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Ensure Value Sensitive Design Responsibly for Social Sustainability: A Case of E-Vehicle Design in Delhi, India

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Abstract. Pre-existing value-biases of the socio-technical landscapes percolate through the innovation process to the 'design' itself. This results in a skewed user pattern, as is the case with less visibility of women in India's emerging e-mobility system. The compromised 'social sustainability of the upcoming e-vehicles has an economic cost to innovators and an environmental cost to society. There is a need to identify these biases and anticipate the desired values from the stakeholder's perspective, to provide reflexive feedback to the innovators. This study's primary **objective** is to anticipate the gender-sensitive desired values from the women's perspective for future e-vehicles. This research study has used both secondary and primary data. For collecting primary data, a field study was conducted in Delhi. The research was designed by using the modified **RI Framework**. The RI framework was modified to make it conducive to the need of developing countries like India. Universe of the study included **stakeholders**- women, e-vehicle innovators & manufacturers, e-vehicle drivers. Survey and semi-structured interviews were conducted among the identified stakeholders along with a Focused Group Discussion with experts. Collected responses were transcribed and analyzed. The study has revealed the desired values of the- comfort, safety, aesthetics, cost, convenience, support & service quality. Each of these values has been defined based on the responses from the field study to make them practical, relevant, applicable, and ready to be embedded in the e-vehicle innovation process. These anticipated values need to be considered from the ideation level of the design of the future e-vehicles.

1 Introduction

The chronic transport poverty of Indian women is no hidden secret. There is plenty of work available regarding unsafe gender conditions in public transportation (Chowdhary, 2019). However, even a cursory observation of public transport systems shows the striking difference between the number of men and women commuters, the latter being far less. Transport poverty (Lucas et al., 2016) translates into poor gender development indicators, including access to education, employment, health facilities, and recreational activities. Case studies spread over the globe also indicate the existing subtle or explicit gender biases in the existing public transportations (Abenoza et al., 2018; Joseph et al., 2014; Kaufman et al., 2018). This brings us to the continuous social reproduction of the gender inequalities in transportation technologies resulting in compromised social sustainability. It is well established that along with

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environmental and economic aspects; the social aspect is equally important for having practical and effective sustainable technologies (Axelsson et al., 2013; Larsen and Jensen, 2019; Mehan and Soflaei, 2017; Missimer, 2015). Against this backdrop, the upcoming technologies in the transportation sectors are crucial for countering and disrupting the conveniently existing gender biases. The emerging E-Mobility-based transportation system is one such area of deep inquiry and action, especially in the current situation of the COVID-19 pandemic.

Public transport the world over is still suffering from the COVID-19 pandemic shock. The highly contagious nature and high mortality had an eroding effect on the safety perception of public transportation. Unfortunately, the pandemic hit hard the public transport when policymakers worldwide recognized it as a key strategic area of action for achieving the Sustainable Development Goals (SDGs). However, this rude shock to public transportation translated differently for men and women. It is well known that the mobility patterns and needs of women are different from that of men. For instance, the ‘care mobility’ (primarily by women) requires more ‘trip chaining’ than regular work trips (Mahadevia, 2017; Mahadevia and Advani, 2016). As a result, women need access to multiple modes of transportation for trip chaining. Further, due to patriarchy-guided cultural norms, the first right to a private vehicle and its use goes to the ‘male head’ of the family (Verma et al., 2016). In the same way, last-mile connectivity through affordable means of transportation is crucial for the smooth mobility of women commuters (Uteng and Cresswell, 2016). Thus, women being more dependent on Public transportation for mobility needs has been more severely affected by the impact of COVID-19 on public transportation. Even among women users of public transportation, the choices are shifting.

The COVID-19 induced norms of ‘social distancing are dictating the transportation choices of the commuters. The preference and demand shift is towards ‘individual mobility’, which is way more expensive than ‘collective mobility’ through public transportation (Bhaduri et al., 2020; Borkowski et al., 2021, p. 19; Dandapat et al., 2020, p. 19; Gajendran, 2020, p. 19). This situation is even more unique to Delhi, where the field survey was conducted. In Delhi, as a part of the government’s strategy to enhance women's safety in public transportation, all public buses were made free for women. The argument was that with more affordability, more women would choose public buses, and inclusion of more women commuters in public buses would lead to gender-sensitivity in public transportation (“Free rides for women in public transport is part of Delhi govt’s push to make city safe | The Indian Express,” n.d.). However, the COVID-19 has a drastic impact on the notion of safety, leading to an exponential rise

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in the demand for Hygiene[1]. On the other hand, there is legitimate skepticism towards public transport's (especially public bus transport system) capacity towards achieving hygiene standards or maintain the social-distancing norms. Private vehicle-based mobility models increasingly occupy this gap between demand and supply. The latest data on car sales in Delhi has shown a steep rise despite the economic slowdown ("India," n.d.). Further, families are planning to purchase a second vehicle to address the need for private individual mobility. Similarly, popular taxi operators like OLA and Uber are aggressively campaigning for their superior hygiene standards. The individual mobility-based mode of transportation is environmentally unsustainable as vehicular pollution is already identified as the most crucial factor behind Delhi's air pollution woe (Bhalla et al., 2019). Thus, there is a need to think about affordable and sustainable models of transportation.

Initial trends in emerging E-Mobility systems have exhibited the promise of addressing multiple concerns. On the face of it, battery-operated vehicles are considered environmentally friendly. The smaller affordable vehicles are also considered a solution for the last mile connectivity for congested city lanes. In view of the approaching timeline of SDG's government is also promoting E-Mobility with various policy incentives (Delhi, 2015; "Union Budget 2019-20: Steps taken to boost production of electric vehicles," n.d.). An excellent example is e-rikshaws in India, which has become the most important transportation mode for last-mile connectivity in big cities, remote and smaller towns having a fair share of women in big cities and smaller towns users (Singh et al., 2021). However, the gender bias is clear from the fact that nearly all e-rikshaw drivers are male. Similarly, the e-bike and e-cars, ownership, and use exhibit strong gender biases, which have been discussed in detail later in this paper. This indicates the embedding of the social biases in the upcoming E-Mobility sector in terms of technology, design, and economy. Despite being functional to everyday practical needs, the gender response towards the e-vehicles has not been enthusiastic. Even in affordable e-vehicle rental services like Yulu[2], the

[1] Hygeine: In the context of ongoing pandemic of COCID-19, hygeine has become an important criterion for transportation choice influencing criteria in comparison the pre-pandemic time. The concept hygeine also broadened as earlier it was related with the general cleanliness, but now regular sanitization, social-distancing norms and availability of masks and hand sanitizers are also the part of the hygeine. These indicators of hygeine have an overlapping with indicators of safety and comfort of the commuters.

[2] Yulu bikes: Yulu bike service was launched in September 2019 in Delhi. Yulu provides the rent-based e-bike service for which the customer needs to download the companies App and pay the rent online on hourly bases. After use the e-bike needed to be dropped at fixed dropout points. Yulu bike is a single seat vehicle without any carriage and have maximum speed of 20 KM per hour. Yulu has opened up near metro stations but very few people are seen riding this e-bike and women riders are even more rare. Most of the Yulu users are young students.

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women's ridership is very low. Since E-Mobility can address present challenges for sustainable transportation, the natural question is why the diffusion of E-vehicles among women is slow? There is a need to identify the gender-sensitive values from the women's own perspective for the value-sensitive design of the upcoming e-vehicle. This could be a win-win situation for women commuters as well as innovators. The current transition phase in transportation towards E-Mobility offers the opportunity to embed gender-sensitive values in the innovation process itself (Kumari and Singh, 2019). It is crucial to identify the gender concerns, needs, and demands, even wishes for having a gender-sensitive mobility system in the future. The following section has discussed the research design and methods used to identify the relevant values for a socially sustainable E-Mobility system.

2 Research Design and Methods

A field survey was conducted in Delhi to collect the relevant primary data. The Responsible Innovation (RI) framework is used to design the research. However, there are multiple types of RI frameworks (Armstrong et al., 2012; Blaskó et al., 2014; Burget et al., 2017; Fitjar et al., 2019; Von Schomberg and Hankins, 2019), a particular RI framework (Singh and Kroesen, 2012a) specific to the needs of developing countries is adopted for this research. This specific framework of RI has the simultaneous dimensions of, Anticipation, Responsiveness, Reflexivity, Deliberation, and Participation for achieving sustainability in technological innovations (Singh and Kroesen, 2012b). It must be noted that in the RI framework, sustainability includes not only economic sustainability and environmental sustainability but also social sustainability. The focus of the adopted RI framework is identifying the relevant values from the stakeholder's perspective and embed identified values at the ideation level of the innovations. Thus, resulting in the inherently value-sensitive design of the upcoming technologies. For this research work, a field survey was designed by keeping the five dimensions in mind. The universe of the study is the women users of public transport in Delhi, and the sample size is 500. A semi-structured questionnaire was administered to the selected sample. The questionnaire broadly had two types of questions. First related to Identifying the barriers in the diffusion of e-vehicles from women's own perspective, and second related to future expectations from the e-vehicles. Within the emerging E-Mobility system, questions focused on e-rikshaw, e-bikes (rental and private), and e-cars. The collected responses were analyzed for anticipation of the desired values for the future e-vehicles. Focused Group Discussion (FGD) with relevant field experts was also utilized to identify the pathways for value-sensitive future e-vehicles. Six experts from sustainability, science policy, NGO working for women safety, innovating firm, and public health expert participated in the

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FGD. In the spirit of the RI framework, this work has used some methodological novelties to maintain reflexivity and participation. For instance, the field survey is three tired- the first round 500 women respondents were approached twice again for their feedback on the findings. For the second and third rounds, the response rate is 38% and 86%, respectively. This method kept the feedback loop live throughout the research and maintained the reflexivity and responsiveness of the research process. The following section discusses the significant findings from the field survey.

3 Findings and Discussion

The findings from the field study are arranged into three broader categories as- Identifying the barriers in the adoption of e-vehicles from women's perspective, anticipated desired values for future e-vehicles, and pathways for faster adoption of e-vehicles among women.

3.1 Barriers in Adoption of E-vehicles

The respondents were asked to list the issues with e-vehicles and rate these issues regarding the significance of a specific issue. Issues listed by most of the respondents are related to Design, Economy, Charging Infrastructure, Weather, Speed, and Hygiene. The ratings of the various identified barriers are given below in figure 1.

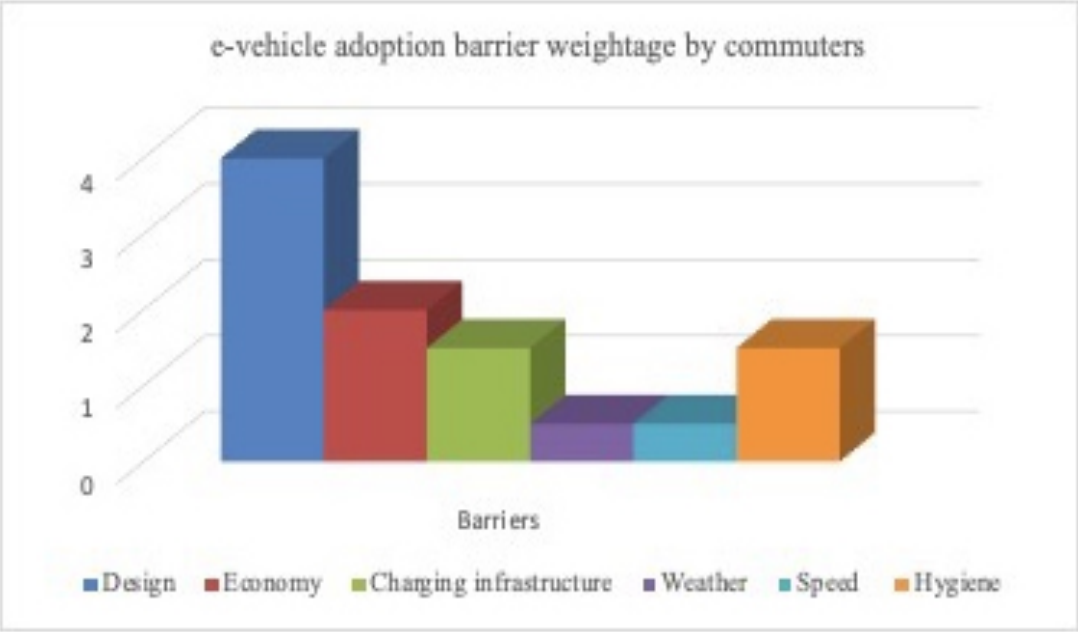

Fig.1. Rating of various barriers by respondents.

It is interesting to note that none of the respondents own an e-car, and very few were interested in buying it shortly. For example, a young student respondent stated that

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"*buying an e-car is like keeping a white elephant; it's expansive, very slow, and there is no charging infrastructure in my parking lot. It may be environment friendly, but petrol cars are more functional*". This reflects the general attitude of the majority of respondents, as they acknowledge the environmental benefits of e-vehicles but do not consider them adequate for everyday needs related to mobility.

However, the case of the e-rikshaws is very different as most of the respondents consider it an affordable and safe solution for mobility needs of short distances. But, when women respondents asked whether they would prefer to drive an e-rikshaw (as occupation), the majority response was negative, and the reason for such reaction can be easily traced to the identified barriers. To quote one former e-rikshaw driver, woman respondent, "*e-rikshaw is not designed for women drivers, it's open from all sides with no privacy. There is no protection from heat, cold, or even monsoon rains. But, most importantly, the charging stations were dominated by male drivers. I was the only female driver, and it felt very uncomfortable; in the end, I gave up*". Similarly, the respondents were not enthusiastic about e-bike rental services mostly located near metro and bus stations for last-mile connectivity functions. Yulu bike is one of such rental bike services studied for this research. Responding women were primarily critical of the bike's design as it does not have any attached carrier basket or second seat. The requirement of care mobility is not kept in mind while designing the e-bike. Thus, many women termed e-bikes as a 'fun' vehicle than being a utility vehicle. One respondent stated that "*first, I need to download the app then pay online, its expansive, I wear sari it is tough to sit crossed leg, and without a second seat, I can't take my child with me. They should know our culture and needs beforehand*". However, few respondents thought of e-bikes as more hygienic (in the context of COVID-19) as it provides the affordable individual mobility option compared to the shared mobility of e-rikshaws. Yet, almost all respondents expressed a desire for a better design of the e-bikes.

3.2 Anticipated Desired Values

The responding women were asked about their expectations and wishes from the future e-vehicle. Identification of such expectations is crucial for meaningful input to the innovating firms and making e-vehicles more appealing to the women commuters (Kumari, 2017). The initial response was towards the changes in the designs of existing e-vehicles (e-bikes & e-rikshaws) and cutting down on the costs of the e-cars. In the second and third rounds of feedback, more specific details related to the design of the e-vehicles became clear. All the responses are clubbed together in terms of the specific values, which are defined based on the responses collected. The identified values include Safety, Affordability, Hygiene, Comfort, and Support. These values are not mutually exclusive and are having some overlapping indicators. For instance, Hygiene

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is also part of Safety and Comfort, yet it has some specific underlying indicators. However, it has been found that different values are considered more significant for different modes within E-Mobility. In the case of e-cars, the value expectation is for affordability and support. Affordability is about cost, maintenance, and access to government subsidies. At the same time, the value of support is about the expectation of robust charging infrastructure (which is considered as currently inadequate) and future upgrades of the vehicle. The values of safety, Hygiene, and comfort were found to be more significant for e-rikshaws. All these values are related to the physical design and operation of the e-rikshaws. For example, the safety from tripping from e-rikshaw or protection from Delhi's harsh weather conditions can be addressed by changing the design of e-rikshaws. Further, respondents expressed the desire that some sort of sanitation mechanism must be installed in the e-rikshaws to provide for shared mobility. In the case of e-bikes (for rental), the respondents mainly emphasized the need for comfort in the design, including a second seat, a carriage basket, and some inbuilt balancing. One respondent observed that "*like most of my female friends, I grew up without any basic training in cycling. It's anyways difficult to ride a two-wheeler in the crowded streets of Delhi. I fear that I won't be able to balance and fall down*". Such a response indicates the cultural gender discrimination in mobility training. Therefore, innovating firms need to keep in mind such cultural nuances while ideating on future e-bikes. Another point in an e-bike is related to the aversion towards the app-based rental models. As many respondents pointed out that, there are multiple apps, and each one can't be downloaded due to data limitations. Thus, there is a need to think the alternative models for making e-biking a success among women commuters.

3.3 Pathways for Faster Adoption of E-vehicles

This section is based on the outcomes of the FGD, which was conducted on the broader theme of identifying the strategy for government policy and innovating firms. Currently, the government in Delhi provides a substantial subsidy on the purchase of e-vehicles like two-wheelers and cars. Despite the subsidy, the sale of e-vehicles is still poor ("Growth of EV Sales in India Consistent Since Past Three Years; 1,67,041 Units Sold in 2019-20," 2021), clearly indicating that this strategy is not working. Thus, there is a need for an alternative policy of incentivizing the innovation process in the E-Mobility sector. Experts were of the view that subsidies should be directed towards the responsible innovations in e-vehicles for achieving value-sensitive designs. Government schemes also support the social innovators and enhancing women's mobility is one such area of action. But at times, these schemes are reduced to tokenism. Therefore, there is a need to combine social innovations with responsible innovation processes (Bolz and de Bruin, 2019). It also came into the discussion that instead of pushing the sales of e-vehicles, making future e-vehicles appealing to

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people would automatically boost the faster adoption. It is crucial for the economic sustainability of innovative firms to adopt a value-sensitive approach for designing the future e-vehicles. Further, there is a need for the continuous operation of the feedback loop from stakeholders for a responsible innovation process so that reflexivity and responsiveness of the e-vehicle designs could be maintained. In short social sustainability of the e-vehicles is crucial for the economic survival of the innovating firms.

4 Conclusion

The most important finding of this research is the significant role of the 'design' in the adoption of e-vehicles by women users. The design includes physical aspects, technology, supporting infrastructure such as a charging network, and making the design of the future e-vehicle conducive to the needs and demands of the women-centric mobility will effectively enhance the chances of faster adoption of e-vehicles. In this direction, government policies directed towards encouraging responsible innovation processes can play a positive catalytic role. Gender equity is an essential part of social sustainability, which in turn is crucial for the economic sustainability of E-Mobility. Thus, there is a need to promote value-sensitive design in a responsible manner in the E-Mobility sector.

References

Abenoza, R.F., Ceccato, V., Susilo, Y.O., Cats, O., 2018. Individual, Travel, and Bus Stop Characteristics Influencing Travelers' Safety Perceptions. Transp. Res. Rec. 2672, 19–28.

Armstrong, M., Cornut, G., Delacôte, S., Lenglet, M., Millo, Y., Muniesa, F., Pointier, A., Tadjeddine, Y., 2012. Towards a practical approach to responsible innovation in finance: New Product Committees revisited. J. Financ. Regul. Compliance 20, 147–168.

Axelsson, R., Angelstam, P., Degerman, E., Teitelbaum, S., Andersson, K., Elbakidze, M., Drotz, M.K., 2013. Social and cultural sustainability: Criteria, indicators, verifier variables for measurement and maps for visualization to support planning. Ambio 42, 215–228.

DOI: 10.3217/978-3-85125-855-4-14

Bhaduri, E., Manoj, B.S., Wadud, Z., Goswami, A.K., Choudhury, C.F., 2020. Modelling the effects of COVID-19 on travel mode choice behaviour in India. Transp. Res. Interdiscip. Perspect. 8, 100273.

Bhalla, N., O'Boyle, J., Haun, D., 2019. Who Is Responsible for Delhi Air Pollution? Indian Newspapers' Framing of Causes and Solutions. Int. J. Commun. 13, 24.

Blaskó, B., Lukovics, M., Buzás, N., 2014. Good practices in responsible innovation.

Bolz, K., de Bruin, A., 2019. Responsible innovation and social innovation: toward an integrative research framework. Int. J. Soc. Econ.

Borkowski, P., Jażdżewska-Gutta, M., Szmelter-Jarosz, A., 2021. Lockdowned: Everyday mobility changes in response to COVID-19. J. Transp. Geogr. 90, 102906.

Burget, M., Bardone, E., Pedaste, M., 2017. Definitions and conceptual dimensions of responsible research and innovation: A literature review. Sci. Eng. Ethics 23, 1–19.

Chowdhary, D.R., 2019. Opinion: Women Safety issues in Public Transportation of Delhi. Urban Transp. News. URL https://urbantransportnews.com/opinion-women-safety-issues-in-public-transportation-of-delhi/ (accessed 7.23.19).

Dandapat, S., Bhattacharyya, K., Annam, S.K., Saysardar, K., Maitra, B., 2020. Impact of COVID-19 Outbreak on Travel Behaviour: Evidences from early stages of the Pandemic in India. Available SSRN 3692923.

Delhi, S.I.-N., 2015. Fame-India Scheme—Putting E-Mobility on Road. Auto Tech Rev. 4, 22–27.

Fitjar, R.D., Benneworth, P., Asheim, B.T., 2019. Towards regional responsible research and innovation? Integrating RRI and RIS3 in European innovation policy. Sci. Public Policy 46, 772–783.

Free rides for women in public transport is part of Delhi govt's push to make city safe | The Indian Express [WWW Document], n.d. URL https://indianexpress.com/article/opinion/columns/free-metro-for-women-safety-gender-violence-rapes-bonanza-5781490/ (accessed 9.28.19).

Gajendran, N., 2020. Impact of novel Coronavirus (COVID-19) pandemic on travel pattern: A case study of India. Indian Jour-Nal Sci. Technol. 13, 2491–2501.

DOI: 10.3217/978-3-85125-855-4-14

Growth of EV Sales in India Consistent Since Past Three Years; 1,67,041 Units Sold in 2019-20 [WWW Document], 2021. URL https://www.news18.com/news/auto/growth-of-ev-sales-in-india-consistent-since-past-three-years-167041-units-sold-in-2019-20-3543386.html (accessed 6.19.21).

India: number of registered vehicles in Delhi 2020 [WWW Document], n.d. . Statista. URL https://www.statista.com/statistics/665712/total-number-of-vehicles-registered-in-delhi-india/ (accessed 4.12.21).

Joseph, M.G.C., Kirchhoff, G.F., Barkhuizen, J., 2014. Asian passengers' safety study: the problem of sexual molestation of women on trains and buses in Chennai, India. Acta Criminol. South. Afr. J. Criminol. 27, 57–74.

Kaufman, S.M., Polack, C.F., Campbell, G.A., 2018. The Pink Tax on Transportation 9.

Kumari, S., 2017. Responsible Research & Innovation Pathwayfor the Future of Sustainability of E-Mobility 11.

Kumari, S., Singh, R., 2019. E-Mobility Through RRI to Achieve Social Sustainability: A Case Study of Women Commuters of Delhi, India 16.

Larsen, N.B., Jensen, L.B., 2019. Current work on social sustainability in the built environment, in: IOP Conference Series: Earth and Environmental Science. IOP Publishing, p. 012063.

Lucas, K., Mattioli, G., Verlinghieri, E., Guzman, A., 2016. Transport poverty and its adverse social consequences, in: Proceedings of the Institution of Civil Engineers-Transport. Thomas Telford (ICE Publishing), pp. 353–365.

Mahadevia, D., 2017. Gender sensitive transport planning for cities in India. Low Carbon Transp. India Proj.

Mahadevia, D., Advani, D., 2016. Gender differentials in travel pattern–The case of a mid-sized city, Rajkot, India. Transp. Res. Part Transp. Environ. 44, 292–302.

Mehan, A., Soflaei, F., 2017. Social sustainability in urban context: Concepts, definitions, and principles. CRC.

Missimer, M., 2015. Social sustainability within the framework for strategic sustainable development (PhD Thesis). Blekinge Tekniska Högskola.

DOI: 10.3217/978-3-85125-855-4-14

Singh, R., Kroesen, O., 2012a. Understanding responsible innovation from developing countries perspectives, in: The 2nd Conference on Responsible Innovation 2012.

Singh, R., Kroesen, O., 2012b. Understanding responsible innovation from developing countries perspectives, in: The 2nd Conference on Responsible Innovation 2012.

Singh, R., Mishra, S., Tripathi, K., 2021. Analysing acceptability of E-rickshaw as a public transport innovation in Delhi: A responsible innovation perspective. Technol. Forecast. Soc. Change 170, 120908.

Union Budget 2019-20: Steps taken to boost production of electric vehicles [WWW Document], n.d. URL https://urbantransportnews.com/union-budget-2019-20-steps-taken-to-boost-production-of-electric-vehicles/ (accessed 9.25.19).

Uteng, T.P., Cresswell, T., 2016. Gendered mobilities: towards an holistic understanding, in: Gendered Mobilities. Routledge, pp. 15–26.

Verma, M., Manoj, M., Verma, A., 2016. Analysis of the influences of attitudinal factors on car ownership decisions among urban young adults in a developing country like India. Transp. Res. Part F Traffic Psychol. Behav. 42, 90–103.

Von Schomberg, R., Hankins, J., 2019. Introduction to the International Handbook on Responsible Innovation, in: International Handbook on Responsible Innovation. Edward Elgar Publishing.