *Safety* (S), *habitat protection* (HP), and *affordability* (Af) are addressed only in a few projects.

4.1 Projects with national funding and European Union funding

As can be seen in Fig. 4a, minor differences in addressing different categories between EU and nationally funded projects can be found. *Resource use*, *equity*, and *climate change* slightly more addressed in nationally funded projects whereas *accessibility* and *welfare* are slightly more addressed in EU funded projects.

The results of the QCA analysis can be found in Table 2. The first model containing projects receiving EU funding as an outcome comprises four recipes with an overall consistency of 1 and a coverage of 0.66. The recipes show that conditions of *climate change, accessibility, welfare,* and *efficiency* are relatively important factors, while *equity* and *resource use* also have considerable contributions in obtaining EU funding. However, projects consider the least *habitat protection, safety, affordability,* and *health* with this outcome.

The second model that included nationally funded projects includes nine recipes, which have an overall consistency of 1 and a coverage of 0.82. The results show that *climate change, efficiency,* and *welfare* have a high level of dominance comparatively when it comes to receiving national funding. Additionally, the presence

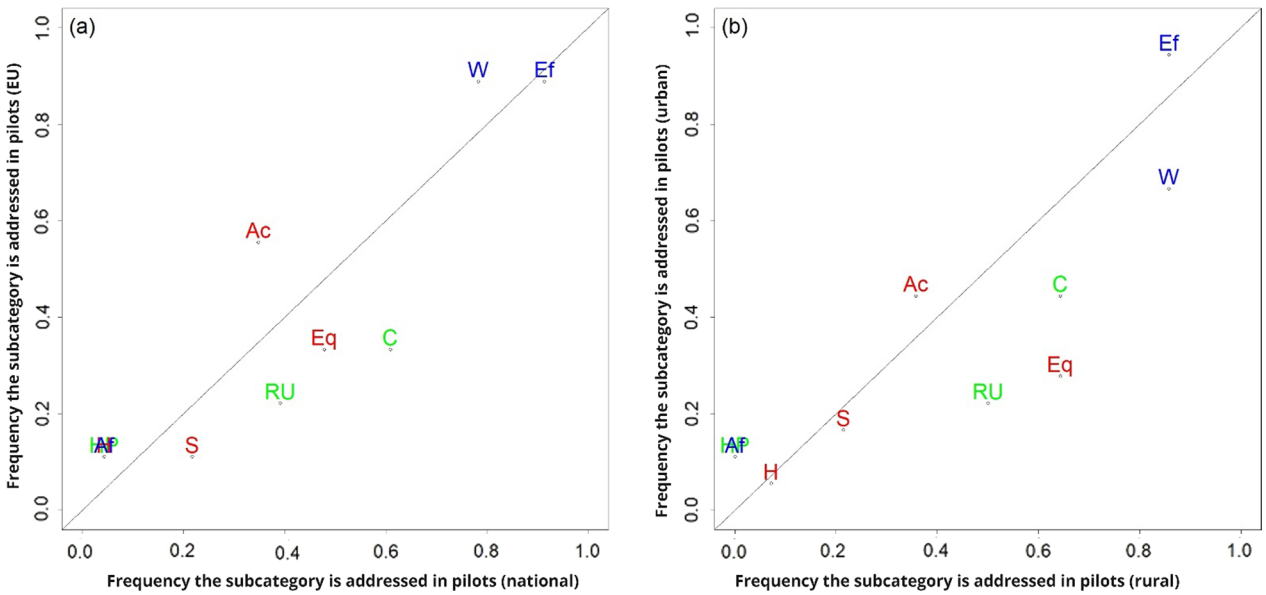

Fig. 4 Frequencies of addressed categories with EU/national funding (**a**) and urban/rural focus (**b**)

Table 2 The recipes from QCA analysis

EU = f (C, RU, HP, Eq, S, Ac, H, Ef, Af, W)	NF = f (C, RU, HP, Eq, S, Ac, H, Ef, Af, W)	Urban = f (C, RU, HP, Eq, S, Ac, H, Ef, Af, W)	Rural = f (C, RU, HP, Eq, S, Ac, H, Ef, Af, W)
~C*~RU*~HP*~Eq*~S*Ac*~H*Ef*~Af*~W C*RU*~HP*~Eq*~S*Ac*~H*Ef*~Af*W C*~RU*~HP*Eq*~S*Ac*~H*Ef*Af*W C*RU*HP*Eq*S*Ac*H*Ef*~Af*W	C*RU*~HP*~S*~Ac*~H*Ef*~Af*W C*RU*~HP*Eq*Ac*~H*Ef*~Af*W C*RU*~HP*Eq*~S*Ac*Ef*~Af*W C*~RU*~HP*~Eq*~S*~Ac*~H*Ef*~Af*~W ~C*~RU*~HP*~Eq*~S*Ac*~H*Ef*~Af*W ~C*~RU*~HP*Eq*S*Ac*~H*~Ef*~Af*W C*~RU*HP*~Eq*S*~Ac*~H*Ef*~Af*W ~C*~RU*~HP*Eq*S*Ac*~H*Ef*Af*W C*~HP*Eq*~S*~Ac*H*Ef*Af*W	~C*~RU*~HP*~Eq*~S*Ac*~H*Ef*~Af ~C*~RU*~HP*Eq*Ac*~H*Ef*Af*W C*~RU*~HP*~Eq*~S*~Ac*~H*Ef*~Af*W C*~RU*HP*~Eq*S*~Ac*~H*Ef*~Af*W C*RU*~HP*~Eq*~S*Ac*~H*Ef*~Af*W C*RU*HP*Eq*S*Ac*~H*Ef*~Af*W ~C*~RU*~HP*~S*Ac*~H*~Ef*~Af*W ~C*~RU*~HP*Eq*~S*Ac*H*Ef*W	~C*~RU*~HP*~Eq*~S*~Ac*~H*Ef*Af C*~HP*Eq*~S*~Ac*H*Ef*~Af*W C*RU*~HP*Eq*Ac*~H*Ef*~Af*W ~C*RU*HP*~Eq*~S*Ac*Ef*~Af*W ~C*~RU*~HP*Eq*S*Ac*~H*~Ef*~Af*W
Coverage: 0.66, consistency: 1	Coverage: 0.82, consistency: 1	Coverage: 0.72, consistency: 1	Coverage:0.64,consistency:1

of *accessibility* and *equity* contributes considerably to obtaining national funding. Conversely, projects receiving national funding least consider *safety & security, resource use, habitat protection, health,* and *affordability.*

4.2 Projects with an urban and rural focus

Figure 4b. shows the frequencies of addressed categories in urban and rural projects. Slight differences exist. *Welfare, climate change, equity, and resource use* seem to be more addressed within the projects focusing on rural transport while *efficiency* and *accessibility* are considered less in rural projects.

The results of the QCA analysis can be found in Table 2. The third model (urban projects) comprises eight recipes with an overall consistency of 1 and a coverage of 0.72. The results highlight that the factors *accessibility, efficiency,* and *welfare* play a crucial role in urban projects, while *climate change* and *equity* have a moderate presence. Conversely, *resource use, habitat protection, safety & security, health,* and *affordability* have the least influence on projects working in an urban environment.

The fourth model (rural projects) includes five recipes with an overall coverage of 0.64 and consistency of 1. The analysis indicates that *equity, accessibility, efficiency*, and *welfare* are highly contributing factors to rural-based sustainability projects, while *climate change* and *resource use* moderately contribute. *Habitat protection, health, affordability, and safety & security* have the least influence on the outcome of sustainability projects working in a rural environment.

Further analysis in addressing different categories in urban and rural projects reveals that there are some differences in *what sustainability means* or *how it is perceived* in rural and urban projects. Figure 5 illustrates the topics that mostly occurred in the material and compares the differences between urban and rural projects.

In the environmental dimension can be noticed that although urban and rural projects are both aiming at reducing GHG emissions, urban projects' objectives are in clean and electric vehicles and renewable and alternative fuels. In rural projects, the focus seems to be on energy and resource efficiency. In the social dimension, rural projects are addressing the urban–rural divide by aiming to increase mobility in rural areas. Mobility for user groups with restricted mobility such as children and the elderly is addressed only in one urban project. In economic dimensions, urban projects are focusing on improving the use of time and changing the mobility culture more sustainable. In rural projects, the focus seems to be on stakeholder collaboration and combining different transport actors. Strengthening local businesses and increasing services, competitiveness, and employment are also in focus in rural projects.

5 Discussion

The analysis shows that in Finnish smart mobility innovation projects *efficiency* and *welfare* categories were addressed almost in every project. According to Poltimäe et al. [18], these are typical aspects of making transport-related decisions. *Affordability* seems to be an aspect that is not addressed, which shows that economic aspects consider mostly costs for the whole transport system and its stakeholders. New smart mobility solutions have the potential to reduce individual transport costs (e.g. Butler et al. [47]). For this reason, it is surprising that the aspects of individual costs in smart mobility are disregarded in these projects. In Finland, basic mobility needs are guaranteed for the most vulnerable people through

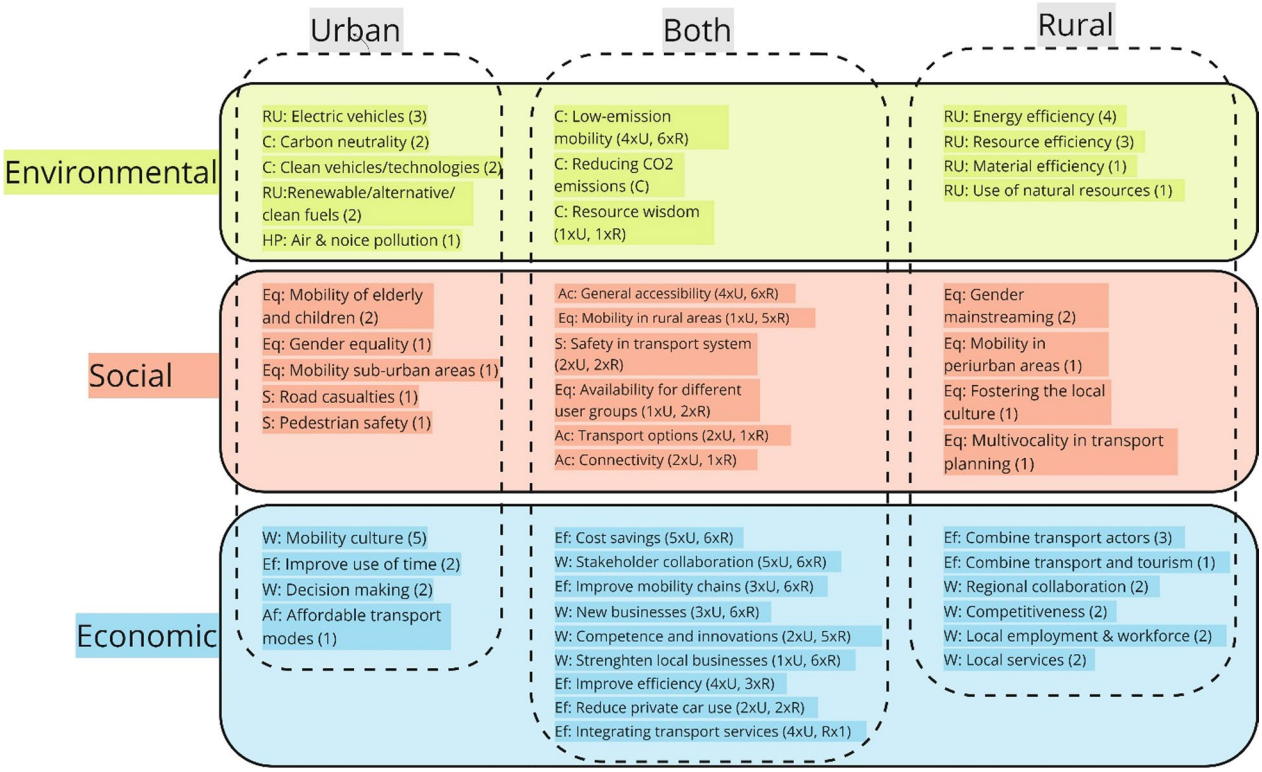

Fig. 5 A matrix consisting of topics that occurred mostly in the project material with the number of projects addressing the topic in parenthesis. The category of the topic is annotated also. U = urban project, R = rural project

social support and social services which might be the reason that affordability does not seem an issue that is tried to solve in these projects. However, transport costs for passengers are known determinants when they decide on the preferrable mode of transport (e.g. [48]). In the rural context, the high cost of smart mobility solutions is seen as a disadvantage for both temporary and permanent residents in rural areas [18] and that is why it should be acknowledged.

In scientific literature, environmental aspects of sustainability have been the focus of the research as mentioned before by Leviäkangas and Ahonen [4]. Many of the projects studied addressed *climate change* and *resource use* by for example trying to reduce emissions and increase energy efficiency. This is a positive observation although concrete actions in the materials were mostly absent and different sustainable solutions, such as on-demand transport were assumed to be more energy-efficient and climate-friendly which is not automatically the case (e.g. Rayle et al. [49]). *Habitat protection* was mostly disregarded even though transport has major effects on surrounding environments [50]. For smart mobility projects, it would be important that the benefits and costs of different solutions to the surrounding environment and ecosystem would be addressed.

Social aspects visible in the projects were mostly related to *accessibility, gender equality,* and *urban–rural equality*. Aspects related to *safety & security* and *health* were disregarded in most of the projects. In the *health* category, the projects focused mostly on external effects harmful to humans and not positive effects such as fitness from healthy choices of mode.

In scientific literature, a phenomenon called *easy-to-measure* has been recognised [51] where social and socio-economic indicators are disregarded because they are mostly measured with qualitative data which is often harder to interpret than quantitative data which is how environmental and economic aspects are typically measured. Karjalainen and Juhola [6] conclude that the indicators frameworks assessing social and socio-economic sustainability in the scientific literature were less presented in their extensive review than frameworks assessing environmental and economic aspects. One of the reasons for the result that they suggested was the *easy-to-measure* phenomenon. The results in this paper show similar observations. Easy-measurable aspects such as *cost efficiency*, *cost savings*, and *CO2 emissions* were often mentioned in project objectives. More complicated aspects to measure such as *accessibility, equity*,

and *health* were not addressed that much in the project objectives.

There are only minor differences between EU and nationally funded projects and the differences seem to be similar to the urban–rural comparison. The subsets used in this part of the analysis are unbalanced as there are 9 EU-funded projects and 23 nationally-funded projects. Another thing to notice is that all the EU-funded projects are urban projects, which partly explains the similar results in the analysis between urban and rural projects.

The differences between urban and rural projects are related to the current state and challenges of the operating environment. Electric mobility and clean technologies have been studied only in urban projects which is likely because of the short radius of electric vehicles at the time of the projects and the lack of charging or fueling infrastructure in rural areas. Environmental aspects in rural areas appear as reducing kilometers traveled and increasing the efficiency of transport with green technology. As electric vehicles' range is increasing constantly and charging infrastructure is enhancing it is expected that electricity and other alternative fuels become more relevant in rural smart mobility projects.

The urban–rural and urban-suburban divide is addressed in many projects and it seems to be a major equity issue in rural areas. Mobility of the children or elderly is addressed only in one urban project, even though fitting the transport needs of different user groups is a challenge especially in rural areas [18].

In rural projects, economic aspects such as *strengthening local businesses, creating new business opportunities, increasing employment*, and offering *more services* are present. These projects try to solve the economic downturn in economies in rural areas caused by depopulation, aging, and a lack of competent workforce. Additionally, *stakeholder and regional collaboration* has been studied in many rural projects and the objective is mainly to combine competencies within a larger area to cope with the brain drain caused by depopulation. Also, *cost savings* and *increases in efficiency* are pursued by trying to integrate or combine travel chains between public and private actors in transport systems.

The framework and methodology in this paper can be used to evaluate a set of projects in the early stage of the projects. It can be exploited for example by regional/national decision-makers and persons responsible for making funding decisions to evaluate and modify the project portfolio wanted for a different project call or development program.

Based on the analysis, the authors suggest that aspects related to *affordability, equity, health, safety & security,* and *habitat protection* should be addressed more in future projects located in Finland. Topics such as *user cost, fitness and public health,* and *inclusivity* should be considered especially in rural areas where these issues are amplified. Decreasing the need for private cars (especially cars running on fossil fuels) is one of the key aims for achieving affordable, inclusive, and healthy transport to rural areas.

There are some limitations in this research. Firstly, dividing these categories into sustainable dimensions is not unambiguous and for that reason, some of the categories are overlapping between the dimensions. For example, *affordability* can be considered also belonging to the social or socio-economic dimension but in this paper, it is put to the economic dimension. The same goes with some topics in the *welfare* category such as *better working conditions, employment and education,* and *use of local services* could be categorised into the social dimension. *Welfare* as a category belongs more to the socio-economic dimension than just the economic dimension but in this paper, the authors have chosen to use only three dimensions of sustainability. Moreover, the authors suggest the readers not focus on the dimensions but on the categories presented as they are mainly investigated in this study. Figure 5 uses sustainability dimensions to divide different topics into categories to make the figure clearer and to show the bigger picture in addressing different sustainability aspects in urban and rural-focused projects.

Secondly, even though earlier studies and frameworks in smart mobility have been used, categories are based partly on authors' knowledge, interpretation, and decisions. In addition, the material is coded by two researchers which makes the work subjective even though the work has been cross-evaluated afterwards. This makes the results prone to personal biases which cannot be fully avoided in these types of studies.

Thirdly, project material was different for each funding source so the format was not standardised. This made it challenging to objectively evaluate the projects from different funding sources. In addition, some of the funders are requiring certain aims to be addressed in the project applications which is leading the individual projects towards the objectives of the project funder. In future works, data should be collected from a single funding framework. This limits the possibility to generalise results to a certain country, for example.

Finally, the sample of projects is limited in numbers, but not in terms of data population coverage. As there are 32 projects out of the population of 60, the number of samples is partly offset. However, and as always with statistical analysis—be that quantitative, descriptive or qualitative—some caution should exercised in interpretation. For example, ten subcategories is in the limits of the recommended amount of causal conditions in QCA [52].

6 Conclusion

The data used in this study represents the root-level research in smart mobility innovation projects. Not all of the innovation projects ongoing in this period were included in the material, but it can be said that the used sample of projects represents very well the status of research in the covered time window between 2016 and 2021. The stated objectives of the innovation projects implicate what were the prioritised focal categories of sustainability.

In sum, the initial research questions may be answered as follows:

- RQ1: Do smart mobility projects in Finland address sustainability in a balanced and integrated manner? *No*, not entirely. Some of the categories are not that well presented in the root-level research of Finland. These include *affordability, health, habitat protection*, and *safety & security*.
- RQ2: Do differences in addressing sustainability exist between projects with funding from European Union actions and national/regional funding sources? In conclusion, *no*. No significant differences exist between projects funded by EU and nationally.
- RQ3: Do differences in addressing sustainability exist between projects focusing on rural areas and projects focusing on urban areas? The conclusion is that there is no notable difference in addressing sustainability if only the number of categories addressed is analysed. However, there are differences in topics that are addressed in these categories. As the operational environment and challenges in urban and rural areas differ, the focuses differ too on a scale that it can be said that the perception of sustainability is different in rural and urban smart mobility innovation projects.

The Finnish smart mobility research goes along with the directions given by the research funding sources, centred on digitalisation and new low-carbon technologies. The addressed issues are mostly economic, as the priorities of the funding sources entail encouraging businesses, especially SMEs, to develop and exploit new sustainable solutions. The environmental aspect is shown mainly in underlining low-carbon technologies in order to build up economic resilience and competitive skills. The social aspect is considered by highlighting the prospects of new technologies and digitalisation to increase the accessibility and availability of transport services to different user groups.

External effects, environmental and social were by and large disregarded in the objectives of the projects. This is an interesting notion as transport is still causing extensive negative impacts on human health and surrounding habitats. The initial presumption seems to have been that reducing private car use and providing alternative transport options are mitigating the negative external effects, such as air pollution, noise pollution, and accidents.

When comparing the topics between projects focusing on urban and rural areas can be seen that the root-level research is related to the current challenges in projects' operational environments which is a positive remark. However, especially in rural areas, some of the issues addressed in scientific research are not addressed in the objectives of the projects. All in all, the focus seems to be on the potential benefits of the new technologies and not on the negative impacts. Although smart mobility has great potential to increase the sustainability of transport it does not automatically solve the problems and for that reason, the possible negative effects should be studied also at the root level of research.

Innovation projects are the main contributors in showcasing and testing technological solutions based on science. For this reason, the project objectives should acknowledge the indications of sustainability pointed out by research, and not only focus on market-driven trends and technologies. This study shows that based on the material researched some of the aspects of sustainability addressed in the scientific research are disregarded in setting the objectives for sustainability in innovation projects. This should not be the case but the projects as well as funding frameworks seem to be somewhat deterministic in favouring certain innovation project objectives.

Finally, this study repeats the fact that sustainability is often perceived as 'a lump', being there or being absent. In reality, the spectrum of dimensions is quite wide and there are issues that sometimes receive more attention than others, be it a result of the political rhetoric or media attention [53]. One of the theoretical underpinnings is *selective attention theory*, where attention is given to relevant stimuli while ignoring the stimuli that is irrelevant in the particular environment where this selection process is taking place. The early work on this theory can be found in Broadbent's [54] and Treisman's [55] research, for example. In simple words, attention is given to issues that are in the forefront, most visible and loudest, and hence make the most sense to tackle with. Even if the early work on selective attention theory is based on individual's attention, there are already attempts to connect the theory to organisational behaviour [56–58]. The core message is that like individual human attention, also organisational attention is a limited resource, and some filtering is done in order to focus attention on collective and generally preferred efforts. It may well be that innovation projects tend to follow high-level stated objectives

in a slightly repetitive manner. At least the Finnish data seems to point in that direction.

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Author contributions
V.A. authored most of the paper. S.H. authored the section concerning QCA analysis and contributed to the development of the framework. V.M. and V.P. reviewed the pilot projects in Finland and collected the relevant pilot data for this study. The data were supplemented by V.A. with a review of publicly available documents regarding the objectives of the pilots. The data was analysed by V.A., V.M., and P.L. P.L. supervised the authoring process. All authors have approved the manuscript for submission.

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Availability of data and materials
Not applicable.

Declarations

Competing interests
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