Micromobility in a smart environment - a spatial approach

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Abstract

This paper is concerned with the role of a new business model based on micromobility, which is part of the concept of intelligent environmental management. An analysis of the subject, the available literature and published research has shown that there is a research gap, with an apparent lack of research into the users of micromobility solutions, particularly in the important aspect of daily school commuting and adult use. The authors present the results of a study on perceptions of micromobility and preferences of adults and primary and secondary school students in this area. The article shows the responsiveness of adults to proposed micromobility solutions. In addition, special attention was given to research on how to get to and from school among primary and secondary school students. The research has helped to reveal the role of and differences in attitudes towards micromobility among urban and rural residents. Furthermore, the authors identified and described the barriers restricting the development of micromobility and provided recommendations for its further development.

Keywords: micromobility, smart cities, smart environment, sustainable mobility, business model

1. Introduction

Smart mobility is one of the smart city elements of the smart environmental management concept [5]. One of the smart mobility solutions is a solution based on micromobility. Micromobility is the use of transport modes such as electric bicycles and scooters, among others. It should be noted that these solutions have experienced rapid global growth due to the increasing demand for sustainable urban mobility solutions. Despite the potential to reduce impacts on the environment and promote social equity, there are still challenges in its implementation, such as the regulatory framework, infrastructure and user behaviour.

It has been noted that environmental benefits depend on careful management of production and charging processes [11]. With the growth of cities and their urbanisation, the need for sustainable transport solutions is emerging. In this context, micromobility has emerged as a promising business model for sustainable urban mobility. In smart cities, it has been shown [9] that optimised micromobility management through vehicle-infrastructure and vehicle-to-vehicle communication systems can significantly reduce traffic congestion. The need for careful integration with existing transport infrastructure to

maximise these benefits is also highlighted. Conversely, in the context of less urbanised areas (in rural areas), micromobility can be considered as an alternative mode of transport that is a substitute for rarely or no public transport.

This article aims to indicate the degree of perception of activities related to the development of micromobility and the use of this form of transport by inhabitants in Poland.

The authors aimed to answer the following main research questions:

1. How are micromobility-related activities perceived by adult residents?
2. To what extent is micromobility used by primary and secondary school students on their way to and from school?

2. The essence of micromobility

In recent years, many different types of micro-vehicles, both for shared and private use, have been introduced into urban spaces and have met with great acclaim [17]. The term 'micromobility' is often used interchangeably with microtransport, reflecting the evolving nature of urban mobility solutions [15]. Microtransport, also known as micromobility, includes a range of small, lightweight vehicles designed for short-distance travel in urban environments or in rural areas. These include electric scooters, bicycles, electric bikes, shared bikes and even walking [20]. The development of micromobility can be seen as an increasingly common trend in urban mobility. Human-powered micro-vehicles such as bicycles, including electric bicycles, as well as electric scooters and various other electric-powered micro-vehicles can now be found in cities and in villages around the world.

A definition of micromobility based on vehicle kinetic energy is given by the International Transport Forum (ITF), according to which it is "the use of micro vehicles: vehicles weighing no more than 350 kg and with a design speed of no more than 45 km/h. This definition limits the kinetic energy of the vehicle to 27 kJ, which is one hundred times less than the kinetic energy achieved by a compact car at maximum speed" [12]. This definition includes both human-powered and electrically-assisted vehicles. The list of listed vehicles related to the definition of micromobility is not exhaustive, as the concept of micromobility is constantly evolving and may include further micro vehicles [3,2]. The term 'micromobility' is often used interchangeably with microtransport, further indicating the evolving nature of urban mobility solutions [15], or rural mobility.

Micromobility is mostly used for short distances. However, in combination with other existing publicly available means of transport, it can become a very good alternative to private car use for longer journeys as well [13]. The most relevant example of the use of micromobility is its use for the first and last mile of a trip on public transport [14,16,17]. This is an advantageous solution that reduces traffic congestion and at the same time solves the problem of lack of parking spaces in city centres [9].

The integration of micromobility and public transport is very important for sustainable development, especially in urban areas [7]. Research on the impact of micromobility on sustainable urban development focuses on the benefits of micromobility, the legal regulations in this area, the technology used and the determinants of microtransport development [10]. Above all, the potential of micromobility to be a sustainable and effective low-carbon solution is highlighted [1]. Combining public transport with flexible, customised microtransport such as bicycles, scooters both traditional and electric is seen as a promising solution that can provide a competitive alternative to private car travel. Results indicate that a significant proportion of daily car travel can be replaced by micromobility while at the same time allowing for a significant reduction in overall harmful emissions from private cars [7,8,19]. Micromobility is part of research into environmental sustainability. It is a key issue for realising its full potential and minimising potential challenges. Another important advantage of this form of mobility is the promotion of an active and healthy lifestyle [4]. It should be emphasised that research to date has focused primarily on urban transport, while micromobility also applies to rural areas.

3. Research methodology

This article presents two different surveys, namely: among adults (aged 18 or over) and among primary and secondary school students. The survey with adults was conducted using the CAWI (Computer-Assisted Web Interview) method in September-October 2024.The stratified random sampling used proportional allocation at the level of provinces in proportion to the number of inhabitants over 18 years of age and at the level of the class of place of residence in proportion to the number of municipalities of the respective sizes. A total of 1080 interviews were conducted. The quantitative method and sampling used in the study allow the results to be generalised to the entire adult population with an estimation error of +/- 3.0% (95% confidence level).

The survey with primary and secondary school students was conducted in the first quarter of 2024. The survey was conducted on a group of 1,349 students - 575 primary school students (351 from urban areas and 224 from rural areas) and 774 secondary school students (550 from urban areas and 224 from rural areas) representing the zachodniopomorskie, pomorskie and lubuskie provinces. The questionnaire consisted of single-choice and multiple-choice questions, as well as open-ended questions.

4. Analysis of research results

4.1. Results of surveys among adults

Analysing the results of the survey, it should be pointed out that one of the key determinants of micromobility development is an appropriate road infrastructure, adapted to these means of transport. The respondents indicated that activities within the scope of micromobility development were noticeable by the respondents (fig.1).

The construction or extension of cycle paths in the vicinity of the place of residence was noticed by three quarters of the respondents (74.6%). These results testify to a high interest in this form of mobility. Significantly more people, who noticed such activities in their area of residence, were inhabitants of large cities (91.4%) than in rural areas (59.5%). These differences are statistically significant, as the correlation result for these variables was 0.438 p=0.000. Thus, the larger the locality, the more noticeable was the construction or extension of cycle paths in the area of residence. This means that this new business model, based on micromobility, is a welcome solution in the context of the traffic problems faced by residents of both large cities, towns and rural areas. In larger cities, the problem relates to excessive travel times, while in rural areas and smaller towns there is a problem of accessibility. The panacea for these problems is the development of micromobility. Significant correlations are also found for the age (correlation is 0.111, p=0.000) and income of the respondents (correlation is 0.126, p=0.000), so the higher the age and income, the more noticeable these measures were by the respondents.

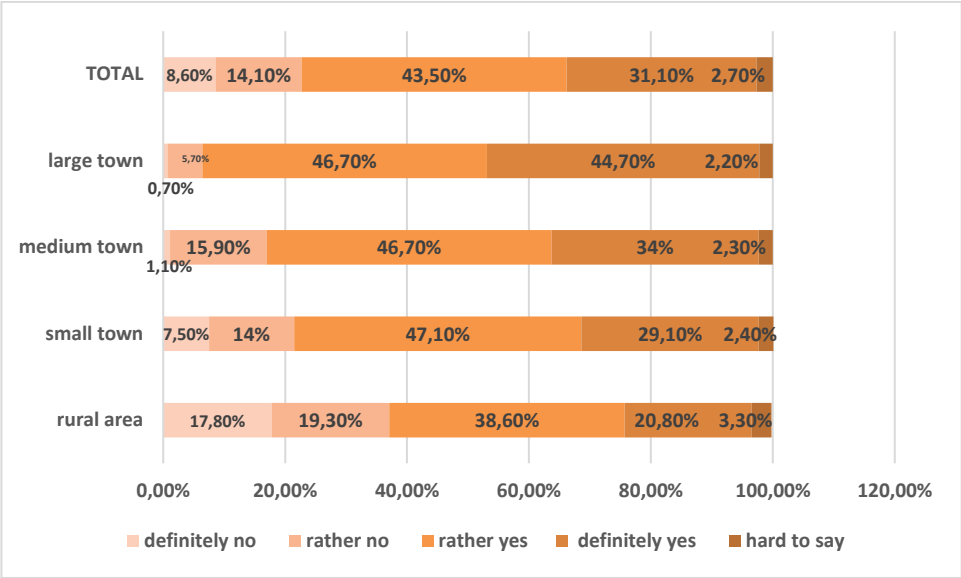

Fig 1. Respondents' perceptions of moves towards micromobility

Source: own elaboration

The second aspect assessed in the area of cycling was the construction or extension of one of the micromobility measures, i.e. the urban bicycle system (fig.2). Opinions on this are divided, as 48.1% of the respondents indicated that they had noticed such measures and 47.4% had not. Residents of large cities (77.2%) were again much more likely to notice these activities than residents of other localities, especially rural areas (30.4%) and small towns (32.8%). These results support the thesis that a greater need for micromobility solutions exists in large cities

The correlation between the size of the locality and this question is 0.321, p=0.000, which means that it is statistically significant. Thus, the larger the locality, the more noticeable was the construction or extension of the urban bicycle system. A significant correlation was also observed for income (correlation is 0.086, p=0.009), so also the higher the income, the more noticeable this measure was.

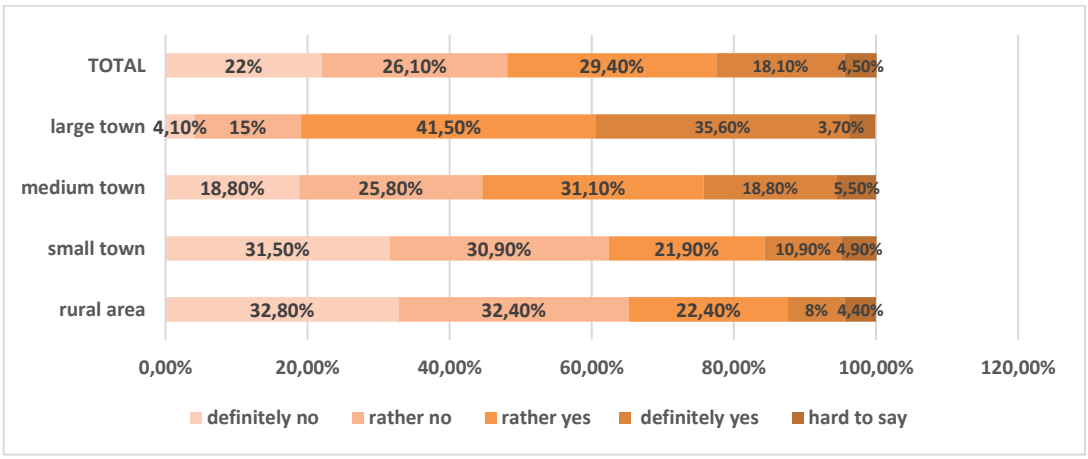

Fig. 2. Respondents' perceptions of activities related to the development of the bicycle system

Source: own elaboration

4.2. Results of surveys among school students

Since schoolchildren are frequent users of micromobility solutions, the authors surveyed this group, a generation that is open to modern solutions and increasingly environmentally aware.

The first issue investigated was how to get to and from school, as presented in Figure

3. For students living in urban areas, it is important to reduce car use in favour of public transport/biking/walking (92% of indications). This solution gained less supporters among those living in rural areas (76%).

In the case of urban pupils, almost half of the pupils get to school on foot and 23% by bicycle/scooter. 12% use public transport. In contrast, the situation is somewhat different for pupils from rural areas. Only 19% of them get to school on foot. Bicycles/scooters are more popular - 32% of pupils - than among urban pupils. In contrast, almost a third use public transport.

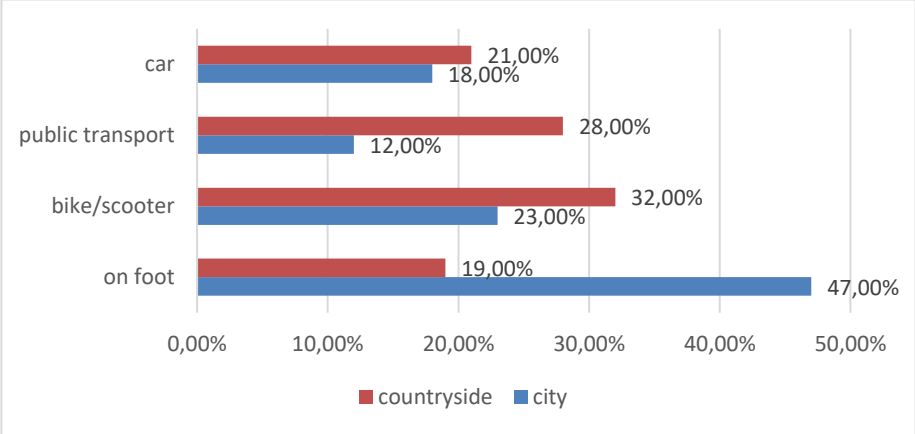

Fig. 3 The most common way to get to and from school

Source: own elaboration

The analysis of the above behaviour regarding the movement of pupils was supplemented by information on the distance of the school from the residence. This allowed for a more complete picture. Fig. 4 shows the students' responses regarding the distance of the school from their residence.

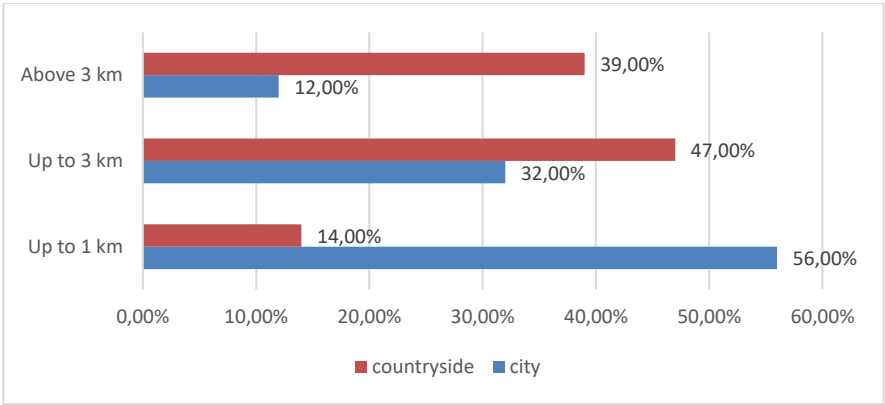

Fig. 4: Distance of school from home?

Source: own elaboration

Verification of the pupils' answers shows that more than half of the pupils living in urban areas have their school at a maximum distance of 1km from their residence. This has the effect of getting to school on foot, with no negative impact on the natural environment. Another almost 1/3 of urban pupils live more than 1km to 3km away. These distances also allow them to get to school on foot or by using a bicycle or scooter. Only 12% of urban pupils have to travel more than 3 km to school. And here, pupils often opt for public transport or the car.

The situation is different for pupils in rural areas. Almost half of the pupils live between 1 and 3 km away. Only 14% of pupils live within 1 km of the school. These distances translate into how they get to school. Nearly 60% of pupils in rural areas get to school

using a bicycle/scooter or public transport. In the context of distances of more than 3 km, almost 40 pupils have this distance of their school from their residence, which implies a choice of car as a means of transport. However, it should be noted that this is a slightly higher percentage compared to urban pupils. This shows the greater independent mobility of pupils from rural areas.

Another behaviour aimed at reducing the negative impact on the environment is to reduce car use in favour of public transport or selected micromobility solutions. Such actions are carried out by 41% of urban youth and 37% of rural youth, which is often determined by distance and location from school or work.

Another question addressed the issue of commuting to school, as shown in Figure 5. The young people surveyed indicated that they mainly use public transport (67% of rural and 71% of urban students).

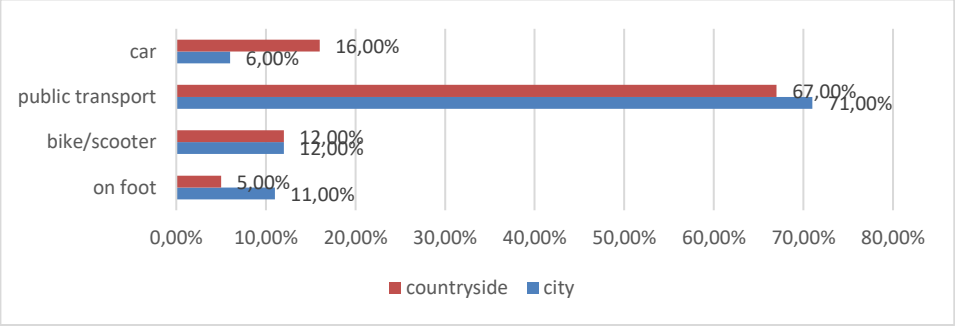

Fig. 5. The most common way to get to and from school

Source: own elaboration

16% of respondents from rural areas use a car, often with parental support. The figure for urban young people is only 6%. Young people are keen to use a bicycle or scooter. These were equally indicated by 12% each. This is a very environmentally friendly solution and also often faster than public transport (traffic jams, delayed public transport). On the other hand, young people get to school on foot relatively rarely (only 5% of young people from rural areas and 11% from urban areas).

The next question was strongly correlated with the previous one, as it is the distance from the school that determines how to get there.

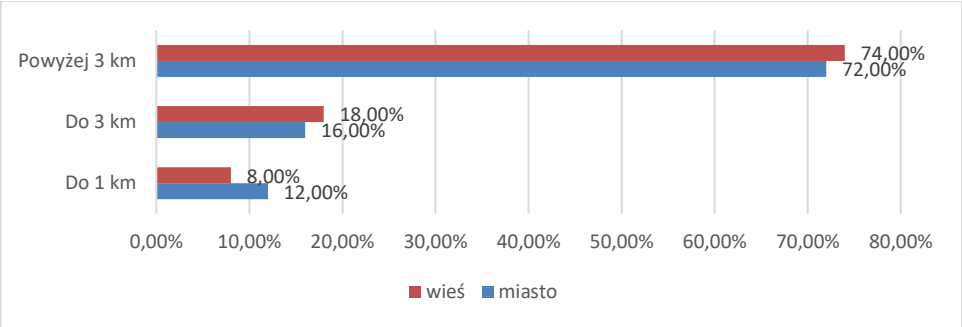

Fig. 6. How far is your school from where you live?

Source: own elaboration

Up to 3 km from school live 26% of rural youth and 28% of urban youth. On the other hand, more than 3 km from school, which requires the involvement of a means of transport, lives in the case of rural youth more than 70% (74% of rural youth and 72% of urban youth). It is important to emphasise that these distances determine more or less environmentally friendly forms of transport.

5. Discussion

In response to the research objectives, it is important to point out that adult residents note the development of infrastructure for the development of micromobility. It is a solution desired by adult residents. Activities related to the adaptation of infrastructure dedicated to micromobility are more desirable and perceived by residents of large cities, so it is important to build awareness and present the advantages of micromobility also in smaller towns and rural areas. As far as pupils are concerned, pupils in rural areas are more likely to use micromobility, but the main determinant of micromobility use is the distance from home to school. If this distance is large, pupils use public transport rather than micromobility solutions. The development of micromobility faces a number of significant constraints and challenges.

Micromobility is a response to the needs of city dwellers and a way out for sustainable transport. Micromobility is a global trend that adapts means of transport to the needs of cities and their inhabitants, in the concept of smart city and environmental management. Many cities and countries lack clear and consistent usage regulations. The increase in popularity of micromobility is associated with an increase in accidents, often involving pedestrians. Inappropriate parking of scooters and bicycles blocks pavements, pedestrian crossings and access to buildings, creating hazards and impeding mobility, especially for people with disabilities.However, it is necessary to address the barriers limiting the development of micromobility, which are on the side of society.

The first of these is the economic barrier. This occurs when the user would like to own a micromobility device. The cost of purchasing a micromobility device, such as a bicycle or scooter, can be a major limiting factor. A solution to this problem is the possibility to use shared solutions [6], i.e. through an app that allows the user to find the nearest scooter or city bike, unlock the device with a QR code and start riding. However, another barrier arises here. For people who do not have the right digital competences, i.e. to operate digital apps, the lack of access to digital apps can actually hinder the use of these devices. Many companies offer rentals mainly through apps, which are used to find free vehicles, book them and launch them. Without access to apps, finding and using the devices can be difficult, if not impossible.

Another issue that should be discussed is the impact on urban space. In the case of urban bicycles, they have in most systems designated stations where they can be rented and returned. As a result, it is not possible to leave the bike elsewhere. The situation is different for electric scooters. Over the last few years the impact of these devices on urban space has been clearly visible. Lack of the necessity to leave them in a strictly defined place, results in leaving them in places, which block efficient transport based on micromobility.

This problem is closely correlated with another group of barriers, infrastructural barriers. The use of micromobility requires a developed road infrastructure dedicated to these devices. A properly developed transport infrastructure dedicated to micromobility determines appropriate transport behaviour, increasing the safety of users of micromobility devices.

On the basis of the barriers presented, it should be pointed out that micromobility is a challenge for societies, public authorities dealing with urban transport, as well as manufacturers of means of transport. It is necessary to take measures that, on the one hand, allow for an intensive development of micromobility with a neutral impact on the environment. On the other hand, it is necessary to remove the barriers that hinder this development. It is therefore necessary to involve both the public (improving digital competence) and decision-makers at local and regional levels who are responsible for road infrastructure dedicated to micromobility.

The promotion of active lifestyles through the use of bicycles or scooters is a challenge and a necessity, as it can contribute to improving public health. In some societies the car culture is still dominant, making it difficult to change transport habits and adapt alternative means.

In order to overcome these limitations, a holistic approach is needed, which includes the development of appropriate legal regulations, investment in infrastructure, user

education, technological innovation and close cooperation between local governments, operators and the community.

The authors are aware that there are limitations to the results of the study that may affect the generalisability of the results, the interpretation of the data or their application in practice. These include the complexity of the phenomenon, namely that micromobility is part of a wider transport ecosystem. Isolating it from other factors, e.g. economic factors such as fuel cost, may lead to oversimplified conclusions. In addition, the local context, e.g. a well-developed mobility infrastructure in a particular city or region, causes limitations in transferring the results to other cities or rural areas.

6. Conclusion

One of the most important arguments in favour of micromobility is its low environmental impact. In this era of fighting the climate crisis, any solution that contributes to reducing greenhouse gas emissions is extremely valuable. In smart cities, where air pollution is a serious problem, the mass use of micromobility could contribute to a significant improvement in air quality.

They are also much quieter than internal combustion vehicles, helping to reduce urban noise - another factor that negatively affects residents' health and quality of life. Looking at the development of urban transport in the context of increasing urbanisation, it is increasingly clear that micromobility can play a key role in shaping the future of cities and the countryside. In cities that prioritise sustainability, clean air and efficient transport, unicycles could become the primary means of short-distance travel. In rural areas, on the other hand, in addition to the priorities identified, increasing transport accessibility is a key factor. From the perspective of both urban and rural users, micromobility offers solutions that can contribute to a more sustainable and friendly environment.

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