Digital Data in Support of Innovation for Urban Practice: Women-Inclusive Walkable Cities–Naples, a Case Study

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Abstract. Urban planning is increasingly focused on solutions for sustainable urban mobility, including the achievement of "walkability", i.e. friendliness to walking, in criteria such as availability of nearby services, street connectivity, and comfort of public spaces. Although city administrations in some countries, partially as a response to the Covid-19 pandemic, have adopted short or long-term plans for reassignment of vehicular space in favour of cyclist and pedestrian infrastructures, traditional approaches to urban planning, tend to overlook urban users in terms of their individual characteristics, which can significantly impact their perceptions of level of walkability for public spaces. Women in particular face harassment, aggression and other safety concerns that can inhibit their mobility in public spaces, especially at night. Despite robust research on other aspects of walkability in cities, there is a lack of knowledge at the intersection between mobility and gender. Addressing the need for further investment in qualitative, and particularly in quantitative analysis, the current contributions proposes and reports on the use of GIS-based methodology, with data collected directly from women in urban contexts, and other open-access location-based data, producing analyses that can support decision-makers concerning policy for walkability in urban environments. In particular, the contribution summarizes the first product of a new, replicable methodology, focused on urban planning and gender inclusion, applied to the city of Naples, Italy.

Keywords: Urban Planning · Gender Inclusion · GIS · Naples

1 Introduction

In current times, urban planning for sustainable urban mobility is crucial. The concept is that of guaranteeing walkable urban environments, through the availability of services, street connectivity and provision of safe public spaces. The perceived levels of urban walkability, however, depend to a significant extent on the individual characteristics of the users, which tend to be overlooked in traditional approaches to urban planning.

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In particular, urban and transport planning have long neglected the issue of the intersections between gender and urban mobility, with severe consequences, among which inequitable accessibility to different parts of the city, with reduced opportunities for the female gender. Several studies have shown that, in fact, there are differences between men and women in mobility behaviour. In the Italian context, for instance, women in are one and a half times more likely to walk on their daily trips than men, and are generally more diverse in their choices of transport mode [1]. At the same time, still in Italy, only one in twelve women say they feel safe and comfortable walking at evening or night, while for men the ratio is three times higher [2]. These data on the Italian scenario are consistent with studies in other nations [3–5]. Walkable environments, featuring populated and well-lit walkways, can increase women's sense of safety. Research has shown that women with access to walkable neighbourhoods are more likely to engage in regular physical activity, have better mental health, and feel more connected with their community. Additionally, walkable urban environments facilitate social interactions among neighbours, and support local business operations. On the other hand, poor walkability can limit mobility for the female gender; increase dependence on cars both for women and more generally, and negatively affect access to vital services and resources. For trips under a certain distance, walking will obviously be the primary mode of transportation, but it is also a crucial component of longer journeys using private cars or public transport. Given all this, when generating urban mobility plans, it becomes essential to devote close attention to the nexus of gender and walkability, and meet gender-specific requirements. As emphasized by Golan et al. [6], Andersdotter Fabre et al. [7], and Sethi and Velez-Duque [8], males and females experience the urban environment differently, partly because women are more concerned about harassment, aggression, and general personal security. The experience of personal safety is a significant element in the transportation experience, in turn impacting transportation decisions. The constraints for woman, arising from the sense of vulnerability, from the real or perceived risk of violence or other harm, especially at night, give rise to precautionary measures and avoidance behaviours, among which delaying or completely avoiding walking trips, thus significantly hindering their mobility in public spaces [9–13].

However, the knowledge regarding the needs and expectations of women while walking remains shallow, challenged by the limited availability of relevant data from public authorities [5, 14–17]. Most data and statistics on transport are very simply categorized, for example treating gender as a binary male/female variable, without relation to age, ethnicity, disability, caring responsibilities, etc. But gender-related needs in mobility are not homogenous across all women, who cannot be considered a uniform cohort experiencing a sole set of needs. First of all, gender is a multi-dimensional and intersectional construct [5]. The concept of "intersectionality" as proposed by Kimberlé Crenshaw [18] in her critique of antidiscrimination doctrine, highlights the overlapping effects of different social identities, such as race and class, on shaping women's subjective experiences. This naturally includes the mobility experiences of women in the city, not dictated by gender alone, rather differing depending on intersecting social identities, which for "doubly-disadvantaged" persons, could raise still further barriers.

Our research aims to analyse how women perceive urban environments, and to assess their sense of safety as an indicator of various urban factors, including physical, functional, socio-economic, and environmental elements. More specifically, the objective of the current contribution is to evaluate the impact of these factors on the walkability for women in different urban zones and at different times of day.

The experimental work represents a first "delving" into to the use of data collected by a mobile app, which suggests the safest walking journey for women, based on the comments and assessments of the female users themselves. The assessments and comments are usually made by younger adult women, and for this factor and others, the nature of the collected data prevents a comprehensive overview of women's perception of the urban environment. The research strategy has also included surveys designed to gain the views of a broader population, but these results too could be influenced by a heterogeneity of age not sufficiently reflective of the larger population of women. In any case, even though a first attempt at collecting data via such a digital platform, and using it for assessments in planning in the area of urban safety, the research still addresses a prominent data gap and advances innovative methodologies in doing so. The methodology, described in the next section, has first been applied to the city of Naples, Italy, and the case study and results from this application are described in the subsequent sections.

2 Methodology

Various methods have been developed for the measurement of walkability in urban environments, usually considering several factors, among which the availability of public services in close proximity, the overall comfort level and the sense of safety in the spaces, as experienced by pedestrians, as well as the appeal of their architectural design and social context. Only a few scientific methods have delved into gender issues in connection with assessment of walkability, and in fact, in spite of the investigations and potential proofs on the theoretical side, there has been little empirical demonstration of the relationships between gender and perceived safety of urban environments.

The current study introduces a quantitative methodology to compute an index of safety, based on women's experiences, for the investigation of connections between urban space and gender issues.

The index of safety is based on data collected through the mobile app "W-her".[1] W-her is a publicly available mapping application that supports women in urban walking journeys by offering a navigator function that considers the opinions of other users in suggesting secure routes. The app, developed by Italian researchers, is now maintained and operated by the Walk21 Foundation, an England-Wales registered charity.[2] The app solicits data from women on their perceptions of safety in urban spaces in terms of three ranked options (*Go easy*, *Be careful, Avoid*), relative to three times of day (*Day, Evening*, *Night*). Users are encouraged not only to rate streets and spaces, but also to provide comments that could help others walk the city safely.

The methodology presented in this contribution is the early product of a comprehensive research project delving into gender-based issues, among which the relationships

[1] For more information visit https://Wher.com/.

[2] For more information visit https://walk21.com/.

between gender and urban environments. The spatial analysis is conducted using a Geographic Information System (GIS) to link W-her data with reference spatial units. The most detailed reference unit is the "census tract" as mapped by the Italian National Institute of Statistics (ISTAT), to which are related the relevant social and economic data on the resident population (ISTAT, 2011).

Figure 1 shows the methodological workflow.

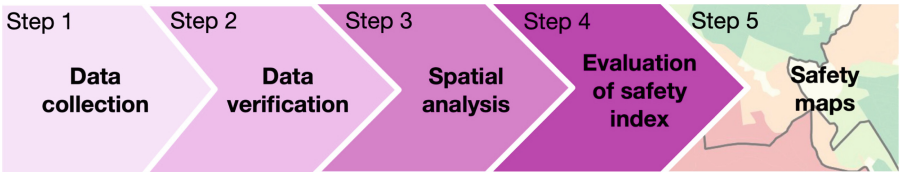

Fig. 1. GIS methodology for the evaluation of the summary Index of Safety

The first stage is that of data collection, using two investigative instruments: the W-her app and a questionnaire. The design and application of the questionnaire are aimed at gaining information on areas where coverage in the Where database is insufficient, with a view to collating the information from the two sources.

The second stage involves checking the sufficiency of the data coverage from the two sources, and their merging.

In stage three, the data on perceived safety data are harmonized with the GIS spatial units corresponding to census tracts, and from there related to the administrative level spatial units, with the aim of usefully informing the decision-making of local authorities.

$$i_s = \left(\frac{L_1}{L_{Tot}} \cdot S_1\right) + \left(\frac{L_2}{L_{Tot}} \cdot S_2\right) + \left(\frac{L_3}{L_{Tot}} \cdot S_3\right) \quad (1)$$

The fourth methodological stage is the measurement of the summary Index of Safety (i_s), which considers the safety perception of women experiencing urban spaces according to formula (1). The i_s is calculated for the ISTAT census tract. The L_1, L_2 and L_3 correspond to the length of the streets within the census tract, classifiable in terms of the three ranks of safety. The total value of length of streets for each census tract is L_{Tot}, while S1, S2 and S3 correspond with the safety ranks *Avoid*, *Be careful* and *Go easy*, which are respectively set equal to 0, 0.5 and 1.

The product of the fifth and final stage is the categorization and illustration of the different safety levels for women, in GIS maps. Our approach, aimed at providing an accurate representation of the safety levels in the reference area, involves the application of the Natural Breaks (Jenks) methodology, thereby computing the safety values in terms of five categories, from Level 1 (*Avoid*) to Level 5 (*Go Easy*). Apart from immediate service to users, the representation of safety ratings for streets and other urban spaces will also serve in further statistical and spatial analyses for the investigation of gender-based issues in mobility.

The methodology is validated through application in a case study in the country of Italy, as reported in the following section.

3 Case Study

The selection of Naples for the purposes of case study considers a number of factors, first of all its rank as third in population size among Italian cities, and fifth in population density. With 913,462 inhabitants (ISTAT, 2022) distributed over an area of 119.02 km^2, the average population density is slightly over 7,600 persons per km^2. The city is divided into thirty administrative neighbourhoods, grouped in turn into ten municipalities.

The urban area of Naples presents a substantial range of socio-economic and more purely morphological characteristics. The "historic centre", focused around the original Greco-Roman port, has a high population density and excellent accessibility to public and private services, including commercial and administrative functions. Conversely, the peripheral areas, developed during the 19th and 20th centuries, have lower accessibility to urban services and are primarily residential. On the basis of these differing attributes, the Neapolitan urban fabric can be categorised into three fundamental types, or "zones": Central, Semi-Central, and Peripheral (Fig. 2).

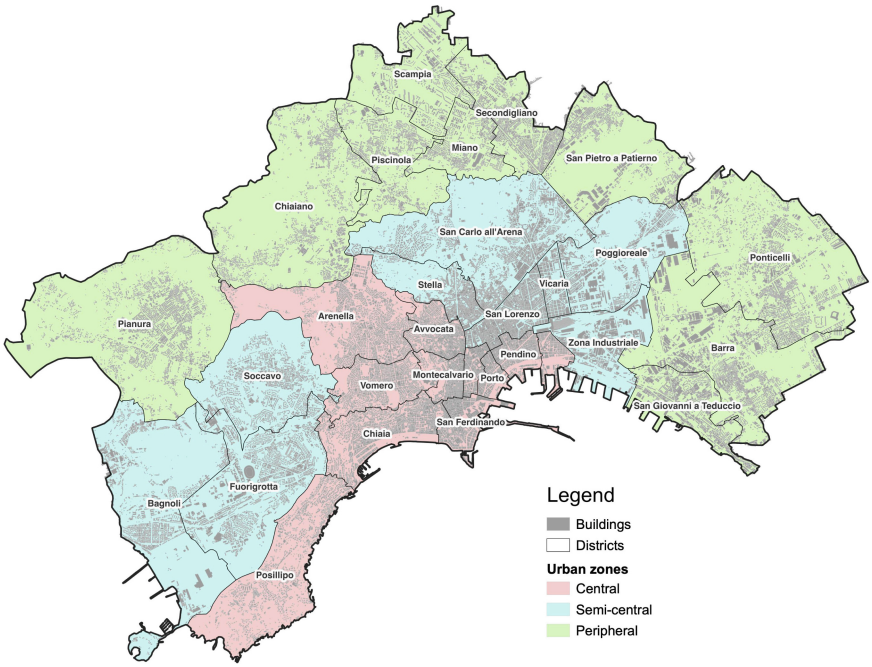

Fig. 2. City of Naples: thirty administrative districts, classified in three urban zones

The residents of Naples include 474,264 female persons, comprising 51% of the total population (data from ISTAT 2022). Figure 3 shows the distribution of females by tract and zone (data from ISTAT 2011 census). The distribution of the female population is: 153,491 in the Central zone, 175,448 in the Semi-Central and 176,967 in the Peripheral zone.

This descriptive analysis of the females present in Naples does not account for non-residents who work or engage in other activities within the city, on which no data is currently available. It should be noted that data on worker gender, from the national census of labour activities, are not accessible. Although the lack of this data represents a critical limitation, affecting the reliability of the results and conclusions of the current study, the method of gaining insight into the safety perceived by women in Naples still provides insight and understanding of the complex interplay of socio-cultural factors affecting their experiences of the urban space, and can support policymakers and urban planners in the design of more inclusive and safe cities for everyone.

Since 2019, data on safety issues in Naples have been collected under a partnership between the coordinators of the W-her app and the researchers of two institutions: the Laboratory of Land-Use, Mobility and Environments (TeMA Lab) of the Department of Civil, Building and Environmental Engineering of the University of Naples 'Federico II', and the non-profit Transform Transport Foundation, based in Milan.

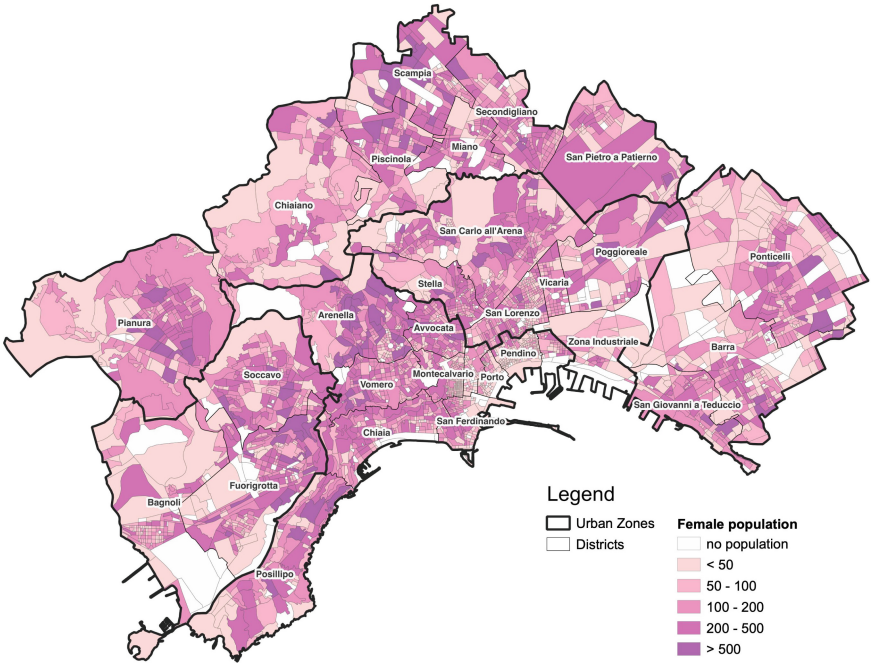

Fig. 3. City of Naples: distribution of female population (ISTAT, 2011).

The W-her app (https://W-her.com/.) was first used for data collection on the safety of streets and spaces with university students, then with women both resident in Naples and present as non-resident users of city streets and spaces, such as for work. The data collected from more than 3,000 assessments referred to over 45% of the city street network. On-site interviews were also conducted with women present in city streets, focused in particular on collecting information on their perceptions of safety for spaces in areas of lesser data from the W-her app, and also aimed at obtaining responses from

women not typically participant in "app based" projects. Table 1 summarizes the data collected through interviews (Fig. 4).

Table 1. Summary of interviews

	Residents	Non-residents
N° of interviews	560	253
Avoid [%]	52.1	25.9
Be careful [%]	13.5	26.3
Go easy [%]	35.4	48.8

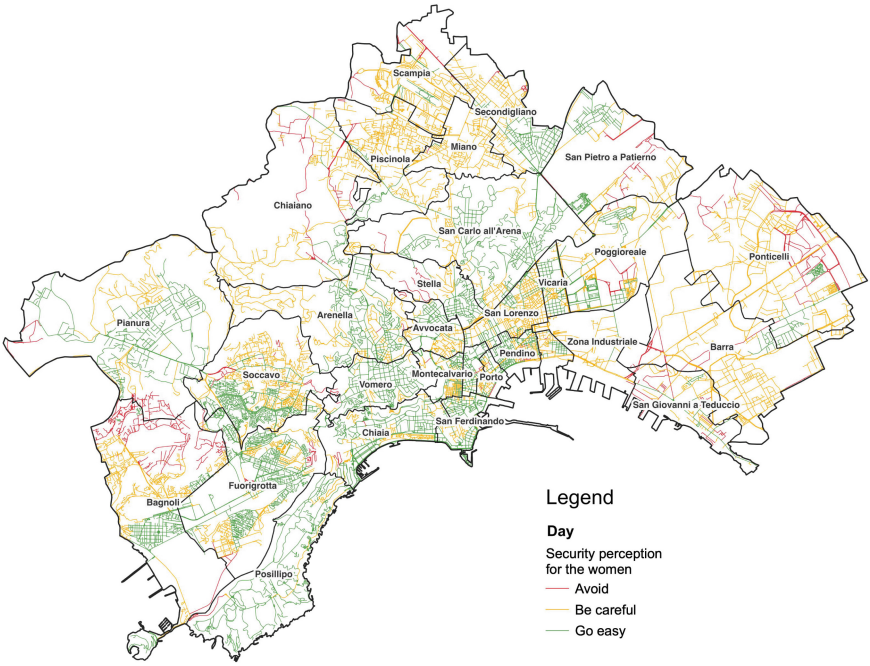

Fig. 4. City of Naples: safety assessment of the street network (Day scenario)

3.1 Results

This section presents the numerical values obtained by measurement of (i_s) for each census tract of the study area, under the three scenarios, *Day, Evening, Night*, Fig. 5 provides the mapping of the Index of Safety, by census tract, for the Day scenario. The map reveals the presence of perceptions of greater safety for the Central zone and some adjoining residential areas, for example in the western part of the city (Semi-Central),

versus perceptions of lower safety in the Peripherical zones. Looking in more detail, women tend to consider almost all parts of the Central zone secure, with only two of its census tracts, both near its outer edges, classified as Level 1 (Avoid). In contrast, in the Peripheral districts, women view few tracts as secure, and where tracts are mapped as Level 5 (Go easy) or Level 4 (the two "green" levels), these coincide with the most historically established and densely populated census tracts.

The districts with the perception of highest safety during the Day scenario (Fig. 5), but also at Evening and Night, are Posillipo, Vomero and Chiaia,

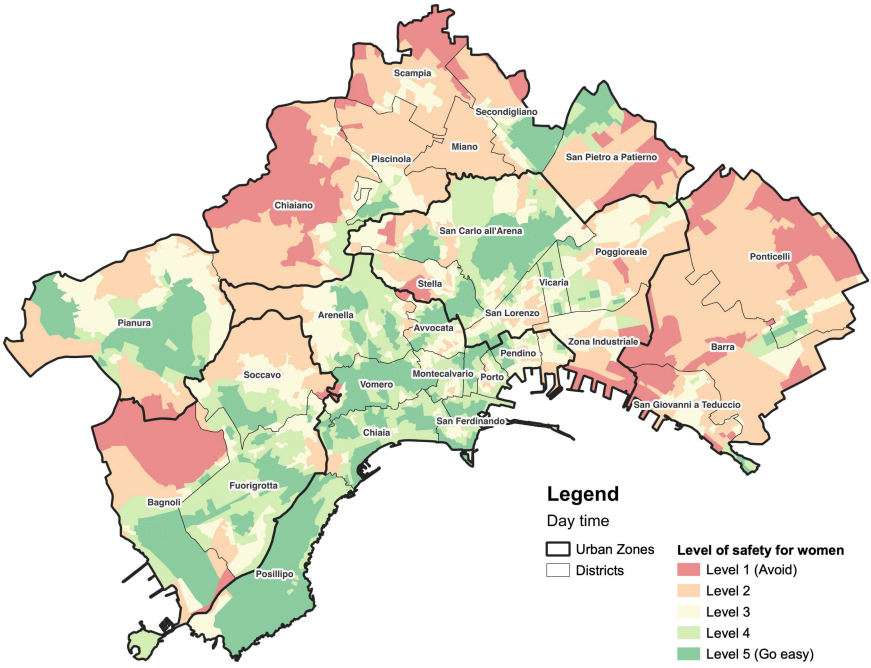

Fig. 5. City of Naples: map of safety perceived by women (i_s) for each census tract (Day scenario).

The proposed methodology can be used to gain deeper understanding of women's perceptions of safety by comparing, at the district level, the calculations of Index of Safety at the three times of day, also considering the female population resident in the different districts.

Figures 6, 7 and 8 present the results obtained, for the Index of Safety for the urban districts, respectively, of the Central, Semi-Central and Peripheral zones, at the three different times of day. In all urban zones the results demonstrate a significant reduction of perceived in the night scenario, with this reduction most pronounced in some residential districts of Peripheral zone. At the right side of each figure, we show the values of female population for the respective districts, in illustration of the direct impact of perceptions of safety for women, measured by Index of Safety. This type of reporting, relating data on female population with values of i_s can support decision-makers and authorities, such

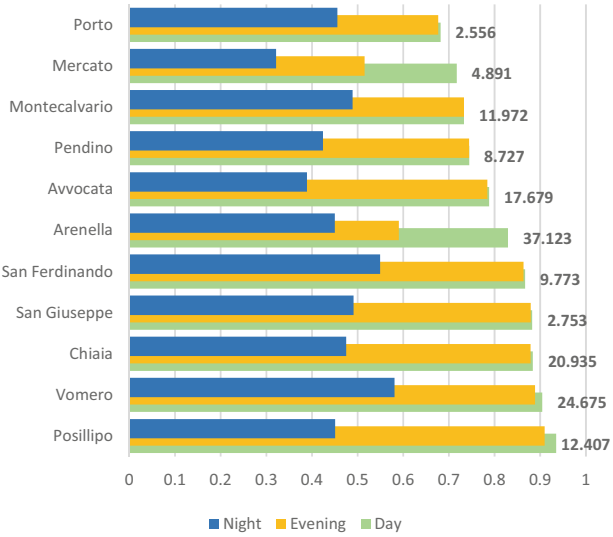

Fig. 6. Index of Safety calculated for the districts of Central Naples (Night, Evening Day scenarios), with indication of resident female population per district (in thousands)

as those of the municipalities and police forces, in implementing functional strategies and practices promoting higher qualityoflife for this vulnerable category.

Looking at the districts of the Central zone, we observe similar values of i_s for the Day and Evening scenarios, except in Mercato and Arenella districts, which show significant reductions of the Index of Safety from Day to Evening, with consequences for the over 41,000 women residing in these areas.

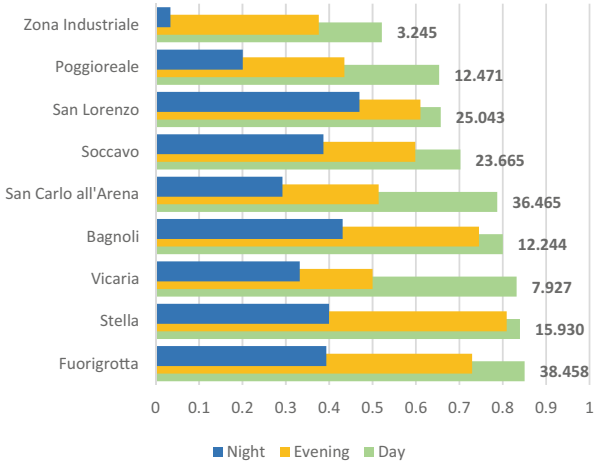

Fig. 7. Index of Safety calculated for the districts of Semi-Central Naples (Night, Evening Day scenarios), with indication of resident female population per district (in thousands)

The results obtained for Semi-Central districts (Fig. 7), similarly to the Central districts, in general show a halving of the values of i_s from the Day scenario to that for Night. Moreover, there is a significant reduction in the index from Day to Evening, for the districts of Vicaria and Poggioreale. The San Lorenzo district show the index values that are most similar across the three scenarios.

In Fig. 8, presenting results for the Peripheral zone, we see that the most populated districts (Pianura and Secondigliano) suffer a great reduction of i_s values safety from the Day to the Night scenario, indicating that there would be particularly significant impacts on freedom of life and movement for women present in the urban spaces of these districts. The Ponticelli district presents a value for the "Day" Index of Safety that is typical for the Peripheral Zone, but with only minimum differences to the index values for Evening and Night.

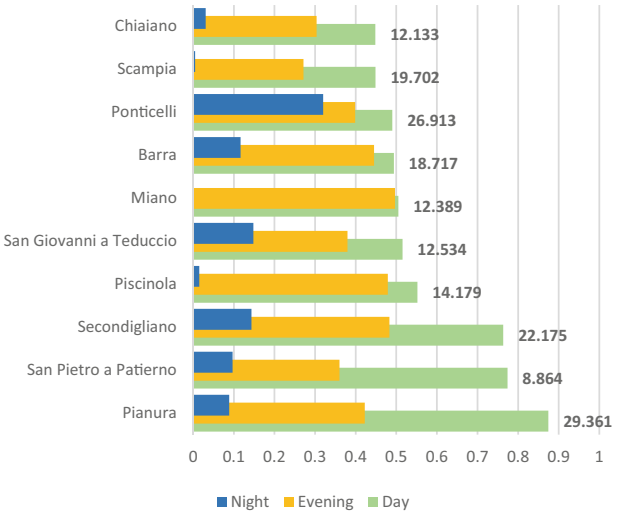

Fig. 8. Index of Safety calculated for the districts of Peripheral Naples (Night, Evening Day scenarios), with indication of resident female population per district (in thousands)

4 Planning Applications, Conclusions

United Nations Sustainable Development Goal 11 states is "about making cities and human settlements inclusive, safe, resilient and sustainable" (UN, 2015). To ensure equitable and safe access to mobility and city services for all, the conception and planning for sustainable urban mobility must consider the gender dimension. The lack of safe mobility options for women in urban areas not only restricts their access to essential services, but also their participation in economic and social activities. Women's choices concerning mobility are significantly impacted by factors such as time of day, frequency of public transit, and the contributions of other infrastructure to safety. Examples would be that women, as users of public transit, in considering the choices of moving at certain

times the day, would need to factor in expectations of overcrowded and unsafe conditions; or in considering entry into certain urban areas, would choose not to go at any time of day, over safety concerns.

Gender-related violence is in fact a critical concern for women in urban areas, and the fear of harassment or assault can significantly restrict their mobility. To mitigate the greater risk of violence, women will be more willing than men to modify their behaviour, travel routes, and avoid certain public spaces, and these choices will impact their overall quality of life.

Urban planning must take up a gender-responsive approach, prioritizing the needs and experiences of women. Policies on infrastructure investment, outreach programs, and other targeted strategies can ensure that women achieve equitable access to safe, reliable, and affordable options of mobility, with consequent reductions in gender inequalities, but more in general, leading to more sustainable, inclusive, and thriving cities for all.

Women face unique challenges in urban environments, with impacts on mobility experiences and choices, however traditional approaches to urban planning often fail to address the intersections between gender and urban mobility, resulting in inequitable accessibility and reduced opportunities.

The current research explores the safety perceptions of women in urban areas, applying an innovative methodology of collecting data via the W-her app, used on mobile devices. The results presented in this contribution represent the first experimental product of a comprehensive research project delving gender-based issues in the contexts of urban environment. The methodology presented derives from the know-how of the ongoing research project "STEP UP-Walkability for Women in Milan", submitted under the call for proposals "Inequalities Research–Generating new knowledge to reduce inequalities" of Fondazione Cariplo, and funded under Grant No. 2022-1643. The STEP UP project is aimed at: identification of challenging areas and neighbourhoods in Milan, considering the needs and expectations of women while walking; serving as an analytical testbed for development of a set of policy recommendations aimed at enhancing walkability for women in cities.

By prioritizing environments of safety, connectivity, and access to public services, and thereby walkability, policy makers can contribute to the empowerment of women and, in general, promote the development of more equitable and sustainable cities. Addressing gender inequality in urban mobility is crucial to achievement of the United Nations Sustainable Development Goals and the development of more inclusive and liveable cities for all.

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