

## **E-Mobility Through RRI to Achieve Social Sustainability: A Case Study of Women Commuters of Delhi, India**

**Swati KUMARI, Rajbeer SINGH**

Centre for Studies in Science Policy, Jawaharlal Nehru University, New Delhi, India

### **Abstract**

Due to various external and internal factors, the Public Transport System (PTS) is at the cusp of transition in Indian cities. In the current socio-technical landscape, the big question is how this transition should be guided towards social sustainability. For this purpose, the innovation process starting from the ideation level should have certain identified desirable values at its core. How to embed these values in the innovation process is the main focus of this research work. This research paper has been divided into four parts. Part one is focused on introducing the research problem in the contextual background of the policy, economy, technology, and cultural aspects to pave the way for the field study. Part two has discussed in detail Responsible Research and Innovation (RRI) as a theoretical framework along with rationale for selecting this framework and need of further developing this framework to suit the need of the different social, cultural and economic contexts. Part three has discussed the field study which is done in the city of Delhi (India). Primary data has been collected through in-depth face to face interviews with women commuters of the PTS in Delhi. Part four has brought forward the insights from the field study and policy suggestions which can make adoption of E-Mobility more socially sustainable along with providing a pathway for a smooth transition from the current environmentally unsustainable fossil fuel-based technology used in the PTS.

### **1 Introduction**

Delhi is one of the world's most populated cities with large and complex Public Transport System (PTS). The PTS in Delhi is an amalgam of road transport including buses, auto-rickshaws, small vehicles, etc., along with rail network and ever-expanding metro train connectivity network. Still, road PTS plays a significant role in the mobility of people including the last mile connectivity which is very critical for the unrestrained mobility in the congested city like Delhi. Within road PTS, new trends are emerging to fulfill the need of commuters as well as to address environmental concerns(De et al., 2017; Harding, 2017;

Harding and Kandlikar, 2017). The new emerging transport systems in Delhi have witnessed a series of challenges for commuters, residents, policymakers, the environment, and investors (Aggarwal and Jain, 2016; Lucas et al., 2016; Paget-Seekins, 2015; Rizvi and Sclar, 2014). Some of the issues are related to the social and legal aspects of human life. One such issue is women's 'safety'. In December 2012, gruesome sexual assault (popularly known as the Nirbhaya-Kand) on a woman, in a bus, created a wave of protests across the nation. This public demand created pressure for many safety steps by the government. Yet, the perception studies shows that there is no improvement in the woman's perception of the road PTS in Delhi (Bharucha and Khatri, 2018; Gopal and Shin, 2019; Govinda, 2019; Madan and Nalla, 2016; Nieder et al., 2019; Zietz and Das, 2018) which indicates the gap between the 'policy at paper' and 'policy in operation'.

There are other associated culturally complex issues. For example, it was found in Indian cities that women are more dependent on public transport than men (Verma, 2015; Verma et al., 2016 ). Due to prevalent patriarchy guided societal norms, the first right to a private vehicle is often going to the male members in the family. Further, the intermediate public transport such as auto-rickshaws becomes very important for the mobility of the women in cities (Mahadevia and Advani, 2016). Despite women's more dependence on public transport, Delhi has performed very poorly on women's safety in PTS. For instance, in the report in 2014, Delhi ranked 4th unsafe city in PTS for women (Foundation, n.d.). As such, poor mobility planning can lead to a situation where it hampers women's full and free access to employment, social support networks, health facilities, recreational and sports facilities (Hamilton and Jenkins, 2000; Natarajan, 2016). Similarly, the media reports, along with personal experiences of women, act as a demotivation for using public transport. For example, it was found that instances of the so-called 'eve-teasing' hamper the young girl's access to educational institutions by using public transportation (Dhillon and Bakaya, 2014; Natarajan, 2016). Such instances have far-reaching consequences. As it has been found that harassment in the PTS has resulted into the emergence of the phenomena of the 'private student' in the peripheral areas of the city, which is only for the social sciences, as result denying the young girl students opportunities in education and

career in sciences<sup>1</sup>. In the present situation the concern for the 'safety' get priority over the need for mobility (Fernando and Porter, 2002; Mahadevia and Advani, 2016; Srinivasan and Rogers, 2005). Therefore, a responsive, gender-sensitive PTS is critical for women empowerment in the cities.

The other dimension is sustainable urban development which is also a part of the identified Sustainable Development Goals (SDGs), which India supposed to achieve by 2030. Inclusive, safe and environmentally sustainable, the public transport system is an indispensable part of 'sustainable urbanization' and stated as one of the objectives of the national program on the Smart Cities (Cervero, 2016) as well. In the past decade, Delhi has faced severe air pollution, of which vehicular pollution has been identified as a major contributing factor (Bhalla et al., 2019; Bhanarkar et al., 2018; Tiwari et al., 2018). There are two dimensions to this problem, one is related to an increasing number of private vehicles. The other associated factor is that current PTS failed to cater to the rising demand for mobility. In this context, the government has envisaged adopting e-mobility by 2030 for the public road transport system. Though the mission was launched in 2013, it has accelerated after the government's FAME scheme in 2015-16. Further, in the light of achieving the SDGs by 2030, the mission is expected to garner the thrust in 2020 (Delhi, 2015). This mission of adoption of e-mobility by 2030 would demand a better understanding and embedding of women's safety as part of the new public transport system (Hopkins and Higham, 2016). There is a need to look into future transport demands and patterns and the meaning of travel for better mobility planning. Making

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1. 'Private student' is a unique phenomenon specific to the Indian education system. In the educational institutions including schools (offering education in the 10th and 10+2) and colleges for graduation, have the category of the 'private student' for student enrollment. Students registered under this category are exempted from attending the regular classes held at the respective educational institution. This provision has been provided keeping an eye on the socio-economic realities of the society. For instance, girls who are also burdened with domestic work are not able to attend the classes, as a result, they are denied an educational degree altogether. Such students can study at home and can appear directly for the exams. However, the provision of private students is only for social sciences subjects. Under the Indian education system, a science subject students must attend the classes on 'laboratory experiments' regularly. Lack of 'safe mobility' options from home to education institution is found to be one major reason behind girl students opting for the 'private student' category. Lack of safe mobility is also a reason behind that ninety percent of the enrolled private students in Delhi are women. This fact also translates into the poor presence of women students in the discipline of science.

public transport safe and accessible would enable women to commute regularly to educational institutes, workplaces, and communities without the fear of being socially, psychologically or physically exploited. Thus, a public transport system with embedded women's safety would enhance the functionality, productivity, participation, confidentiality of women as part of society and economy.

The 'safety aspect' has also impact on the number of commuters choosing the bus PTS. It has been found that despite the rising city population the ridership in the public buses has gone down in the past decade (Suman et al., 2017, 2016). This brought us to the fact that current PTS does not address the needs and issues of the women commuters. Gender studies often talk about the 'denial of agency to the women' (Mosedale, 2005; Rahman and Rao, 2004) as both cause and effect of the poor development among women. Exclusionary PTS, by restricting the mobility of the women, is an important factor in denying the agency to women which have adverse cumulative effects on various dimensions of life. Some studies talk about 'transport poverty' and its social consequences (Cervero, 2016; Lucas et al., 2016). Yet, women face various issues in accessing public transportation freely, which leads to the exclusion of women from social and economic spheres by limiting their participation opportunities. Such, gendered exclusion is fundamentally antithetical to the goal of sustainable urbanization (Mills, 2015; Reeves, 2014; Williams, 2017). Though the term 'sustainability' embraces three equally important aspects of environmental, economic and social, yet the social aspect has not been developed much particularly in the developing countries especially in the urban context (Axelsson et al., 2013; Larsen and Jensen, 2019; Mehan and Soflaei, 2017; Missimer, 2015). Despite this, certain parameters are agreed upon as an inseparable part of social sustainability. Social inclusion, the fulfillment of basic needs such as employment, equity and future orientation are some of them (Mani et al., 2016; Mehan and Soflaei, 2017). Therefore, the future e-mobility PTS in India must include the women-centric values to be socially sustainable. There are various studies located in the Indian cities which have focused on the economic and environmental aspect of the e-mobility, but the social aspect has been neglected on which this research paper is focused.

'Women's safety' as a part of public safety and as well as part of inclusive mobility opportunities have emerged as significant issues for public transportation planning and policy during the last decade in India. The major identified issue is a lack of common

understanding of the concept of women's 'safety in public transport'. This is a wicked problem, as even the problem itself is not clear (Buchanan, 2010, 1992). For instance, the problems faced by women in PTS, against which the concept of safety of women could be constructed are not identified from the first-person perspective. This issue becomes more complex with a new emerging transportation system by transitions from old public transport systems. The new technology and innovations are bringing more challenges to the concept and issues of women's safety. However, as of now, there is no existing consensus on the concept of 'Women's Safety' in PTS. The women's safety in the workplace, house, educational institutes, and public transport systems would vary significantly. Moreover, the concept of 'Women's Safety' would also vary from Women and Men's perspectives. The understanding of women's safety would be different when we consider experiences of different age group females (school-going girls, College going girls, Working Girls below the age of 20 years, working women, etc.) and public. Similarly, the 'safety' also varies with time. For example, the concerns regarding safety are different during day and night time. It means the different meanings of women's safety would lead to different futures of women's safety. There is a challenging task of reconciling these different futures of women's safety into concrete concepts.

Therefore, this research has explored the contested concept of 'women's safety' in public transport systems by the inclusion of women's perspectives and experiences as commuters in the PTS. At the same time, it is important to keep in sight the experiences of other stakeholders as well. The other issue is about the non-inclusion of empathetic understanding and women's experience about Women's Safety as 'value' in public transport systems from policy designing to deployment level. As the sociologist, Talcott Parsons noted that "values exert pressure on the empirical reality, thus, intangible values effectively mold the tangible manifest action"(Parsons, 1978, p. 98) Values play a most important part in guiding the behavior, actions, and perceptions. This lack of empathetic understanding about women safety as 'value' among the designers, innovators, planners, and policymakers deprives the PTS of becoming adaptive to the needs of women for their safety. Another serious issue is the lack of enough evidence, research results, non-participation of women in innovation and technology adoption as well as less representation to women among relevant policymakers. Therefore, there is a need for including the women's experience and women's safety as 'value' in the whole process of

adoption of the new transport system. Though the science, technology and innovation policy (2013) has emphasized the inclusion of gender and social aspect for the deployment of innovations and technology to ensure social sustainability (Axelsson et al., 2013; Missimer, 2015). But, the ways and mechanisms that how to include the aspect of social sustainability as part of public transport systems are not identified or understood. further, there is not enough understanding regarding, how innovation policy would have to enable the effect on women's safety in public transport systems. There is a need to take care of such issues at the policy design and planning level.

## **2. Theoretical Framework: Responsible Innovations**

A suitable theoretical framework is critical for the successful completion of the research. The process of the selection of the theoretical framework is very important in itself. After literature review gaps are identified based upon which research problem is formulated, but it is the theoretical framework that offers the guidance for achievement of the research objectives in a systematic manner. Since the research problem is centering around the technological evolution in PTS in the form of e-mobility, 'Innovation Studies' frameworks offered an opportunity to study the changes. Within Innovation Studies, various frameworks were analyzed for suitability. The Systems Perspective including Sectoral Innovation were carefully considered (Bergek et al., 2015, 2008; Breschi and Malerba, 1997; Carlsson et al., 2002). One of the key limitations among these frameworks was the lack of the focus on the innovation 'process' itself, which is central to the core 'idea of embedding the women's safety as a value' to future e-mobility PTS. At the same time, this work is dealing with the 'wicked problem' where the clarity over the problem itself would require the inputs from the field (Head, 2018; Termeer et al., 2019). For instance, threat and the potential threat to the future of women safety in e-mobility PTS is not identified from the women's perspective, without which any conception of women's safety largely remains superficial. However, the responsible innovation framework, especially amended to suit the needs of developing countries (Setiawan and Singh, 2015), has provided a way forward to address such 'action-oriented research'.

In the developing countries, the primary objective of the innovations is largely constituting the eradication of poverty and underdevelopment. As a result, a theoretical framework with features responsive to such needs of society is needed. Therefore in the context of the

developing countries, a Responsible Innovation framework essentially includes key dimensions such as Anticipation, Reflexivity, Deliberation, Responsiveness, and Participation (Singh and Kroesen, 2012). These five dimensions enable the sustainability analysis of the new technologies. Here it must be noted that sustainability to be effective and practical includes social, economic and environmental sustainability (Koops, n.d.).

The responsible innovation (Armstrong et al., 2012; Blaskó et al., 2014; Burget et al., 2017; de Jong et al., 2015; Macnaghten et al., 2014; Muniesa and Lacoste, 2012; Owen et al., 2013a, 2013b, 2012; Ravesteijn et al., 2014; Setiawan and Singh, 2015; Singh and Kroesen, 2012; Van den Hoven, 2013; Von Schomberg, 2013; Zahinos et al., 2013) and design thinking (Chou, 2018; Plattner et al., 2012; Stickdorn et al., 2011; Warnecke, 2016) framework is capable of offering ground level evidences for meaningful policy on the desired future scenario. For this research work, responsible innovation is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (Von Schomberg, 2007). A collective commitment of care for the future through responsive stewardship of science and innovation in the present (Owen, Stilgoe, Macnaghten, Gorman, Fisher, and Guston 2013) is essential. Being caring or ensuring care for certain values (such as women's safety) for social, economic and environmental sustainability by engaging in anticipation, reflexivity, deliberation, responsiveness and participation for bringing up any change in the existing public transport systems to bring them in specific market or use in specific society (Indian)(Setiawan and Singh, 2015; Singh and Kroesen, 2012) is the framework for this study. The responsible innovation framework focuses on the Certain Values, which include Universal and Culture-Specific Values, along with five dimensions. The Value of 'Women's Safety' has both aspects – Universal and Culture-specific meanings. Due to this variability in the socio-cultural public perception of women's safety, the threats and issues also vary. The responsible innovation framework through its interactive transparent process help in navigating through these socio-cultural varieties by engaging in i) Anticipation- an act of forwarding looking, plausibility or foresight and helps in decisions about usage and adoption, funding, regulation, and policy issues. ii) Reflexivity Creating and shaping innovations at different stages. iii) Deliberation- exploring and carefully considering various aspects and discussions. iv) Participation- involvement of stakeholders in the innovation

process. v) Responsiveness- the reaction and response of the process towards different needs, views, issues, and values. Anticipation emphasizes the 'foresight' for different aspects of the innovation including the possible impacts. Such foresight shall help in the innovation process, adaptation, and diffusion of innovations. Such an exercise is also important for minimizing the risk associated with the implementation of new technologies, as a result providing higher ethical credibility to the new technologies (Hoven, 2014). The dimension of reflexivity correlates with the empathetic understanding of the cause and effects. Here for a broader perspective 'influences' are also taken into account (Owen et al., 2012). All these dimensions of responsible innovation framework provided the suitable analytical framework to make innovation process inclusive and providing inputs from the field level for effective, inclusive, evidence-based policy on e-mobility based public transportation system in Delhi and India. The framework also constitutes goals of sustainability (Voegtlin and Scherer, 2017) for the innovation process which includes Social sustainability, Environmental sustainability as well as Economic Sustainability. This paper, as discussed earlier is focusing on Social sustainability (Fisher, 2017; Missimer, 2015) as its main objective without compromising on economic and environmental sustainability.

### **3. Field Study**

For collecting the primary data field study was conducted in the 'Munirka' area of South Delhi. There are multiple reasons for the selection of this particular site. The infamous 2012 rape and murder of a woman, happened in the vicinity of this area only. Poor public transport infrastructure and the facility were identified as one of the causal factors by an expert committee on the incident (Atluri, 2016). Another important factor is that this area, though part of South Delhi, forms the periphery of transport route connecting to the neighboring, fast-expanding city of Gurugram (part of Haryana state) therefore, witnesses the interstate routine mobility. It is also important to note that the economic profile of the women commuters (who are using the public buses) is mostly lower income levels and most of them engage in the service sectors. Munirka got connected by metro only in 2019, despite having a university, schools and other public institutions adjacent to it. Therefore, road transport has always been an important mode of transportation here. Another factor that made Munirka an interesting site is related to the 'legal-cultural' aspect. Officially, Munirka is still identified as 'village', despite its location in the city. At the cultural front, as



well, many rural areas like features are quite visible. It offered the unique cultural context of a village embedded in an urban center, which is a unique feature specific to Delhi. All these factors made Munirka an interesting site for conducting a field study.

In-depth face to face interviews was conducted on various bus stops of the Munirka. Building rapport is very important for conducting interviews among women commuters, therefore, the nature of collected data is qualitative. Since 'time' is a very crucial parameter in women's safety, these bus stops were visited at four different times as 7:00 AM, 11:00 AM, 3:00 PM, and 7:00 PM, on five working days of the week. Inputs were also taken from the workshop conducted with the school going girls and one focus group discussion. The participants were selected based on the parameters of 'age' and 'income level'. The participating women commuters are classified in the age brackets as, below the age of 18 years, 18-40 years, 40-60 years and 60 years and above. The collected data was analyzed for providing the technological and policy inputs for technology developers and policymakers. From the collected data, a definition of women's safety also derived. Conceptualized definition very important for embedding the value of women's safety in future e-mobility from the ideation level of innovation itself. As experiences from the implementation of metro rail project (Kumar et al., 2017; Pradhan, 2018) shows, that after adoption and mainstreaming it is very difficult to alter the values, which is very much in line with what Schumpeter has said about the 'social inertia' towards change (Schumpeter and Backhaus, 2003).

#### **4. Reflections from the Field**

Firstly, it is important to bring forward that, for women safety, the term 'mobility' is not limited to the vehicles only rather, it also encompasses the areas of a bus stop, pick up and drop points of smaller vehicles such as e-rickshaws, etc. Further, it is also to be noted that battery-operated e-rickshaws have already become very popular over short distance trips, in future the private cars, public buses and e-scooters are also going to be part of the e-mobility. There are specific technological features if embedded in e-mobility PTS, would enhance women's safety along with creating gender-sensitive values.

Based on the conducted interviews and focus group discussion we propose the following definition of women safety in road PTS, *"A reliable, predictable and comfortable road PTS, in which women commuters of all age group are, physically, psychologically &*

*environmentally safe, feel welcomed and treated equally without undue financial burden*". Here the term 'reliable' is closely associated with 'trust', but it is a reliable and predictable system that leads to the trust-building among commuters. The term 'psychological safety' encompasses the 'feelings & internal experiences' which ultimately lead to the building of the 'perception' among the commuters. Therefore, along with the percentage of women commuters based on overall commuters' load, trust and perception are identified as important criteria to measure the efficacy of future e-mobility PTS on gender sensitivity scale. The captive women commuters (who have the comparatively higher financial capacity to pay for rides) emphasize on having more 'comfort' in road PTS. For example, it was brought forward that no additional passengers should be taken beyond stipulated capacity during peak hours. Most of the women respondents agreed that they experience more harassment in the overcrowded buses. 'Overcrowding' is also found to be one of the leading factors behind the near absence of women commuters above the age of 60 years, particularly during peak hours. The majority of the respondents were aware of the environmental benefits of e-vehicles. The introduction of 'e-rickshaws' has enhanced their mobility and due to its design added more comfort, more frequency made the trips less time consuming (Mahadevia et al., 2018; Mohanty and Kotak, 2017). Further, it was also found that, due to smaller size, no standing capacity and direct contact with the driver women feel more cared for and welcomed at the e-rickshaws. However, only a few women were found to be aware of the problem of e-waste to be generated by the disposal of the batteries. These batteries have harmful chemicals and can lead to public health hazards of which women are particularly vulnerable (Heacock et al., 2015; Trottier et al., 2018). Therefore, the policy on e-waste management will have a direct impact on the environmental sustainability of e-mobility.

On the technology front, the availability of the 'real-time information' was rated of highest significance by most of the respondents. Such information was desired not only on stations but also within the vehicle. Some kind of 'color code' was also suggested for those commuters who are illiterate. In the focus group discussion 'staring by the male fellow commuters' emerged as one of the most complicated forms of harassment which is difficult to prove and punish legally, but make women uncomfortable and at a time make them feel 'threatened'. It is suggested that the audio-visual system displaying the offenses should be installed in the e-vehicles so that it can educate and make aware of the commuters about

such instances. Similarly, most of the women also favored the installing of the CCTV cameras within the vehicles. It must be noted that women commuters under the pressure of unsafe PTS, found to be supporting strong surveillance despite a threat to their privacy. Other demands on the technology fronts were the installation of the 'stop button' which is specially activated during night time so that women can get down near their place and have to walk less distance in the darker areas. Further, the installation of 'audio communication set' to talk with the driver directly which will help in immediate reporting to the driver. Post-2012, if women commuter report to a driver of 'sexual harassment', in such a situation, the driver is bound to take the bus to the nearest police station. Respondents with smartphones are found to be aware of the government's 'Himmat' app, through which mobile police vans can be contacted in case of harassment. But economically less privileged women commuters are found to be not aware of this app, for them it is suggested that such applications installed in the vehicles only can be tracked through GPS.

On the policy front, most respondents supported the inclusion of women drivers and assistants in the road PTS. It must be noted that in the present road PTS there are not even one present women drivers. In the future e-mobility PTS, there is an opportunity to have the design of the vehicle which is more appealing to women. Further, the government policy on the recruitment of drivers should also be more gender-neutral. Further, more women representation is required in the committees responsible for formulating the transport policies. Providing incentives to the technology developers in the field of e-mobility would also act as motivation for embedding gender-sensitive values in the upcoming technologies.

This research work is highly relevant to these practical questions at the interface between the application of new technology through innovation and societal interaction and influences. As 'technological fixation' alone is no answer to the deeper social issues rooted in the particularities of the cultural contexts. Therefore, there is a need for timely research with both theoretical and empirical studies to address these gaps, which this research proposing to undertake systematically.

The research in this direction has the further scope in the direction of developing a matrix system of women safety from women's perspective with identifiable and measurable parameters. Such a quantitative matrix can be based on the qualitative data such as

collected by this work. Further, there is a need for continuous operation of the feedback loop until the mainstreaming of e-mobility to ensure the true participation and reflexivity in the entire innovation process.

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