

MAIN SECTION

Mapping Sustainable Futures: Cartographic Maps' Role in Citizen Science for Participatory Research in Sustainable Urban Mobility

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ABSTRACT

Nowadays, climate change shows irreversible consequences for the well-being of humanity, territories, and resources. The city of Bologna (Italy) is facing environmental, societal, and digital challenges that are currently featured in urban spaces worldwide: air pollution and intense urban mobility, due to anthropic activities and ever-increasing urbanization. To tackle these issues, the H2020 I-CHANGE project "Individual Change of HAbits Needed for Green European transition" aims to illustrate the possibility of collective behavioral change by engaging civil society in citizen science initiatives (Goudeseune et al., 2020; Vohland, 2021). Emphasizing climate change awareness and sustainable lifestyles, the research prioritizes openness, accessibility, and participatory knowledge production. Investigating cartographic maps' role in citizen science, the study explores behavioral shifts towards sustainability. This contribution proposes the "Mani in Mappa!" (Hands on maps) initiative as a potential citizen science activity that involves maps as a dynamic tool for scientific research, education, and participation. The scientific component involves applying the concept of citizen science, engaging people in the shared collection and processing of data on Bologna's mobility system. The educational dimension is expressed through serious games, transforming gaming into a tool for message transmission, information exchange, and training. Finally, participation is facilitated by using geographic information systems for public involvement. This multidimensional approach aims to enhance active citizen awareness in sustainable urban mobility and to promote behavioral change to sustainable mobility.

KEYWORDS

citizen science, mapping serious game, sustainable urban mobility, participatory geographical information system

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Introduction

In the contemporary world, climate change is influencing the well-being of humanity, the health of urban areas, and the accessibility to resources, with irreversible implications. Its effects impact complex socio-spatial systems marked by economic, social, and territorial inequalities resulting in diversified consequences on social groups. To achieve a just Socio-Ecological Transition, aiming to establish a new sustainable perspective for urban spaces, it is crucial to open the promote collaboration among all stakeholders identified in the Quintuple Helix of Innovation.¹ The concept of Just Transition, as understood in this paper, promotes social, economic, and environmental equity in the pursuit of a sustainable future. By sustainable future, we mean one that “meets the basic needs of the present without compromising the ability of future generations to meet their own needs”.² This process must occur within an ethical framework of equity, which refers to the level of fairness in outcomes for different individuals or social groups.³ The overarching goal is to ensure that the transition towards a more sustainable society does not leave anyone behind but instead reduces inequalities and provides equal opportunities for well-being and development. Civil society plays a pivotal role in sustainability projects, aimed at democratizing knowledge and research in the environmental field. To incorporate non-expert knowledge, research should pursue objectives of openness, accessibility, and participatory knowledge creation. Among the potential tools of collaborative research in the processes of participatory knowledge production, citizen science is one of the most frequently utilized.

Citizen science or collaborative science is a research method that involves people who are not trained in science:⁴ research activities combine an openness of researchers to the public and local communities with

1 Elias G. Carayannis, Thorsten D. Barth, and David FJ Campbell. “The Quintuple Helix innovation model: global warming as a challenge and driver for innovation.” *Journal of innovation and entrepreneurship* 1 (2012): 1-12. <https://doi.org/10.1186/2192-5372-1-2>. The Quintuple Helix model builds upon the foundational frameworks of the Triple Helix and Quadruple Helix. The Triple Helix framework centers on the production and utilization of knowledge within the context of university-industry-government relations - Leydesdorff, Loet and Meyer, Martin. (2003). *Triple Helix of University-Industry-Government Relations. Scientometrics*. 58. 191-203. 10.1023/A:1026276308287 - and the Quadruple Helix expands this model by incorporating a media-based and culture-based public dimension - Carayannis, Elias and Campbell, David. (2009). ‘Mode 3’ and ‘Quadruple Helix’: Toward a 21st century fractal innovation ecosystem. *International Journal of Technology Management - INT J TECHNOL MANAGE*. 46. 10.1504/IJTM.2009.023374 - As a further elaboration of this model the natural environment is integrated in the framework, emphasizing how essential it is to incorporate this dimension into the construction of a comprehensive analytical framework that interlinks knowledge and innovation with environmental considerations. In this context, the perception and experience of the environment by the citizenry become crucial elements in the development of climate awareness and into the formulation of environmentally and urban sustainable solutions.

2 Gro H. Brundtland, *Our Common Future: Report of the World Commission on Environment and Development*. (Geneva, UN-Dokument A/42/427, 1987).

3 Deborah S. Rogers, “Socioeconomic Equity and Sustainability.” In *Global Environmental Change*, 933–41, 2014. https://doi.org/10.1007/978-94-007-5784-4_62

4 Mordechai Muki Haklay, Daniel Dörler, Florian Heigl, Marina Manzoni, Susanne Hecker, and Katrin Vohland. “What is citizen science? The challenges of definition.” *The science of citizen science* 13 (2021). https://doi.org/10.1007/978-3-030-58278-4_2

a process of shaping scientific citizenship that leads to wider accessibility of traditional scientific knowledge.⁵ The European Citizen Science Association (ECSA) articulates the inclusivity of science toward non-exclusively technical domains as an experimental arena embracing alternative models of democracy and the production of public knowledge.⁶ The basic idea is to build knowledge and expertise that is accessible and participatory, producing new data, information, and perspectives, creating domains of knowledge able to grasp the complexity of a multifaceted phenomenon such as climate change, environmental challenges, and future urban scenarios.

The research here presented used mapping methodologies in addition to the traditional data collection activities with low-cost sensors and participative scientific actions. Mapping, far beyond a mere spatial representation, has increasingly become a central and transformative process in disciplines focused on understanding and shaping territories. From the ancient period, maps have been used as directional tools for spatial orientation, and graphic instruments designed to represent places with particular attention to scales, objectives, symbols, and legends (e.g., Mercator projection)⁷ Powell⁸ observes that while maps have historically been conceived as directional tools, their function has evolved to include a variety of different forms in contemporary disciplines.

According to Corner,⁹ the distinction between tracing and mapping lies in their intrinsic nature: tracing is limited to reproducing existing reality, propagating the redundancies of a pre-described world, while mapping is an act of discovery and revelation. Mapping does not merely represent what is visible and known but explores the hidden connections between what was and what is, uncovering previously invisible links and reformulating the existent. This process applies to topographical features and extends to the hidden forces that shape space, from natural processes to social relationships, making mapping an inherently creative and formative act in any design process. Mapping, therefore, is distinguished by its ability to represent existing complexities and actualize their potential. This process allows for the imagination and creation of new spatial and social

5 Rick Bonney, Jennifer L. Shirk, Tina B. Phillips, Andrea Wiggins, Heidi L. Ballard, Abraham J. Miller-Rushing, and Julia K. Parrish. "Next steps for citizen science." *Science* 343, no. 6178 (2014): 1436-1437. <https://doi.org/10.1126/science.1251554>; Hauke Riesch, and Clive Potter. "Citizen science as seen by scientists: Methodological, epistemological and ethical dimensions." *Public understanding of science* 23, no. 1 (2014): 107-120. <https://doi.org/10.1177/0963662513497324>

6 Jaume Piera, Karen Adriana Soacha Godoy, Sonia Liñan, Carlos Rodero García, Xavier Salvador, and Ana Álvarez. "European Citizen Science Association (2022). Conference Proceedings." (2022).

7 The Mercator projection is a conformal cylindrical map projection of the Planet Earth presented by Flemish geographer and cartographer Gerardus Mercator in 1569.

8 Kimberly Powell, "Making Sense of Place: Mapping as a Multisensory Research Method," *Qualitative Inquiry* 16, no. 7 (June 16, 2010): 539-55, <https://doi.org/10.1177/1077800410372600>

9 James Corner. "The Agency of Mapping: Speculation, Critique and Invention." In *The Map Reader*, edited by Martin Dodge, Rob Kitchin, and Chris Perkins, 89-101. Wiley Books, 2011. <https://doi.org/10.1002/9780470979587.ch12>

configurations, transcending the rigidity and simplification of current reality. Corner emphasizes that the greatest power of mapping lies in its *exploratory inventiveness*, which renders mapping an active agent of cultural intervention. In this sense, mapping becomes a tool for representing the world and for transforming it, opening new possibilities for interpretation and intervention.

Further elaborations on this perspective, several studies describe mapping as an analytical practice that goes beyond the mere representation of data.¹⁰ The process of mapping begins with the selection of a particular characteristic of interest, followed by the collection of data and its organization into a map. The goal is to create a visual construct that is more than the mere sum of its parts - a pattern that, when brought together, can add a new layer of understanding to the data itself. In this way, the map becomes a powerful tool for visualizing connections between data and for looking beyond, revealing hidden patterns and actual connections that would otherwise remain unseen. Moreover, the process of mapping inverts the traditional analytical power, which often separates theoretical knowledge from practical, situated experience.¹¹ Hall and Smith identify a “logic of inversion” in which movement itself—the act of moving through space—becomes an action of knowledge, a way of exploring and understanding the external world. In this sense, mapping is not merely an act of static representation but a dynamic process that integrates experience and knowledge, allowing for a deeper and more situated understanding of space. An important perspective considers the city and the urban fabric as representations of human complexity¹². However, contemporary science often fails to capture this complexity, seeking to reduce phenomena to simplifications that ultimately lose their nature and explanatory power.¹³ This inability to represent complexity has serious consequences for understanding and managing urban space, as it leads to the fragmentation of interactions that compose it, compromising the ability to think, create, and live the urban environment meaningfully.

Given these premises, the integration of mapping in citizen science has emerged as a promising avenue for enhancing public involvement and data collection.¹⁴ In recent decades, the methodological function of maps has expanded, taking on new and more articulated forms that surpass

10 Tom Hall, and Robin J Smith. “Knowing the City: Maps, Mobility and Urban Outreach Work.” *Qualitative Research* 14, no. 3 (January 24, 2013): 294–310. <https://doi.org/10.1177/1468794112469623>; Franco Moretti, *Atlas of the European Novel: 1800-1900*. (United Kingdom: Verso Books, 1999).

11 Hall and J Smith. “Knowing the City: Maps, Mobility and Urban Outreach Work.”

12 Darko Radović. “Measuring the Non-measurable: On Mapping Subjectivities in Urban Research.” *City Culture and Society* 7, no. 1 (February 9, 2016): 17–24. <https://doi.org/10.1016/j.ccs.2015.10.003>

13 Sandra D. Mitchell, *Unsimple truths: Science, complexity, and policy*. (Chicago: University of Chicago Press, 2009).

14 Andrea Wiggins, and Kevin Crowston. “From conservation to crowdsourcing: A typology of citizen science.” In *44th Hawaii international conference on system sciences*, 1-10. IEEE, (2011). <https://doi.org/10.1109/HICSS.2011.207>

their traditional use as the sole means for orientation. In this context, mapping has become a powerful tool for describing physical space while also exploring the relational, conceptual, and cognitive dimensions of places.¹⁵ Social maps, for instance, highlight the relational nature of phenomena, while conceptual and mental maps are used to graphically describe ideas or concepts, and cognitive maps organize and render legible the physical and social characteristics of how a place is perceived by an individual.¹⁶ In this way, maps not only represent physical space but also explore its experiential and perceptual dimensions. Within the social sciences, maps are used as research tools, which are then accompanied by explanatory texts. The themes addressed vary according to the specific objectives of the research, but all maps share the ability to represent space in ways that go beyond cartography, capturing the living experience and the historical, geographical, and social context of a place.

In this context, integrating data and maps is emphasized with an approach that values the direct experience of space, identifying and describing the connections and complexities that only those who live in the urban fabric can recognize. This type of research does not replace but complements and enriches traditional cartographic approaches, which have become too intertwined with top-down power and a reductive and simplified view of the world.

These are the theoretical foundations upon which the citizen science activity "*Mani in Mappa*" (trad. "Hands on Map!" from now on MIM) was built, as part of the broader Horizon 2020 "I-CHANGE" project. After the mapping activity, in-depth interviews were conducted with participants, aiming to explore the relevance of using maps both as tools for data collection and representation and as a process of co-constructing shared knowledge, specifically regarding the mobility system in the Municipality of Bologna, Italy. The following sections will outline the research context, I-CHANGE, and its theoretical underpinnings, including living labs and citizen science, before briefly describing the urban mobility mapping activity in Bologna, "*Mani in Mappa*!" Finally, we will present participants' reflections on the role of maps and the conclusions drawn from the entire research experience.

15 Powell, "Making sense of place: Mapping as a multisensory research method."

16 Kevin Lynch. *The image of the city*. (Boston: MIT press, 1964).

The I-CHANGE Project

The H2020 I-CHANGE project “Individual Change of HABits Needed for Green European Transition”¹⁷ aims to illustrate the possibility of collective behavior change by engaging civil society in citizen science initiatives¹⁸. The project is structured around the recognition that developing and strengthening citizen science initiatives enhance awareness of climate change impacts in urban areas and encourage behavioral shifts toward more socially and environmentally sustainable lifestyles.

The Project is structured around a network of Living Labs (LL)¹⁹ set up in six cities in Europe (Amsterdam, Barcelona, Bologna, Dublin, Genoa, Hasselt), two in extra-European countries, one in West Asia (Jerusalem) and one in West Africa (Ouagadougou). Firstly, implemented in urban areas,²⁰ LL used to be carried out for the design of information and communications technology (ICT) innovations²¹ as “a user-centric research methodology for sensing, prototyping, validating and refining complex solutions in multiple and evolving real-life contexts.”²² In recent years, we witness a growing implementation of LL methodology in participatory and collaborative research²³ across the level of sustainability, environment and

17 The I-CHANGE project is a 3.5-year H2020 funded project started in November 2021. The project is coordinated by CIMA Foundation and the University of Bologna serves as the scientific coordinator. The main objective is to enhance awareness regarding the issues associated with climate change by directly collecting environmental and socio-economic data using innovative and user-friendly tools. The competences involved span from climate and meteorological modeling to social and economic sciences, citizen engagement, stakeholder management, ethics and responsible research and innovation as well as communication of scientific findings through continuous storytelling and serious games. All the information is available at <https://ichange-project.eu/>.

18 Goudeseune, Lise, Hilde Eggermont, Quentin J. Groom, Xavier Le Roux, Carole Paleco, Helen Elizabeth Roy, and T.C.G.E. van Noordwijk. “Citizen Science Toolkit for Biodiversity Scientists”. *Zenodo*, November 6, 2020. <https://doi.org/10.5281/zenodo.3979343>; Katrin Vohland, Anne Land-Zandstra, Luigi Ceccaroni, Rob Lemmens, Josep Perelló, Marisa Ponti, Roeland Samson, and Katherin Wagenknecht. *The science of citizen science*. (Springer Nature, 2021). <https://doi.org/10.1007/978-3-030-58278-4>

19 Mokter Hossain, Seppo Leminen, and Mika Westerlund. “A systematic review of living lab literature.” *Journal of cleaner production* 213 (2019): 976-988. <https://doi.org/10.1016/j.jclepro.2018.12.257>; Hans Schaffers, and Petra Turkama. “Living labs for cross-border systemic innovation.” *Technology Innovation Management Review* 2, no. 9 (2012). <http://doi.org/10.22215/timreview/605>

20 Diana Chronéer, Anna Ståhlbröst, and Abdolrasoul Habibipour, “Urban Living Labs: Towards an Integrated Understanding of Their Key Components,” *Technology Innovation Management Review* 9, no. 3 (March 26, 2019): 50–62, <https://doi.org/10.22215/timreview/1224>

21 Veronika Zavrtnik, Argene Superina, and Emilija Stojmenova Duh. “Living Labs for Rural Areas: Contextualization of Living Lab Frameworks, Concepts and Practices” *Sustainability* 11, no. 14 (2019): 3797. <https://doi.org/10.3390/su11143797>

22 Mats Eriksson, Veli-Pekka Niitamo, and Seija Kulkki. *State-of-the-art in utilizing Living Labs approach to user-centric ICT innovation-a European approach*. Lulea: Center for Distance-spanning Technology. Lulea University of Technology Sweden: Lulea. 2005. Online under: http://www.cdt.ltu.se/main.php/SOA_LivingLabs.pdf?fileitem=2402350

23 Soini, Katriina, Carl Cyrus Anderson, Annemarie Polderman, Carlone Teresa, Debele Sisay, Prashant Kumar, Matteo Mannocchi, et al. “Context Matters: Co-creating Nature-based Solutions in Rural Living Labs.” *Land Use Policy* 133 (August 7, 2023): 106839. <https://doi.org/10.1016/j.landusepol.2023.106839>; Birgitta Bergvall Kareborn and Anna Stahlbrost, “Living Lab: An Open and Citizen-centric Approach for Innovation,” *International Journal of Innovation and Regional Development* 1, no. 4 (January 1, 2009): 356, <https://doi.org/10.1504/ijird.2009.022727>

climate change related issues, for its ability to pilot actions and initiatives in “real life” contexts and involve stakeholders to co-create innovations and/or practical solutions to environmental or societal problems.²⁴ The local context of LL appears to be crucial as the main idea is to integrate aspects of the contextual sphere – cultural, environmental and economical,²⁵ to activate innovation processes in that system.

Each LL involved in I-CHANGE works on several aspects ranging from monitoring climate-related phenomena (air pollution, extreme events, energy consumption), to evaluating intervention as means to mitigate the effects of climate change and generate co-benefits for the environment at urban level (sustainable mobility/transportation, waste management). These activities are being conducted using citizen science methodologies, whereby relevant stakeholders are engaged in the collection of data pertaining to the phenomena under examination. This process is intended to facilitate the identification of potential social, policy, and economic solutions, as well as to promote individual and collective behavioral change.

The implementation of citizen science is a crucial element in the pursuit of a just Socio-Ecological Transition. It serves as an effective instrument for fostering environmental awareness, behavioral change, and social transformation within communities. The Just Transitions Framework²⁶ underscores the significance of citizen science as a means of facilitating equitable societal transitions towards sustainability. This framework highlights the practical aspects of stakeholder engagement that facilitate behavioral and social change. By incorporating the input of citizens at the level of scientific research, we can ensure that a range of perspectives and local knowledge are integrated into sustainability efforts, thereby enhancing the relevance and effectiveness of these initiatives. By employing citizen science within the Just Transitions Framework, we can collectively devise sustainable solutions that are equitable, inclusive, and anchored in the lived experiences of diverse community members, thereby propelling a Just Ecological Transition.²⁷

24 Margarida Rodrigues, and Mário Franco. “Importance of living labs in urban Entrepreneurship: A Portuguese case study.” *Journal of Cleaner Production* 180 (2018): 780-789. <https://doi.org/10.1016/j.jclepro.2018.01.150>

25 Karin Feurstein, Alexander Hesmer, Karl A. Hribernik, K. D. Thoben, and J. Schumacher. “Living Labs: a new development strategy.” *European Living Labs-a new approach for human centric regional innovation* (2008): 1-14.

26 Stephen Williams and John Robinson, “Measuring Sustainability: An Evaluation Framework for Sustainability Transition Experiments,” *Environmental Science & Policy* 103 (November 6, 2019): 58–66, <https://doi.org/10.1016/j.envsci.2019.10.012>

27 David J. Abson, Joern Fischer, Julia Leventon, Jens Newig, Thomas Schomerus, Ulli Vilsmaier, Henrik Von Wehrden, et al. 2016. “Leverage Points for Sustainability Transformation.” *AMBIO* 46 (1): 30–39. <https://doi.org/10.1007/s13280-016-0800-y>

Bologna Living Lab

The city of Bologna is a northern medium-sized Italian city with almost 400,000 inhabitants. Due to its location at the intersection between the northern and southern sides of the Italian country, the city is the major junction of road and railway traffic in Northern Italy. The regional infrastructure network consists of 10,726 km of roads and 1,400 km of railways in continuous expansion to sustain the increasing mobility demand for private and public.²⁸ The mobility demand is absorbed for the major part by the private sector, with 65.2% of transfers occurring by private cars (increasing by 6.8% within the period 2001-2014), 8.3% by public transport (+0.4% within 2001-2014) and 21.9% by cyclo-pedestrian movement (-6.8% within 2001-2014). Previous studies suggested that the impact of a shift towards more sustainable mobility management will provide multiple co-benefits on air quality, especially in critical areas like the city center.²⁹

Mani in Mappa!

The participatory approach adopted in the I-CHANGE project implements citizen science activities trying to trigger social innovation to foster changes in a wider context, based on new scientific and environmental consciousness. The promotion of a co-designed learning approach aims to improve citizens' knowledge of climate change impacts and help citizens understand how their behavior can make a difference and participate in a just and inclusive transition.³⁰ Involving a broader public in scientific projects, citizen science fosters a sense of community engagement and harnesses the collective intelligence of diverse participants.³¹

With this perspective, the gameboard-based activity MIM rethinks citizen science by enhancing public involvement in data collection, analysis, and discussion of results to better identify climate change-related phenomena, with a multi-dynamic point of view. It explores how the use of maps and the interaction with cartographic elements can assess climate awareness among participants, specifically to further developing and designing accessible, equal, and fair public transport in collaboration with urban planners and policymakers.

28 Regione Emilia-Romagna. "Strategia di mitigazione e adattamento per i cambiamenti climatici della Regione Emilia-Romagna", *Regione Emilia-Romagna, DG Cura del Territorio e Ambiente* (2019a).

29 Silvana Di Sabatino, Erika Brattich, Francesca Di Nicola, Francesco Barbano, Muhammad Adnan, Shiraz Ahmed, Kristi Jylhä, Kimmo Ruosteenoja, Marco Deserti, Chiara Agostini, and Vanes Poluzzi. *Report on policy options for AQ and CC*. iSCAPE Project, 2019. https://www.iscapeproject.eu/wp-content/uploads/2020/06/iSCAPE_D4.5_Report-on-policy-options-for-AQ-and-CC.pdf

30 Stephen Williams, and John Robinson. "Measuring sustainability: An evaluation framework for sustainability transition experiments." *Environmental Science & Policy* 103 (2020): 58-66. <https://doi.org/10.1016/j.envsci.2019.10.012>

31 Christopher Kullenberg, and Dick Kasperowski. "What is citizen science? A scientometric meta-analysis." *PloS one* 11, no. 1 (2016): e0147152. <https://doi.org/10.1371/journal.pone.0147152>; Sarah-Kristin Thiel, and Peter Fröhlich. "Gamification as motivation to engage in location-based public participation?" In *Progress in location-based services 2016*, 399-421. (Springer International Publishing, 2017). https://doi.org/10.1007/978-3-319-47289-8_20

The MIM activity is designed as a tool to address the complexity of the urban mobility system, aiming to overcome the limitations imposed by the current power imbalance that often disadvantages citizens, leading to urban planning that is neither inclusive nor equitable. This research highlights the intricate dynamics of mobility systems, which integrate social, economic, and technological variables, intending to guide sustainable urban development initiatives. Although the mobility system involves citizens at individual, technological, and policy levels, citizens often take on passive roles, constrained by inadequate infrastructure and limited resources.³² Despite their willingness to engage in eco-friendly behaviors, they are largely excluded from decision-making processes, which hinders the widespread adoption of environmentally conscious practices. The research underscores how top-down regulations and technological developments dictate citizens' mobility options, limiting their ability to make active choices and resulting in an urban environment that does not fully

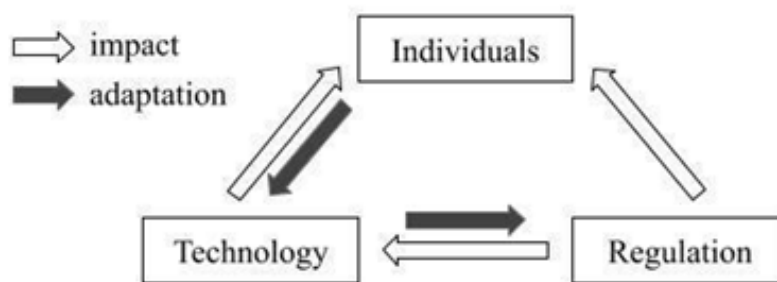


FIG. 1 Multilevel dynamics of the mobility system. Source: elaboration by Selene Tondini

address the needs and voices of its inhabitants.

We can grasp this dissonance through research efforts by engaging in participatory reflections with social groups within the urban setting. This engagement should involve the use of creative and participatory research tools, fostering reflective and chorographic processes on the specific topic. MIM generates a collective co-production of data; the data analysis grasps some dimensions of criticality and complexity, representing a central element in the construction of knowledge linked to the dimension of space,³³ less likely to be produced through conventional research methodologies such as in-depth interviews. The collaborative aim of MIM can be contextualized,³⁴ and embraces a dynamic approach aimed at engaging

32 Anja Kollmuss, and Julian Agyeman. "Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior?" *Environmental education research* 8, no. 3 (2002): 239-260. <https://doi.org/10.1080/13504620220145401>

33 Federica Burini, *Cartografia partecipativa. Mapping per la governance ambientale e urbana*. (Franco Angeli, 2016). <https://hdl.handle.net/10446/75688>

34 Burini, *Cartografia partecipativa*.

communities, facilitating decision-making, and promoting empowerment.

Methodology

Phase 1: Mapping Activity

Between March 2023 and April 2024, 116 university students from four departments (Engineering, Service Design, Sociology, and Political Science), 30 local stakeholders and 20 middle school students participated in the MIM activities, resulting in 45 maps. Stakeholders were selected through an initial mapping of local civil society organizations, including NGOs, associations, and collectives focused on sustainable mobility, public space, and environmental issues. Students engaged in 8 hours of in-person activities with researchers during class, while stakeholders participated in a 3-hour evening workshop.

The “Mani in Mappa!” activity was developed to address the complexity of urban mobility systems by employing a methodological approach that integrates serious game and participatory mapping into citizen science activity in Bologna Living Lab.

Born in the field of design,³⁵ serious games are activities that combine “serious” objective -pedagogical, informational, or training - with playful elements. Usually, serious games refer to activities aimed at learning and training,³⁶ and are employed in educational and learning processes.³⁷ Serious games possess the potential to revolutionize citizen science by creating immersive and engaging experiences that motivate participants to actively contribute to scientific goals³⁸. This integration aims to rethink citizen science by enhancing public involvement in data collection, analysis, and discussion of results to better identify climate change related phenomenon. Participants, engaged in mapping through a serious game conducted as a board game, overcome the passivity of simply representing data in a geo-referenced digital system exercising their judgment in structuring the map by incorporating the collective imagination of all participants.

35 Ralf Dörner, Stefan Göbel, Wolfgang Effelsberg, and Josef Wiemeyer. *Serious games*. (Cham: Springer, 2016). <https://doi.org/10.1007/978-3-319-40612-1>

36 Jan Cannon-Bowers, and Clint Bowers. “Synthetic learning environments: On developing a science of simulation, games, and virtual worlds for training.” In *Learning, training, and development in organizations*, 229-261. (Routledge, 2009).

37 Julian Alvarez, and Damien Djaouti. “An introduction to Serious game Definitions and concepts.” *Serious games & simulation for risks management* 11, no. 1 (2011): 11-15 ; Nuri Kara. “A systematic review of the use of serious games in science education.” *Contemporary Educational Technology* 13, no. 2 (2021): 295. <https://doi.org/10.30935/cedtech/9608>

38 Seth Cooper, Firas Khatib, Adrien Treuille, Janos Barbero, Jeehyung Lee, Michael Beenen, Andrew Leaver-Fay, David Baker, and Zoran Popović. “Predicting protein structures with a multiplayer online game.” *Nature* 466, no. 7307 (2010): 756-760. <https://doi.org/10.1038/nature09304>; Sara Cravero. “Methods, strategies and tools to improve citizens’ engagement in the smart cities’ context: A Serious Game classification.” *Valori e Valutazioni* 24 (2020) <https://www.proquest.com/scholarly-journals/methods-strategies-tools-improve-citizens/docview/2529186058/se-2>; Didone Frigerio, Anett Richter, Esra Per, Baiba Pruse, and Katrin Vohland. “Citizen science in the natural sciences.” *The science of citizen science* (2021): 79-96. https://doi.org/10.1007/978-3-030-58278-4_5

Specifically, MIM participants were divided into groups and each group were assigned with fictional characters (personas), with specific socio-demographic characteristics such as gender, age, health status, family composition, employment status, and financial situation.³⁹ Specifically, personas were designed based on analytical dimensions that could play a role in mobility choices. Gender, age, ability can significantly impact the use of mobility choices in various ways, influencing individuals' access to transportation options, preferences, and experiences. These factors intersect and create complex dynamics that shape mobility patterns and opportunities for different segments of society.

Each persona is accompanied by a brief life story, with daily routine locations geolocated on the map (Appendix A). Using personas, each group was asked to address challenges related to urban mobility practices. Through route-tracking activities and transportation choices, each group had to complete a mobility agenda that reflected the personas' needs and also daily activities (going to work, shopping, getting to places for recreation) related to the personas' requirements. Each group could choose between three means of urban transport (private car, bicycle/foot, public transport) and have different policy scenarios (30 km/h areas, low emission areas).

The primary goal of the mapping activity is to identify barriers that prevent city inhabitants from shifting from private to public transport and sustainable mobility and drawing on map optimal routes (**Fig. 4**) based on speed, cost, and environmental sustainability, following urban mobility policies, including public transportation schedules. The activity has been conducted in two formats: as a competitive board game for stakeholders and a non-competitive exercise for students. Participants work to find the most suitable way to complete the personas' daily mobility agenda using the city's infrastructure and integrated systems, aiming for the most sustainable, fast, and economical route. In the competitive version, detailed in Appendix 2, participants earn or lose points based on their chosen mode of transport and the level of CO2 emissions during the journey. During the activity, participants can also test hypotheses directly in the field, developing various mobility solutions and gathering information using tools provided by interactive digital maps from Municipality of Bologna,⁴⁰ personal experience, and other digital maps (open street map or Google maps). At the end of each session, participants engage in a collective discussion of the most relevant issues that emerged during the mapping activity. This sharing moment allows them to propose strategies and interventions

39 Flore Vallet et al., "Tangible Futures: Combining Scenario Thinking and Personas - a Pilot Study on Urban Mobility," *Futures* 117 (January 13, 2020): 102513, <https://doi.org/10.1016/j.futures.2020.102513>

40 The maps used are available at the website <http://sitmappe.comune.bologna.it/pugviewer/#/app/map/default> (last access September 2024).



FIG. 2 Stakeholders playing "Mani in Mappa!". Source: photo by Teresa Carlone

to mitigate difficulties related to public, sustainable, and shared mobility, thereby promoting a shift towards sustainable mobility habits.

Maps, conceptualized as a board game, serve as common shared workspaces where stakeholders with diverse skills and experiences come together leveraging their individual expertise to reproduce the urban complexity and co-create new dynamic solutions. This process is not merely an aggregation of ideas but an active engagement of all stakeholders, who, starting from individual analysis, collaboratively construct a new reality composed of multiple dynamics and solutions (Fig. 2). Moreover, role-playing further enhances their ability to reimagine reality while excluding cultural and social biases.

Eventually, participants are involved in the scientific process of creating "human data"⁴¹ and identifying best practices or areas for improvement in

41 Giorgia Lupi, and Stefanie Posavec, *Dear data*. (Chronicle books, 2016). ; Giorgia Lupi, *Data Humanism, the Revolution will be Visualized*, (Medium press, 2017), available at <https://medium.com>.



FIG. 3 Example of map outcome from "Mani in Mappa!" session.
Source: photo by Teresa Carlone

Bologna's urban mobility system, fostering environmental awareness and stimulating innovative solutions for urban mobility. It links the adoption of sustainable mobility practices to the complexity of citizens' lifestyles, involving social, economic, and technological variables.

Phase 2: In-Depth Interviews

To gain insight into the effects of map use and serious game experience on participants, five people previously involved in the MIM activity were interviewed in depth. Despite the limited number of participants, efforts were made to include representatives from all degree programs and from a stakeholder group, with an effort to maintain gender balance. The interviews were conducted in January 2024, both online and in person, and represent the initial phase of a comprehensive investigation that will be conducted through focus groups, which are currently underway. The interview addressed two main topics: first, the frequency of interaction with maps by the interviewees and any previous knowledge of maps or cartographic mapping activities (crowd mapping, map design, etc.) for work or recreational purposes. Secondly, the focus was on the personal experience with the serious game and whether active interaction with the map tool accompanied a process of speculation on the complexity inherent in the concept of sustainable urban mobility. All interactions were recorded and transcribed verbatim. The findings from the interviews were subsequently analyzed through content analysis, identifying thematic areas to cluster the main points arisen from respondents. The following section will address the most pertinent issues, with a particular focus on the following four areas: a. the impact of the collaborative mapping process on

awareness of critical issues and limitations related to sustainable urban transportation; b. comparative merits of digital maps and paper maps; c. the role of collaborative mapping as a research tool in citizen science; d. limitations and potential of collaborative mapping.

Discussion

In this section, we will discuss the main takeaways from the collective discussions that followed these cartographic activities, as well as insights from interviews with participants. Although the research is ongoing, preliminary observations suggest that mapping activities serve as valuable tools for collaborative research, education, and informed dialogue on complex issues. They also offer opportunities for engagement and empowerment, helping to raise awareness of urban mobility challenges and increase understanding on sustainable mobility practices.

Sustainable Urban Transport Critical Issues and Limitations

As for research purposes, it emerges that participation in citizen science activities in general has stimulated greater awareness of urban mobility related problems. During the discussion that followed each group's work participants stressed out that identifying with a citizen with specific socio-demographic characteristics led to reflection on physical, economic, and social limitations never experienced before. Using the serious game method, participants were immersed in alternative scenarios, requiring them to abandon cultural and cognitive preconceptions to address mobility challenges in an innovative and unusual way. The integration of personas in serious game development fosters a deeper understanding of the players' characteristics, preferences, and needs.⁴²

Preliminary results show how in Bologna, the public transportation system does not consider the needs of the most fragile groups (people with disabilities, caregivers, the elderly, precarious workers) even then these categories tend to be the most represented among public transportation users. Moreover, all participants emphasized that gender is a highly discriminatory variable concerning mobility choices and constitutes a significant inequality, especially for those who oversee the reproductive and care work. Caregiving work turns out to be, along with disability, one of the main obstacles to sustainable mobility choices, such as urban public transportation or the use of bicycles. However, the responsibility for the solution is recognized to lie with administrations and governments in implementing integrated mobility policies that citizens can follow, aided

42 Francesco Bellotti, Bill Kapralos, Kiju Lee, Pablo Moreno-Ger, and Riccardo Berta. "Assessment in and of serious games: An overview." *Advances in human-computer interaction* 2013 (2013): 1-1. <https://doi.org/10.1155/2013/136864>; Luis De-Marcos, Adrián Domínguez, Joseba Saenz-de-Navarrete, and Carmen Pagés. "An empirical study comparing gamification and social networking on e-learning." *Computers & education* 75 (2014): 82-91. <https://doi.org/10.1016/j.compedu.2014.01.012>

by the provision of appropriate infrastructures and services.

Digital vs Paper Map

When confronting the research tool, differences between the use of paper and digital maps have been distinctly highlighted in the responses. While paper maps are seen as slower and more challenging to comprehend “*It was challenging to orient myself. The map is an additional difficulty(...) It's like knowing how to use a compass*” (int.1), they offer an advantage presenting a more comprehensive view of the urban system and mobility, thereby fostering deeper critical reflection.

“The overall view that the paper map gives you, in my opinion, is less on the digital one(...) even on the digital map, I can see maybe the whole city of Bologna, but I don't have it all on the desk, I mean it's really a different thing, which is bigger, more immersive.” (int.2)

Using the paper map was deemed crucial in making the experience more tangible and facilitating comparison with digital platforms. It “adds a sense of reality” and is helpful in “getting a local perspective” compared to solely relying on digital tools, reflecting the concept of “imageability” of the mapping support to evoke a vigorous image postulated by Lynch (1964)⁴³. Another benefit of paper maps emphasized by certain respondents is their clarity to a wider audience, facilitated by a standardized decoding method that enables anyone engaging with them to obtain consistent information.

“It's more convenient because it allows you to be intuitive even when talking to other people” (Int.5)

“The map, although it should be an objective tool, actually becomes highly subjective at the moment it's represented.” (Int.3)

On the other hand, digital maps, like Google Maps, provide dynamic information which is not easily integrated into paper maps, such as bus schedules, city traffic simulations that change the travel times of a given route, or the calculation of costs and CO2 emissions.

“Google Maps is a very powerful tool that allows you to calculate everything you need to solve the challenges. I could have gone to the field to confirm the data found, for example, to measure distances and times, but Google Maps is reliable enough, even simulating schedules.” (int.1)

Collaborative mapping and citizen science process

A central aspect of the interviews was the ability of mapping activity to support a research process. Participants revealed that the serious game helped contextualize and represent as a visual tool the mobility system about the ideal citizen experiences of Bologna, identifying critical issues and difficulties among the city's neighborhoods. Using primarily online

43 Lynch, *The image of the city*.

navigation systems and maps (Google Maps, Via Michelin, Bologna Municipality), it was noted how online information is inaccurate or even missing, especially on some aspects related to the most vulnerable segments of the population. No apps efficiently indicate the presence of architectural barriers under the arcades, which bus stops are accessible, or which buses have ramps. Other missing information is related to architectural barriers on sidewalks or in some streets/squares in the city center. In some cases, to overcome the problem of missing information, some participants used Google Street View or directly explored the field to collect information.

"Maybe I try to understand, Ok, it's located in this area, so it means it's far from(...) a certain service, so that's why I have this problem, simply that, maybe, I mean if I see it on the map it stays in my mind compared to the study, but only because maybe I have more, I mean visually" (int.2)

To explore the use of maps as a support for educational and training process, participants were initially prompted to undertake a thorough consideration of the nature of their relationship with maps, whether in paper or digital form, as well as their perceptions of spatial representations more broadly. Some participants initially found it challenging to acknowledge the pervasive influence of various forms of maps in their everyday lives. When asked about the frequency of map usage in their personal lives before the MLM activity, some participants spontaneously responded negatively. However, upon closer examination, it became evident that these participants, originally confining the concept of a "map" solely to the tool comparable to the one used in the activity, had indeed interacted repeatedly with the concept of maps in different contexts, pursuing diverse purposes and employing various forms and designations.

"At most, reference is made to company floor plans, primarily to building layouts rather than maps focusing on a broader portion of the territory." (Int.5).

In this context, interaction with a graphic symbol delineating a space is not qualified as a "map", similar to what occurs when using a geographical map for orientation in a natural environment *"for example, during the summer season, on vacation periods, often using maps depicting forest or mountain environments"* (Int.5). Other participants have stated they have used the map as a reporting tool for an investigation in research activity, activism or as support in the urban planning process to transpose geolocated data into a territorial dimension.

Exploratory questions have also shed light on the predominant theme of orientation, highlighting various ways in which people interact with maps, understood as the ability of individual parts of urban space to be recognized and organized within a coherent system.⁴⁴ Some prefer to deliber-

ately get lost and then find their way through map analysis, while others rely on prior studies or sports experiences (e.g., orienteering) to develop orientation skills. However, in general, the sense of navigating with a map, whether paper or digital, is seen on one hand as a means of representing oneself in space *"in terms of presence(...) I know where I am, I know how to move"* (Int.4), and on the other hand, as a way of taking ownership of space:

"I really like to see, or maybe when you need to find a route, I mean I don't want to see it's one thing, but this is my thing, maybe I want, I want to study it, before crossing the city and then I do it without the phone" (Int.2).

"I arrived in Bologna,(...) I don't use Google Maps anymore and so randomly I took a map, let's say, and(...) I spent a day getting lost in the middle of Bologna with the map and(...) it was the first time, in short, that I remembered the streets" (Int.4)

In terms of training and learning, the group's experience was positively evaluated for the diversity of perspectives and the wealth of shared knowledge, to *"[...] have a vision that is not just the individual's personal one that we know better."* (Int.3). The collective aspect of MIM has been recognized as an additional asset, serving both to fulfill the challenge presented in the serious game and as an opportunity for engaging with diverse and complementary perspectives.

"Everyone had a piece of knowledge, a piece of practicality, some with the phone, some with the map, some with the means and so this helped us in the elaboration, let's say, of the path that we then proposed" (Int.3).

Along with that, a crucial theme emerges from the interviews concerning the ability of the participatory approach of MIM to gather different and composite viewpoints and perspectives. As highlighted multiple times, those who engage in such activities are often already conscious of the topic. However, a cartographic serious game can serve as a valuable tool to collect data to describe the mobility system in a more human-centered and less "engineered" manner, while also increasing citizens' awareness of more sustainable mobility styles. Among participants, it has proven crucial to find ways to involve even the underrepresented categories of citizens.

"People who then participate are clearly more inclined to active engagement; those who attend but do not actively participate. Right? And so, in my opinion, this somewhat skews the discussion of achievable results and presents a limitation..." (Int.3)

Limits and Opportunities of Collaborative Mapping

In this context, all participants have highlighted the lack of direct engagement with individuals embodying the characteristics presented through the personas and mobility agendas of MIM. This led to the need to verify the hypotheses developed during the workshop through field investigations (e.g., measuring the height of bus steps) or through personal experiences. The importance of involving underrepresented categories of citizens was emphasized by the interviewees, highlighting that those who participate are already willing to be engaged in the activity, making it necessary to adopt strategies to attract a broader audience.

"There could be all these problems, so since I don't know, because anyway I'm maybe distant at that moment to confront myself, maybe in a process where there are also many representative people" (Int.2)

In some groups, this issue was resolved by going into the field to verify the hypotheses developed during the workshop, with measurements and sample interviews, or by relating them to personal experiences occurring in other contexts (e.g., through the experience of grandparents).

Finally, the future utility of MIM was considered in terms of its political and urban design potential. Participants suggested that the game could be dynamically used to identify immediate problems and engage citizens in urban planning, enabling a participatory vision rather than solely top-down approaches. Additionally, the importance of involving underrepresented categories was emphasized to ensure a more inclusive and accurate representation of city life.

"The obvious advantage is, I mean, putting people's vision into, I mean, into a design, maybe top-down. I mean, that then becomes not top-down anymore but participatory with other people. And so, it's not like, okay, I decide the line should pass here and here, but maybe I find out that the stop can be placed 100 meters earlier, benefiting 100 people who are much happier. Maybe nothing has changed for the bus itself, but I don't know, by listening to those people, I made it easier to go to school or to work." (Int.2)

Final Remarks

As mentioned earlier, the "Mani in Mappa" activity is part of a series of initiatives promoted by the European I-CHANGE project. In this context, the data and reflections that emerged on the theme of sustainable mobility will be integrated into policy recommendations and then delivered to local administrators as guidelines for future planning, also based on the direct experiences of citizens. The presented preliminary results of the research can represent a good starting point for reflecting on the use of

maps in citizen science activities to enhance participatory research activities with a significant social and spatial dimension on issues related to climate change studies. Moreover, the study yields a systematization of tools to be employed in collaborative research and knowledge production processes, to promote critical reflection on the current state of knowledge and stimulate an individual and collective commitment to contribute to a social and cultural transition towards a more sustainable lifestyle.

However, some critical issues require further investigation. One potential concern arising from this work is that a “subjective” mapping process might appear dissonant with the objectives of citizen science, particularly due to possible issues like data inaccuracy. Contrary to this, it has been observed that the mixed use of online and offline tools leads to a data plateau that represents a scientific and shared description of reality. By involving the participants’ personal experiences, a new “citizen” reality is created, revealing information that would otherwise be difficult to integrate into a standard investigation.

Another critical issue could be the scalability of the activity. The mapping activity in its competitive form was also tested with local administrators in the Porto area (Portugal), who were interested in developing a more participatory approach to their sustainable mobility choices. It emerged that with appropriate adjustments, especially regarding the personas (which must represent the local social fabric), “Mani in Mappa” can adapt to any context while maintaining its transformative power. The research underscores the potential of mapping activities to facilitate collaborative research, educational advancement, and community involvement in tackling complex urban mobility challenges. Through involvement in mapping activities, participants from diverse socio-demographic backgrounds found and discussed the physical, economic, and social barriers encountered by various community segments in accessing sustainable urban mobility, including individuals with disabilities, caregivers, the elderly, and those in precarious employment. MIM can be the chance for practitioners and policymakers to grasp experiences also from underrepresented and marginalized categories in mapping activities, even though it remains an ongoing challenge. The issue of digital maps and their relationship with paper maps reflects how digital tools may be perceived as complex and daunting by those less familiar with mapping activities, risking further processes of exclusion and alienation.

In conclusion, several significant future developments regard the implementation of mapping activities as instruments for collaborative research, educational goals, and informed discourse on intricate urban mobility matters. In discussions of mobility, the bond between the city and the surrounding territory is inseparable; hence, the utilization of maps in the activity has proved pivotal. Maps effectively pinpoint the issue, rendering it tangible rather than abstract.

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Appendix A

Name: Daniela Sandrelli	Frequented places:			
	House	via dello Scalo		
	School	IIS "Manfredi-Tanari", viale Felsina 40		
	Sport	Baratti Sports Facility, Via Irnerio, 4		
	Friends Hangout	Parco 11 Settembre 2001, via Azzo Gardino		
Bio:	Means available:			
Daniela, 17 years old, is a student at the IIS 'Manfredi-Tanari' in Bologna. Passionate about volleyball since she was a child, she spends most of her free time at the Baratti sports facility, where she trains with passion and perseverance. In the evenings and on weekends, when she has no matches, she goes out with her group of classmates, walking along Via Indipendenza and chatting at the 11 September 2011 Park.	Personal scooter, bicycle, free bus pass			
	Mobility Agenda:			
	7-8 am	Arrival at school	6-8 p.m.	
	8 a.m. -1 p.m.		8-9 p.m.	Return from the sports facility
	1-2 p.m.	Back from school		
	2-5 p.m.	Leisure		
	5-6 p.m.	Arrival at the sports facility		

Name: Daniele Sandrelli	Frequented places:			
	House	via dello Scalo		
	School	IIS "Manfredi-Tanari", viale Felsina 40		
	Sport	Baratti Sports Facility, Via Irnerio, 4		
	Friends Hangout	Parco 11 Settembre 2001, via Azzo Gardino		
Bio:	Means available:			
Daniele, 17 years old, is a student at the IIS 'Manfredi-Tanari' in Bologna. Passionate about volleyball since he was a child, he spends most of her free time at the Baratti sports facility, where he trains with passion and perseverance. In the evenings and on weekends, when he has no matches, he goes out with his group of classmates, walking along Via Indipendenza and chatting at the 11 September 2011 Park.	Personal scooter, bicycle, free bus pass			
	Mobility Agenda:			
	7-8 hours	Arrival at school	6-8 p.m.	
	8 a.m. -1 p.m.		8-9 p.m.	Return from the sports facility
	1-2 p.m.	Back from school		
	2-5 p.m.	Leisure		
	5-6 p.m.	Arrival at the sports facility		

Name: Maria Ancona	Frequented places:			
	House	via Pampera, Imola		
	Work	Via Pietralata, Bologna		
	Friends Hangout	Via Mascarella		
Bio:	Means available:			
Maria, 26 years old, is a financial consultant at an agency located in the center of Bologna. It is her first job with a permanent contract after graduating with a degree in economics. She decided to live in Imola as the cost of rent is lower than in Bologna and commuting is cheaper in comparison. Her working hours are flexible, but she always tries to be in the office before 9 a.m. to have time around 5 p.m. to have an aperitif with friends and colleagues in his favorite bar, L'Ortica in Via Mascarella, before returning home.	TPer subscription for train and bus, private car, folding bike			
	Mobility Agenda:			
	7-9 a.m.	Arrival at work		
	9 a.m. - 5 p.m.			
	5-7 p.m.	Aperitif with colleagues		
	7-9 p.m.	Homecoming		

Name: Marco Ancona	Frequented places:			
	House	via Pampera, Imola		
	Work	Via Pietralata, Bologna		
	Friends Hangout	Via Mascarella		
Bio:	Means available:			
Marco, 26 years old, is a financial consultant at an agency located in the center of Bologna. It is his first job with a permanent contract after graduating with a degree in economics. He decided to live in Imola as the cost of rent is lower than in Bologna and commuting is cheaper in comparison. His working hours are flexible, but he always tries to be in the office before 9 a.m. to have time around 5 p.m. to have an aperitif with friends and colleagues in his favorite bar, L'Ortica in Via Mascarella, before returning home.	TPer subscription for train and bus, private car, folding bike			
	Mobility Agenda:			
	7-9 a.m.	Arrival at work		
	9 a.m. - 5 p.m.			
	5-7 p.m.	Aperitif with colleagues		
	7-9 p.m.	Homecoming		

Name: Simona Panieri	Frequented places:			
	House	via Nosadella		
	Work	Strada Maggiore, 45		
	Supermarket	Conad, via Sant'Isaia, 67		
	Friends Hangout	Mercato delle Erbe, via Ugo Bassi, 25		
Bio:	Means available:			
Simona, 33, works as a researcher at the University of Bologna. Since she was a child, she has suffered from an illness that forces her to use a wheelchair or crutches to get around. However, she has obtained a driver's license and her private car is equipped with all the necessary systems so that she can drive it without using her legs. She enjoys cooking and hanging out with friends.	Bus pass with discounts, private car specially adapted according to the needs of the owner.			
	Mobility Agenda:			
	8-9 a.m.	Expense	6-8 p.m.	Aperitif with friends
	9 a.m. -10 a.m.	Arrival at work	8-9 p.m.	Homecoming
	10 a.m.-5 p.m.			
	5-6 p.m.	Homecoming		

Name: Simone Panieri	Frequented places:			
	House	via Nosadella		
	Work	Strada Maggiore, 45		
	Supermarket	Conad, via Sant'Isaia, 67		
	Friends Hangout	Mercato delle Erbe, via Ugo Bassi, 25		
Bio:	Means available:			
Simone, 33 years old, works as a researcher at the University of Bologna. Since he was a child, he has suffered from an illness that forces him to use a wheelchair or crutches to get around. However, he has obtained a driver's license and his private car is equipped with all the necessary systems so that he can drive it without using his legs. He likes to cook and hang out with friends.	Bus pass with discounts, private car specially adapted according to the owner's needs.			
	Mobility Agenda:			
	8-9 a.m.	Expense	6-8 p.m.	Aperitif with friends
	9 a.m. -10 a.m.	Arrival at work	8-9 p.m.	Homecoming
	10 a.m.-5 p.m.			
	5-6 p.m.	Homecoming		

Name: Francesca Neri	Frequented places:			
	House	via Rialto		
	Work	Via Marconi		
	School	"Carducci" Primary School, via Dante		
Sports Centre	Energym Gym, via Scipione Dal Ferro			
Bio:	Means available:			
Francesca, 40 years old, is an employee at an accountant's office in Bologna. A former great lover of cycling, she now juggles work and her 8-year-old daughter, Rita. She takes her to school around 8 a.m., and then goes to work. Shortening her lunch break, Francesca leaves work around 4 p.m. to pick up Rita from school and take her to the gym where she practices artistic gymnastics. She then takes the opportunity to go shopping at the nearby "Coop" supermarket and returns home to prepare dinner. Her husband, Charles, picks up their daughter before dinner.	Own car, bicycle, moped. No bus pass.			
	Mobility Agenda:			
	7.30 a.m.-8 a.m.	Accompanying daughter to school	5-6 p.m.	Expense
	8-9 a.m.	Arrival at work	6-7 p.m.	Homecoming
	9 a.m.-4 p.m.			
	4-5 p.m.	Withdrawal of daughter from school, accompaniment to the Gym		

Name: Francesco Neri	Frequented places:			
	House	via Rialto		
	Work	Via Marconi		
	School	"Carducci" Primary School, via Dante		
Sports Centre	Energym Gym, via Scipione Dal Ferro			
Bio:	Means available:			
Francesco, 40 years old, is an employee at an accountant's office in Bologna. A former great lover of cycling, he now juggles work and his 8-year-old daughter, Rita. He takes her to school around 8 a.m., and then goes to work. The evening before dinner he picks Rita up from the gymnasium, where she practices artistic gymnastics. Although he tries to help his partner Carlotta with the housekeeping, his work schedule does not allow him to go shopping during the working week.	Own car, bicycle, moped. No bus pass.			
	Mobility Agenda:			
	7.30 a.m.-8 a.m.	Accompanying daughter to school	7-8 p.m.	Daughter withdrawal from the gym
	8-9 a.m.	Arrival at work	8-9 p.m.	Homecoming
	9 a.m.-6 p.m.			
	6-7 p.m.	Homecoming		

Name: Gabriela Romero		Frequented places:			
	House	Via Fornasini			
	Work	A) Via Farini B) Via Manin			
	School	"Casaralta" Primary, via Dante			
	Supermarket	ALDI, Via della Liberazione			
Bio:		Means available:			
Gabriela, 38, moved to Bologna with her husband Marcus and their first child in 2017. They left the Philippines in 2010 and lived for a few years in Rome and then in the Milan hinterland. Her husband was then hired by a company based in Zola Predosa and for this reason they decided to move to Bolognina, a working-class district of Bologna. Gabriela is a domestic worker and has to move to two or three different houses every day. Since her husband's schedule is not flexible, she also takes care of the two children and the house. The children both attend the "Casaralta" primary school and are 6 and 10 years old. She has not yet acquired a total command of the Italian language, but she is very integrated into the social fabric, especially in her neighborhood.		Public transport pass			
		Mobility Agenda:			
		7-8 hours	Arrival at Job A	4 p.m. - 5 p.m.	Withdrawal of children from school
		8-11 a.m.		5 p.m. - 6 p.m.	Expense
		11 a.m.-12 p.m.	Transfer from Job A to B	6 p.m. - 7 p.m.	Returning home with the children
		12 p.m. - 4 p.m.			

Name: Gabriel Romero		Frequented places:			
	House	Via Fornasini			
	Work	Zola Predosa			
Bio:		Means available:			
Gabriel, 38, moved to Bologna with his wife Maria and their first son in 2017. They left the Philippines in 2010 and lived for a few years in Rome and then in the Milan hinterland. Gabriel was then hired by an industrial cleaning company based in Zola Predosa and for this reason they decided to move to Bolognina, a working-class district of Bologna. He has to go to the workplace with his own vehicle and then move all day with the company's vehicle between the various tasks. He never manages to return home at a fixed time as the traffic between Zola Predosa and central Bologna is very variable, especially during rush hour.		Own car, bicycle. No bus or train pass			
		Mobility Agenda:			
		7.30 a.m.-8 a.m.	Arrival at work		
		8 a.m.-6 p.m.			
		6-7 p.m.	Homecoming		

Name: Giovanna Grandi	Frequented places:			
	House	Via Musolesi		
	Commissions	Cyrenaica District		
	School	Primary School "Mattiuzzi Casali", via Azzurra		
Bio:	Means available:			
Giovanna, 70 years old, was born and raised in Bologna. Married to Arnaldo, she has two grandchildren whom she takes care of. The eldest grandson is 8 years old and attends elementary school, while the 3-year-old stays at home with his grandparents all day. Giovanna takes the older man to school in the morning and picks him up in the afternoon. He usually goes to run small errands in the neighborhood shops: to the fruit and vegetables, to the baker and to the seamstress. After lunch, tidy up the house and prepare dinner for everyone. He is still able to drive the car, while on the bike and on foot he feels that he is starting to get tired.	Public transport pass, bicycle, own car			
	Mobility Agenda:			
	8-9 a.m.	Accompanying 8-year-old granddaughter to school	4 p.m. - 5 p.m.	Withdrawal of the grandchild from school
	9-11 a.m.	Errands	5 p.m. - 6	Homecoming
	11 a.m.-12 p.m.	Homecoming		
	12 p.m. - 4 p.m.			

Name: Giovanni Grandi	Frequented places:			
	House	Via Musolesi		
	Mail	Via Carlo Alberto Pizzardi, 17		
	School	Primary School "Mattiuzzi Casali", via Azzurra		
	Bar	Via Sante Vincenzi, 2/A		
Bio:	Means available:			
Giovanni, 70 years old, was born and raised in Bologna. Married to Teresa, he has two grandchildren whom he takes care of. The eldest grandson is 8 years old and attends elementary school, while the 3-year-old stays at home with his grandparents all day. Giovanni takes the older man to school in the morning and picks him up in the afternoon. He usually goes to the post office and runs small errands at neighborhood stores. In the afternoon, after lunch, he often goes to the café near his home where he gets together with friends to play cards and talk about sports. He often takes his youngest grandson with him. He is still able to drive the car, while on the bike and on foot he feels that he is starting to get tired.	Public transport pass, bicycle, own car			
	Mobility Agenda:			
	8-9 a.m.	Accompanying 8-year-old granddaughter to school	4 p.m. - 5 p.m.	Withdrawal of the grandchild from school
	9-11 a.m.	Mail	5 p.m. - 6	Homecoming
	11 a.m.-12	Homecoming		
	2 p.m. - 3 p.m.	Arrival at the bar		

Appendix B

HANDS ON MAP!

Game rules

Objective: The objective of Hand on Map is to efficiently plan and execute the daily mobility agenda of your persona, utilizing a combination of offline and online tools to minimize points spent on transportation.

Setup

- Form groups of 5 people
- Get your game kit: 1 map, sticky notes, color pen

1. Planning Phase

- Draw points of interest on a map representing the locations relevant to your persona's daily agenda.
- Analyze the agenda to identify the order of visitation and prioritize the points of interest.
- Consider the transportation options available for each part of the journey.

2. Execution Phase

- Each group must balance the use of transport modes private cars, public transport, bicycles, and walking to minimize the total points spent:
 - Private car trips cost = 30 points
 - Public transport trips cost = 20 points
 - Bicycle/foot trips cost = 10 points
- Participants can interact with real people for firsthand experiences (offline tool) or use public transport apps and online maps for information (online tool).

3. Balancing the Variables: speed, cost, and CO2 emissions

Optimize the route to achieve the best combination of speed, cost-effectiveness, and environmental sustainability. Consider trade-offs between variables and make strategic decisions to minimize overall impact.

- Speed (km/hours)
 - Participants must prioritize creating a fast route to complete the daily agenda efficiently.
 - Evaluate the time for each transport mode and choose the fastest option whenever possible.
 - Factor in traffic conditions, speed limits, and potential delays to optimize route speed.
- Cost of the Trip (euros/km)
 - Participants must consider the financial implications of each transportation choice.
 - Calculate the total cost of private car, public transport, bicycle, and walking trips based on ticket prices, fuel expenses, and any additional fees.
 - Aim to minimize costs while still meeting the speed requirement and minimizing CO2 emissions.
- CO2 Emissions (CO2 eq g/km)
 - Participants must take into account the environmental impact of their transportation choices.
 - Estimate the CO2 emissions associated with each mode of transport based on distance traveled and vehicle type.
 - Strive to reduce CO2 emissions by prioritizing eco-friendly transportation options such as walking, cycling, and public transport wherever feasible.

4. Scoring Phase

- Calculate the total points spent by each group based on the transportation choices made during the execution phase.
- Lower scores indicate more efficient route planning and utilization of transportation options.
- The group with the lowest - but reasonable - total points spent wins the challenge.

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Selene Tondini, PhD in Sociology and Social Research, develops her work at the intersection of environmental sciences and environmental sociology, with a strong focus on climate change. She has been actively involved in several EU Horizon and Life projects, where her research centers on participatory approaches to scientific inquiry, stakeholder engagement, and inclusive decision-making. Her work pays particular attention to the involvement of marginalized groups in climate action and policy processes, with the aim of fostering more democratic and socially just responses to the climate crisis.

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