

Air Pollution and Reproductive Health of Women: A Case Study of Delhi National Capital Region

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Abstract: Air pollution in Delhi National Capital Region (NCR) has emerged as a critical public health concern, with increasingly severe implications for women's reproductive health. Exposure to pollutants such as particulate matter (PM_{2.5} and PM₁₀), sulphur dioxide (SO₂), nitrogen oxides (NO_x), ozone (O₃), and carbon monoxide (CO) has been associated with adverse reproductive outcomes, including infertility, miscarriage, stillbirth, and low birth weight. Despite growing scientific evidence on these health risks, the gendered dimensions of air pollution remain insufficiently addressed within environmental governance frameworks in India. This paper examines the intersection of air pollution, women's reproductive health, and environmental governance by analysing key policy interventions implemented over the past 15 years, including the 2010 National Green Tribunal Act, the Graded Response Action Plan (GRAP), the 2019 National Clean Air Programme (NCAP), and the 2021 Commission for Air Quality Management (CAQM). Adopting a documentary analysis approach, the study draws on policy documents, academic literature, and available health data to assess the extent to which these frameworks recognise gender-specific health vulnerabilities and incorporate women into decision-making processes. The analysis finds that while these policies have contributed to pollution control, they largely remain gender-blind, lacking statutory provisions for women's representation and failing to adequately address differentiated health impacts across socio-economic groups. The paper argues for the integration of gender-sensitive approaches in environmental policymaking, emphasising targeted interventions and the institutionalisation of women's participation to achieve more inclusive and effective environmental governance.

Keywords:

1. Air Pollution
2. Environmental Governance
3. Gender Equity
4. Reproductive Health

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1. Introduction

Air pollution across major cities in India is worsening with time, but the situation in Delhi National Capital Region (NCR) is the most worrisome. A study conducted by the Centre for

Research on Energy and Clean Air found that Bhubaneswar (Odisha), Delhi, and Gurgaon (Haryana) ranked as the top three most polluted cities in India, with average PM_{2.5} concentrations of 126 µg/m³, 105 µg/m³, and 91 µg/m³, respectively (N & Raj, 2021). It is beyond debate that poor air quality jeopardises human health. However, an important aspect often overlooked is the disproportionate impact air pollution has on women, newborns, and young children. The United Nations Development Programme (UNDP) calls it an environmental crisis intertwined with inequality.¹ The disproportionate impact manifests across multiple dimensions, including health and financial outcomes, among others. The focus of this paper is on the impact of air pollution on the reproductive health of women. Various studies have established that air pollution has a detrimental impact on the reproductive health of women. However, far less attention has been paid to how the state responds to women's reproductive health concerns in the context of worsening air quality and to the extent to which women are meaningfully involved in shaping and implementing environmental policies. The paper attempts to fill this gap in the existing scholarship on women and environmental governance by analysing policies implemented by the Indian state in the last 15 years.

2. Air Pollution in Delhi NCR

Air pollution in Delhi NCR is multifaceted, with both outdoor (ambient) and indoor sources of pollutants. The major air pollutants and their sources include: particulate matter PM_{2.5} (stubble burning, fine particles from vehicles, industries, road construction, and dust) and PM₁₀ (coarse particles from road dust, smoke, construction, and open burning), nitrogen oxide (vehicle exhaust, thermal power plants and industrial combustion), sulphur dioxide (burning coal and furnace oil in industries and power plants), carbon monoxide (emitted from incomplete combustion in vehicles, diesel generators, biomass burning), ammonia (agricultural activities like use of fertilizer, waste burning), lead and heavy metals (lead, arsenic, nickel, manganese and cadmium produced from industrial emissions, e-waste burning, road/soil dust). The season also plays a major role in determining the severity of air pollution. During winter, a mix of PM, NO_x, SO₂, and ozone is worsened by low wind speeds and temperature inversion. During autumn, smoke from crop residue burning in Punjab and Haryana fields drifts to Delhi NCR, spiking PM_{2.5} and PM₁₀. During the summer months, dust storms blowing in from Rajasthan and neighbouring regions raise PM levels in Delhi NCR.

In the year 2014, the World Health Organisation (WHO) declared New Delhi the most polluted city in the world.² Around the same time, public and scientific attention to the deteriorating air quality escalated significantly. Many studies were conducted (and some are still in progress) to examine the causes and extent of air pollution in Delhi NCR, depending on the season and pollutant. We discuss the findings of some of the prominent ones. A study conducted during the winter of 2013 and the summer of 2014 found that particulate matter posed the most serious air pollution concern in the city, with PM₁₀ and PM_{2.5} levels reaching four to seven times the national air quality standards in both seasons (IIT Kanpur, Dept. of Civil Engineering, 2016, p. 8). Delhi's annual average PM_{2.5} concentration in 2021– 22 was 100 µg/m³, 20 times more than the WHO guideline of 5 µg/m³ (Guttikunda et al., 2023). A study by the Centre for Science and Environment reported a sustained rise in PM_{2.5} levels for the second consecutive year since 2022, pointing to a deepening pollution problem in the region

¹ UNDP. "Environmental Justice." <https://www.undp.org/rolhr/justice/environmental-justice>

² Mallica Joshi (2015, 5 November). "Delhi, be prepared to breathe dirtiest air of season today". The Hindustan Times <https://www.hindustantimes.com/delhi/delhi-brace-to-breathe-dirtiest-air-of-season-today/story-jOocKTJELK8SE31OIDWCcl.html>

(Roychowdhury & Kaur, 2025). The same study found that this increase reflects the growing intensity of pollution in the region. It also reported a 26% rise in peak pollution levels compared to the previous year, along with two prolonged smog episodes (ibid.). In 2016, TERI, along with the Automotive Research Association of India, carried out a scientific source-apportionment study of PM_{2.5} and PM₁₀ levels across Delhi NCR. Based on monitoring at twenty representative locations over two seasons, the study found that average concentrations of both pollutants consistently exceeded the national ambient air quality standards set by the Central Pollution Control Board (ARAI & TERI, 2018). In the year 2024, PM_{2.5} air pollution in Delhi worsened to around 21 times the 5 µg/m³ limit prescribed by the WHO. In a study on gaseous pollutants, it was found that SO₂ is likely to increase by 1.24 µg/m³, NO₂ is likely to increase by 16.77 µg/m³, O₃ is likely to increase by 6.11 µg/m³, benzene is likely to reduce by 1.33 µg/m³ and NO₂ is predicted to reduce by 0.169 µg/m³ in the coming years (Sharma et al., 2018). The highly polluted air of Delhi NCR is also responsible for many deaths. In 2020, Delhi experienced an estimated 54,000 avoidable deaths attributable to PM_{2.5} air pollutants.³ In a time series analysis of air pollution levels in Delhi between 2008 and 2019, it was found that Delhi had the largest attributable fraction and highest attributable yearly deaths (de Bont et al., 2024).

Based on the above discussion, it can be inferred that the combined presence of gaseous, particulate, and seasonal pollutants has rendered the air in Delhi NCR region highly toxic and unsuitable for healthy living.

3. Impact of air pollution on women's reproductive health in Delhi NCR

Harmful particles in the air, including sulfur dioxide, PM_{2.5}, PM₁₀, ozone, nitrogen oxides, and carbon monoxide, affect the reproductive health of women. Particulate matter of ≤ 2.5 µm and between 2.5 and 10 µm are associated with reduced fertility, whereas sulphur dioxide, carbon monoxide, and nitrogen dioxide might promote miscarriage and stillbirths (Conforti et al., 2018). Air pollution can also cause premature labour during pregnancy due to inflammation of the lining of the uterus (Margiana et al., 2023). Toxic air pollutants can also increase the incidence of cancers of the reproductive system and lower the birth rate (ibid.).

The adverse impact of air pollution on women's reproductive system has been highlighted by practitioners as well. According to Pristyn Care Fertility, air pollution wreaks havoc with hormone levels and the menstrual cycle. It further says, "High levels of pollution can lower Anti-Müllerian Hormone (AMH), which affects fertility. It reduces the Antral Follicle Count (AFC), a key factor in ovarian reserve. This disruption causes higher rates of miscarriage and even stillbirth."⁴ The immediate impact of air pollution includes: endocrine disruption, reduced egg quality, and an increase in risk of miscarriages.⁵ At the same time, there are long-term effects on fertility as well.⁶ They include epigenetic changes and delayed puberty in offspring.

The increase in female infertility seems to parallel the increase in toxic emissions, which suggests that the impact of air pollution on human health could increase in the coming years (Margiana et al., 2023). As air quality continues to deteriorate, doctors in Delhi NCR have expressed growing concern about the harmful effects of polluted air on pregnant women. Dr

³ Greenpeace Southeast Asia (2021, 18 February). "PM_{2.5} air pollution behind an estimated 160,000 deaths in world's 5 biggest cities in 2020." <https://www.greenpeace.org/southeastasia/press/44319/pm2-5-air-pollution-behind-an-estimated-160000-deaths-in-world-5-biggest-cities-in-2020/>

⁴ Pristyn Care Fertility (2024, 29 November). "The Hidden Impact of Air Pollution on Fertility: A Growing Concern." <https://fertility.com/the-hidden-impact-of-air-pollution-on-fertility-a-growing-concern/>

⁵ Centre for Infertility and Assisted Reproduction (2025, 17 January). <https://www.cifarivf.com/how-does-air-pollution-affect-your-fertility/>

⁶ ibid.

Jayasree Sundar⁷ said, “If I was seeing 10 miscarriages in a month, now I am seeing 20. Not only miscarriages, but a number of newborns have low birth weight, and there is an alarming increase in this. Women are healthy throughout the pregnancy, but it seems the child is not growing; blood flow to the baby stops in most cases. Baby starts compensating. This is happening more than ever.”⁸ Another gynaecologist, Dr Vaishali Sharma, based in Delhi, is also seeing similar trends. In her words:

We get a higher percentage of women getting spotting during pregnancy at this point. In the last 10 days, I have had cases of 4-5 pregnant women who had completely asymptomatic pregnancies but started having bleeding and spotting without any reason. Air pollution is one of the major factors for such miscarriages. In case women do not take care and venture out in this pollution, they get such spotting which leads to miscarriage.⁹

Growing infertility has pushed many couples, as well as single individuals, to turn to assisted reproductive technologies in their efforts to have a child. Unfortunately, air pollution has a severe impact on those trying to get pregnant through assisted reproductive technologies as well. Among individuals undergoing in vitro fertilisation (IVF), exposure to nitrogen dioxide and ozone was linked to lower live birth rates, while exposure to particulate matter (PM10) was associated with a higher risk of miscarriage (Conforti et al., 2018). It cannot be denied that a major section of the population would be affected by this. In Delhi NCR, approximately 11,800 to 12,000 IVF cycles are performed annually. This indicates a significant demand for IVF treatment in the region (Ernst and Young, 2015). The National Family Health Survey (NFHS-5) also shows a decline in fertility rates in Delhi, with a Total Fertility Rate of 1.5 (Ministry of Health and Family Welfare, 2022). This fertility decline further contributes to the high demand for IVF. We can expect a good number of IVF pregnancies to be impacted by air pollution in Delhi NCR. These pregnancies are already complicated; air pollution further complicates them.

From the above analysis, it becomes clear that the state must urgently acknowledge the gendered health impacts of air pollution and develop policies that are sensitive to women’s specific needs and experiences. Failing to act now could have far-reaching and devastating consequences for women’s wellbeing and for Indian society as a whole.

4. Air pollution exposure among women across different social strata in Delhi NCR

While ambient air pollution poses serious risks to women's health, we must also examine indoor air pollution sources since many women spend most of their time indoors, whether managing households or working in offices. The World Health Organisation has stated that, “Household air pollution was responsible for an estimated 2.9 million deaths per year in 2021, including over 309 000 deaths of children under the age of 5.”¹⁰ According to a report released by the Ministry of Health and Family Welfare in the year 2015, household air pollution due to the use of solid fuels accounts for 25% to 30% of the outdoor air pollution (Ministry of Health and Family Welfare, Govt. of India, 2015). The combined effects of ambient air pollution and household air

⁷ Senior Gynaecologist, Madhukar Rainbow Children’s Hospital

⁸ Sherine Elizabeth (2023, 17 November) “Delhi-NCR Air Pollution Fuelling Rise in Miscarriages, Other Complications among Pregnant Women, Babies.” <https://www.news18.com/india/delhi-ncr-air-pollution-fuelling-rise-in-miscarriages-other-complications-among-pregnant-women-babies-8664536.html>

⁹ *ibid.*

¹⁰ World Health Organisation (2025, 16 December). “Household Air Pollution.” <https://www.who.int/news-room/factsheets/detail/household-air-pollution-and-health>

pollution are associated with 6.7 million premature deaths annually (ibid.).

A woman's experience of suffering from indoor air pollution often depends on her socio-economic background. Those from lower-income households are especially vulnerable as they are more likely to rely on highly polluting fuels for cooking and heating, which exposes them to harmful smoke and pollutants every day. Limited financial means make it harder for them to access cleaner alternatives or healthcare, and often, they may not even be fully aware of the health risks they face. In lower-income homes, highly polluting fuels have been found to be a major contributor to indoor air pollution, releasing pollutants with extremely adverse impacts on women, including: particulate matter (PM2.5 and PM10), carbon monoxide, black carbon (soot), sulphur dioxide, and nitrogen oxide. The World Health Organisation also says, "Household air pollution is generated by the use of inefficient and polluting fuels and technologies in and around the home that contain a range of health-damaging pollutants, including small particles that penetrate deep into the lungs and enter the bloodstream. In poorly ventilated dwellings, indoor smoke can have levels of fine particles 100 times higher than acceptable. Exposure is particularly high among women and children, who spend the most time near the domestic hearth" (World Health Organisation, 2024).

Although a major section of Delhi NCR has switched to clean energy for cooking, a major section of the society still uses highly polluting fuels (Sreenivasan et al., 2023). The usage of liquified petroleum gas (LPG) has expanded; however, its consistent use is a challenge. There are two major factors responsible for this, namely, affordability and easy availability of cheap or non-monetised solid fuels (ibid.). Despite the wide coverage of schemes like Pradhan Mantri Ujjwala Yojna (PMUY), many families continue to use biomass even today due to various barriers and access issues. Studies have found that although PMUY has played a crucial role in increasing the usage of LPG, there are several factors, ranging from socio-cultural norms to systemic gaps, acting as barriers against its sustained use. In a study conducted under the Cleaner Air Better Air project in five urban slums of Delhi (both notified and non-notified bastis),¹¹ it was found,

for the users, ease of access is more important than ease of use when deciding which fuel to use. Users' perceptions regarding LPG, such as LPG being unsafe, food cooked on LPG being unhealthy and less tasty, combined with supply-side bottlenecks such as challenges in applying for and getting an LPG cylinder, lump-sum cash outflow during ordering refills for an LPG cylinder are some of the factors that act as a hindrance in its sustained use by women in low-income households.¹²

Women employed in formal office spaces across Delhi NCR are also exposed to the hidden threat of indoor air pollution during long working hours. A study (conducted in three offices in Delhi, namely, Nirman Bhawan, BKK Copernicus Marg, and National Polio Survey Project Office, Safdarjung Enclave) by TERI underlines the importance of indoor air pollution as a significant health concern due to prolonged time spent indoors, especially in office environments (TERI, 2012). A study was conducted in Delhi NCR in four air-conditioned office buildings for the criteria pollutants PM2.5 and CO₂. The study showed high concentrations of these two pollutants in the office buildings. The close proximity to busy urban roads, insufficient ventilation conditions, and poorly maintained HVAC ducting systems are likely to be the causes. The concentrations of CO₂

¹¹ The sites include Lohar Basti, Sansi Camp, Khichripur, Kanchan Kunj, and JJ Colony.

¹² Express News Service (2023, 22 August). "High refill cost, lack of access deter the poor from using LPG: study" The Indian Express, <https://indianexpress.com/article/india/high-refill-cost-lack-of-access-deter-the-poor-from-using-lpg-study-8903063>

and PM_{2.5} are recorded to be above the National Ambient Air Quality Standards (NAAQS) and the American Society of Heating, Refrigerating and Air-Conditioning Engineers Indoor Air Quality Standards (ASHRAE 62.1) (Gupta et al., 2020). A study was conducted on the indoor air quality of two office buildings and one educational building in Delhi in the pre-monsoon season. The average CO₂ levels in both office buildings were found to be considerably higher than the ASHRAE standard. A ductless air-conditioning system, combined with poor ventilation and inadequate air filtration, likely contributed to the elevated concentration of particulate matter observed in one of the offices. Significantly lower concentrations of all pollutants were recorded in the educational building (Datta et al., 2017). These studies underscore that even women in office settings remain vulnerable to indoor air pollution's insidious effects, with potential consequences extending to reproductive health.

The foregoing analysis suggests that women across different social strata experience exposure to air pollution in distinct ways. This underscores the importance of identifying pollution sources accurately and designing targeted policies to reduce their impact on women's reproductive health accordingly.

5. Women and environmental governance

Recognising women's disproportionate air pollution vulnerability requires gender-sensitive policies tailored to diverse socio-economic realities. To realize such policies, the inclusion of women in the decision-making process is essential, as women bring with them their lived experiences. At the same time, local women are also the knowledge holders. Research has established their prominent role in the conservation of nature through their knowledge. Local women as knowledge holders and decision makers in community-based conservation are linked to better protected area management (Allendorf & Allendorf, 2012).

In India, women have long been at the forefront of conservation and sustainability efforts. In the past, ecofeminists (especially in the Global South) have drawn a special relationship between women and nature due to their roles in food production, seed preservation, and caregiving. They link women's fertility with natural regeneration, and position both as forces that have been subjugated by patriarchal and capitalist systems (Merchant 1980; Shiva, 1988; Ruether, 1992; Mies & Shiva, 2014). However, Bina Agarwal calls for rejecting this claim. She argues for the inclusion of women in environmental governance (Agarwal, 2010). According to her, a stronger presence of women in the executive committees of community groups can play an important role in promoting more just and equitable forms of green governance in community forestry (*ibid.*). Highlighting the link between women's participation in policy decision-making on climate goals and policies, Strumskyte et al. (2022) have argued:

Environmental leadership can not only bring about improvements in representational justice and increased focus on gender-specific environmental impacts. It can also lead to stronger and more effective environmental action. Studies find that women's participation in decision-making can lead to better environmental outcomes, including by strengthening environmental policies and promoting sustainable investments, in both the public and private sectors (Strumskyte et al., 2022, p. 7).

The Centre for Sustainable Systems also calls for a meaningful involvement of all people in environmental decision-making to ensure full protection from disproportionate environmental and health impacts, and equitable access to a healthy, sustainable, and resilient environment

(Center for Sustainable Systems, 2024). On similar lines, to form well-informed policies, Wray and others argue, “perspectives outside of dominant systems, and engaging the voices, values, and ideas of underrepresented groups is critical to accelerating urgently needed, practical, and life-sustaining climate and environmental action” (Wray et al., 2023, p. 1088). Women’s voices in India often remain marginalised, particularly those belonging to socio-economically disadvantaged groups. For example, in a study in Gujarat, India, it was found that the lack of gender participation in the environmental hearing process is failing rural women. Hence, exacerbating discrimination and inequality. It is essential to respect the diversity of interests and their identities within the institutionalised public sphere to promote participation and recognition of their knowledge and role as crucial stakeholders (Gill & Joshi, 2024).

However, gender gaps in environmental decision-making persist across regions and sectors worldwide. In the context of good governance for sustainable ecosystem management, the International Union for Conservation of Nature seeks to understand these gender gaps and address the specific barriers involved, including the limited access women often face to resources such as land, technology, and finance. As a result, they may be excluded from decision-making processes related to ecosystem management, which limits them from contributing (IUCN, 2020). This gap is most pronounced in low-income countries that depend heavily on environmentally sensitive industries (ibid.). Women hold 39% of environment minister positions in OECD countries, yet their representation drops sharply in nations facing the heaviest climate impacts, where women already bear disproportionate environmental risks (Strumskyte et al., 2022, p. 7). Women are similarly underrepresented in key infrastructure ministries, such as energy, transport, and communications, which play a central role in shaping environmental outcomes (ibid., p. 7). They have highlighted areas where women’s experiences and representation are under-represented:

Heads of environmental ministries/agencies, number of female heads of delegations to UNFCCC COPs, number of female delegates to UNFCCC COPs and other international negotiations, participants in national-level environmental fora, composition of corporate boards and senior management positions in green private sector companies, share of women on boards of climate mechanisms and funds, number of female entrepreneurs with adequate access to financing for low-carbon and climate resilient investment (ibid., p. 24).

India lies in the low-middle-income category with many environmentally sensitive industries, where rapid economic growth coexists with deep inequalities in income, opportunities, and access to basic services. Women, as a result of this disparity, have limited opportunities to contribute to the protection of the environment. While many women have made important contributions in their individual capacities, efforts that the state has increasingly acknowledged, their presence in environmental leadership remains most visible within civil society organisations and international environmental negotiations. Across the world, women have built strong and influential networks within civil society to address environmental degradation and confront climate-related inequalities (ibid., p. 7). However, women’s engagement should not be confined to civil society or environmental activism alone. Meaningful inclusion of women in environmental policymaking is essential, and achieving this requires the state to mandate women’s representation within formal environmental governance institutions.

Building on the discussion of air pollution in Delhi NCR, its harmful effects on the reproductive health of women, and the urgent need to include women in environmental decision-making, the following variables have been identified to analyse government policies aimed at reducing pollution in Delhi NCR:

- Inclusion of women in policy making process for mitigating air pollution
- Recognition of gendered health impact and needs across different social strata.

Before policy analysis, the following section provides a concise overview of the selected air pollution mitigation policies.

6. Policies to mitigate air pollution in Delhi NCR

After the 1972 Stockholm Conference, environmental concern for air pollution began to be expressed in India in legislative terms (Mathur, 2013, p. 124). In the 1980s, civil society started raising its voice for clean air in Delhi. However, a lack of political will was evident in the government's inability to introduce legislation for curbing air pollution.

Over the next two decades, there was a constant tussle between the then Delhi government, judiciary, experts, and technocrats for the adoption of clean energy to reduce vehicular pollution. It was in the year 2002 that the Supreme Court of India was able to introduce Compressed Natural Gas as a single mode of fuel for public transport in the midst of considerable social and political conflict (Mathur, 2013, p. 117). However, this tussle clearly showed that, on one hand, political parties (in power or in opposition) lacked the political will to introduce strong laws for clean air. On the other hand, the citizens lacked awareness regarding the harmful impact of air pollution in Delhi. Political parties (both the party in power and in opposition) also did not make any efforts to educate the people about the Supreme Court's aims to promote a healthy environment. The focus of the public debate, carried out in the media, was more on the travails of the commuters rather than the need for clean air for the people living in Delhi (ibid., p. 136).

However, it was the "Great Smog of Delhi" in November 2016, which alerted the common man like never before. Since then, the air quality has remained very poor in Delhi NCR. Over time, this issue has drawn attention from the media, medical professionals, civil society, and academic scholars, as discussed earlier. The mounting pressure on the central government to take action to address this crisis has culminated in many policy interventions. Although the Government of India has introduced multiple policies and measures to control air pollution in Delhi NCR, for the present study only selective policies have been used for analysis. These policies were initiated by the government in the last 15 years. These policies are different in nature, dealing with different dimensions of the issue. Here is a brief description of the policies selected for the study.

6.1. National Green Tribunal Act

National Green Tribunal Act was enacted in the year 2010 to provide for the establishment of a National Green Tribunal for the effective and expeditious disposal of cases relating to environmental protection and conservation of forests and other natural resources including enforcement of any legal right relating to environment and giving relief and compensation for damages to persons and property and for matters connected therewith or incidental thereto.¹³

The National Green Tribunal is headed by a full-time Chairperson and includes between ten and twenty full-time Judicial Members, along with an equal number of full-time Expert

¹³ National Green Tribunal, <https://www.greentribunal.gov.in/about-us>

Members. In addition, the Chairperson has the discretion to invite individuals with specialised knowledge or experience to assist the Tribunal in specific cases.¹⁴

6.2. Graded Response Action Plan (GRAP)

Following a Supreme Court directive in *M. C. Mehta v. Union of India* in 2016, the Graded Response Action Plan (GRAP) was introduced to address deteriorating air quality in Delhi NCR. The plan laid out specific measures to be implemented under different Air Quality Index (AQI) levels, namely, moderate & poor, very poor, and severe, based on the National Air Quality Index. To deal with extreme pollution episodes, an additional category, “severe+” or “emergency,” was later incorporated (CPCB, 2017). It is a strategic framework launched to control air pollution in Delhi NCR by taking predefined actions based on the level of air pollution, especially Particulate Matter (PM10 and PM2.5) concentrations. GRAP actions are pre-emptive and mandatory.

Initially, it was to be implemented by the Environment Pollution (Prevention and Control) Authority, but it is now enforced by the Commission for Air Quality Management (CAQM) with coordination from the State Pollution Control Boards, Municipal Corporations, Traffic Police, Transport, and Industry Departments.

6.3. National Clean Air Programme (NCAP) 2019

Introduced in 2019, the National Clean Air Programme (NCAP) represents India’s major long-term effort to tackle air pollution, targeting 131 cities across 24 States and Union Territories by bringing together governments, institutions, and other key stakeholders. It envisages achieving reductions up to 40% or the achievement of National Ambient Air Quality Standards for Particulate Matter₁₀ (PM₁₀) concentrations by 2025-26. Its motto is “Clean Air for All.”

NCAP has adopted an integrated, collaborative, multi-scale, and cross-sectoral approach.¹⁵ There are committees at the national, state, and city levels for coordinating, monitoring, and evaluating the programme. At the national level, there are four committees, namely; Apex Committee, the Steering Committee, the Monitoring Committee, and the Implementation Committee Chairman. At the state level, there are two committees, namely the Steering Committee and the Monitoring/Implementation Committee. Lastly, at the city level, there is one committee, namely the Implementation and Monitoring Committee.

6.4. Commission for Air Quality Management (2021)

The Commission was established to improve air quality management in Delhi NCR and adjoining areas by strengthening coordination, supporting research, identifying key challenges, and addressing issues related to air quality and its broader impacts. The Preamble of the Act clearly identifies the objectives sought to be achieved, which are the ‘better coordination, research, identification and resolution of problems related to the air quality index’ and incidental, connected matters.¹⁶

¹⁴ Ibid.

¹⁵ Prashant Gargava (2024, 9-10 December).” National Clean Air Programme (NCAP). Asia-Pacific Regional Action Programme on Air Pollution. Regional Workshop for South Asia.

¹⁶ PRS Legislative Research (n.d). “The Commission for Air Quality Management in National Capital Region and Adjoining Areas Bill,” 2021 <https://prsindia.org/billtrack/the-commission-for-air-quality-management-in-national-capital-region-and-adjoining-areas-bill-2021>

The Commission is headed by a chairperson and supported by a Member-Secretary, who holds the rank of Joint Secretary and serves as the Chief Coordinating Officer. Its membership includes a serving or former Joint Secretary from the central government, three independent technical experts specialising in air pollution, and three representatives from non-government organisations.¹⁷ The Chairperson and other members serve for a term of three years or until they reach the age of seventy, whichever comes earlier. In addition, the Commission includes *ex officio* members from the central and concerned state governments, as well as technical representatives from institutions such as the Central Pollution Control Board, the Indian Space Research Organisation, and NITI Aayog. When necessary, the Commission may also appoint representatives from relevant ministries.¹⁸

7. Analysis

7.1. Inclusion of women in the policy making process for mitigating air pollution

Previous sections of this paper have analysed the impact of inadequate participation of women in decision-making processes related to environmental protection. All the policies and bodies discussed above have an elaborate mechanism for implementation. NGT, drawing from the experiences of retired as well as currently employed judges and experts, is capable of making well-reasoned judgments regarding the protection of the environment and people. It has been established that the involvement of technical experts in decision-making promotes better environmental results, as environmental problems are complex and increasingly transnational in nature (Gill, 2016, p. 176). Their inclusion is necessary for values such as participation, inclusion, deliberation, and transparency for effective environmental governance (*ibid.*). Although Justice Pushpa Sathyanarayana was appointed as a Judicial Member of the National Green Tribunal in 2024 under the NGT Act, 2010, Dr. Nagin Nanda and Dr. A. Senthil Vel have been appointed as Expert Members. This shows that inclusion of women in NGT has been on a case-by-case basis and is not based on statutory inclusion. The tribunal does not include any provision that mandates the representation of women. Women's inclusion is necessary not only for their empowerment but for stronger and more effective environmental action as well (Strumskyte et al., 2022, p. 7).

The inclusion of women in the National Green Tribunal (NGT) holds significant potential for advancing gender-sensitive environmental justice in India. As discussed earlier, women from marginalised sections of society face disproportionate exposure to environmental hazards. Mandatory representation of women in the NGT can help ensure that the gendered dimensions of environmental harm are adequately recognised in adjudication and remedies. Their presence may also enhance access to justice by making the tribunal more approachable for women petitioners.

NCAP has an elaborate system to implement the program. There are bodies at the national, state, and city levels to ensure a hassle-free implementation of the program. The attempt to involve administration at the lowest level is an apt example of good governance. There are efforts by the government to involve women in the programme. For example, the District administration of Dimapur, Nagaland, organized training cum skill development of women leaders under NCAP in efficient waste management to reduce air pollution.¹⁹ Olivi G. Choppy, a

¹⁷ *ibid.*

¹⁸ *ibid.*

¹⁹ The Morung Express (2024, 11 March). "Women leaders trained under National Clean Air Prog in Dimapur," <https://morungexpress.com/women-leaders-trained-under-national-clean-air-prog-in-dimapur>

Senior Scientific Assistant, Nagaland Pollution Control Board, also urged women leaders to use the knowledge they have learnt from the training for the benefit of society as a whole, as mostly children and elderly people are victimised by air pollution.²⁰ The Council on Energy, Environment and Water, through its project called Cleaner Air and Better Health, is assisting in the implementation of NCAP in its capacity as knowledge partner, capacity builder and community outreach facilitator. Gender and social inclusion are intrinsic to the project. As part of these efforts, more than 3,869 women were trained on issues related to household air pollution and clean cooking (Council on Energy, Environment and Water, n.d). However, no comparable direct and structured initiatives have been undertaken in Delhi NCR.

GRAP has an elaborate mechanism to take pre-emptive actions. It has involved every institution responsible for controlling pollution, taking it down to the lowest level. CAQM has retired bureaucrats bringing rich experience with them, as well as experts from organisations like NITI Aayog, Indian Space Research Organisation, Central Pollution Control Board (CPCB). However, there is no gender dimension when it comes to the inclusion of women in its core body. In fact, in the year 2024, the central government assured the Supreme Court of the capability of the members of CAQM. Unfortunately, there was no mention of gender dimension when it comes to the membership.²¹ On similar lines, there is no proof of mandated inclusion of women in the Commission for Air Quality Management (2021). They may hold office in an *ex officio* capacity. However, there is no clause for statutory inclusion.

Yet, it is appreciable that women were involved in the successful implementation of NCAP 2019, as women play a key role in community mobilisation and awareness. Their inclusion strengthens bottom-up compliance with households adopting cleaner fuels, schools adapting schedules, and local monitoring of burning practices. However, the mandated inclusion of women in the decision-making bodies of NCAP and GRAP could have led to the formulation of more gender-sensitive policies, as women also bring their lived experiences into the policy-making process. These two programmes in particular deal with particulate pollutants, i.e., PM10 and PM2.5, which have an extremely adverse impact on the reproductive health of women (as discussed earlier). Also, a major section of women living in Delhi NCR are primary caregivers and manage the household. These women face direct burdens from air pollution (e.g., children's health, cooking exposure, mobility restrictions). Women in GRAP as decision-makers would ensure the formulation of policies that reflect household and community-level impacts, not just macro air quality data. Therefore, mandated inclusion of women in decision-making bodies of these programmes can bring gendered health impacts and needs into discussion. This would make adopted measures and policies gender sensitive and would ensure that they are not only technical but also socially inclusive, eventually encouraging women-led groups, Residence Welfare Associations, and Non-Governmental Organisations to engage with GRAP rather than seeing it as purely technocratic. Research has also highlighted the importance of including women in decision-making processes for more effective environmental protection. An analysis of grassroots movements across India shows that women's knowledge and leadership play a crucial role in strengthening biodiversity conservation and climate resilience. The study argued for integrating ecofeminism into environmental governance for achieving ecological sustainability and social justice in India (Mahamuni, 2023).

CAQM (2021) may have appointed women who serve as *ex officio* members of the commission. However, there is no provision for mandated inclusion of women. Apart from

²⁰ Ibid.

²¹ Sophiya Mathew (2024, 16 October). "Air quality panel members have sufficient experience, Centre tells SC." The Indian Express, <https://indianexpress.com/article/cities/delhi/air-quality-panel-members-have-sufficient-experience-centre-tells-sc-9622285/>

better coordination, regulation, enforcement, and resolution, CAQM is also responsible for research and identification of problems regarding air quality. Women members may help in identifying gender sensitive topics for research, which could lead to environmental protection policies designed with gender sensitivity.

The National Green Tribunal (NGT) primarily addresses environmental concerns. It has the power to invite women experts for cases they deem necessary. In October 2021, a three-judge bench of the Supreme Court delivered a verdict in *Municipal Corporation of Bombay v Ankita Sinha*. The bench ruled that the NGT is empowered to take *Suo Moto* action under the National Green Tribunal Act, 2010. It observed that the Tribunal's broad mandate to ensure environmental protection allows it to identify issues and intervene on its own initiative. This power cannot be restricted by procedural requirements of a complainant or a formal petition.²² This reinforces that NGT can proactively protect women's environmental rights without waiting for formal petitions. In 2014, a foreign national Ms. Betty, challenged violations of the Coastal Regulation Zone in Goa. In *Ms Betty C. Alvares v. State of Goa* case, the Tribunal held that the term "person" under Section 2(j) of the NGT Act includes foreign nationals. Consequently, women, even non-citizens, have *locus standi* to bring environmental cases in the NGT framework. It can be inferred from the aforementioned cases that women can have legal access to file petitions in cases where their rights are violated due to environmental degradation. At the same time, NGT should also intervene on its own, given its *Suo Moto* power, as NGT can ensure that environmental pollution impacting women is addressed swiftly.

7.2. Recognition of gendered health impact and needs across different social strata

GRAP and NCAP aim to reduce levels of particulate matter in the air. While these frameworks do not explicitly address gender concerns, cleaner air directly benefits women's health. Since particulate pollution has been shown to severely affect the reproductive health of women, efforts to lower its concentration can play an important role in improving not just overall air quality, but also women's well-being and quality of life. Studies conducted on GRAP in different time periods also show a high percentage of particulate matter in Delhi NCR. A study focused upon Graded Response Action Plan (GRAP) action during 2018 in terms of PM_{2.5} and NO₂ was conducted in Delhi NCR. The Environment Pollution (Prevention and Control) Authority directed the GRAP to advise local industries and other sources of pollution to suspend operations on specified dates whenever the AQI reached severe levels. Twenty-four-hour averaged AQI data for the periods September 2017–January 2018 and September 2018–January 2019 was analysed at two monitoring sites, namely Delhi Technical University and the Income Tax Office. The results indicated a significant decrease in AQI levels at both sites following each order issued by the GRAP task force. In general, the PM_{2.5} values were always higher during the year 2017-18 as compared to 2018-19 at both sites (Singh & Kulshreshtha, 2020). A study conducted by the Council of Energy, Environment and Water in the winter of 2021 in Delhi on the implementation of GRAP found that there had been no significant improvement in Delhi's winter air quality since 2019. In winter 2021, air quality was in the 'very poor' to 'severe' category on about 75% of days (Khan et al., 2022, p. 2). The study also found fault with the technology used. While air quality forecasts picked up the pollution trends, they were not yet very accurate in predicting high pollution episodes (ibid.). Air quality spiralled back into the severe category when the restrictions were lifted, although the quality had improved with all the restrictions in place,

²² Gauri Kashyap (2021, 7 October). "Suo Moto Powers of the NGT: Judgment Summary." Supreme Court Observer. <https://www.scobserver.in/reports/municipal-corporation-of-bombay-v-ankita-sinha-suo-moto-powers-of-the-national-green-tribunal/>

aided by better meteorology. Apart from Delhi NCR, it is necessary to study the implementation of GRAP in other cities as well, as about 64% of Delhi's winter pollution load comes from outside of Delhi's boundaries (ibid.). Centre for Research on Energy and Clean Air conducted a study on the implementation of GRAP in twenty-six cities, between October 1, 2022, and February 15, 2023. They found, "PM2.5 levels under the 'Severe+' category, 38 cities reported 'Severe', and 78 cities reported 'Very Poor' air quality" (CREA, 2023, p. 2). It suggested that non-attainment cities and Delhi NCR should initiate GRAP implementation as soon as air quality reaches 'Poor' levels" (ibid.). CREA also found that no city other than Delhi NCR had any "public communication or direction to the relevant stakeholders about the implementation of GRAP stages between October 1, 2022, and February 15, 2023, indicating failure of the regulation" (ibid.).

The NCAP operates on a much wider scale; it becomes important to understand how actions taken in other cities affect Delhi's air quality. Pollutants often travel long distances, and this movement of emissions from neighbouring areas plays a significant role in worsening the air pollution levels in Delhi NCR. In a study conducted on NCAP after the initial time limit of five years, it was found, "For 49 cities, PM2.5 data was available for all five years. Out of these, 27 cities recorded improvements in PM2.5 levels from 2019 to 2023. Similarly, for PM10, data across five years were available for 46 cities. Of these, 24 cities saw an improvement in their PM10 levels" (Respirer Living Science Private Ltd., 2024, p. 1). In a study by Urban Lab, Centre for Science and Environment, it was found,

Trends in particulate matter pollution (PM2.5) between the cities under the National Clean Air Programme (NCAP) and those outside its ambit have remained the same. Only 14 of 43 (NCAP) cities registered a 10% or more reduction in their PM2.5 level between 2019 and 2021. Out of 46 non-NCAP cities with adequate data, 21 recorded significant improvement in their annual PM2.5 value, with a 5% or more decline between 2019 and 2021. 16 NCAP cities and 15 non-NCAP cities registered significant increases in their annual PM2.5 levels, with nearly identical numbers (Somvanshi et al., 2022)

Another study was conducted in 28 cities of Uttar Pradesh, assessing the changes in PM10 using the measurements collected by CPCB for the period of 2018-2022. They found,

Most cities exhibited unhealthy air quality. Jhansi had the lowest AQI (72.73) in 2023, classified as 'moderate' by WHO standards. Gorakhpur consistently showed 'poor' AQI levels, peaking at 249.31 in 2019. Western Uttar Pradesh cities such as Ghaziabad, Noida, and Moradabad had significant pollution burdens. Predictions showed Bareilly with over a 70% reduction in PM10 levels, Raebareli 58%, Moradabad 55%, Ghaziabad 48%, Agra around 41%, and Varanasi 40%, meeting NCAP targets. However, Gorakhpur and Prayagraj predicted increases in PM10 levels by 50% and 32%, respectively. Forecasting PM10 concentrations in Uttar Pradesh's non-attainment cities offers policymakers substantial evidence to enhance current efforts. While existing measures are in place, our findings suggest that intensified provisions may be necessary for cities predicted to fall short of meeting program targets. (Bera et al., 2024, p. 1).

However, in another study, it was found that the implementation of the NCAP has contributed to a decline in PM10 levels across India and has been associated with improvements

in public health, including a reduction in pollution-related fatalities. Strengthening the enforcement of existing regulations has therefore been recommended to help achieve the programme's objectives (Gopikrishnan & Kuttippurath, 2025). While appreciating the government's efforts, CREA noted that the NCAP has helped place air quality firmly on the policy agenda through sustained action, even though significant challenges remain in meeting the programme's targets (Centre for Research on Energy and Clean Air, 2025). The government has granted ₹9631.23 crores to support its objectives (Respirer Living Science Private Ltd., 2024) The revision of the programme's initial target to a 40% reduction in particulate matter concentration by 2026, is a positive development as it demonstrates a commitment to more ambitious environmental goals (Centre for Research on Energy and Clean Air, 2025).

CAQM has a wider jurisdiction and the required mandate to fulfil policy objectives. It replaced the apex pollution control body in the NCR, i.e., the Environment Pollution (Prevention and Control) Authority. However, the UNDP said that CAQM faces jurisdictional and coordination challenges (UNDP, 2025). It highlighted the importance of expanding CAQM's mandate, strengthening its enforcement authority, and bringing in representatives from a wider range of sectors to support a more comprehensive approach to air quality management (ibid.). In the year 2022, it took into cognisance the problem of indoor pollution, which is also responsible for the poor health of women.²³ The need to integrate the mitigation of household air pollution with outdoor air quality management across urban and rural landscapes was stressed. CAQM recommended providing induction stoves to migrant and floating low-income populations in Delhi NCR who lack access to clean cooking fuels, as part of a broader policy framework aimed at reducing air pollution in the region. It is a significant initiative.

From the preceding discussion on policy implementation, it can be concluded that although various policy measures have been introduced to curb pollutants that adversely affect women's reproductive health, their impact remains limited. A key gap lies in the insufficient recognition of the gendered nature of health impacts and how these impacts are experienced differently across social strata. As a result, policy responses remain fragmented and fall short of achieving their intended outcomes. Moreover, addressing air pollution requires a coordinated and nationwide approach, as pollution levels in Delhi NCR are shaped by multiple factors that extend well beyond its geographical boundaries. Without such integrated efforts, region-specific interventions are unlikely to deliver sustained improvements in women's health.

8. Recommendations

Based on the findings of the studies conducted on the policies, the following measures are suggested.

Firstly, public communication serves as the linchpin of effective GRAP implementation, transforming regulatory intent into actionable compliance across diverse stakeholders. Without clear timely directives reaching district administrations, industrial units, construction agencies, and citizens beyond Delhi's core, the graded response remains theoretical rather than operational. Transparent communication builds trust, prevents blame-shifting between states, and enables citizens to hold local authorities accountable, converting regulatory failure into collective climate action.

Secondly, jurisdiction and coordination are major hurdles in implementing these policies efficiently. According to the UNDP, the CAQM faces challenges related to jurisdiction and coordination. Addressing these gaps would require expanding the Commission's mandate

²³ The Print (2022, 14 July) "In a first, CAQM suggests measures to address household air pollution." <https://theprint.in/india/in-a-first-caqm-suggests-measures-to-address-household-air-pollution/1039400/>

beyond the NCR, strengthening its enforcement powers, ensuring broader representation from diverse sectors, improving implementation at the local level, and fostering stronger regional collaboration to enable a more holistic approach to air quality management (UNDP, 2025).

Thirdly, a short-term solution may not be as effective unless long-term solutions are well formulated and implemented. For example, while GRAP effectively imposes immediate restrictions during pollution episodes, it fails to address persistent sources such as stubble burning, industrial clustering, and vehicular proliferation. CAQM in August 2025 admitted that it had not conducted any study on the pollution impact of diesel vehicles older than 10 years and petrol vehicles older than 15 years, even though these vehicles constitute the primary focus of Delhi NCR's overage vehicle ban.²⁴ CAQM has yet to take the first and fundamental step in tackling air pollution, i.e., conducting comprehensive research to build a deeper and evidence-based understanding of the problem. Hence, policies should be designed to work in synergy with one another.

Fourthly, it is essential to conduct regular studies throughout the country to measure air pollutants in order to formulate effective solutions. Continuous, spatially disaggregated measurement of PM_{2.5}, NO₂, SO₂, and other pollutants enables precise source apportionment. For e.g., distinguishing crop residue impacts from vehicular emissions or industrial effluents. Without such data granularity, interventions remain speculative. Regular studies across urban-rural gradients also reveal socio-economic exposure disparities, essential for gendered pollution analysis, where indoor cookstove PM_{2.5} (30-40 µg/m³) compounds ambient risks for low-income women. This data infrastructure underpins NCAP's 131-city expansion and CAQM's GRAP refinements, converting environmental governance from reactive crisis management to proactive public health protection.

Fifthly, efficient technology needs to be used, for which a greater emphasis on research needs to be laid in order to develop new and efficient technologies to curb air pollution and implement the existing policies efficiently. Strategic R&D prioritisation is essential to bridge the technological efficacy gap in India's air quality governance.

Sixthly, in the west, there is a strong body of research on women's involvement in protecting the environment. Some interesting findings include that women are more concerned about the environment than men. It was found that women have stronger beliefs about the harmful consequences of poor environmental conditions for others, the biosphere, and self and that these beliefs predicted more pro-environmental behaviour (Stern et al., 1993). The studies have focused on their lifestyle choices; choices made at home, and their participation in organisations working on the environment. Such studies not only deepen our understanding of how women engage with and care for the environment but also provide valuable guidance for policymakers to design more gender-sensitive and inclusive environmental policies. In India, however, this area has remained under-researched. Although the government of India is also encouraging women in research through various initiatives like WISE-KIRAN (Women in Science and Engineering - Knowledge Involvement in Research Advancement through Nurturing), Amba Subba Rao Fellowship for Women Researchers, SERB-POWER (Promoting Opportunities for Women in Exploratory Research), among others. However, research focusing on curbing the impact of air pollution on the reproductive health of women needs to be encouraged, along with encouraging women researchers. Also, including women in decision-making bodies and research bodies responsible for curbing air pollution is vital. Women in the CAQM, NCAP, and NGT can strengthen efforts to promote women's participation and influence in environmental

²⁴ Business Standard (2025, 8 August). "CAQM admits no research has been done behind overage vehicle ban". https://www.business-standard.com/india-news/caqm-admits-no-research-has-been-done-behind-overage-vehicle-ban-125080801048_1.html

research and policy. It will also help in building long-term institutional capacity for gender-sensitive environmental governance.

Seventhly, the policies should include targeted measures aimed at protecting the reproductive health of women. To achieve this, it is important to recognise gendered health impact, and more studies need to be conducted on women in Delhi NCR, as this is a multicultural city that encompasses a wide spectrum of socio-economic groups. Pollution sources vary across different social groups, and so does their capacity to cope with its impacts. Therefore, the state must first develop a nuanced understanding of the problem to avoid superficial policy responses. This requires a systematic collection of disaggregated data first. So far, no such study has been carried out, even though academic research has repeatedly emphasised how air pollution affects women's health. India can also learn from countries that have already taken such initiatives. For example, in Mongolia, Ulaanbaatar Gestation and Air Pollution Research was introduced, in which air filters were distributed to pregnant women during winters with extremely high PM_{2.5} levels. It led to a reduction in in-utero exposure to pollution (Barn et al., 2018). This example demonstrates that policies which meaningfully recognise gendered health impacts and respond to women's specific needs are far more likely to generate transformative and enduring change. Hence, the same can be done in India as well. For example, air purifiers can be distributed to women from lower income section. At the same time, they should also be suggested natural methods to minimise the impact of air pollution. As discussed earlier, women working in the office also face the problem of indoor pollution, which is primarily caused by faults in the architecture and poorly maintained HVAC ducting system. The state can make it mandatory for all buildings to be well ventilated and to undergo regular monitoring of the HVAC ducting system.

Eighthly, there is an urgent need to increase awareness at a country-wide level with a special campaign targeting women. Discussing the impact of environmental hazards on pregnant women, Kim and Jeong argue, "As environmental hazards continue to increase, pregnant women should receive effective motivational education on eco-environmental protection to increase their sensitivity to environmental risk factors and to encourage active environmental health behaviours" (Kim & Jeong, 2022, p. 1). We also have many successful examples. The findings of a randomised controlled trial in Tehran, where pregnant women were subject to an educational intervention (motivational interviewing, booklet, SMS) to increase preventive behaviours toward air pollution exposure, suggest, "TTM-based educational interventions can increase preventive behaviours aimed at reducing exposure to pollution" (Araban et al., 2017). Women were more consistent and effective in adopting recommended preventive behaviours, such as limiting their exposure to hazardous outdoor air pollutants. The findings also suggest that a strong sense of self-efficacy can enable women to reduce the adverse effects of air pollution on their reproductive health (ibid.). Hence, women can be the agents of change and not just beneficiaries. TTM-based educational interventions can help them become one. Apart from spreading awareness among women, it is important that it is taught in schools to spread awareness at an early stage. Learning early in life about the current problems is a good way to prevent them.

Some countries have already taken the initiative. South Korea introduced an environmental health education program for pregnant women in the year 2022. 8-sessions of an online educational program on air pollution, endocrine disruptors, and protective behaviour were held (Jo & Kim, 2025, p. 2). As a result, awareness and intention to take preventive measures during pregnancy improved. Also, there was a significant improvement in personal and community environmental health behaviours, lifestyle adjustments, dust avoidance, recycling habits, quality of life, and e-learning satisfaction. There was no noticeable effect on participants' self-

reported health status or on levels of depression and anxiety (Jo & Kim, 2025, p. 1). The study demonstrated the feasibility and preliminary effectiveness of a mobile-based environmental health program for pregnant women (Kim, 2023).

Lastly, it is important to note that the statutory or regulatory air quality laws (ambient air quality regulation, emissions regulation) do not have legal clauses that specifically mandate protections for pregnant women or maternal health in the law text. The recognition is more in policy/program or advisory instruments. This underscores the urgent need for strong statutory laws that protect women's reproductive health from the harmful effects of air pollution and uphold their right to live, conceive, and raise families in a cleaner and healthier environment.

9. Conclusion

Air pollution has a profound toll on women's reproductive health, yet government responses have yet to fully acknowledge this crisis or craft targeted safeguards. While fragmented studies highlight Delhi-NCR's air quality woes, a holistic, region-wide evaluation encompassing emerging pollutants is urgently needed to shape policies attuned to women's needs across social strata.

Implementation of existing anti-pollution measures falls short, denying women their indirect benefits. This study urges robust enforcement of current frameworks nationwide, alongside long-term strategies and emergency plans explicitly protecting women's reproductive health, as seen in progressive international models. Achieving this demands a robust research ecosystem, with state incentives to deepen evidence on these intersections, coupled with mandatory women's inclusion in decision-making for truly gender-responsive policies.

Amid overlapping agencies, action plans, and mandates, jurisdictional clashes and misaligned goals undermine progress. Enhanced coordination and clarity are essential to harmonise efforts. Nationwide awareness campaigns must empower women with knowledge of air pollution's reproductive risks and broader harms. In response, mandating women's representation in Delhi-NCR air quality bodies would affirm their stakeholder role, bolster policy legitimacy while honouring India's CEDAW obligations and SDGs 5 (gender equality) and 13 (climate action).

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