Università
Ca'Foscari
Venezia

Master's Degree

in Environmental Humanities Course

Final Thesis

Air pollution in India

Supervisor:
Stefano Beggiora

Assistant supervisor:
Davide Zanchettin

Graduand:
Iuliia Paul

Academic Year
2022/2023

CONTENT

ACKNOWLEDGEMENTS

I am deeply grateful to my supervisor Stefano Beggiora and assistant supervisor Davide Zanchettin for their mentorship and guidance in the course of preparation of the master's thesis. Their help, support and timely feedback have been really important to me. In addition, I want to thank my university teachers who helped me discover the world of environmental humanities and encouraged me to develop further in this field. I have also been lucky to have the company of my supportive groupmates, who were always ready to answer the questions and share the necessary information. Thank you all for the wonderful 2 years that have significantly influenced my life!

INTRODUCTION

The paradox of modern society is that along with the rapid development of technology, the state of the environment is significantly deteriorating. Nature suffers greatly from the activity of a person, who often conducts in an effort to get maximum profit and without thinking about the consequences.

Only a few countries manage to find a balance in their relationship with the environment, while the rest fail in this, and this leads to the fact that the population lives in a polluted environment. India belongs to the countries of the second group, and it terrifies with the scale of pollution. One of the most widespread problems in India is air pollution, and this is the focus of our work.

The relevance of the topic of the thesis is due to the aggravation of environmental problems, in particular, poor air quality in Indian cities. This country is one of the largest and most densely populated states in the world. There is a significant amount of world production, a huge industrial sector, and industrialization processes are actively developing. Now India is becoming the new world leader in economic growth, largely due to accelerated industrialization.

This research work is aimed at evaluating the causes, consequences, and potential solutions for air pollution in India. We have set a goal to study both theoretical and practical aspects of poor air quality affecting people's health, provoking chronic and respiratory diseases, their negative impact on certain groups of the population, such as pregnant women, children and the elderly being even devastating. The paper provides a detailed analysis of the environmental situation in Delhi, Mumbai and Kolkata, highlights practical surveys of the population that allow empirically identifying factors of poor air quality for individual population groups and considers possible solutions. In this thesis, an analysis of the impact of climate change on the change in air quality is carried out, and the influence of energy dependence on natural resources on its quality is determined. We have considered the importance of the country's transition to an eco-friendly path of development with the help of state investments in the green economy.

In this work, solutions are proposed to ameliorate the air quality and improve the overall environmental situation in the country. The material is prepared on the basis of scientific articles, books, electronic sources, and analytical data taken from official monitoring and information review sites.

The thesis comprises 3 chapters with sub-paragraphs along with conclusions and a list of sources used.

The first chapter deals with general characteristics of air pollution regardless of place. There we mention various organizations dealing with this problem, some global statistics, and brief information about different air pollutants, existing methods for determining air quality,

sources of air pollution and its influence on health and climate change. It is considered in some detail how air pollution and climate change are related. Also, in this part we give a brief overview of the situation in India. That is the Environmental Performance Index for India, air quality monitoring in the country, some statistics on air pollution, the main reasons for air pollution and factors complicating the situation.

In the second chapter we mainly concentrate on 3 Indian cities – Delhi, Mumbai and Kolkata. We try to understand which of the sources of air pollution makes the greatest contribution in each of the cities and provide statistics on the concentration of pollutants. The influence of religious festivals, in particular Diwali, on air quality is considered. This chapter also contains an interview with a resident of Delhi and a survey of local residents. A separate section of this part tells about the history and features of globalization in India, and about its connection with air pollution.

In the final third chapter, we look at the existing legislative acts in India, which bodies, ministries and organizations are involved in resolving the issue and what initiatives they have proposed. In one section, we try to analyze why the measures that have already been taken do not lead to the desired result and propose actions that people and the government can take to reduce the scale of the problem. Along with that we consider nature-based solutions and how they can be applied to the Indian scenario. A separate section is devoted to the connection of Environmental Humanities and the topic of air pollution.

As a result of the work, measures to prevent the problem at the macro level and micro level have been identified**.**

I. THE ESSENCE OF THE AIR POLLUTION PROBLEM

1. General characteristics of air pollution

It is unlikely that there is a person in the world who has not heard about environmental problems, in particular, about the problem of air pollution. This problem has been known for thousands of years, but the attitude towards it was different. In a way, in the past the presence of air pollution meant development and prosperity (Fenger 2009). And indeed, it is often a large number of industrial enterprises that, together with large profits, bring air pollution. Nowadays the problem and its negative consequences cannot be denied. In various ratings of environmental problems, air pollution is consistently in the top ten. In different sources we can find a lot of frightening information, which is not the plot of a disaster movie, but our reality.

Ambient air is the most important life-supporting natural environment and is a mixture of gases and aerosols in the surface layer of the atmosphere, whose current state is the result of seamless variations determined by chemical and physical processes during the evolution of the Earth, and, in recent times, also strongly influenced by human activity (Glossary of Meteorology 2012). The characteristics of the atmosphere have an intense impact not only on humans and biota, but also on the hydrosphere, soil, geological environment, buildings, structures and other man-made objects. Therefore, the protection of atmospheric air and the ozone layer is among the most priority environmental problems and it is given close attention in all developed countries (Ibid).

The problems of protecting the air constitute an extensive field of research at the intersection of sciences. They include both general tasks of chemical technology, mechanical engineering and meteorology, as well as issues that can be solved by narrow specialists – mathematicians, physicists, electrical engineers, software analysts, doctors, hygienists, biologists, geologists, lawyers, designers and others.

In general, air pollution can be defined as *air contamination as a result of the release into the atmosphere of gases, vapors, droplets, particles, as well as an increase in the concentrations of conventional components (solid particles, carbon dioxide, plant pollen)* (Glossary of Meteorology 2012). Air pollution is caused mainly by the work of industrial enterprises, the burning of fuel in various systems (automobile and other engines, on energy devices), household activities of the population, smoking, etc. Eventually, there is a change in the natural environment and/or ecosystem.

Changes in air quality inevitably affect air pollution and this happens simultaneously in the form of several processes in which the nature of the agents is fundamentally different (Suzdaleva and Goryunova 2020, 3). The most significant of them, which have reached global scales by now or are naturally approaching them, include the following forms of pollution:

- radioactive;

- mechanical (aerosol);

- chemical;

- thermal (energy);

- secondary, the agents of which are formed during physico-chemical processes occurring under the influence of man-made factors directly in the atmosphere.

At the same time, the growth of the planet's population and the urbanization of its surface give the processes of diffuse atmospheric pollution increasing importance. Its source is every new house, released car or tractor.

The introduction of more environmentally friendly technologies in these areas (for example, the spread of electric vehicles in developed countries) will not be able to change the global trend of increasing atmospheric pollution in the foreseeable future. At the present stage, it is impossible to create large structures capable of effectively purifying the surface air of an urbanized region from diffuse pollution (for example, constantly filtering large volumes of it), both for financial and technical reasons. In addition, the operation of such devices will inevitably have a negative impact on the avifauna and other biological objects spread by air currents. The idea of contrasting the diffuse pollution of the atmosphere with the organization of a system of diffusely placed pollution absorbers in the environment seems more promising. As elements of this system, green spaces can be used, capable of detaining a significant part of chemical and mechanical pollution agents (Ibid 2020).

Various organizations deal with the problem along with ongoing monitoring of air quality in different parts of the world and holding conferences and forums during which this problem and possible solutions to it are discussed. The World Health Organization (WHO) is one of the main organizations showing genuine interest in this problem, but in addition to it, the following can be listed: Environmental Protection Agency, National Oceanic and Atmospheric Administration, World Meteorological Organization, Clean Air World, National Association of Clean Air Agencies and Air & Waste Management Association. Many other organizations of both global and regional importance can be added to this list.

According to 2019 WHO statistics, almost 99% of the world's population breathes air whose quality exceeds WHO air quality limits and poses a threat to their health (World Health Organization 2022)[1]. This happens despite the geography of air quality monitoring being expanded. It is worth mentioning that now more than 6000 cities in 117 countries are engaged in the monitoring process. The combined effect of outdoor and household air pollution is connected

[1] In this paragraph, the statistics are taken from the website https://www.who.int/news/item/04-04-2022-billions-of-people-still-breathe-unhealthy-air-new-who-data

to 6.7 million premature deaths every year. It is estimated that outdoor air pollution in 2019 caused 4.2 million premature deaths around the world. Some of these premature deaths were in countries with low and middle income, and the largest number was recorded in Southeast Asia and the Western Pacific. Based on the statistical data provided, it can be concluded that the measures taken to solve this problem are insufficient. In addition, there is probably a link between the level of income of the population and the level of air pollution.

Substances of chemical or biological origin that are contained or enter the atmospheric air and can directly or indirectly negatively affect human health and the state of the natural environment are called *air pollutants*. They can exist in solid, liquid or gaseous form. There is also a division into natural and human-made pollutants and into primary and secondary ones.

In general, air pollutants in solid form are referred to as "particles," and are categorized based on their size into PM10, PM2.5, PM2.5-10, and UFP. These particles have different characteristics and come from different sources. UFP and PM2.5 in cities are usually from primary sources such as industrial activities, vehicles, and heating while fine particles in non-urban areas are mostly from secondary sources that result from chemical reactions. Coarse particles consist mainly of sea salt and crustal materials, and can come from transportation patterns or dust resuspension. NO_2, a gaseous pollutant, comes from burning fossil fuels and is commonly emitted by vehicles and industrial plants in urban areas. Tropospheric ozone is a harmful air pollutant generated by photochemical reactions involving NOx and VOCs, and its concentration is inversely related to NO_2 (Stafoggia 2020, 1-2). Studies show that the concentrations of all pollutants vary from day to day, with fluctuations caused by differences in weather conditions, road traffic (Cummings et al. 2021, 5).

As mentioned above, air quality is being regularly monitored around the world. Many of the data obtained can be found in the public domain, while it is possible to find out not only the total level of air pollution, but also the concentration level of individual pollutants.

There are various methods for determining the level of air pollution. One of the most widespread is the air quality index (AQI) (Kanchan, Gorai, and Goyal 2015, 101). It is a total indicator showing the level of health risk associated with air pollution by particulate matter and gaseous substances. The index appeared in 1998 on the initiative of US Environmental Protection Agency. It evaluates the air quality by the concentration of PM10, PM2,5, ozone, SO_2, NO_2 and CO. Later, a similar index-based approach to expressing health risk was developed in France, the UK and Germany.

Currently, AQI is calculated daily in different parts of the world. There are several variations of this index: AQHI (Canada), AQI (China, the Netherlands, the UK, India) and CAQI (Europe). Different variants of the indices can be explained by different approaches to

quantitative and qualitative analysis of pollution, as well as regional differences in permissible concentrations of hazardous substances.

AQHI is based on epidemiological studies. That is the sum of the excess mortality risk associated with individual pollutants, taking into account the analysis of time series of air pollution and mortality in Canadian cities. The data is displayed on a scale of 0-10. AQHI is calculated every hour based on the average concentrations of pollutants over the last 3 hours (Gayer et al. 2018, 5). CAQI is a common air quality index. It has both hourly and daily versions, and is also divided depending on the place where measurements are taken ("roadside" vs "background")[2].

There are websites where up-to-date information about the level of air pollution can be found. An application *Air Quality App* has also been developed for the convenience of people. Due to its ease of use, this index is a means of warning about health hazards.

https://air-quality.com is a website that provides real-time air quality and pollen information for over 180 countries in the world. The website is a part of the Air Matters project, which aims to provide accurate and up-to-date air quality information to people around the world. Users can access information on the AQI for their location, which tells them how clean or polluted the air is and what associated health effects might be a concern for them. The situation can be seen in real time. For example, if we look at the rating by city, then among the cities with the worst air quality the following can be seen: Urumqi (309), Gurugram (248), Noida (235), Delhi (221), and New Delhi (213). There are 4 Indian and 5 Chinese cities in the top ten (Figure 1).

At the end of the list we can see the cities with the cleanest air such as Vilnius and Toulouse (14), Vancouver (11), Gothenburg (11) and Venice (8). That is, there is a more favorable situation in European cities.

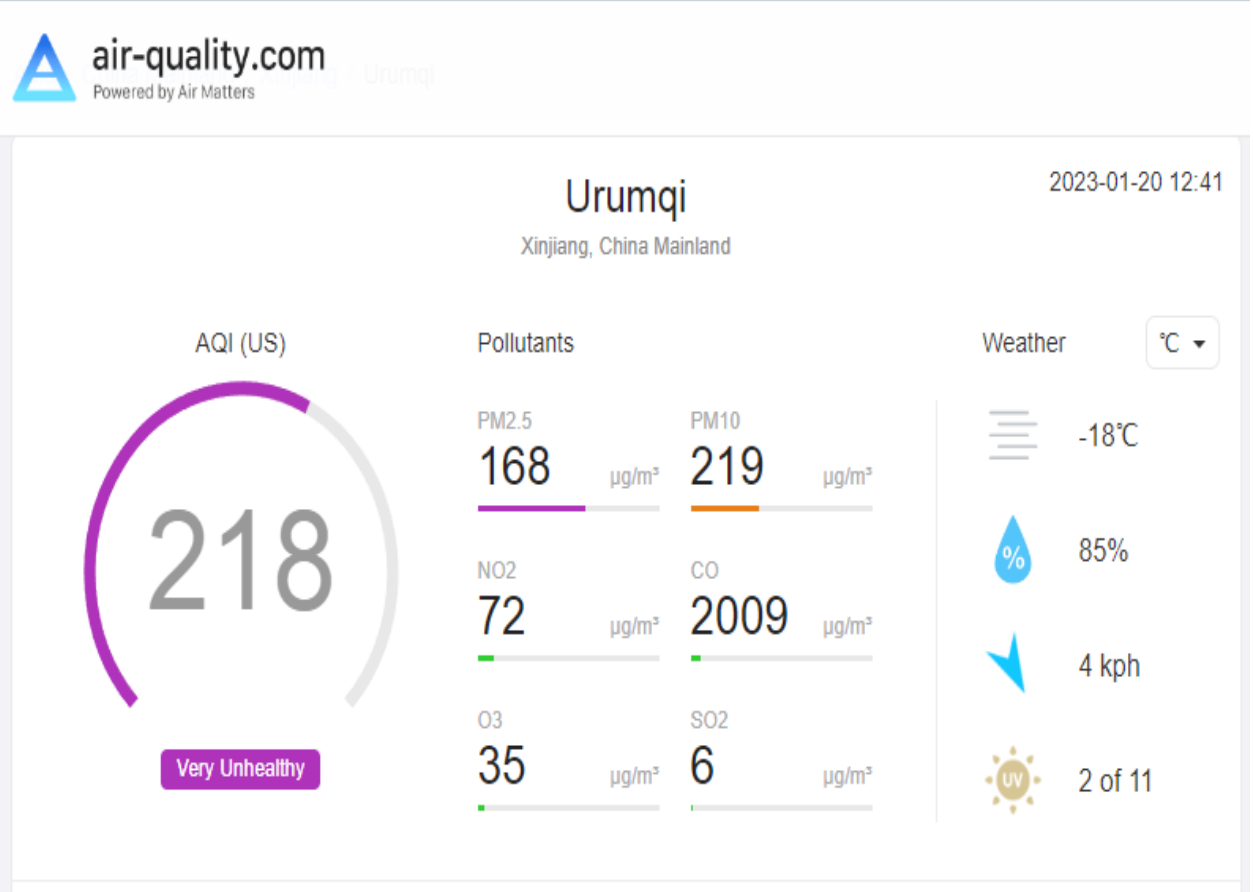
[2] https://airly.org/en/air-quality-index-caqi-and-aqi-methods-of-calculation/

Figure 1. Air quality index in different cities as of January 20, 2023.

The air quality index can take values from 0 to 500+. In addition, different color designations are assigned to different levels of air quality. Values 0-50 (good) indicate that the air is fresh and does not contain toxins. In this case people are not exposed to any health risk. An index in the range of 51-100 (moderate) means acceptable air quality for healthy adults, but a small threat to sensitive people. Numbers in the range 101-200 (poor) indicate that inhaling such air can cause mild discomfort and difficulty breathing. Values 201-300 (unhealthy) are indicative of the air situation being problematic for children, pregnant women and the elderly. 301-400 numbers (severe) show that exposure to air can lead to chronic diseases or even organ damage. The largest values are 401-501+ (hazardous) and they mean that people's lives are in danger, and prolonged exposure can lead to premature death. Moreover, on this website we can see the

concentration of air pollutants (PM, NO_2, CO, O_3, SO_2) in a particular city or country. An example is shown below (Fig. 2).

Figure 2. Air quality index in Urumqi as of January 20, 2023.



In Figure 2, we can see that the air quality index in Urumqi is very unhealthy with an extremely high PM 2.5 concentration and a quite high PM 10 level. Concentrations of substances such as NO_2, CO, O_3 and SO_2 are within acceptable limits.

WHO publishes recommendations on the permissible concentration level of certain substances, which are called Global Air Quality Guidelines (AQGs). In 2021 WHO updated their recommended air quality guidelines. In the table we can see what changes have been made regarding PM 10 and PM 2.5 concentrations (Fig. 3).

Figure 3. WHO AQGs in 2005 and 2021

Air Pollution Norms	WHO AQGs (2005)		WHO AQGs (2021)	
	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
daily	50	25	45	15
yearly	20	10	15	5

It can be seen that the accepted daily and annual values for PM 10 and PM 2.5 have been reduced in the course of time. The revision was made due to the overwhelming scientific evidence that even a small exposure to PM2.5 and PM 10 for a short time can harm human health.

Thus, we can see that technologies in the field of determining the level of air pollution are constantly developing, the air monitoring network is expanding, and air quality standards are changing in accordance with modern research.

2. The sources of air pollution

Sources of air pollution can be classified in different ways, for example, based on location or types of activities. First of all, they can be divided into two large groups – anthropogenic and natural, which in turn are divided into smaller categories[3] (Duggal 2019).

Technological progress is sometimes seen as responsible for the growth of anthropogenic sources of air pollution. Anthropogenic sources (related to human activity, caused by economic activity) in quantitative terms are much superior to natural ones, and they can be divided into:

1. “Stationary sources” – non-mobile technological units (installation, device, apparatus, etc.) that release air pollutants during operation.

This group comprises chimneys of power plants, production facilities (factories) and incinerators along with furnaces and other types of heating devices running on fuel.

2. “Mobile Sources”. These are motor vehicles, sea vessels, aircraft, sound effect, and so on. The share of mobile sources of air contamination is significantly higher than stationary ones.

Exhaust gases contain more than 200 chemicals, including products of incomplete combustion of fuel (carbon dioxide, aldehydes, ketones, hydrocarbons, hydrogen, soot, peroxide compounds), products of thermal reactions of nitrogen with oxygen, due to which nitrogen oxides are formed, and substances that are part of the fuel (lead compounds, sulfur dioxide).

[3] Information about air pollution sources in this section is taken from https://www.indiacelebrating.com/environmental-issues/causes-and-sources-of-air-pollution/

A number of factors affect the degree of air pollution by motor transport: vehicle emission factors (technology), speed and driving mode, degree of fuel purification, weight of the car and environmental factors such as street width, weather conditions and terrain.

An increase in the density of vehicles on highways and roads leads to a change in the driving mode and an increase in acceleration time, which is characterized by the most intense exhaust emissions. The intensity and density of traffic flows are of great importance. With a low flow density (10 cars/km), it is possible to move at a free speed, with a group movement (11-30 cars/km), a drop in flow velocity leads to additional fuel consumption. When moving in columns (31-100 cars/km), the flow rate decreases down to congestion, which further increases fuel consumption and, consequently, increases the level of air pollution.

3. Chemicals, dust and controlled combustion methods in agriculture and forestry. Insecticides, pesticides and fertilizers that emit harmful chemicals into the air are actively used in agriculture.

4. Fumes from paint, hairspray, nail polish, spray cans and other solvent substances.

5. Deposition of waste in landfills that emit methane. Landfills emit methane gas, which creates a greenhouse effect threatening our planet, keeping heat in the Earth's atmosphere. Waste incineration also leads to the release of dangerous gases containing toxic heavy metals: cadmium, mercury, lead.

6. Military sources. For instance, atomic weapons, toxic gases, germ warfare and rocket science.

Next, a table for various sectors of industry and the corresponding pollutants will be provided (Table 1).

Table 1. Industry sectors and corresponding air pollutants.

Industry sector	Non-specific substances	Specific substances
Non-ferrous metallurgy	suspended solids, sulfur dioxide, carbon monoxide, nitrogen dioxide, nitrogen oxide, soot, inorganic dust: 70-20% SiO_2	solid fluorides, hydrogen fluoride, benzene, xylene, toluene, graphite dust, naphthalene, anthracene, phenanthrene, white spirit
Ferrous metallurgy	carbon dioxide, solids, sulfur dioxide, nitrogen oxide	chromium, compounds of manganese, lead, phosphorus, arsenic, vanadium, mercury; formaldehyde, benzene, phenol, ammonia, benzo(a)pyrene

Oil industry	carbon monoxide, sulfur dioxide, nitrogen oxides	various hydrocarbons, hydrogen sulfide
Machine building	carbon dioxide, carbon monoxide, sulfur dioxide, nitrogen oxides, dust	vapors of oils, alkalis, acids, gas emissions from welding
Chemical industry	sulfur oxide, nitrogen oxide	The composition depends on the production: fluoride compounds, ammonia, superphosphate dust and apatite, phosphoric anhydride, ammonium nitrate aerosols, etc.
Oil refining industry	carbon monoxide, carbon dioxide, nitrogen oxide, dust, sulfur dioxide	hydrocarbons, hydrogen sulfide
Pulp and paper industry	dust, sulfur dioxide, carbon monoxide	sodium sulfide, sulfur-containing compounds (hydrogen sulfide, methyl mercaptan, dimethyl sulfide, dimethyl disulfide), methanol, turpentine, chlorine, chlorine dioxide, alkaline aerosols, sulfurous anhydride
Coal mining industry	carbon dioxide, dust	methane
Production of building materials	dust	cement dust, asbestos, quartz
Woodworking industry, furniture production	wood dust	formaldehyde, phenol. ammonia

Natural air pollution, as the name implies, has a natural origin and has always existed. Natural sources include the following groups:

1. Dust coming from natural sources (from lands with low vegetation or without it).

2. Methane released during the digestion of food by animals, such as cattle. For example, a cow is able to produce 4-5 hundred liters of methane per day.

3. Radon gas formed as a result of radioactive decay within the terrestrial crust. Radon is a very dangerous gas, which is one of the causes of lung cancer, and it tends to accumulate in buildings.

4. Smoke and carbon monoxide from forest fires. Since the forest is the main supplier of oxygen, after its destruction, oxygen is not formed; therefore, carbon dioxide harmful to human health is not absorbed, which pollutes the atmosphere. This leads to a decrease in air quality.

5. Volcanic activity. The eruption of a volcano is catastrophic for the environment. Tons of solid particles and ash enter the atmosphere; dangerous gases (sulfur compounds, carbon) are formed. In addition to mechanical, thermal pollution is noted, because substances have a high temperature. Heated vapors, gases, incandescent magma burn everything in its path. When the volcano subsides, the balance of gases gradually normalizes.

It is difficult to determine the most dangerous source of air pollution. On the one hand, natural sources of pollution can arise spontaneously, regardless of human actions, but often their impact is not as serious as anthropogenic. On the other hand, anthropogenic sources directly depend on human actions so they are easier to control, but the consequences of pollution from such sources are much more significant. In addition, anthropogenic sources are superior in number. Thus, we can conclude that anthropogenic sources seem to be more dangerous than natural ones.

3. The impacts of air pollution

When talking about the effects of air pollution, health disorders and climate change are usually mentioned. The impact of atmospheric air pollution on human health has been studied in a large number of epidemiological studies conducted around the world and aimed at morbidity and mortality, both general and specific, mainly due to respiratory and circulatory diseases. In research from Manisalidis et al. (2020, 7-8) the various effects of exposure to air pollutants on the human body are listed[4].

Damage to health is the most formidable consequence of air pollution, since most xenobiotics enter the body through the respiratory organs, behind which there is no chemical barrier. In addition, it must be borne in mind that a person consumes a significant amount of air every day. The body's reaction to the effects of atmospheric pollution will depend on individual characteristics, age, gender, health status, weather conditions. The most susceptible categories of the population are the elderly, children and people with diabetes or having a predisposition to heart/lung disease.

[4]In this section, information about the health effects of air pollution is taken from the article "Environmental and Health Impacts of Air Pollution: A Review." by Manisalidis et al. (unless otherwise specified).

When people are faced with a high amount of pollutants, they experience health problems/states of varying degrees of complexity. These states can be divided into short-term and long-term.

There is a wide range of short-term states from eye/skin/nose irritation and wheezing or coughing to asthma, pneumonia, bronchitis, lung and heart problems. By prolonged exposure to air pollutants, these problems can be exacerbated. This can manifest itself in neurological, reproductive and breathing problems. Long-term states are chronic, last for years or a lifetime and ultimately may result in death.

Respiratory disorders are closely related to the inhalation of air pollutants. The pollutants enter through the respiratory tract and accumulate in the cells. Cell damage depends on the component of the contaminant involved, its source and amount. Among the most harmful substances for the respiratory system are Particulate Matter (PMs), dust, benzene, and O_3. Chronic obstructive pulmonary disease may be the result of exposure to these pollutants on the human body, especially for people predisposed to lung diseases.

Also, people exposed to air pollutants may experience cardiovascular problems. Prolonged exposure can lead to changes in blood cells, and this, in its turn, may affect the functionality of the heart. Diseases and states such as coronary arteriosclerosis, hypertension, stroke, myocardial infarction and heart failure are among possible consequences. NO_2 in the long term can lead to ventricular hypertrophy.

Other researchers (Gurjar, Molina, and Ojha 2010, 2) argue that continuous exposure to PM increases the likelihood of developing respiratory and cardiovascular illnesses, as well as lung cancer. In addition, in underdeveloped nations, the usage of open fires or conventional stoves to burn solid fuel inside contributes to a greater threat of acute lower respiratory infections and related mortality among young children. For adults the frequent usage of solid fuels inside leads to chronic obstructive pulmonary disease and lung cancer, making it a substantial risk element.

Neurological and psychological disorders are also possible. Long-term exposure to air pollution is considered to be one of the factors for Alzheimer's and Parkinson's diseases. In addition, it was found that air pollution negatively affects the state of the immune system. Dysfunction and neuroinflammation are associated with this environmental problem.

As for the skin, it can also be negatively affected by air pollutants. As a result of their exposure, pigmented spots may appear. Moreover, if pollutants penetrate the skin, there may be organ damage, since some of the pollutants are mutagenic and carcinogenic, and, in particular, they have a negative impact on the liver and lungs. However, air pollutants are also able to have a positive effect on the skin. They can mitigate the negative effects of ultraviolet radiation.

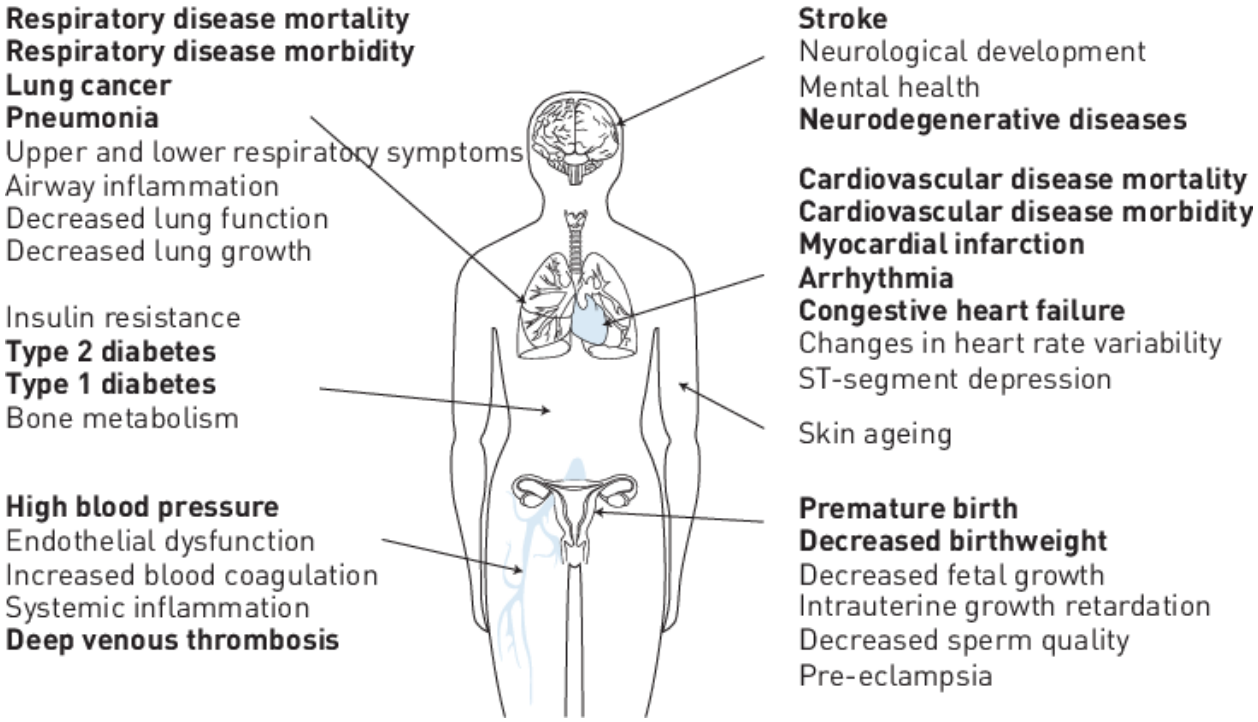
Undoubtedly, this does not compensate for their negative impact, which can lead to skin aging, psoriasis, acne, urticaria, eczema, and atopic dermatitis.

Eyes may also be influenced by air pollution. Among the possible consequences are asymptomatic eye outcomes, irritation, retinopathy and dry eye syndrome.

Fetuses and children have a higher mortality rate if they are exposed to polluted air. Fetal growth disorders, low birth weight and autism have been observed.

In a schematic form, the negative effect of air pollution on the human body is shown in Figure 4.

Figure 4. The effects of polluted air on the human body.



Source: Conibear 2019, 50

Air pollution brings harm not only to humans, but also to the environment. Below we will list the main areas involved (Manisalidis et al. 2020, 9-10)[5].

Acid rain, which represents wet or dry precipitation, has a big quantity of nitric and sulfuric acids in its composition. Among the negative consequences may be acidification of water and soil, damage to buildings and various structures located in the open air.

[5] In this section, information about the effects of air pollution on the environment is taken from the article "Environmental and Health Impacts of Air Pollution: A Review." by Manisalidis et al. (unless otherwise specified).

Haze is formed as a result of the dispersion of fine particles in the air and decrease in the transparency of the atmosphere. This is due to the release of gases into the air coming from industrial enterprises, power plants and transport.

Ozone is formed both at ground level and in the stratosphere. While stratospheric ozone is useful because it protects against the dangerous effects of ultraviolet rays, ground-level ozone is detrimental. In humans, it can cause respiratory problems and/or irritation of the eyes, nose and throat, and in plants it causes blocking of carbon dioxide transmission and thus slows down the photosynthesis process, eventually leading to reducing yields. Stratospheric ozone is steadily being destroyed by chemicals, pesticides and aerosols. With the thinning of the ozone layer, the risk of irradiation of the surface with ultraviolet rays increases.

Undoubtedly, it is impossible not to mention global change. As a result of active human activity, the greenhouse effect, which maintains a stable Earth temperature, has been disrupted. A large amount of greenhouse gases is produced, increasing global warming in scale that, in its turn, negatively affects human health, fauna and flora, agriculture and the aquatic environment. High levels of CO_2 and global warming are responsible for altering plant communities and their ecological mechanisms, in a direct or indirect way (Ciumasu and Costica 2010, 456). These changes can have a significant impact on both nutrient dynamics and the way flowering plants reproduce.

Wildlife suffers from toxic pollutants, and thus animals may have health problems if they are exposed to a large amount of pollutants. In addition, cases of reproductive failure and birth defects have been observed.

When increased concentrations of nutrients (in particular, nitrogen) foster the flowering of aquatic algae, eutrophication occurs, which can result in imbalance in the variety of fish and their death.

Air pollution has a detrimental effect on both soil and water. With regard to PM as an air pollutant, its influence on crop capacity and food productivity has been noticed. Its impact on the aquatic environment is related to the survival of fish and other species and their productivity potential. Another threat to ecosystems and living beings is toxicity of lead and other metals.

Air pollution harms not only the environment and living organisms, but also has a negative influence on economic growth. Pollution can lead to health problems affecting the economy on a macro level due to negative market externalities, although the exact extent of these impacts for individuals and the economy as a whole is unclear. The costs of air pollution on the market comprise both direct and indirect costs, such as changes in productivity and health expenses, and changes in agricultural yield or international trade. It is estimated that by 2060,

pollution-related economic costs will equal 1% of global GDP and there will be an annual loss of working days equivalent to US$3.7 billion globally (OECD 2016, 1).

All in all, air pollution causes irreparable damage to human health, the environment and the economy. The consequences of air pollution reach far beyond the tangible effects on our physical well-being and financial stability. In its essence air pollution is a fundamental flaw in our relationship with the planet. We have become so disconnected from nature that we now view it as a resource to exploit, rather than a complex and interconnected web of life that we are an integral part of. Moreover, our addiction to convenience, technology, and instant pleasure has created a culture of consumption and waste that is incompatible with a healthy planet. We have lost touch with the value of simplicity, sustainability, and community, and instead prioritize individualism, competition, and material wealth. This disconnect has led to a global crisis that threatens not only our physical survival, but our spiritual, emotional, and psychological well-being as well.

4. Climate change and air pollution interconnections and similarities

4.1. Lessons from climate change action, limitations and problems

In order to try to better understand and define the air pollution problem both in India and worldwide, the global struggle to contain climate change could provide useful insights in this process and phenomenon. In fact, part of the recent increasing attention to the problem of air pollution is directly connected to the increased awareness of the impacts of climate change. The scientific community has understood that the problems related to climate change often appear to be too far in the future and not related to actual peoples' life, which makes international climate action difficult to advance. The initiatives to limit climate change are often unpopular and even undesirable because people are largely interested in their present life while they don't see any benefits of thinking for the future. The effects of today's emissions will be to a greater extent felt by people living in the future. In fact the average lifetime of CO_2 in the atmosphere, while difficult to assess and precisely define, could be in the range of even hundreds of years[6]. Therefore people could actually not perceive climate change and this makes the issue very distant from the public with some exceptions as could be the case for instance for extreme events[7]. For the general public it is still difficult to understand and grasp the complexity and many spillover effects of climate change. In order to make progress possible and to take action in

[6]Carbon dioxide's lifetime cannot be represented with a single value because the gas is not destroyed over time, but instead moves among different parts of the ocean–atmosphere–land system. Some of the excess carbon dioxide is absorbed quickly (for example, by the ocean surface), but some will remain in the atmosphere for thousands of years, due in part to the very slow process by which carbon is transferred to ocean sediments. URL: https://www.epa.gov/climate-indicators/greenhouse-gases

[7]Extreme events attract a lot of public attention and climate change is often mentioned as partially responsible for them. According to the IPCC reports they are becoming more frequent due to climate change.

many countries, climate policies are centered on a top-down approach where mitigation goals are achieved through government regulation. The air pollution issue, which is felt every day by millions or even billions of people, could make climate change more familiar and tangible especially to people living in polluted cities. This would allow greater participation from the public and foster bottom-up approaches with the participation of local communities at a local and regional level. In this regard, in the last couple of years cities around the world are playing a greater role in the fight against climate change[8]. Adopting clean energy, for example, could decrease emissions while at the same time could significantly improve urban air quality, although not immediately. The shared benefits are one of the reasons why air pollution is becoming more important in the climate change debate besides the fact that there is growing awareness and scientific proof of the interconnectedness of issues and problems[9].

While climate change is not the topic of this thesis, it is important to mention just some related critical issues and to put it in the context of recent known existential threats to human life on earth. Unfortunately, climate change action and activism has been often carried on through narratives and discourses which put in direct connection climate change and the continuation of human life on Earth. Many times such popular proclamations put even the existence of an inhabitable Earth in question and the effects of climate tipping points are exaggerated in time and scale[10]. There is large consensus in the scientific community that there is a growing risk posed by climate tipping points[11] like sea level rise, permafrost trapped methane emissions or structural ocean circulation changes, however, they do not pose an immediate existential risk to the human species on planet Earth or to the planet itself. They pose a risk to our society, to many world regions especially sea level cities, to our livelihood and to the world economy according to the Stern Review of 2006 and many other studies. A better perspective would be to consider climate change as an additional stressor for the human society and the environment. According for example to the calculations and estimates of the Stern Review of 2006 the global economy in 2200 would be on average smaller by 13.8% of GDP, with a 90% interval of confidence that the true loss will be between 2.9% and 35.2% which is a considerable value (Nordhaus 2007). What the Stern Review points out is particularly the long run lower costs for the economy to choose the adaptation and mitigation pathway compared to the business as usual scenario with no

[8]URL: https://unfccc.int/topics/education-youth/youth/global-youth-video-competition/global-youth-video-competition-2019/cities-and-local-action-to-combat-climate-change

[9]URL: https://www.eea.europa.eu/publications/zero-pollution/cross-cutting-stories/cross-cutting-story-5-co

[10]It is often reminded that the life of planet Earth is not the same that the life of humans on planet Earth. Even in the case of the most extreme and unimaginable scenarios humans could cease to live but the planet Earth would still exist. It is important to distinguish them.

[11]URL: https://www.oecd.org/environment/climate-tipping-points-abc5a69e-en.htm

mitigation and adaptation policies. Nevertheless there could be other events which could have a drastic impact on the world economy as, for example, was the case for the Covid pandemic and year 2200 is very far away. The climate change effects should be rather understood in their cumulative nature as an additional negative factor for the future of the world economy and human society. However, such considerations do not hold true at a regional level where climate change could have a dramatic impact on certain world regions.

The suggestions of the end of the world are very present in public events, demonstrations and protests when people demand action from politicians, however, such narratives could be harmful for a sound understanding of the issue. While the Earth climate has been changing for millions of years, what the scientists point out today is the unprecedented speed of the climatic changes happening today. An average temperature rise of one or two degrees in a couple of centuries is something never observed before in recent planet history[12]. This is largely attributed to the human activities and especially to the extensive burning of fossil fuels which started at the beginning of the industrial revolution in the 18th century. In two hundred years the world climate has changed to an extent it could possibly do in many millennia. Today's concentrations of CO_2 have reached levels never seen in recent human history and they are exceeding even measurements from tens of thousands of years in Earth history based on data taken from ice cores and sediments measurements. This is the so called anthropogenic factor of climate change because a large part of these emissions is human made. However, it is still very difficult to exactly separate the anthropogenic and the natural factors of climate change and to provide solid scientific quantitative evidence for each of them or to exactly assess how much carbon the oceans could still absorb and what would be the future technological advancements and breakthroughs. In addition, there are many factors responsible for CO_2 emissions in addition to human energy use like, for instance, food production and land use change. Moreover, it is extremely difficult to capture and to predict abrupt events which could have a huge impact on the world climate which are not related to human activities. In this regard many scientists and normal people struggle to see the fight against climate change as the top priority in their everyday lives. Strengthening such attitudes could be also recent emerging studies showing that climate change is not among the top threats to the human life on our planet as, for example, the studies of the Future of Humanity Institute at Oxford University would demonstrate[13]. Although the supporters of radical action for climate change often depict pessimistic and dark scenarios for our future, it is becoming increasingly clear that unfortunately this is just one of the many

[12] Recent history is referred to the time of available observations or plausible estimates a timescale of some million years while in Earth history there were five or six mass extinctions and other extreme changes on a timescale of four billion years.

[13] URL: https://www.fhi.ox.ac.uk/research/research-areas/

potential existential threats facing our lives. Paradoxically today the issue of climate change gets much more attention in the media than other issues which could pose a more serious threat to our life on Earth[14]. However, the positive side of this attention is that the global human society has started to take such issues seriously, extending many good established practices related to climate change to other areas such as biodiversity conservation and other threats to humanity.

Some scientists claim the importance of scientific skepticism. Richard Muller, professor of physics at the University of California at Berkeley, holder of a doctorate, author of the popular books "Physics for future Presidents" and "Energy for Future Presidents", until recently was known for a consistent critical attitude to the problem of global warming[15]. Since 2010, Richard Muller has been conducting an experiment to study the temperature of the Earth's surface (the BEST - Berkeley Earth Surface Temperature Project) in order to independently recheck data on temperature changes that have occurred over the past two and a half centuries in different parts of the globe.

After the research that Richard Muller conducted with the BEST group, he is convinced that global warming is not a myth and its main cause is human activity, but immediate effects still do not occur. According to official data, over the past 50 years, the average temperature on the globe has increased by 0.64 degrees — less than two-thirds of a degree. This value can be called insignificant. When the physicist and a group of scientists began to look at the readings of monitoring stations around the world, it turned out that a third of them had recorded a cold snap in the last hundred years. The remaining two-thirds showed warming, but 33% of the Earth's surface has become colder over the past hundred years. Global warming does not lead to the melting of the Kilimanjaro ice. According to the scientist, the danger does not threaten us either now or in the near future, but we must seriously prepare for significant climate changes in the following decades.

It is extremely important to try to put climate change in a more defined context even for the understanding of the air pollution problem. The above paragraph points out some important issues. It appears clear that nor the planet Earth nor the entire human life on Earth is endangered, there are still many difficulties to clearly separate and evaluate anthropogenic climate change and natural climate change, the importance of abrupt non human related events and most importantly the presence of other possibly even more serious existential threats to humanity. Unfortunately, in the public debate about climate change this is often missing, while a more systemic, interdisciplinary, multi-actor and multi-level and global approach would be extremely

[14] e.g. nuclear war, super intelligence, deadly microbes etc.

[15] Information about Berkeley Earth Surface Temperature Project is taken from https://arstechnica.com/science/2012/07/berkeley-earth-project-is-back-to-re-re-confirm-earth-is-warming .

needed. This would avoid unnecessary polarization around this topic and allow us to better understand the global human priorities according, for example, to their level of danger to human life or to other agreed metrics. In the same spirit it is reasonable to understand why people don't perceive air pollution to be one of the main problems in their life. Air pollution kills indirectly, it is often labeled as the “hidden killer” that shortens people's lives but it is not an existential threat to humanity nor to people's everyday life, although there is growing evidence of the negative effects on people's health and working performance in polluted cities. For people in poor countries, and especially in many Indian regions, air pollution is often a trade over between survival and improving living conditions and starvation and poverty. People have other priorities in their lives or simply they do not have a choice to change. Many of them think that this is the price to pay for better living standards, which is a priority for the majority of them. In order to promote change education and knowledge is needed and any environmental action both for climate change and for air quality improvement should be preceded or go in parallel with inequality reduction and sustainable economic development of poor countries and regions.

4.2. Climate change and air pollution connections

Climate change and air pollution have many connections. Air pollution is partially responsible for climate change, acid rain and other externalities. According to some recent studies higher levels of sulfate aerosol emissions on the Indian subcontinent caused less rainfall over the Indo-Gangetic plain (Varanasi 2022). At present, Bangladesh, Pakistan, and India have the most polluted air in the world. However, vice versa climate change also fosters air pollution. One of the effects of climate change is that extreme events are becoming more frequent. It means more frequent extreme cold winter weeks or especially more frequent heat waves in summer. Extreme heat waves increase the frequency of forest fires which put enormous amounts of pollutants into the air at a transnational level due to wind currents and air circulation. They also transform the nature of forests from a carbon sink to an additional emitter of greenhouse gases. In order to cope with these events people in cities need to use more energy and electricity for heating or for air cooling in hot temperatures. The energy and electricity is still largely produced by burning of coal and natural gas which increases the greenhouse gases emissions. At the same time, however, for decreasing greenhouse gases emissions and improving living standards other sources of energy are needed. The fight against climate change passes through the ongoing revolution of the world energy system from fossil fuels to renewable energy sources like wind and solar energy, with nuclear energy[16] probably still playing a role in it, and other emerging technologies. This transition would indirectly benefit air quality in many cities since electricity

[16]It is questionable if nuclear energy could be considered a renewable source of energy and especially if it is a clean and environmentally acceptable source of it due to the possibility of nuclear accidents and the disposal of used nuclear fuel.

would no longer be produced by burning coal or other dirty fuels in the power plants located near the cities but by other cleaner sources. In addition, the transportation networks would be based on cleaner and more environmentally sustainable fuels.

The goal behind the governments pledges to limit climate change is to reach the peak of emissions in the near future and then to bring the world economy to carbon neutrality possibly already in the middle of this century. On paper the goals seem very ambitious and they are welcomed by the majority of climate researchers worldwide. However, they raise a series of extremely important issues regarding human rights to development, global equity and it appears immediately clear how difficult is to compare, for example, Italy to India and how they could reach together such a global goal without limiting the development of entire continents. In addition, with projections of an expanding human population in developing countries and especially in the Indian region and Africa, at least until the middle of this century, it is not clear how land use change for food production and expanding urbanization could be stopped or even reversed since bigger areas would be needed to produce food and for other living needs for a growing population. Agricultural expansion, for instance, is the leading cause of Amazon forest deforestation in Brazil[17] both legal and especially the illegal one. The controversial issue of an expanding population and human demand for Earth resources has been a subject of debate and contention since at least the works of the classical economist Robert Malthus in the eighteenth century and more recently by books like “The Limits to Growth” of 1972.

In the case of Indian cities air pollution is attributed to well observed and known factors. The most important are probably especially transportation,[18]electricity production, agriculture, cooking and garbage management. In the case of energy production and transportation, the world's struggle to contain climate change could benefit air quality in Indian cities. This is due to the fact that scaling up the adoption of solar and wind energy around the world has made these technologies more competitive to source energy from compared to other fossil sources. However, due to booming energy demand, India is still increasing the use of fossil fuels both for electricity production and for transportation. The recent Chinese enhanced action to clean the skies of the major Chinese cities has shown that the pathway for better air quality is not linear. Paradoxically, a huge reduction of PM2.5 pollutants in China, due to stricter regulations for transportation and other measures, has not lead to cleaner air in Chinese cities since the reduction of PM2.5 has fostered an increase in ozone pollution (Deng et al. 2022). Peaks of pollution in many Indian cities are reached when farmers burn their fields in order to clear and prepare them for the next season. Changes and improvements in the food production system would have a huge impact on

[17]URL: https://www.amazonconservation.org/the-challenge/threats/
[18]Every day about 1500 new cars are put on Delhi streets.

air quality in India. However, such changes would need a lot of investments and technology which rural Indian farmers, struggling to survive and feed their families, do not have. More than 60% of India's 1.4 billion people still depend primarily on agriculture for their livelihood. However, the sector accounts for only about 15% of the country's economic output. A recent attempt by the Indian government to change and liberalize the Indian agricultural sector, which is still subsidized and protected by the central government after the food shortages of the sixties, has led to national protests and uprising by Indian farmers which led the government to abandon these plans (Mashal, Schmall, and Goldman 2021). Changes in the agricultural sector, due to the huge interests at stake, the large number of people involved and political power of this class would be difficult to enact.

4.3. Political action, development inequalities, human rights and conflicting interests

Air pollution and climate change do not have fast and simple solutions. Countries and even regions have different capabilities in order to deal with them. Air pollution is an unresolved problem even for developed regions and cities where national and local governments have more resources to monitor the air, inform the public and to take action. In addition, the majority of these regions have a stable or even shrinking population. It is important to mention the fact that the almost 25 million newborn babies in India in 2022 amounted to the newborn babies of the whole of Europe, USA, Japan, Brazil and China combined. This puts extensive stress on Indian cities, society and infrastructure. According to recent data India would have almost one billion people in their working age under the age of forty and all those people would put tremendous pressure on the job market. The Indian economy would need to create new jobs and this would attract even more people to the cities. Economic growth will put increasing stress on the environment.

India has very limited resources to dedicate to adaptation and building resilience to cope with climate change. There are other problems which have higher priority on the government agenda, for instance, providing food and water to all people and areas of the country, basic healthcare and education just to mention some of them. What is basically currently going on, and especially in India and other developing countries, could be defined also as a struggle between different human rights. The human rights for food and drinkable water and for acceptable living conditions often go against the human right for clean air. In order to provide jobs the Indian economy needs to attract polluting industries from abroad what of course has a positive impact on the economy but at the same time it also worsens the already critical situation of air pollution in many cities. An exception could be the high-tech sector where India is one of the world leaders. Good drinking water is probably one of the greatest problems for many Indian regions and the improvement of water infrastructure is very costly. According to the World Bank India

has 18% of the world's population, but only 4% of its water resources, making it among the most water-stressed regions in the world[19]. The availability of water would be exacerbated by climate change. It appears very clear from just one example how various issues are interconnected and how difficult it is to properly target the government planning in order to deal with all of the issues.

The UN framework COP negotiations for climate change provide another opportunity to understand how "facts on the ground" influence Indian position at the diplomatic tables. At every occasion the Indian representatives stress the importance to balance different interests and especially the right of the Indian government to give priority to poverty reduction through development rather than abandoning fossil fuels too early. Against this background Indian climate pledges at the negotiations table are often labeled as not ambitious enough and India is accused of delaying climate action at home. However, poverty reduction needs economic growth which is closely linked to increased energy use and increased emissions. The decoupling has not happened yet although in the last couple of years, especially in the Chinese case, the country could soon reach such a goal of growing the economy without increasing the emissions thanks to massive renewable energy installations. The reduction in the energy intensity of the economy should exceed the rate of the economic growth in order to make this possible. Air pollution in India follows the same logic as for greenhouse emissions although at a smaller regional or city scale. Unfortunately, current economic development is still technologically trapped in the paradigm where a growing economy needs more and more resources what exacerbates air pollution and other negative effects on the environment.

It appears increasingly clear how different levels of development influence countries' action and policy both on climate change and on air pollution. Additionally, different metrics could provide different pictures of the problem as could be the case with greenhouse gases emissions. India as a whole is amongst the top world emission countries, however, at the per capita level, it is at the lowest end of the ranking. Similarly historical emissions somehow justify current and future Indian emissions because most of the currently accumulated emissions in the atmosphere "belong" to developed countries. For this purpose the UNFCCC introduced the Loss and Damage concept following the idea that rich countries which are responsible for the majority of emissions should pay poor countries which suffer losses because of climate change. The mechanism is often criticized for being too weak, with not enough resources. It could be also seen as a kind of stick and carrot approach where poor and underdeveloped nations are forced to follow rules, limitations and policies imposed by the rich and developed world. It appears clear

[19]URL: https://www.worldbank.org/en/country/india/brief/world-water-day-2022-how-india-is-addressing-its-water-needs

that the current damages of climate change are to a greater extent the consequence of past rich countries emissions. In addition, many of the most vulnerable regions are located in poor and developing countries. This creates and fosters disbalances and inequality at a global level. Against this background climate negotiations are also often criticized for representing the interests of the developed world. In fact most of the climate action, also at a popular level, is happening in rich countries. According to Scott Barrett, Lenfest-Earth Institute Professor of Natural Resource Economics, the development issue has not been prioritized during international climate negotiations. The focus is still on what individual countries could do for reducing their greenhouse gas emissions. According to him, policymakers would need to develop an approach that addresses both the economic interests of developing countries like India, as well as the collective interests of other nations (Varanasi 2022).

One important difference between air pollution and climate change is the timescale of the problem. While air pollution is less a result of cumulative effects, climate change is determined by a decades-long process of concentration of greenhouse gases in the atmosphere. Current air pollution would not have impacts centuries in the future and is not a result of past emissions. However, anyway, changes in the economic systems and energy systems, which are needed to address air pollution, are usually decades' long processes. Climate change could also be defined as a global scale problem compared to air pollution which is a more regional phenomenon, although it is increasingly clear that also air pollution has transnational consequences and implications like, for instance, in the case of forest fires, transboundary pollution and acid rain precipitations teens of kilometers far from the pollution centers. Satellite images confirm every year that borders do not matter for air pollution. Toxic clouds above India move in the direction of other bordering countries which are also heavily impacted by the degree of air pollution in big Indian cities. From this perspective the air pollution issue should be considered at a larger scale as an international problem. One of the best examples which confirms this international vision could be the Arctic region. The northern polar region has been for many decades heavily impacted by transnational air pollution coming to the Arctic from lower altitudes and from big industrial clusters in the southern regions. With a few exceptions, there are no industries in the Arctic which could pollute the polar region. The Arctic at the same time is also experiencing the biggest effects of climate change.

In the scientific community the term Arctic Paradox have been used to define this situation, where the Arctic region and its people, who are absolutely not responsible for the emissions and the pollution, are unfortunately the most impacted by pollutants coming from far away. Many similarities could be found also in other parts of the world with India not being an exception. This reinforces the idea that air pollution should be considered on a more global and

international scale.

The analysis of the Indian population Census[20] offers important insights on the disbalances in living standards and life expectancy across India. While air pollution is more concentrated around big cities, the statistics suggest that its negative effects are largely compensated by other positive factors. Therefore the average life expectancy is at least 5% higher in urban areas compared to rural regions. The difference in life expectancy between urban and rural areas across India is decreasing. The only region where life expectancy is higher in rural areas compared to urban areas is Karala. According to the Census there is a difference of about 4.6 years in urban-rural life expectancy at birth and about 1.8 years in urban-rural life expectancy at age 70, for the country. Based on these general data, interventions to improve air quality would probably improve life expectancy to a greater extent in cities where life expectancy is already higher compared to rural areas. Life expectancy metrics alone would not entirely justify such actions. Urban residents have access to better healthcare, education and higher incomes which compensate for the damages inflicted on their health by air pollution. Of course these statistics do not consider the differences between poor and rich city inhabitants where the differences could be really huge. Undoubtedly, air pollution inflicts bigger damage to low-income people, for example the people of the slums in the city's peripheries. A good example could be the use of polluting cooking stoves and fire to which are mainly exposed to the low income people inside their houses. The black carbon concentrations are extremely high in these houses and residential areas. Higher income houses use natural gas or electricity for cooking so they are not exposed to in-house pollution apart from the pollution coming from the streets. Another good example could be the job of an Indian rickshaw driver working for hours in the middle of the city traffic. The level of air pollution on the most congested crossroads and streets reaches incredibly high levels which are not even reported and captured by official statistics. In a study for Dhanbad city the highest PM concentrations during congestion periods of auto-rickshaw riding were measured at about (844 μgm^{-3} for PM_{10}, 458 μgm^{-3} for $PM_{2.5}$ and 302 μgm^{-3} for PM_1). For PM 2.5 this is 40 times higher than the recommended safe levels of 12 $\mu g/m^3$ (Gupta and Elumalai 2019). According to this study about 20-23% of rickshaw drivers complained of the body pain and eye irritation' and 'a headache' symptoms. On congested streets the pollution is four to five times higher compared to other city areas. Undoubtedly, the effects on life expectancy are more severe for these people compared to others.

[20]URL: SRS BASED ABRIDGED LIFE TABLES 2016-20 https://censusindia.gov.in/census.website/data/SRSALT

The general population data could not capture these differences. Such discrepancies between rural and urban areas and between poor and rich complicate action against air pollution.

In conclusion, the comparison between climate change and air pollution could be very useful in order to try to show how difficult it is to prioritize and to organize regional, national and international action to try to address these problems. What is remarkably clear is that differences between countries and within countries like in the Indian case could play a crucial role in the understanding and people's perception of the effects and severity of the issues. Climate change impacts to a greater extent poor people and poor regions because they have less resources to adapt and lower levels of resilience. The same is true in the case of air pollution. However, at the same time, they are also the people who are less aware of their risks and consider the issues to be of lower priority compared to other problems. The children of foreign diplomats studying in Delhi school have a modern building with an advanced three layer filtration system. They suffer less from air pollution compared to less fortunate children of an Indian slum who probably would not achieve high levels of education if any at all. It is extremely important that climate and air pollution actions do not foster inequalities and put additional burdens on societies. Climate change is also a matter of justice; the same is true for clean air. However, in developing countries food, water, education and basic healthcare are also matters of justice. The models and thinking mindsets coming from the developed world could not be applied to other countries without considering their particular situation and priorities. Environmental activists from rich countries raising the specter of human extinction because of climate change could not be taken seriously in other parts of the world. Climate negotiations should be more inclusive and consider the rights and problems of other countries. The results of climate change action in the future will not be evaluated probably only on the basis of the amount of avoided emissions but also on the basis of other factors like, for example, poverty and inequality reduction, sustainable and equal development and other human rights. The chapter clearly shows how multilevel and multi factors approach is needed and that there are no fast and simple solutions to these problems. Many global issues are really interconnected, often even in hidden ways therefore proposed solutions need well balanced political decisions, based on a balance of interests, priorities and people's needs.

5. Description of air pollution in India and factors complicating the situation

India has significantly increased its economic and political power over the past decades. But the dynamic economic development has turned into an acute environmental crisis for India. Environmental problems are exacerbated by demographic pressure and unfavorable physical and geographical conditions in a significant part of the country.

India regularly ranks among the countries with the highest population, and according to the 2021 Census, its population is 1.4 billion. Over the decade 2011-2021, India's population has grown by more than 19 million people (Census of India 2021).

According to the Environmental Performance Index (EPI) for 2016, India ranked 141st out of 180 surveyed countries. EPI includes many highly-important environmental issues, among which resource consumption, depletion of environmental assets, pollution and species extinction can be found (Hanzala 2017).

One of the reasons why India cannot be among the most environmentally friendly countries is air contamination. It is known that open waste incineration is one of the main sources of toxic air pollutants such as particulate matter, carbon monoxide, black carbon, dioxins, furans and mercury. Air pollution in India is due to the burning of fuel wood and biomass, the mass burning of plant residues in agricultural fields, the use of adulterated fuel, vehicle emissions and traffic congestion.

India ranks third in greenhouse gas emissions after China and the United States. The degree of air pollution is so great that life expectancy among Indians has decreased by 3.4 years on average; while among Delhi residents it is decreasing by almost 6.3 year (Ibid).

In 2022 India ranked 8th in the ranking of countries with the most polluted air. Its average AQI was estimated as 144 (for comparison, in the countries leading in the ranking, the index is equal to 159-169). Of the 15 most polluted cities in Central and South Asia, 12 are located in India. It was found that the average concentration of PM2.5 in India by 2022 is 10.7 times higher than the value of WHO annual recommendations on air quality, but this indicator has even become better compared to 2018. In general, air was found to be unhealthy for sensitive groups. Bhiwadi (Rajasthan state) was recognized as the most polluted city in India with AQI equal to 170. Industry is responsible for more than 50% of pollution, vehicles for 27%, crop burning for 17% and domestic cooking for 7%. In some parts of India, air quality has improved since 2018, albeit very little. Also, in 2019, the number of days when the content of pollutants exceeded the recommended levels for PM2.5 decreased ("India Air Quality Index (AQI) and Air Pollution Information | AirVisual," n.d.).

The increasing scale of the problem is primarily associated with the lack of proper transport management, suitable roads and unplanned distribution of industries. The increase in transport emissions is due to congestion of roads and the resulting decrease in the speed of transport. In addition to this, factors such as growing urbanization, industrialization, population growth and intensive anthropogenic activity exacerbate the problem (Kaur and Pandey 2021, 4).

Let us take a closer look at the problem and see why it is so relevant in India. First of all, electricity and other clean fuels are not available or are not actively used in different parts of the

country. Household stoves use fuel made from a wet mixture of pieces of wood, leaves, hay and dried animal dung. When burning it, five times more smoke and other pollutants are released than when burning coal ("India Air Quality Index (AQI) and Air Pollution Information | AirVisual," n.d.)[21]. Of course, to a greater extent this applies to the population with extremely low income, who cannot afford the most necessary things, not to mention high-quality fuel.

Secondly, often cheaper components are added to fuel for transport. Naturally, when exhaust gases are released, more pollutants are produced. All this is due to high tax rates on gasoline, diesel, kerosene, while volatile liquids such as lubricants and solvents are subject to little or no tax. Therefore, in order to save money, cheap ingredients are added to high-quality expensive fuels. And of course this aspect of the problem is also closely intertwined with the high level of poverty in the country.

In addition, traffic jams caused by a large number of cars and congested roads adds to the scale of the problem. The road system and traffic of India is characterized by the absence of intra-urban divided highways and traffic accidents because of chaotic conditions on the roads of India due to sluggish complying with the laws. This is a question of a high degree of urbanization and insufficient high-quality planning of the transport system of India.

Furthermore, the dust generated as a result of the demolition of buildings and further construction of new ones facilitates the deterioration of air quality in the city. Here we can also talk about the connection with rapid urbanization, leading to active development of territories.

It is believed that in the northern states of India the problem is the most serious. Delhi, Punjab, Uttar Pradesh, Haryana are extremely contaminated and require urgent measures (Shubhankar 2019). This can be explained by the geographical location of Northern India. Its proximity to the Himalayas means that polluted air is very difficult to escape. During the winter months, when the wind strength decreases significantly, this area can be considered as an enclosed space with a high concentration of polluted air.

Also, the problem is especially relevant for large cities in India, for instance, Delhi, Mumbai and Kolkata. Kusum Lata, a resident of Delhi says, "There is smoke all around and we have forgotten the feeling of being in an open, fresh environment, inhaling fresh air. We have been experiencing breathlessness. The moment we step out in the open we start feeling breathless. My children are also facing problems due to the quality of air. They fall sick very quickly and frequently." (Greenpeace India 2022)

Let us focus a little more on 3 big cities of India – Delhi, Mumbai and Kolkata and the problem of air pollution in them. As of 2023, the population of Delhi is approximately

[21] Here and further general information on air pollution in India is taken from https://www.iqair.com/india (unless otherwise specified)

43,345,060 people (World Population Review 2020). It is a dynamic city with an unusually fast pace of development. For example, the length of roads increased 3.8 times in the period from 1971 to 2011, and the number of registered vehicles has increased by 20 times. Back in 2000, 30% of Delhi's population had respiratory diseases, and over time the situation has only got worse (Gurjar, Ravindra, and Nagpure 2016, 4).

Being a big city, Delhi is subject to high levels of pollution all year round. The air is often filled by high levels of PM2.5 and PM10, as well as other forms of pollutants and toxic chemicals entering the atmosphere, with each having its own detrimental effects on human health. An estimated 30.2 million people are registered in Delhi as of 2020, living in a relatively small area of 1.484 km^2, making India an extremely densely populated city. In 2019, the PM2.5 index was 98.6 micrograms/ m^3, which puts it in the category of "unhealthy" according to the US AQI, which requires a PM2.5 value in the range of 55.5 to 150.4 micrograms/ m^3. The fact that the city is in the unhealthy group on average for a year is an indicator that air quality poses a significant health hazard. Delhi is struggling with population growth, with many "urban diseases" becoming more obvious as the city is struggling to keep up with an ever-growing population. Thus, it results in growth in almost all industries and the associated increase in air pollution, directly correlating with industrial and economic growth ("Delhi Air Quality Index (AQI) and India Air Pollution | AirVisual" 2020)[22].

The emissions from vehicles are extremely high in Delhi: it is estimated that as of 2018, 11.2 million vehicles were registered on the roads, which is about 27% more than in 2015. This significant increase plays a very important role in the establishment of Delhi as a city with one of the worst air quality indicators in the world. If we look at the PM2.5 data obtained for 2019 on the IQAir website, we can see that it ranks 2nd in terms of pollution in all of India, second only to Ghaziabad, which ranks first in terms of pollution, with indicators that give it an extremely high rating - 110.2 micrograms/ m^3.

Moreover, Delhi took the 5th place out of all cities with the worst air quality in the world. This place, along with the 2019 ranking in the category "harmful to health", as well as three months a year, rising a step higher in the category "very harmful to health", indicate that Delhi suffers from extremely high levels of pollution, being one of the world leaders in poor air quality with extremely large amounts of PM2.5, PM10 and other harmful chemicals and smoke entering the atmosphere.

Another major city in India is Mumbai, which is the financial capital of the country. Its industrial and commercial growth has been followed by a sharp population growth from 0.9

[22] Here and further statistical information about Delhi is taken from the website https://www.iqair.com/india/delhi

million in 1901 to 18.41 million in 2011. The expansion of industries, the increase in foundry production and in the number of vehicles by 103% has led to a serious air pollution problem in Mumbai (Gurjar, Ravindra, and Nagpure 2016, 5).

Currently Mumbai's 2023 population is about 27,342,820 people (World Population Review 2020). In 2018, Mumbai was ranked as the 37th most polluted city in India. Analyzing data from 2013 to 2018, the Airpocalypse-IV report revealed that for more than 52 days, the level of air pollution in Mumbai exceeded safety standards of 60 micrograms per cubic meter (mcg/ m^3) in the presence of PM10. This amount of 162 micrograms/ m^3 for 2018 is three times higher than the recommended national ambient air quality safety standard and eight times higher than the international standard (20 micrograms/ m^3) recommended by WHO ("Mumbai Air Quality Index (AQI) and India Air Pollution | AirVisual," n.d.).[23]

As in other major cities around the world, most of the pollution is caused by traffic and construction. 29% of PM in the air comes from road and construction dust, while power plants that increase the level of PM by 20%. The main source of traffic pollution is heavy-duty vehicles running on diesel fuel. The areas within Mumbai with the lowest AQI index have the largest number of registered vehicles. In 2019, the number of registered vehicles increased by 9.9%, bringing the total number to about 3.5 million.

Another one big Indian city is Kolkata, so called *City of Joy* but with very poor air quality. Air pollution there is associated with high population density, rapid and unplanned urbanization, uncontrolled density of vehicles and poorly maintained roads along with low turnover of old vehicles (Gurjar, Ravindra, and Nagpure 2016, 5).

Nowadays the city has a population approximately equal to 19,564,170 people (World Population Review 2020). In Kolkata, the PM2.5 index was 59.8, recorded in 2019, on average for the year. This puts it directly into the category of "harmful to health", which requires a PM2.5 value in the range from 55.5 to 150.4 micrograms/m^3. According to these data, in 2019 it ranked 61st in the world in terms of pollution and 28th among all cities in India. This shows that Kolkata is indeed very polluted, and although it may not suffer from such extreme levels of pollution as other cities, there has definitely been a very dangerous level of pollution here for many months.[24]

In terms of air pollution Kolkata is similar to many other states and cities in India, although with differences in what time of year the greatest bursts of smoke and haze are observed because of several different factors. Vehicles always play a big role in the level of

[23] Here and further statistics about Mumbai are taken from the website https://www.iqair.com/india/maharashtra/mumbai

[24] Here and further statistics about Kolkata are taken from the website https://www.iqair.com/us/india/west-bengal/kolkata

environmental pollution throughout the year. Cars, motorcycles and trucks emit huge amounts of smoke, haze and pollutants into the air, and those that run on fossil fuels such as diesel fuel emit more pollutants. Pollutants generated in the automotive industry comprise black carbon and VOCs, which are released during incomplete combustion of fossil fuels such as diesel fuel.

Air pollutants are also released because of methods such as slash-and-burn farming, incineration of organic waste and refuse, and the use of coal to power the numerous factories and industrial enterprises located around Kolkata. The main pollutant released in the automotive industry (as well as from all combustion sources) is nitrogen dioxide (NO_2), which is contained in high concentrations in any area around the world with a large volume of traffic, and Kolkata is not an exception, since NO_2 levels are constantly an impending threat in its growth due to the demographic explosion and, consequently, the growth in the number of personal vehicles.

Despite the fact that the level of pollution in Kolkata has yet to be increased to ensure the best health of its citizens, it is obvious that the level of pollution has improved over the past few years, with a noticeable improvement in PM2.5 levels recorded in 2019 compared to a few years earlier. In 2017, the average annual content of PM2.5 was 76.7 micrograms/m^3, which still belongs to the category of harmful to health, but is significantly higher compared to the recent period. 2018 started with an even worse figure of 85.4 micrograms/m^3, before finally reaching an improved 2019 figure of 59.8 micrograms/m^3, which represents a 25 micrograms/m^3 reduction in PM over the course of the year.

Kolkata still has a long way to go, since the excessive amount of pollution recorded in January greatly distorted the results, its rating for 2019 was not far from dropping one step lower from the rating "harmful to health" to the category "harmful to sensitive groups".

Since we are talking about the major cities of India, we cannot ignore such a concept as Urban Heat Island (UHI). It is a phenomenon that occurs worldwide in urban areas. It is characterized by higher temperatures in the built-up urban areas when compared to the cooler temperatures of the nearby non-urban or rural landscapes. UHI is closely related to air pollution as it causes reduction of the area of green spaces in urban areas, which also contributes to the deterioration of air quality (Menon and Sharma 2021, 3).

Undoubtedly, the government cannot ignore this problem and not take any steps. India has a national environmental surface monitoring network, which was established in 1987 and has become more extensive over time due to a significant increase in the number and spatial extent of continuous and manual monitoring stations between 2015 and 2019. Currently, Central Pollution Control Board (CPCB), along with the State Pollution Control Boards (SPCBs), manages the most extensive monitoring network in the country as part of the National Air Quality Monitoring Program (NAMP). As of 2019, there were more than 220 stations for

continuous monitoring of ambient air quality (compared to less than 50 stations in 2015) (Sharma and Mauzerall 2022, 2). As for the measures taken and planned in relation to this problem, we will discuss them a little later.

II. INDIAN CASE STUDY

1. Air pollution in Delhi, Mumbai and Kolkata and its impact on local population

India is facing a severe environmental crisis as a result of air pollution. The country's rapidly growing population, coupled with industrialization and urbanization, has resulted in a sharp growth of air pollution levels. The problem is particularly serious in densely populated cities like Delhi, Mumbai, and Kolkata.

The death rate in India is very high, and the terrible air quality contributes to this (Table 2).

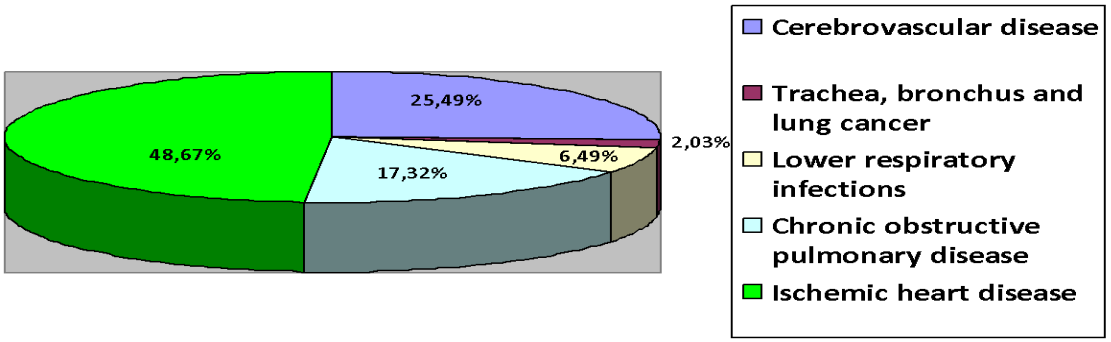
Table 2. Deaths attributable to air pollution in India in 2019

	Number of deaths, millions*	Percentage of total deaths*
Air pollution	1.67	17.8%
Ambient particulate matter pollution	0.98	10.4%
Household Air pollution	0.61	6.5%
Ambient Ozone pollution	0.17	1.8%

Source: AQI India

According to statistics, in 2019, air pollution in India was the cause of death for 1.67 million people, which is 17.8 %. At the same time, the number of deaths from household air pollution has decreased by 64.2% in the period 1990-2019. However, over the same period, the mortality rate associated with particulate pollution increased by 115.3%, and mortality associated with ozone pollution increased by 139.2% (AQI India). Thus, ambient PM and ozone pollution has a larger scale and is more difficult to control than household air pollution.

Figure 5. Percentage of deaths from ambient air pollution in India



Source: Lim et al. 2012

Among the diseases that arose as a result of ambient air contamination and ultimately led to death, there is primarily ischemia, which is responsible for almost half of all death cases (48.67%). It if followed by cerebrovascular disease with 25.49% and chronic obstructive pulmonary disease with 17.32%. Lower respiratory infections and trachea, bronchus, and lung cancer have 6.49% and 2.03% respectively (Lim et al. 2012).

There is ample research, both globally and in India, that demonstrates how air pollution outdoors as well as indoors represents a major environmental risk factor which can either cause or exacerbate acute and long-term diseases. By combining data from the National Family Health Survey (2005-06) with air pollution measures at the city level, six cities in India (Chennai, Delhi, Hyderabad, Indore, Kolkata and Nagpur) were analyzed to investigate the relationship between ambient air pollution and child morbidity (TERI 2015, 9). The results of the study indicated that an increase in ambient air pollution significantly raised the possibility of children experiencing cough and fever in a given week. However, the type of fuel used for cooking at home did not have a significant link to child morbidity when factors such as ambient air pollution and control variables related to the child and their household were considered. In other words, air pollution is more closely related to child health outcomes than the type of cooking fuel used at home.

India's economy is rapidly increasing, but this growth is accompanied by a sharp decrease in air quality, which has proven to be costly. IQAir and Greenpeace Southeast Asia have created a cost calculator that counts the medical and economic costs of air pollution. The cost calculation for an entire year is derived from an algorithm that takes into account the following data: real-time PM2.5 and NO_2 data (if present), specially designed risk models and demographic and health information. Recent research indicates that India endured a considerable economic loss of

36.8 billion USD due to air pollution in 2019, which amounts to about 1.4% of the country's GDP during that year. The study also shows that premature deaths caused by air pollution accounted for 28.8 billion USD in losses and illnesses caused contributed to losses worth 8 billion USD (AQI India 2021).

In 2021, India's annual PM2.5 levels reached an average of 58.1 μg/ m^3, reversing a trend of improving air quality in the past three years. Many cities in India continue to have high levels of air pollution, with none meeting WHO air quality guideline of 5 μg/ m^3. A significant amount of PM2.5 emissions in urban areas can be attributed to internal combustion engines in motor vehicles, which is concerning as India's annual vehicle sales are expected to increase. To combat this issue, India has implemented strict emissions standards for new vehicles, with plans to develop emissions testing methodologies that accurately reflect real-world driving conditions (World Air Quality Report 2021).

When talking about India, it is impossible not to mention the extremely strong influence of religion in this country. Religious festivals and practices have always held a special place in the hearts of Indians. Unfortunately, these festivals not only bring joy and harmony but also have a profound impact on the environment, particularly on air quality.

The air quality index experiences a significant increase post-Diwali, which usually takes place towards the end of October or early November. This rise occurs because the celebratory fires and fireworks, which are typical of Diwali festivals, serve as an important contributor to air pollution. Consequently, pollution levels surpass the dangerous limits swiftly. While the government has taken measures to prohibit the use of fireworks, the residents continue to disobey the rules. This further worsens the already terrible air quality in the city, as toxic fumes and debris from the fireworks accumulate. As a result, the city becomes covered in a haze, and AQI takes on terrifying values (Rajagopal 2021).

In a recent article (Nath and Rosencranz 2017) highlighted the adverse effects of religious festivals on air quality. The authors argue that the responsibility for protecting India's air and water from pollution caused by religious festivals should fall on politicians, not just the judiciary. While religion is deeply embedded in India's social fabric, it has had a detrimental impact on the environment during festivals such as Diwali, Holi, Durga Puja, and Ganesh Puja. Despite restrictions being placed on these practices due to public order, health, and morality concerns, there is a lack of political will to contain them. The Supreme Court has made temporary bans, such as suspending all licenses permitting the sale of fireworks within the National Capital Region of New Delhi, but this is only a temporary solution. Political parties, particularly the pro-Hindu Bharatiya Janata Party (BPJ), are hesitant to impose significant restrictions on religious festivities due to fears of disturbing their majority Hindu vote-bank. To truly combat

environmental pollution caused by religious activities, India needs a comprehensive pollution prevention policy that prioritizes the right to life over the right to practice religion.

While the situation is not improving, the local population is suffering from health problems caused by poor air quality. Air pollution was the second biggest risk in India in 2016, with child and maternal malnutrition ranking first, up from third in 1990. Air pollution exposure contributed in part to four out of the top five leading causes of disease in India (Khan et al. 2017).

Research published in The Lancet Planetary Health journal (The Economic Times 2021) suggests that pregnant women in India, Pakistan and Bangladesh may have a greater risk of miscarriage and stillbirths due to poor air quality. The study analyzed data from 34,197 women who had lost pregnancies between 2000 and 2016 due to exposure to PM2.5 levels above India's air quality standard of 40 micrograms per cubic meter, which the paper claimed caused an estimated 349,681 pregnancy losses per year in South Asia. The research discovered that there was an increased likelihood of pregnancy loss from exposure to PM2.5. Even after taking into consideration other factors, every 10 microgram per cubic meter increase was estimated to increase the risk of pregnancy loss by 3%.

The majority of the research carried out in the metropolises of Delhi and Mumbai revealed a correlation between the amount of air pollution in the environment and the frequency of acute and long-term respiratory symptoms. Studies that analyzed data over time showed three highly significant connections between air pollution and health consequences: a substantial rise in acute respiratory illnesses, an increase in all-cause mortality, and a surge in emergency visits for cardio-respiratory problems (Public Health Foundation in India 2017, 20).

Poor air quality significantly reduces the standard of living of the population. Taking into account data on mortality and reproductive risks, it can be assumed that air pollution in the future may interfere with the full reproduction of the population.

1.1. Delhi

Being the capital of India, Delhi is a very active and developed city with a high population and large flows of tourists. All these factors cannot but affect the ecological state of the city. In addition to this, in Delhi there is a problem with the air being stagnant because of the lack of wind. This causes accumulation of pollutants in certain areas. Also, the winds are trapped by the Himalayas towards the north, thus preventing the pollutants from escaping (Gurjar, Ravindra, and Nagpure 2016, 3).

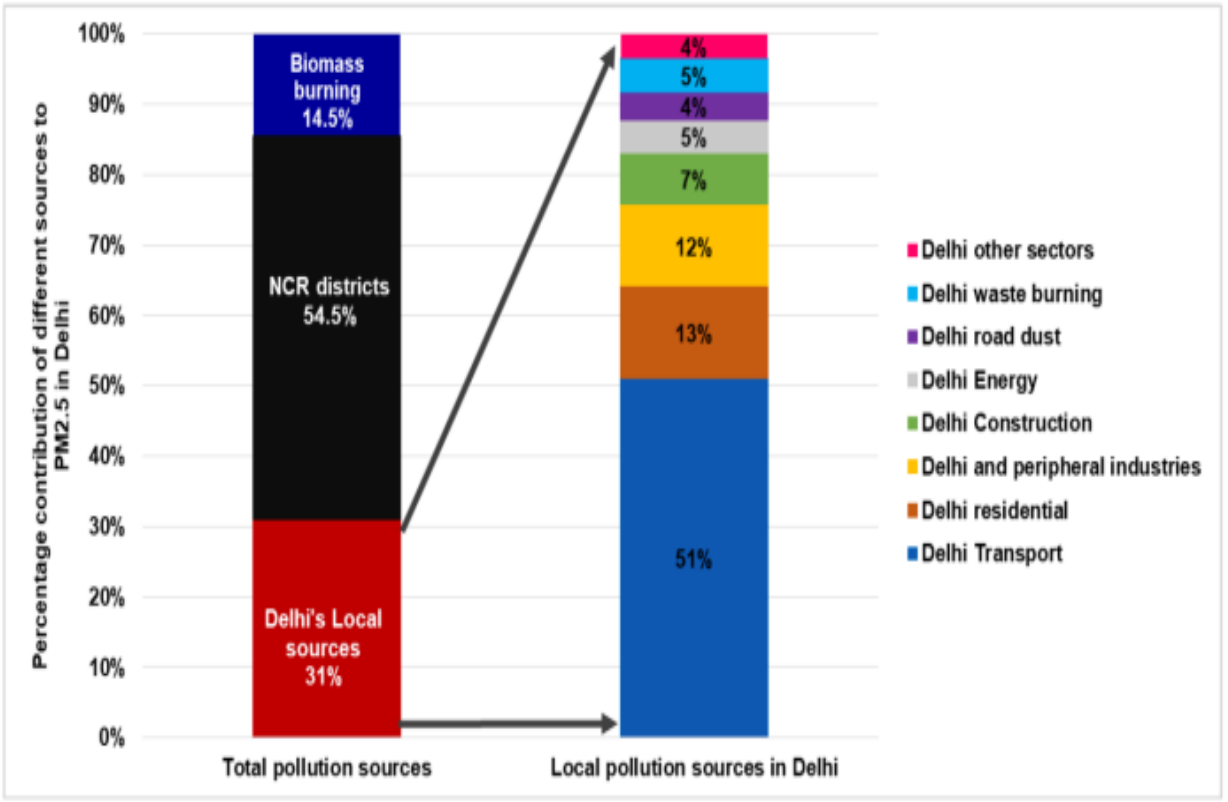
Since the city is large, people often use transport to get around. Earlier we mentioned the growth in the number of transport in Delhi in the period of 2015-2018. Exhaust fumes are considered one of the main contributors to air pollution in Delhi along with industrial factories,

the burning of crop residue for agricultural preparation, and the combustion of fuel (Guttikunda et al. 2014).

Air pollution is a persistent issue in Delhi, with conditions worsening at the start of winter in October and remaining until March. This time coincides with various factors such as agricultural stubble burning, the busy marriage season, and Diwali celebrations (Gurjar, Ravindra, and Nagpure 2016, 4).

Different sources are responsible for increasing air pollutants concentration, in particular, PM 2.5. Further we can see approximate contribution of different areas.

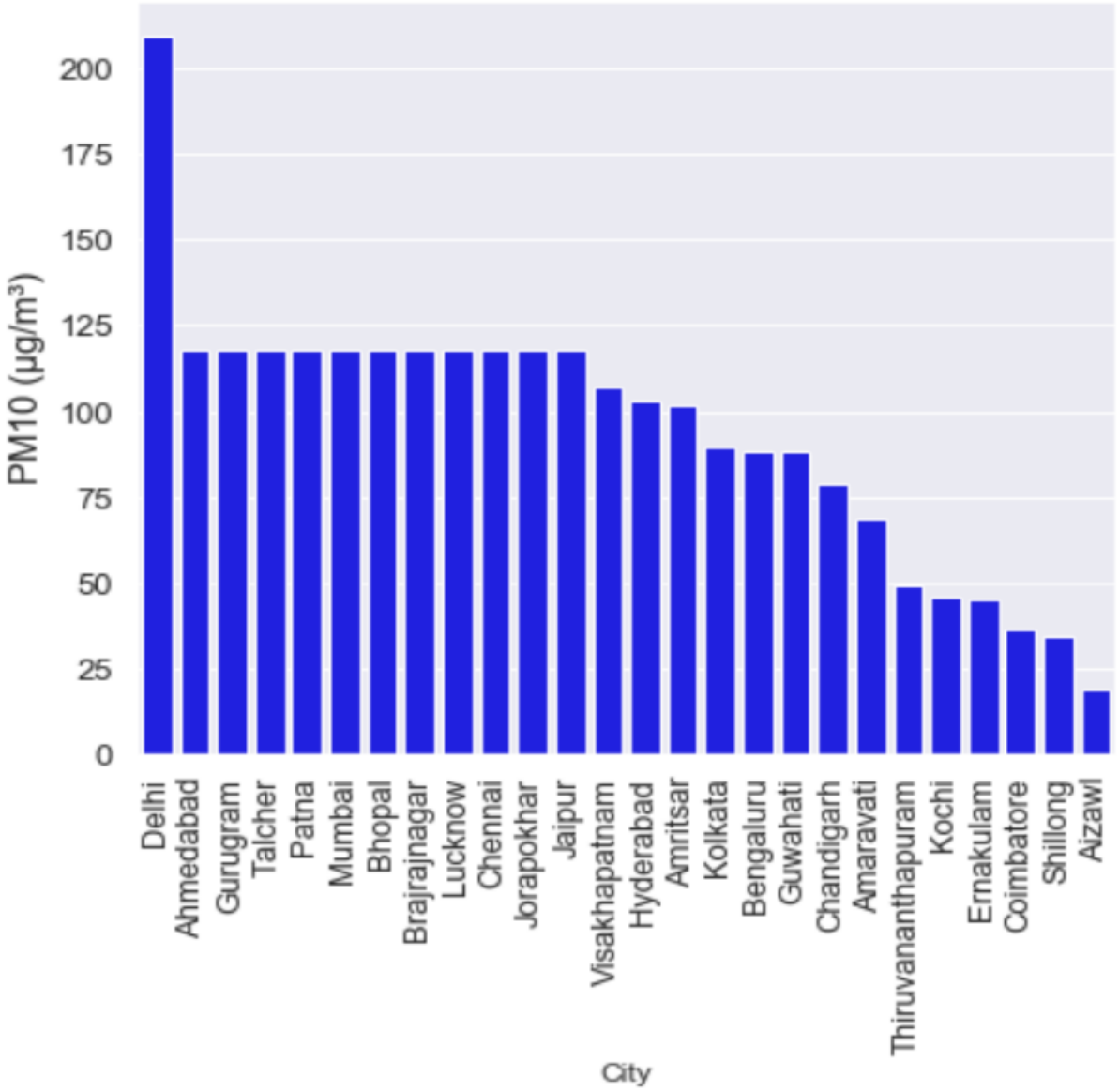
Figure 6. Average fractional contribution of sources of pollution to PM2.5 in Delhi



Source: CSE's analysis based on Decision Support System for Air Quality Management in Delhi of IITM

Transport takes the leading position with 51%. It is followed by residential complexes in Delhi (13%) and industries in the city and beyond it (12%). Less contribution is made by construction (7%), energy (5%) and other factors. Undoubtedly, the use of transport and the transport system in Delhi need to be reviewed.

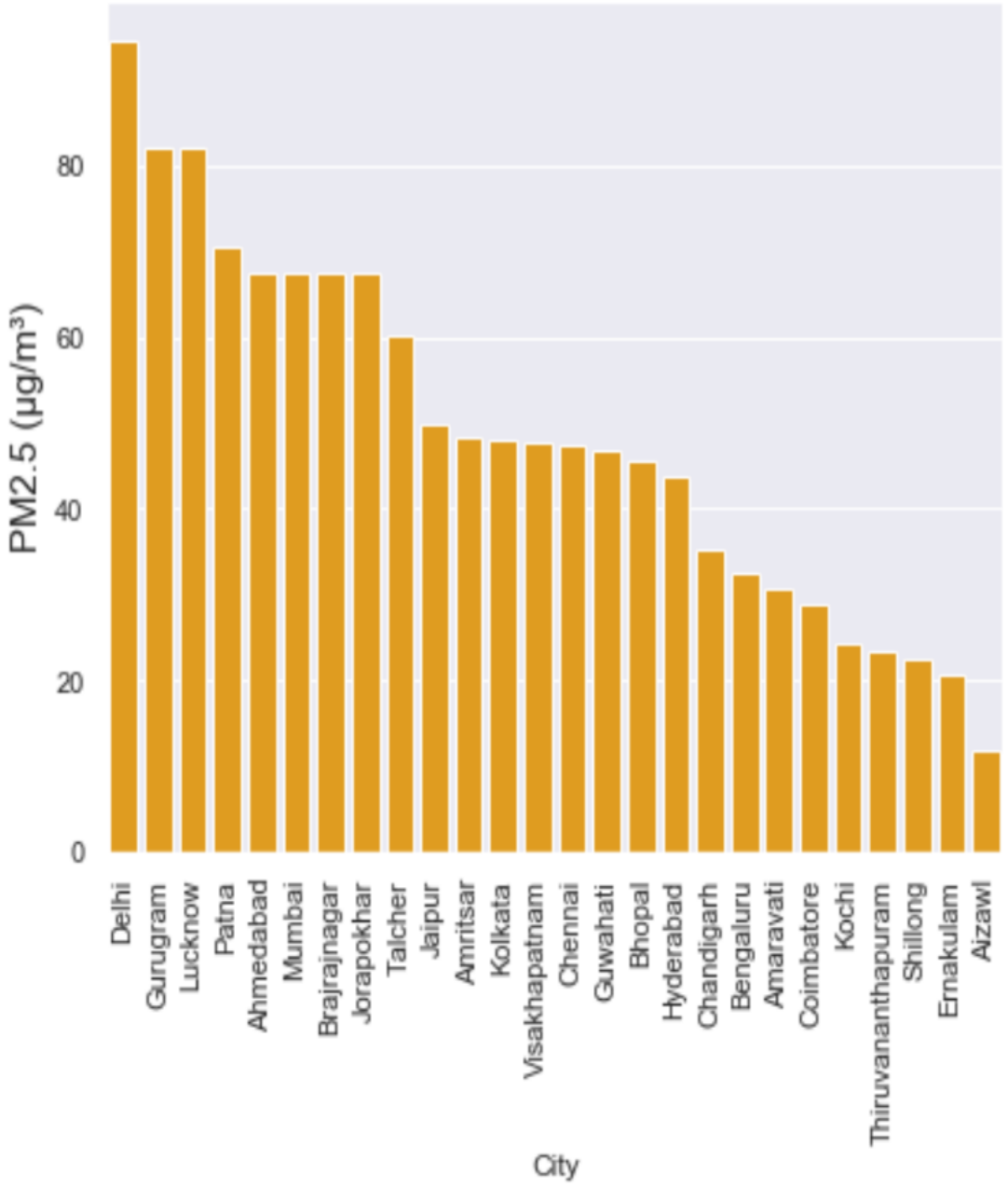
Figure 7. Average concentration of PM10 in different Indian cities



Source: IQ Air India

Delhi is the leader in terms of PM10 content, significantly surpassing other cities in India. In Mumbai, the average concentration level of this pollutant is almost two times less, while in Kolkata it is slightly smaller than in Mumbai.

Figure 8. Average concentration of PM2.5 in different Indian cities



Source: IQ Air India

According to the average level of PM 2.5 concentration, Delhi is also in the lead. Mumbai is slightly inferior to it, and in Kolkata the content level of PM 2.5 is almost two times lower than in Delhi.

After the Diwali festival in Delhi the air quality is significantly reduced. Below the statistics for 2017-2021can be seen.

Table 3. Average air pollution levels in Delhi after Diwali in 2017-2021

	2021	2020	2019	2018	2017
Air quality after Diwali celebrations	462	435	368	390	403
Air quality before Diwali celebrations	382	414	337	281	319

Source: IQ Air India

The greatest difference in the air quality index could be observed in 2018, when air quality decreased by an amount equal to 109, while the smallest difference was in 2020 (21), and this can be attributed to restrictions in connection with quarantine. In 2021 the difference was 80, which is almost equal to the values before quarantine time. Most likely in 2021, restrictions on mass events were cancelled in Delhi.

On November 6th, 2016, the city experienced its most polluted day ever recorded. The US Embassy in Delhi reported a PM2.5 concentration level of 933µg/m³, which is significantly higher than the hazardous rating of 250.4µg/m³. This level of pollution is considered extreme in comparison to other cities around the world, and inhaling such toxic air could have severe implications for an individual's health (IQ Air India).

The air in Delhi has an average of 350 µg/m^3 of PM2.5 pollutants, which is equivalent to smoking at least 15 cigarettes a day. This means that even if a person doesn't smoke, their life span is reduced by two and a half hours daily. Over an average lifespan of 70 years, this adds up to around seven years. Breathing in PM2.5 pollutants can also lead to various health problems like cancer and heart and lung disease, which can result in high medical expenses (Ibid).

The Chittaranjan National Cancer Institute (CNCI), based in Kolkata, released a comprehensive study in 2010, which lasted three years and was conducted in collaboration with WHO. The study evaluated key indicators of respiratory health, lung function, and blood pressure in children aged four to seventeen years in Delhi. Shockingly, the results showed that

these indicators were significantly worse in comparison to those of children from other areas. The study comprised 11,628 school-age children from 36 schools throughout Delhi and 15 rural schools in West Bengal and Uttaranchal. The lung function tests revealed that 43.5% of Delhi's school children had poor or restrictive lungs, which was twice the rate (22%) of their rural counterparts. This indicates that children from Delhi are at a higher risk of developing serious respiratory issues (Slutsky 2017).

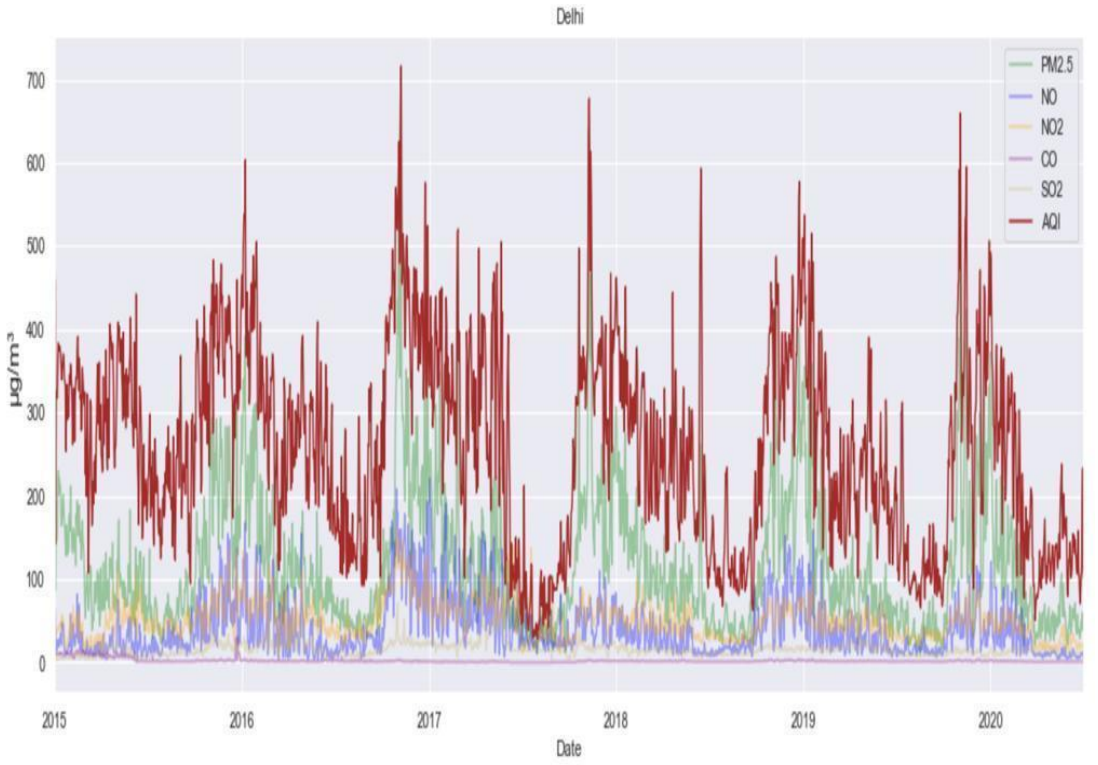
Also, the report highlighted the higher incidence of alveolar macrophages (AM) - lung cells tasked with clearing microorganisms and dust particles - in Delhi school children when compared to their rural counterparts. The AM count was observed to be 2-3 times higher in the former group, which, in turn, indicates their increased exposure to particulate pollution. Such cells act as the first line of defense against inhaled pollutants. Additionally, the report noted that a significantly larger proportion of Delhi children (15%) experience frequent eye irritation when compared to rural children (4%). Similarly, 27.4% report frequent headaches (vs. 12% rural), 11.2% experience nausea (vs. 5% rural), 7.2% report heart palpitations (vs. 3.3% rural), and 12.9% feel fatigued (vs. 6.7% rural). The report concluded that approximately half the 4.4 million children residing in Delhi have already suffered irreversible lung damage (Ibid 2017).

The impact of COVID-19 on our immune systems has been substantial, making the combination of air pollution and the pandemic particularly dangerous. According to research, children in Delhi are prone to smaller lung sizes, with nearly one in three suffering from impaired lungs and a higher risk of pulmonary hemorrhage. Even those who are generally healthy are affected by smog and declining air quality, with hospitals reporting a growing number of cases related to respiratory problems such as chest and nasal congestion, coughing, and other symptoms (Uday et al. 2022).

The polluted air in Delhi has caused not only health issues but also disturbances to the lives of roughly 20 million inhabitants. In November 2019, a public health emergency was declared by the government, resulting in the temporary closure of schools and nighttime construction activities. On other occasions, the thick smog has affected transportation by air and road, leading to numerous flight cancellations and causing congestion in hospitals. During this period, healthcare facilities recorded an increase in patients with respiratory issues, highlighting the severe and far-reaching impact that high levels of pollution can have on public welfare (IQ Air India).

Next, we will present a graph showing the concentration of pollutants in Delhi in the period 2015-2020.

Figure 9. Concentration of pollutants (ug / m3) in air (2015-2020) in Delhi



Source: Sultana 2022, 18

In a given period the level of pollution for NO_2 can be described as moderate, while CO was rated as "good" due to its low concentration. SO_2 was at "satisfactory" level. However, PM2.5 levels were rated as "severe," indicating a high concentration. Thus, the overall period's rating can be accessed as "severe" due to the presence of PM2.5 pollution.

Summarizing the situation in Delhi, we can say that the city is leading in the concentration of PM2.5 and PM10. The situation with air quality worsens in the period from October to March. Exhaust gases, crop burning and fuel combustion are considered the main sources of pollution in this city.

In the following sections, we will try to describe what we managed to learn about the situation firsthand from the residents of Delhi.

1.2. Interview with a local resident

We assume that poor air quality cannot but affect the habitual lifestyle of the population, significantly reducing its quality. To study the problem from the inside, we decided to interview a local resident Kiran, aged 35, who is living in Delhi and working as an engineer. His parents are 65 years old and they live in a suburban area near the city and are engaged in agriculture. I asked him some questions about how the problem of air pollution affects his life. Below is our dialogue.

- What is the current situation with the level of air pollution in Delhi?

- I have been living in Delhi for about 15 years. And according to my feelings, the situation is only getting worse every year. Now it is terrible.

- As far as I know, you are constantly facing this problem. What is it caused by? Is the government doing something about it?

- This is caused by pollution of the environment by vehicles, burning of crops, unrestrained construction and incessant explosions of firecrackers. I'm scared of what might happen after Diwali. I am not sure that the government takes responsibility for solving the problem.

- This is terrible! I have heard that the air quality situation usually gets worse after the Diwali festival. Is it really that serious?

- As far as I know, in 2022, the air quality index in various parts of Delhi exceeded the "dangerous" category at the end of the day. In one of the districts of the city, pollution indicators became 15 times higher than the normal level. People used pyrotechnics, despite the fact that the authorities tried to ban it that day.

- And how does air pollution affect your daily life now? What influence does it have on your health?

- I try not to leave home and work online. Being on the street, I experience eye irritation, sore throat and cough. Also, the visibility on the roads is bad because of the smog. But, of course, sometimes I have to go outside. In addition, my parents have developed terrible breathing problems, and they need to be taken care of. Now they are both in the hospital. I am worried about the health of my loved ones and about my health. Also, I am afraid of how the state of the air may affect future generations.

- I wish them to get well as soon as possible! How do you protect yourself from the influence of polluted air?

- We use air purifiers and I know that quite a lot of residents of the city have them. Also, we use oxygen masks. In my opinion, this is an indispensable thing in our situation.

- But how do you live in such an environment? Are you thinking about moving to a place with a more favorable environmental situation?

- In fact, my family and I are thinking about it. But Delhi is not the only city with disgusting air... It would be better to choose a country with a better ecology. But moving abroad is a much more difficult step. Many of the people I know have moved to other more prosperous countries, such as Canada, New Zealand and the UK. They did not consider other cities in India to move.

In the interview, it is obvious that air pollution makes significant changes in the habitual way of life of people, forcing them to adapt to bad air quality. Among the main sources of pollution the interviewee mentioned transport, burning of crops, large scale construction and firecrackers. He also noted the destructive influence of Diwali on air quality. The worst thing is that according to the speaker the government seems not to notice this problem, leaving the population alone with it.

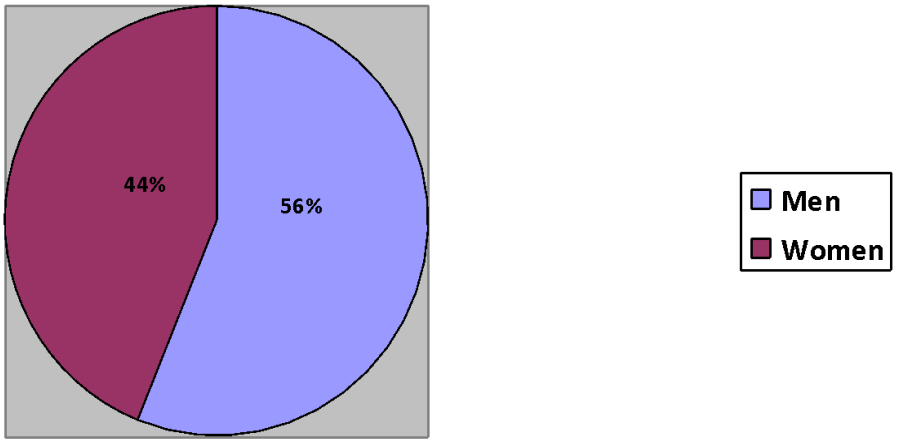
In addition, depending on the level of family well-being, the degree of exposure to air pollutants varies. In poorer families, children are forced to go to schools where there are not even walls, and they are not protected from the influence of polluted air in any way. In contrast, wealthier families can afford air purifiers and more airtight homes (Wu et al. 2021).

1.3. Survey among Delhi residents

In order to better understand how much Delhi residents are aware of the problem of air pollution in their city and how much they are concerned and affected by it, we conducted a survey among 50 people who live there. The respondents include both men and women from the following three age categories: 20-30 years, 31-45 years and older than 45 years old.

The number of men participating in the survey was 28 (56%) and, accordingly, the number of women was 22 (44%). Schematically, the distribution is shown in the lower diagram.

Distribution of survey participants by gender



As for the division by age groups, the largest number of participants in the first age group is 26 people (52%), in the second group there are 14 people (28%) and in the oldest group there are 10 respondents (10%). The first group included people aged 20-30 years, the second - 31-45 and the third - people over 45 years old.

First, we will share general observations for all respondents, and then we will move on to each age group. About 70 % of respondents reported that they rate the current air quality as poor

or very poor. 68 % of people do not know about AQI. Approximately 80 % of respondents are unaware of various air pollutants. 47 out of 50 people (94%) surveyed are aware of the impact of air pollution on health. Slightly more than half of respondents (68%) discuss air pollution at home or with friends/colleagues. 50% of respondents use masks to protect themselves against the effects of air contamination. Half of the people believe that air quality has deteriorated significantly over the past 5 years. 70 % of respondents agree to implement the Government's recommendations on air pollution.

The first age group

Next, let us focus on the youngest age group (20-30 years old) consisting of 26 people.

1. How do you evaluate air quality in your city?

About 80 % of people (20 respondents) rated the air as bad or very bad. The others rated it as satisfactory (4 people) or were unsure of the answer (2 people).

2. Do you know what AQI is?

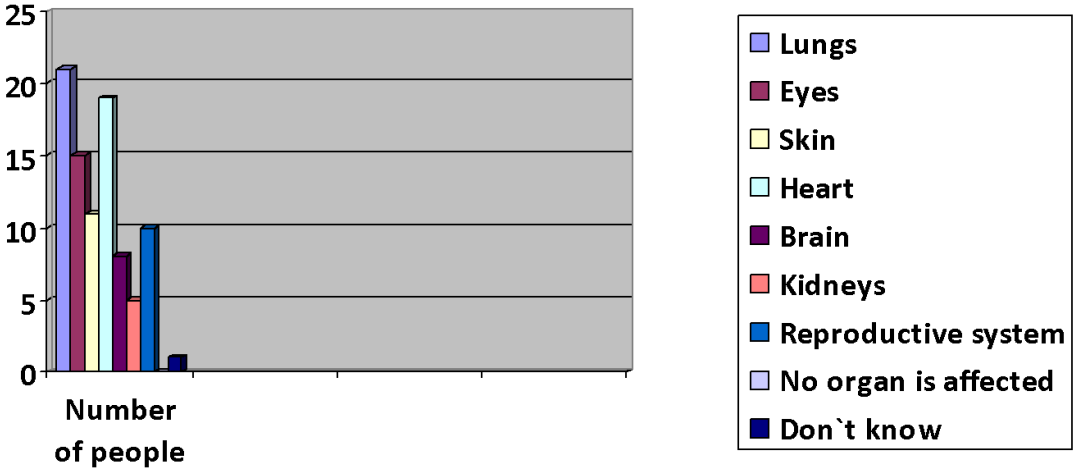
The majority of representatives of this age group (65.4% or 17 people) do not know what AQI is. 9 people gave a positive response to this question.

3. Do you know the difference between PM2.5 and PM10?

Approximately 70 % of young people (18 people) could not answer the question about differences between PM2.5 and PM10, while 8 people knew the answer.

4. Which organs do you think are affected by air pollution? (Multiple choices)

The answer options are as follows – *lungs*, *eyes*, *skin*, *heart*, *brain*, *kidneys*, *reproductive system*, *no organ is affected* and *don`t know*.



Only one person reported that he did not know the answer. It turned out that most people believe that the lungs, heart and eyes are most affected by bad air. Not a single person answered that air pollution does not affect health.

5. Have you visited the hospital due to respiratory discomfort (asthma/cough) in the last one year?

Out of 26 respondents of this age group, 6 people gave a positive answer to this question. The remaining 20 did not have to go to doctors because of respiratory discomfort over the past year.

6. Have you ever been diagnosed with a disease due to air pollution?

Approximately 35% of respondents (that is 9 people) have been diagnosed with respiratory diseases because of air pollution.

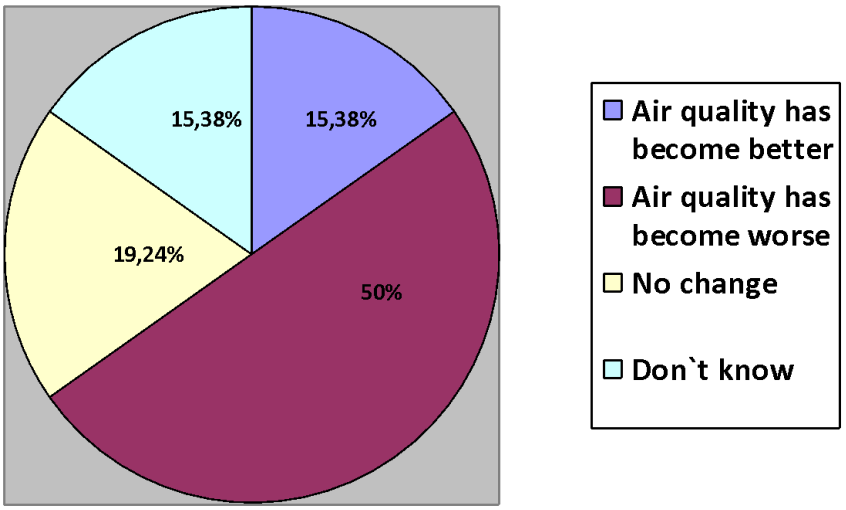
7. Are you aware of the National Clean Air Programme?

15 people (about 60%) said they knew about the programme, while the remaining 11 people had never heard of it before.

8. Do you talk about air pollution at home/with friends or colleagues?

Obviously, the people of Delhi are concerned about the problem, because the majority of respondents, namely 17 people (or about 35%), discuss this problem at home, with friends and colleagues.

9. What are your thoughts on the change in air quality in your city over the last 5 years?



Half of the respondents believe that the air quality has deteriorated, 5 people have not noticed any changes, 4 people believe that it has become better, and other 4 respondents did not know how to answer this question.

10. Do you regularly use a mask to protect yourself?

11 people (this is about 40%) reported that they regularly use masks to protect themselves from exposure to air pollution. The rest of the respondents (15 people) do not resort to this measure.

11. Would you support the steps taken by the Government to reduce air pollution?

Approximately 85% (22 people) said they were ready to support the Government's initiatives.

12. Do you prefer eco-friendly companies when shopping?

6 people (23%) stated that they prefer eco-friendly companies when they make purchases.

13. Do you or your family members burn firecrackers?

9 people (about 35%) said that they burn firecrackers during different celebrations.

The second age group

The second group comprised significantly fewer people compared to the first, which are 14 respondents.

1. How do you evaluate air quality in your city?

Half of the people from this age group (7 people) gave the air a bad and very bad rating. 6 people evaluated the air as satisfactory, and one person did not know how to answer the question.

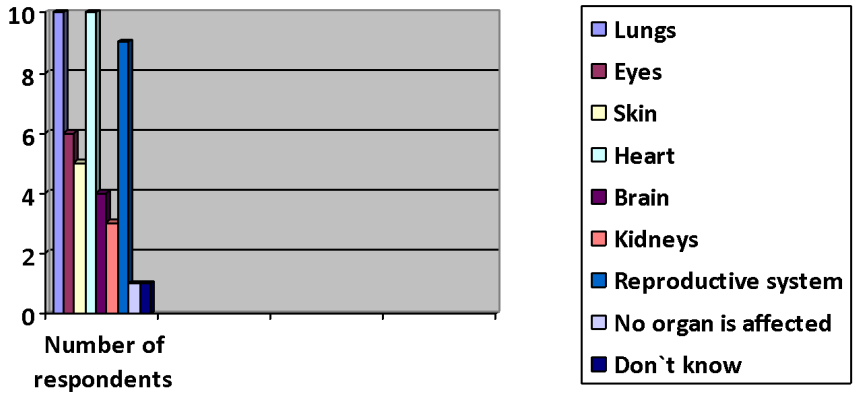
2. Do you know what AQI is?

10 out of 14 people could not answer this question. The number of such people is equal to about 70%.

3. Do you know the difference between PM2.5 and PM10?

Only 2 respondents could explain the difference between PM2.5 and PM10, and approximately 86% do not know the answer.

4. Which organs do you think are affected by air pollution? (Multiple choices – lungs, eyes, skin, heart, brain, kidneys, reproductive system, no organ is affected or don`t know)



Most of the answers were lungs and heart (10 each), 9 people noted the reproductive system. Further, in descending order, there are the following answers: eyes (6 people), skin (5 people), brain (4 respondents), and kidneys (3 people). One person replied that air contamination does not affect any organ, and another replied that he did not know.

5. Have you visited the hospital due to respiratory discomfort (asthma/cough) in the last one year?

4 people answered yes to this question.

6. Have you ever been diagnosed with a disease due to air pollution?

6 people from this age group have been diagnosed with a disease due to air contamination.

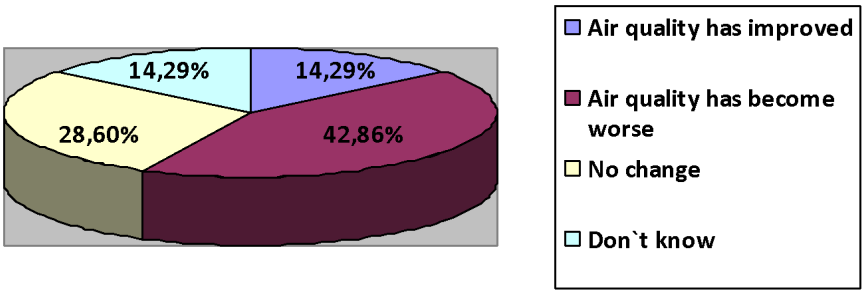
7. Are you aware of the National Clean Air Programme?

5 respondents (35,7 %) reported that they knew about the National Clean Air Programme, and the others heard about it for the first time.

8. Do you talk about air pollution at home/with friends or colleagues?

11 people (78, 6%) said they regularly talk about air pollution at home, with friends and colleagues.

9. What are your thoughts on the change in air quality in your city over the last 5 years?



2 people each replied that they did not know or that the air quality had improved. 6 people noted the deterioration of the air over the past 5 years, and 4 more respondents did not notice any changes.

10. Do you regularly use a mask to protect yourself?

9 people noted that they use masks to protect their respiratory organs.

11. Would you support the steps taken by the Government to reduce air pollution?

8 out of 14 people expressed their willingness to support the steps proposed by the Government of India regarding the problem of air contamination.

12. Do you prefer eco-friendly companies when shopping?

Half of the respondents, that is, 7 people, said that they choose eco-friendly companies when they do shopping.

13. Do you or your family members burn firecrackers?

4 people (i.e. about 30%) reported using firecrackers.

The third age group

1. How do you evaluate air quality in your city?

More than half of the people from this age group (6 people) gave the air a bad and very bad rating. 2 people evaluated it as satisfactory, and 2 people did not know how to answer the question.

2. Do you know what AQI is?

3 people managed to answer this question. This is equal to 30%.

3. Do you know the difference between PM2.5 and PM10?

Only one person from this age group (10%) knows the answer to the question about the difference between PM2.5 and PM10.

4. Which organs do you think are affected by air pollution? (Multiple choices)

Possible answers include *lungs*, *eyes*, *skin*, *heart*, *brain*, *kidneys*, *reproductive system*, *no organ is affected* or *don`t know*).

None of the respondents believes that air pollution does not affect the body, but 1 person replied that he did not know. The lungs (8 people) and heart (7 respondents) became the leaders in the list of answers. The skin, eyes and reproductive system received 5 responses each.

5. Have you visited the hospital due to respiratory discomfort (asthma/cough) in the last one year?

Representatives of this age group are more likely to experience health problems due to bad air. 70% stated that they had seen a doctor because of respiratory discomfort in the last one year.

6. Have you ever been diagnosed with a disease due to air pollution?

80% of respondents said they had a diagnosed respiratory disease.

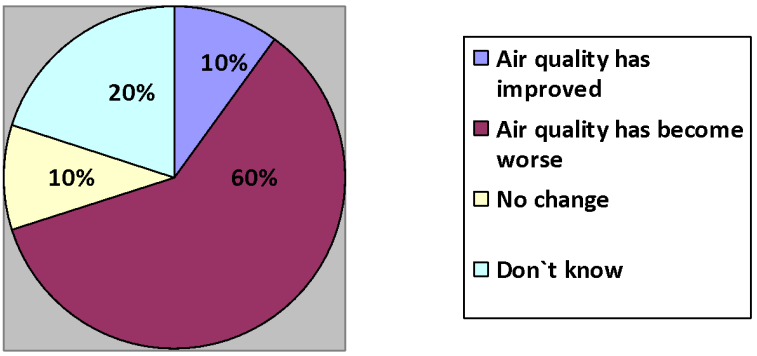
7. Are you aware of the National Clean Air Programme?

2 people out of 10 know about this programme.

8. Do you talk about air pollution at home/with friends or colleagues?

60% of the surveyed people from this age group discuss the problem.

9. What are your thoughts on the change in air quality in your city over the last 5 years?



Most people reported deterioration in air quality, 1 person replied that the quality had improved, another 1 did not notice any changes, and 2 respondents did not answer the question.

10. Do you regularly use a mask to protect yourself?

Exactly half of the respondents (5 people) use masks.

11. Would you support the steps taken by the Government to reduce air pollution?

Exactly half of the respondents are ready to support the Government's steps.

12. Do you prefer eco-friendly companies when shopping?

3 out of 10 people prefer eco-friendly companies when shopping.

13. Do you or your family members burn firecrackers?

Only one representative of this age group (10%) gave a positive answer to this question.

Based on the analysis, we can conclude how air pollution affects individual groups of the population. The most vulnerable were older people who have been exposed to poor air quality for a long time. In the oldest age group 50% adhere to wearing respiratory protective equipment, such as masks and respirators in particularly polluted areas of the city. Basically, all older people suffer from cough, allergic reactions, difficulty breathing or acquired asthma.

Of the middle-aged respondents surveyed, only a part (30%) feels real problems with the respiratory tract and tries to comply with preventive protective measures. 30% of representatives of this age group are aware of the problem and note significant air pollution, but do not suffer from chronic diseases and do not take any special measures, including wearing masks. The remaining 40% of middle-aged respondents have chronic diseases from birth, such as asthma, pneumonia, chronic lung problems and therefore are extremely sensitive to polluted air, which means they constantly visit doctors, take medications and use all possible protective measures to reduce the negative impact.

The interviewed young people also note a significant problem of air pollution, but they are the most stable group among all the respondents, which is still less susceptible to breathing

problems. It should be concluded that the most vulnerable are older people, also pregnant women (there were 3 of them in the survey) and people with chronic or acquired respiratory diseases. As a recommendation, it should be noted the exclusion of tobacco products, an increase in walking not in an urban environment, but in places with more greenery, the purchase of masks / respirators and cleaning agents that moisten the air, sterilizing it in homes and increase safety.

1.4. Kolkata

Kolkata, the capital city of West Bengal, is among the most densely populated urban agglomerations in India and is also a part of the top populous cities across the globe. Positioned along the eastern bank of the River Hooghly, which is a branch of River Ganges, the city is located towards the southern direction of the Bay of Bengal, approximately 90 kilometers away. The increased wind flow caused by the Bay of Bengal's proximity leads to a reduction in the levels of gaseous pollutants with the help of powerful convection currents and enhanced sea breeze ventilation (Spiroska, Rahman, and Pal 2011, 203).

Over the years, Kolkata has transformed into the primary financial, commercial and business center for the eastern part of India. It serves as the entrance to foreign markets of Bangladesh to the east and Nepal and Bhutan to the north. The 'Look East' and 'Link East' initiatives predict Kolkata's growth as a significant transit and economic hub for the broader region by providing dedicated freight corridors, which could lead to a 60% increase in intra-regional trade and open up broader markets in India and beyond, to the west and south. The National Waterways Development Mission and better sub-regional transport connectivity would further enhance Kolkata's potential (British Deputy High Commission Kolkata n.d., 15).

Air pollution in Kolkata is caused by various factors, but the main contributor is transportation due to the large number of poorly-maintained vehicles, the use of petrol fuel, and inadequate regulation. This results in transportation being the most significant sector contributing to air pollution. Furthermore, there are also three thermal power plants situated in and around Kolkata, as well as several small-scale industries that have an impact on the air quality (Haque and Singh 2017, 3).

The rise in the number of vehicles on the roads of Kolkata is much greater compared to the expansion of the roads themselves, causing severe congestion and worsening air pollution. Based on data from the Basic Road Statistics of India and digital mapping of the road network in Kolkata, the total length of roads is approximately 2876 km, of which approximately 2152 km are minor roads, 684 km are major roads, and 40 km are national or state highways (Mangaraj et al. 2022, 5). The movement of heavy vehicles in the city has resulted in broken and dusty roads, which contribute to vehicle-induced road dust resuspension. The quality of the roads and the amount of road space available are insufficient, leading to Kolkata also being called a dusty city.

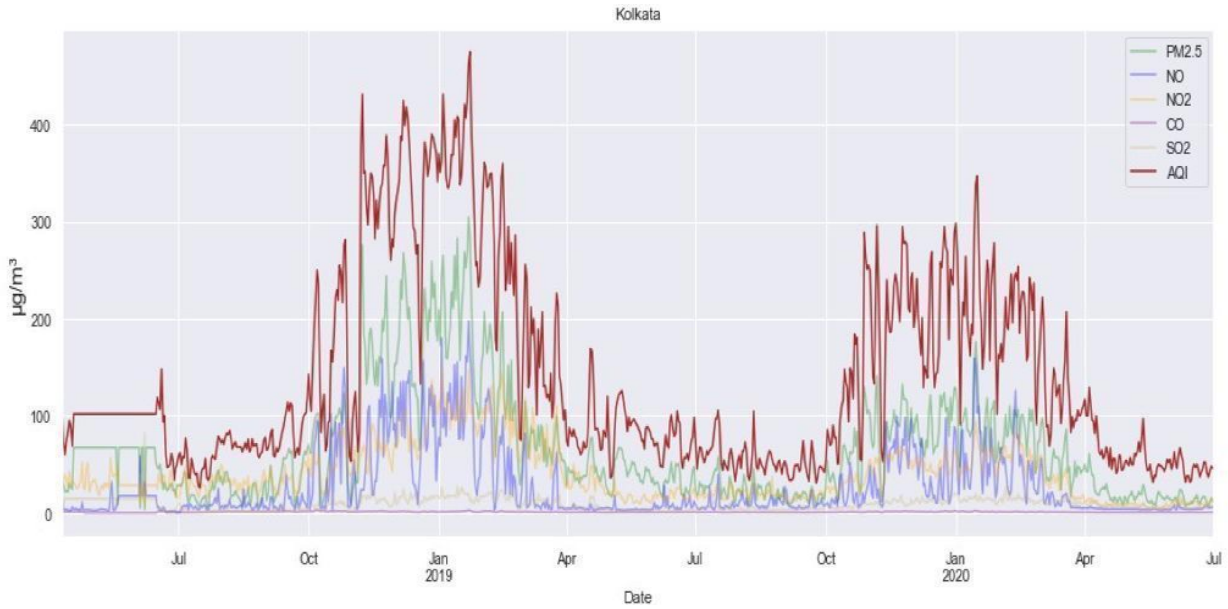
In homes, solid fuels are often used in cooking, and this also contributes to a decrease in air quality. Also, in the city, the sale of food on the street is very common, the preparation of which takes place outside, and it is assumed that it can contribute to air pollution as well, but there is no clear data on this account (Ibid 2022, 5).

The research (Das 2020) has shown that living near high vehicle traffic has a positive impact on respiratory issues, such as coughing and wheezing and is linked to children with current asthma indications. Furthermore, exposure to heavy traffic was also associated with allergic sensitization.

Kolkata has become known as the "diesel capital of the country" due to its high usage of diesel, which is a major concern when it comes to emissions and air quality in the city. Diesel vehicles contribute greatly to the release of particulates, nitrogen oxides, and harmful hydrocarbons, with a significant proportion of commercial vehicles and taxis in the city running on diesel. Additionally, many of these vehicles are older models. According to an assessment by CPCB, 55% of vehicles in Kolkata are diesel-driven, and this number is on the rise (Karmakar 2020, 4).

The use of plastic is another concern in Kolkata, despite the government's efforts to ban it. Many people use plastic bags on a daily basis, and these bags are often burned, which not only causes a foul smell but also pollutes the air with harmful gases. In addition, the regular burning of trash in huge dump yards can be added to causes of air pollution. Furthermore, with the growing population and urbanization, new buildings are being constructed, resulting in dust from cement, wood, and other debris. To make room for these new constructions, trees are being cut down, which leads to a lack of fresh air (Ibid 2020).

Figure 10. Concentration of pollutants (ug / m^3) in air (2015-2020) in Kolkata



Source: Sultana 2022, 25

On the graph above we can see that in the period of 2015-2020 the concentrations of NO and NO2 were at a moderate level, while the levels of CO and SO2 were considered to be "good" or very low. However, the PM2.5 levels were classified as "very poor". Due to the high level of air quality index, the overall period would be evaluated as "very poor".

As for Diwali and its impact on air quality, according to an official from the West Bengal Pollution Control Board, in 2022 air pollution levels in Kolkata have remained 'good' or 'satisfactory' for the second day in a row after Diwali. As of 11 am on Wednesday, the air quality index was measured at 46-61 in different areas of the city (Financial Express 2022).

The average monthly concentration of pollutants reflects the level of pollution present in the ambient air throughout the year, indicating the varying levels of pollutants in different months. This was determined by recording pollutant levels in 17 monitoring stations across Kolkata City, giving an overall representation of the city's pollution levels. Analysis showed that NO_2 and PM levels were particularly high in November and December of 2010, and January and February of 2011, with the highest values recorded in January (Haque and Singh 2017). This high pollution level during these months is believed to be due to seasonal effects, particularly during the winter season when winds are less strong. Conversely, the lowest levels of pollutants were recorded in August and September of 2010, and in July and August in terms of PM, correlated with the monsoon season. The SO_2 level remained within national standards throughout the monitoring year.

In Kolkata there is a moderate increase in the level of harmful particles during the winter compared to other seasons. This is caused by the particles staying in the air longer due to weaker wind and lower air mixing height. Sadly, the air quality in Kolkata and surrounding areas is generally poor during winter and only slightly better during summer (Karmakar 2020, 4).

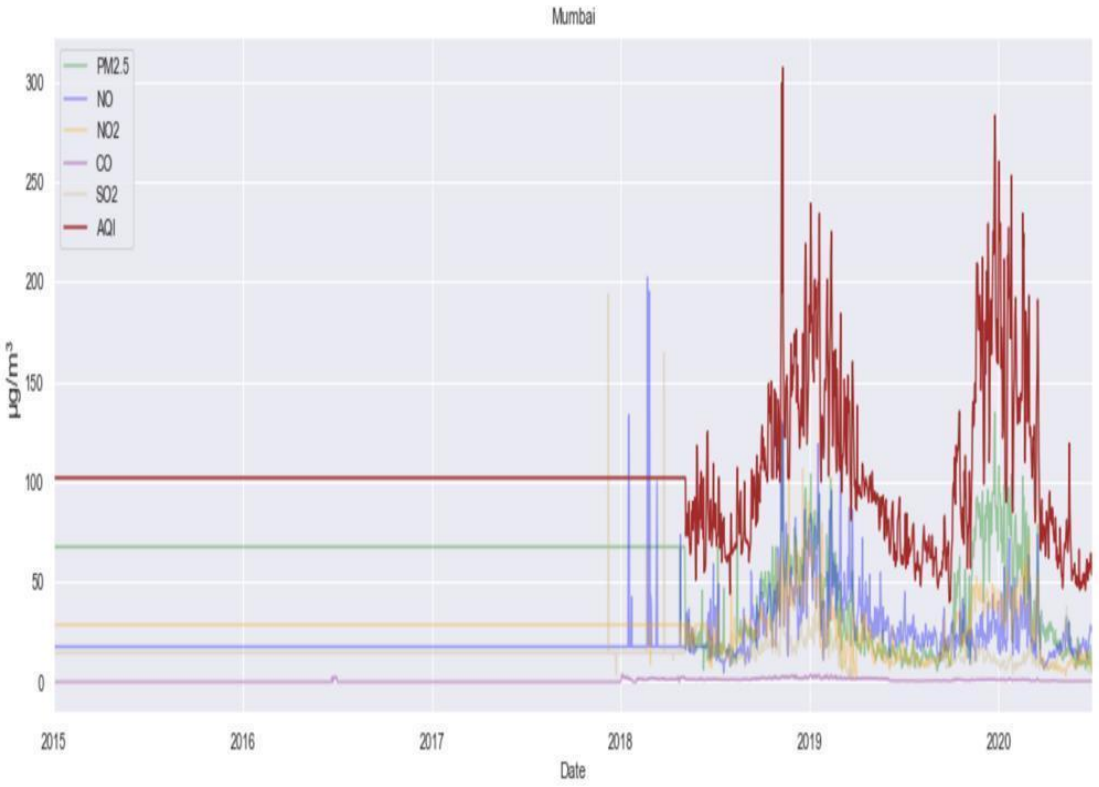
Summing up the information we found about Kolkata, among the most significant sources of pollution we can identify transport, in particular, its poor quality, large-scale use of diesel fuel and a poor road system. High concentrations of PM2.5 pose a particular danger to the city, while other pollutants are within relatively acceptable limits. As Delhi, Kolkata experiences a decrease in air quality in winter due to less strong winds and lower air mixing height.

1.5. Mumbai

In March 2013, the National Air Monitoring Program (NAMP) and State Air Monitoring Program (SAMP) had a total of 25 monitoring stations in the Mumbai Metropolitan Region. These stations regularly measure the levels of SO_2), NOx, and Respirable Suspended Particulate Matter (RSPM) in the ambient air, with a monitoring frequency of approximately two days each week (TERI 2015, 13).

In the graph below, we see how the average concentration of air pollutants changed in the period 2015-2020 in Mumbai.

Figure 11. Concentration of pollutants (ug / m3) in air (2015-2020) in Mumbai



Source: Sultana 2022, 21

Figure 9 demonstrates that NO and NO_2 pollution levels are acceptable. CO pollution is at a good level, while SO_2 pollution rates are satisfactory. However, PM2.5 pollution rates are very low, indicating a very poor overall period. The AQI is well above the recommended levels.

In the year 2022, Mumbai has experienced consistently poor air quality, resulting in an estimated 25,000 fatalities. Furthermore, air pollution has been incredibly expensive, totaling approximately $3.6 billion. The primary cause of this pollution is vehicle emissions, as the majority of industries are located outside of the city. According to research conducted by the System of Air Quality Weather Forecasting, vehicular emissions now make up over 30% of Mumbai's air pollution, a substantial increase from the 16% observed in 2016-17 (IQ Air India 2023).

Here are some statistics about the air condition in Mumbai in 2022 (Ibid 2023):

1. Mumbai consistently has low air quality considered to be dangerous.

2. The time between June and September has the best air pollution levels due to heavy rainfall in September 2022.

3. The AQI in Mumbai remains lower than that of Delhi throughout the year.

4. The period from March to May is crucial because the air quality often reaches the hazardous category.

5. The winter months are not as severe as spring ones.

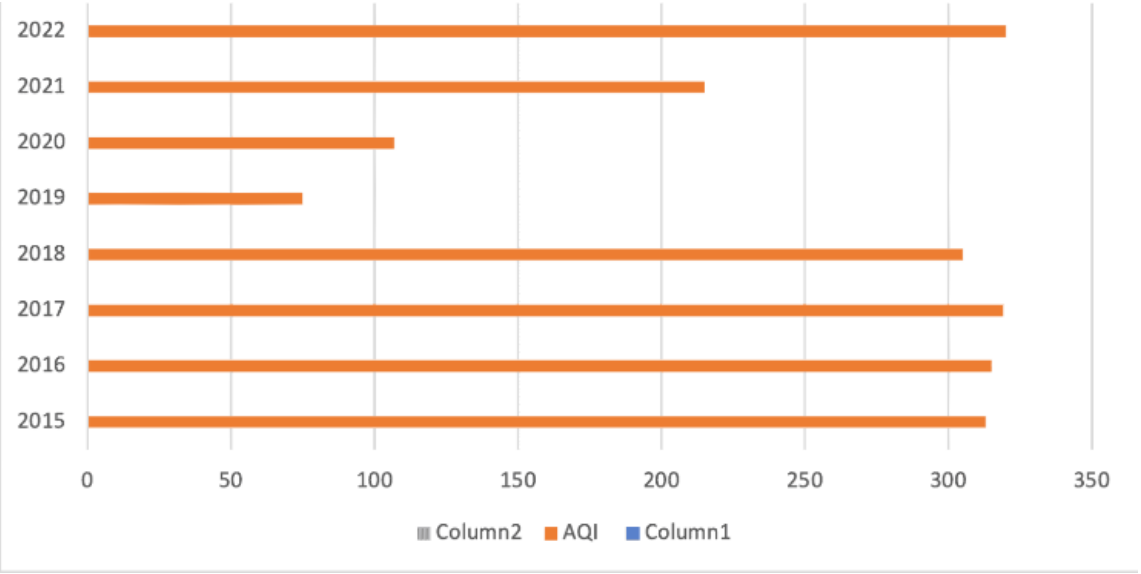
The geographical boundaries of Mumbai extend beyond the city itself and its suburbs. They also include the Thane district and the Navi Mumbai municipal corporation, giving Mumbai a unique distribution. Although most industries are situated outside the city limits, Mumbai serves as the main location for offices and business centers. As a result, people from the suburbs and districts have to commute to work on a regular basis (Gurjar, Ravindra, and Nagpure 2016, 6).

Factories situated outside the city contribute significantly to the city's air pollution problem, due to the release of emissions into the atmosphere. The primary culprits are the industries located in various areas such as Taloja Industrial Estate, Ambernath, Dombivli, Wagle Industrial Estate, Patalganga, Mira-Bhayandar belt, Marol, and Kalyan-Bhiwandi belt. Research conducted by the Center for Science and Environment (CSE) shows that these factories release harmful substances such as sulfur dioxide and nitrogen oxides which are increasingly making Mumbai's air quality worse. The report suggests that the industries operating in the nearby districts are creating a situation similar to the pressure-cooker situation in Delhi (IQ Air India 2023).

According to a report by the National Environmental Engineering Institute (NEERI), approximately 71% of PM10 pollution found in the air of Mumbai is caused by road dust. This dust contains small particles that are generated during the handling and processing of materials used for constructing roads, such as cement and gravel. NEERI's study showed that unpaved roads contribute approximately 45% of the road dust, while paved roads contribute 26%. Additionally, construction activities account for 8%, while vehicles contribute 3%. The rest of the road dust comes from various sources including open eateries, bakeries, crematoriums, aircraft, and marine vessels (BM Global News 2021).

Separately, it is worth considering what effect Diwali has on the level of pollution in this city. The chart below shows the air quality index for the morning after Diwali.

Figure 12.Mumbai AQI the morning immediately after Diwali.



The graph shows how the air quality deteriorates significantly after this religious festival, and AQI reaches critical values exceeding 300. The only exceptions are 2019-2021. The reason for this is prolonged rains, and besides, because of quarantine in 2020-2021 the celebration was not so massive.

As we have already seen, the population of Mumbai is being surrounded by harmful gases. This has resulted in a high frequency of respiratory illnesses, particularly in children and the elderly. Prolonged exposure to polluted air has led to medical conditions such as bronchitis, asthma and COPD. Inhabitants who live near manufacturing facilities often suffer from skin problems and may experience symptoms such as dyspnea, intermittent coughing, as well as issues with their heart and high blood pressure. In addition, there is a risk of lung cancer and premature death from inhaling polluted air. A global study estimates that almost 25,000 people died from air pollution in Mumbai in 2020. This figure was second only to Delhi, where 54,000 people died from air pollution (Greenpeace Southeast Asia 2021).

Let us turn to the opinion of one local resident of Mumbai. Gulshan Mistry, living in Borivali (a suburb of Mumbai), has asthma and it is often hard for him to breathe on crowded roads in the city. “We should be investing in public transportation systems and increasing the green cover,” he says, “but the government is building more roads, flyovers and cutting the trees.” (Varshney 2019). That is, according to the speaker, the problem lies in a poorly developed public transport system and active construction, leading to the felling of trees and, consequently, a low amount of greenery in the city.

In Mumbai the significant increase in fatalities and illnesses due to air pollution is primarily caused by particulate matter (PM10) rather than gaseous pollutants such as SO_2 and NO_2. In this city PM10 is mainly generated through various combustion processes, including

power plants; open burning, commercial food sector, and road transport, which account for 37%, 24%, 18%, and 10% respectively (Maji, Dikshit, and Chaudhary 2017).

Mumbai is one of the most polluted megacities in India with a high level of environmental problems. Despite the fact that water pollution in Mumbai is significant, air pollution can be attributed to an interconnected critical problem, as traffic jams, large amounts of waste, and industrial emissions affect its development. It can be said that in Mumbai the greatest danger in terms of air contamination is the exhaust from transport, and also road dust causes concern with its increasing scale and large contribution to the pollution of PM10. As for the dependence of air quality on the time of year, a different picture can be observed in Mumbai in contrast to Delhi and Kolkata, since deterioration is observed here in the spring.

In Mumbai, the problem of air pollution is also in an alarming continuity with major Indian megacities. This problem does not stand out, but is intertwined with many cultural and social problems, such as: low level of education, poverty, littering, constant pollution of vast areas of the city, etc. A set of measures on the part of the state is extremely necessary for solutions to pressing problems, as well as the fight against unemployment, a general increase in the standard of living and consciousness of people.

2. Globalization and environment in India

What is the impact of globalization processes on the state of the environment and environmental policy? What contribution does India make to international efforts to combat global environmental problems? Will the country become a global leader – an environmental superpower – in the sense of taking global environmental responsibility? How do special economic zones in big cities of India affect the quality of air change? We will try to answer these questions in the section.

Globalization is a word familiar to almost everyone, even to those who are far from economics and politics. It is the ongoing process of interconnectedness of the world's economies, societies, and cultures, which has transformed the way we live and work. Advances in technology, transport and communications have contributed to this phenomenon, allowing people and goods to move around the world easier and cheaper than ever before.

On the one hand, globalization has brought many benefits. It has created new markets for goods and services, driven innovation and productivity, and reduced poverty in some parts of the world. It has also facilitated greater cultural exchange, allowing people to learn from and appreciate different ways of life and perspectives.

However, globalization has also resulted in significant challenges. The widening economic divide between rich and poor countries leaves many people behind. The availability of cheap labor in developing countries has led to exploitation, while multinational corporations

have been able to avoid taxes and regulations. Moreover, cultural homogenization has led to the loss of traditional practices and values in some parts of the world.

The processes of globalization have a significant impact on both the environment and environmental policy. Thus, international trade can significantly worsen the state of the environment in cases where environmental costs are not taken into account in pricing. Those countries that ignore these costs gain comparative advantages in environmentally hazardous activities, which often lead to appropriate specialization and significant environmental degradation. Moreover, states may even lower environmental standards in order to attract foreign capital. Also, international trade can stimulate the raw materials sector of the economy, and, accordingly, excessive extraction of resources for export. Neglect of environmental costs gives competitive advantages in this case as well. Thus, in countries with weak environmental governance, such as India, economic liberalization can lead to environmental degradation and, consequently, to a negative change in air quality (Sablin 2014, 106-107)[25].

Thanks to the economic liberalization reforms that were carried out in India in the 1990s, the country became part of the world economy. India accounts for 1.2% of world exports and 1.9% of world imports, which indicates the importance of the country for the global economy as a whole. It is worth noting that exports and imports also make up a significant percentage of the GDP of India. In general, international trade leads to environmental changes through structural, large-scale, technological and product effects. The structural effect determines the specialization and location of production. In fact, it is not positive or negative, because depending on the environmental policy, which determines who bears the environmental costs, the state can specialize both in exporting products from relatively environmentally friendly industries and importing products from polluting enterprises, and vice versa. The scale effect is mainly a negative impact on the environment due to the greater absolute load on its resources during the expansion of economic activity. The technological effect is considered as positive and consists in the fact that the growth of incomes of the population increases the requirements imposed on the quality of the environment, and therefore leads to the emergence of stricter environmental standards and the introduction of more advanced technologies.

The effect of the product depends on the patterns of consumption and demand, and therefore is determined by the level of ecological consciousness of consumers (Sawhney 2004, 5). Indian scientists are of the opinion that the increase in pollution due to an increase in exports is twice as low as its potential reduction in the event of an increase in imports, which, in fact, is the country`s benefit from foreign trade, and therefore cannot be considered a “haven for

[25] In this section hereafter, statistics on globalization in India are taken from the article by Sablin, I.V. (unless otherwise stated).

pollutants.” There is also an inverse relationship between foreign direct investment and environmental policy: depending on the level of corruption, foreign direct investment can lead to a weakening of environmental legislation, and, accordingly, to the emergence of "safe havens for pollutants". Despite the fact that there is no unity in the scientific world on the issue of the relationship between foreign capital and the state of the environment, many researchers still agree that environmental control over foreign direct investment in the face of transnational corporations is necessary. In practice, most often economic beliefs prevail over environmental ones.

For example, the South Korean TNC Posco received permission from the Ministry of Environment and Forests of India to cut down forests and build a steelmaking complex in Orissa state, despite numerous public protests (Rajshekhar 2011). Of course, everyone understands the negative impact of globalization and many business processes on the environment in general. But we should not forget that the government of India, by increasing the scale of production and attracting foreign direct investment, is struggling with the problem of poverty. Also, empirical studies of India show that not all multinational companies (TNCs) use developing countries as a "refuge": over the past two decades, a number of industries with the most advanced and environmentally friendly technologies have been launched in both countries.

Moreover, environmental management is also becoming relevant at older enterprises, as more and more companies are taking care of their global environmental image. And finally, an important factor is the fact that foreign investors are attracted by such important manufacturing powers as China and India due to cheap labor, and not the weakness of environmental regulation.

Another important transnational aspect of environmental issues is the international trade in waste: the export of waste to developing countries is by far the most profitable way to dispose of them (Nod et al. 2001, 171). For example, a significant amount of European garbage, mainly paper and plastic, is imported to China for recycling. Existing methods and technologies, however, have severe environmental and social consequences for the country, including air and water pollution, difficult working conditions, low wages and high morbidity of workers. Despite significant restrictions on the import of recyclable and a complete ban on the import of non-recyclable waste, corruption, as well as the physical impossibility of checking all imported garbage, make the problem very relevant. There is an acute problem of legal and illegal import of garbage in India, where it is also not processed properly (Tailor 2007, 29).

It is worth noting that the problem of climate change in the last few years has become one of the most popular in the national discourses of India. In many publications, speeches and documents around the world, climate change associated with greenhouse gas emissions (primarily carbon dioxide) is increasingly associated with India. Under the Kyoto Protocol,

developing countries, including India, have not made any commitments to reduce emissions (Kyoto Protocol), but it is obvious that international efforts to reduce greenhouse emissions in the post-Kyoto period without India's participation will be useless. Meanwhile, neither in Copenhagen in 2009, nor in Cancun in 2010, any significant progress was achieved in creating a new global regime to combat global climate change. Politicians and the public in India and other developing countries rightly point out that the current global environmental problems are primarily the result of the development of the countries of the North, and therefore the inhabitants of the countries of the South should not abandon development in favor of the well-being of the inhabitants of rich countries. Indeed, the level of consumption, waste production (Naughton 2007, 76) and greenhouse emissions per capita in India is significantly lower than in developed countries. Some Indian public figures openly blame developed countries for the current environmental crisis. Others claim that climate change will not frighten the inhabitants of India, who are familiar with constant droughts and famine (Tailor 2007, 87).

Globalization has significantly shaped the economic and social landscape of India. Following economic liberalization in 1991, India has become increasingly integrated with the global economy, leading to advancements in commerce, technology, and infrastructure. However, this growth has also come at a cost, most notably in environmental degradation, including air pollution.

India has witnessed a rise in urbanization, industrialization, and vehicular traffic over the last few decades. This has resulted in a mushrooming of air pollution across the country. The concentration of dangerous air pollutants regularly surpasses WHO's safe levels, leading to serious respiratory and cardiovascular problems.

One of the major drivers of air pollution in India is the expanding transportation sector. As India's middle class has grown, so has automobile demand, leading to a rise in the number of vehicles. This trend has been amplified by globalization, which has facilitated India's integration into global supply chains and international trade, leading to increased cargo movement and freight transportation.

Furthermore, industry has been a primary force in driving the country's economic growth, leading to the establishment of several factories and manufacturing units in and around India's cities. Industries such as iron and steel, cement, and power generation emit large amounts of pollutants such as SO_2, NOx, and PM as byproducts of their production processes.

As of 2020, India's globalization index was 63 out of 100 points (for comparison, the leading country, Switzerland, had it equal to 91) (The Global Economy 2020). This indicates a rapid leap in the development of India.

Here are some facts about globalization in India in terms of economy (Devi 2017, 618-620):

1. India's GDP growth rate has increased steadily, starting from 5.6 % in 1980-1990 to 7 % in 1993-2001, with most years in the past 15 years exceeding 7 %. In 2006-2007, the growth rate reached an impressive 9.2 %, and as of 2016, the GDP was growing at a rate of 7.4 % as per the Union Budget 2016-2017.

In the period from 1961 to 2021, the average GDP growth rate was 5.08%. The minimum was -6.6% in 2020, while the maximum was 9.63% in 1988.

2. The country's foreign exchange reserves have also seen significant growth, rising from $39 billion in 2000-01 to a much higher $351.83 billion as of February 19, 2016, according to the Reserve Bank of India.

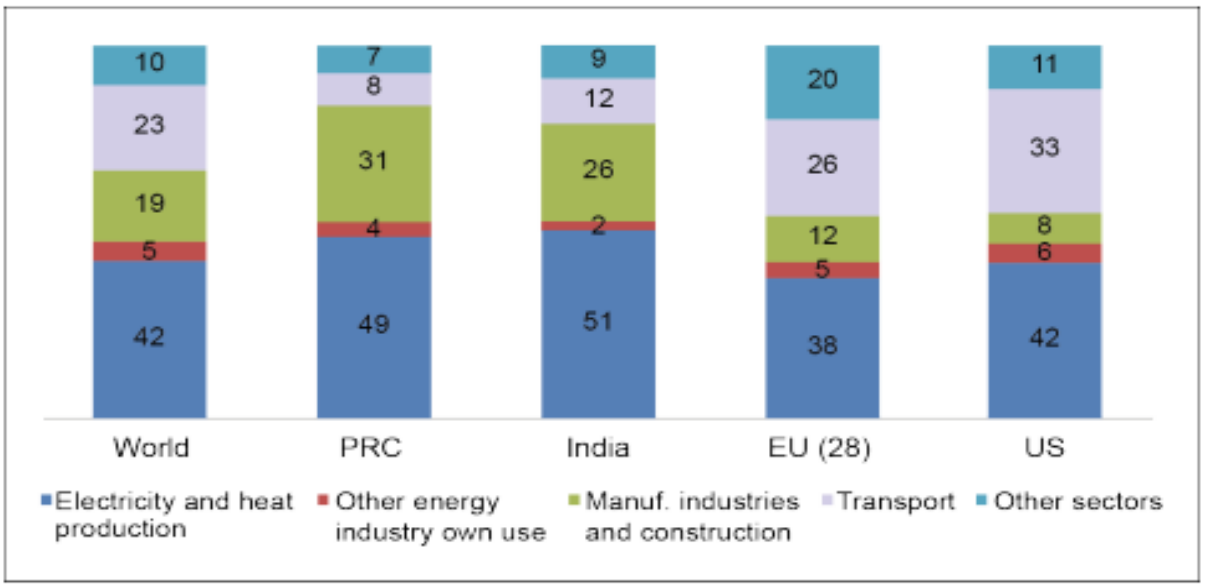
3. In the year 2010, India had a share of 55% in the global outsourcing market.

4. According to Forbes' 2015 list, India now has 100 billionaires. This is a significant increase from the 40 billionaires that were listed in Forbes' 2007 list for India.

However, despite the positive shifts in economic development largely caused by globalization, there is a negative correlation between GDP per capita square and CO_2 emissions (Ayad et al. 2023). Also, it has been found that CO_2 emissions, energy consumption, and population density are closely related in both the short and long term. Due to the government's policy in India over the last fifty years, in particular, the expansion of energy demand, especially for oil, gas, and coal sources, energy use, and population growth have become crucial factors causing environmental deterioration.

In the diagram below, it can be seen how different areas contribute to CO_2 emissions.

Figure 13. CO_2 emissions from different sources



Source: Marjit and Yu 2018

Thus, in India the main source of CO_2 emissions is electricity and heat production (51%), followed by manufacturing industries and construction (26%) and transport (12%). Such a large amount of CO_2 emissions falls on these areas due to their active development, partly due to the influence of globalization.

However, as India looks to maintain its growth trajectory, there is an opportunity to harness the benefits of globalization for environmentally sustainable development, including efforts to address and mitigate air pollution. India's policies should emphasize the adoption of cleaner production processes, renewable energy, and sustainable transportation.

Globalization has the potential to decrease the level of poverty. At present India still has the biggest proportion of the world’s poor. But according to the recently published Global Multidimensional Poverty Index in 2023, 415 million individuals in India could escape multidimensional poverty in the period of 15 years between 2005–2006 and 2019–21, at the same time, the poverty rate dropped sharply from 55.1% to 16.4% (The Global Statistics 2023).

Upon gaining sovereignty, India made efforts to join the global economy on its own conditions. Nevertheless, external entities such as foreign corporations, foreign governments, and international agencies have gradually exerted pressure on India to integrate on their terms (Nayak et al. 2005, 14). Foreign participants of globalization in India are more concerned about their profits, rather than the environmental situation in India, and this cannot but cause concern.

Electronic garbage exported in huge volumes from developed countries to China and India is a particular danger to the environment. Its rough processing results in contamination of water and soil with heavy metals, acids and other dangerous substances, serious health problems among the local population, as well as the emergence of new landfills. To solve the problem, India is considering the possibility of a complete ban on the import of electronic garbage, but here, as in other cases, priority is given to economic benefits. Economic development and environmental degradation in India also affects residents of other countries.

A serious problem is the transboundary nature of air pollution: sulfur dioxide and nitrogen oxides formed during the combustion of fossil fuels can remain in the atmosphere for several days and travel hundreds and thousands of kilometers before falling to earth in the form of acid rain. Unfortunately, at the moment there are virtually no studies on "imported" air pollution in the poorest countries of Asia – India's neighbors. Local residents have to put up with the "import" of polluted waters of the Indus and Ganges, a significant part of the basins of which are located in India. India is also a major importer of energy carriers, thereby influencing the world's reserves of natural resources.

We should not consider the process of globalization only in a negative assessment, since it also has a number of advantages. Globalization is not only economic integration. Its political,

informational and cultural aspects are also of great importance. Thus, India is under international economic and political pressure related to the need to meet higher environmental standards. OECD countries, in particular, demand the harmonization of environmental standards in trade, as they fear that lower standards will give developing countries a competitive advantage. The US Senate, for example, in 1991 introduced additional duties on imports of goods produced to lower environmental standards than those produced domestically. However, India itself actively participates in collective decision-making on topical issues related to trade and the state of the environment, for example, within the framework of the World Trade Organization. Other international organizations and some developed countries are helping India move towards more sustainable development models by providing financial and, to a lesser extent, technological assistance. International non-governmental organizations are also exerting an increasing influence on the eco-political situation.

New consumption patterns in developed countries also influence the environmental policy of the state: in order to maintain its position in foreign markets, India is forced to produce more and more high-quality goods that do not harm the environment and human health (Rogozhina 2009, 84). Increasingly, Indian companies are resorting to international ISO 14000 and 14001 certification. In addition, under the influence of European and American trends, new consumption models are being formed in the domestic market. The demand for software also contributes to economic growth with minimal environmental impacts. However, we should not overestimate these positive trends as India still lacks the technology and financial resources to implement an effective environmental policy.

2.1. The experience of the formation of special economic zones (SEZ) in India.

In April 2000, the Government of India announced special economic zones as part of the country's export-import policy (Sysoev and Lastochkina 2009, 222)[26]. The Government was aware of the need to increase foreign investment, increase the share of the country's exports and at the same time ensure the growth of domestic production, while at the same time guaranteeing producers that they would be externally competitive.

Special economic zones, according to the announcement of the Government of India in 2000, were considered a foreign territory for trade operations, duties and fees. These zones were supposed to provide an internationally competitive and obstacle-free environment for exports. In the special economic zone, it was allowed to open enterprises for the manufacture of goods and the provision of services. All import/export operations of the participants of the special economic zone were carried out on the basis of self-certification (Beggiora 2009). Any goods could be

[26] In this section hereafter, information about the formation of special economic zones is taken from the article by Sysoev and Lastochkina (unless otherwise indicated).

imported duty-free, but sales by participants of the special economic zone in the Internal Tariff Area were paid in full according to the Customs Duty and the current import policy. In the future, offshore banks could become participants in special economic zones. The policy provided for the creation of special economic zones in the public, private, national sector or in government states. On August 31, 2004, the Ministry of Commerce of India announced the Foreign Trade Policy for 2004-2009 to create an appropriate organizational structure and political environment for the assistance and growth of foreign trade.

The main goal of this policy was to double India's share in world trade by 2009 and make exports an effective tool for economic growth, providing employment for the population. As a result of this policy, the Laws "On the Special Economic Zone" (2005) and "On the Rules of the Special Economic Zone" (2006) were adopted to regulate and accelerate the development of these industrial enclaves. The Law of India has defined special economic zones as a duty-free enclave, which will be considered as a foreign territory only for trade operations, taxes and tariffs.

According to this legislative act, no license is required for import and the usual control should not be carried out by the customs authorities of the exported and imported cargo. To help the lagging economy integrate into the advanced one, the law provides benefits to the participants of the special economic zone and its developers, exemption from all indirect taxes, including basic customs duty, countervailing duty, taxes on education, and exemption from direct taxes, while domestic sales are subject to full customs duty according to the current import policy.

Special economic zones are concentrated in special areas created by the Government of India and aimed at exporting goods. We can identify several such special economic zones in India, for example, Santa Cruz in Mumbai, Noida in Delhi, Falta in Kolkata, and so on (there are only 12 of them). Such economic zones occupy a huge space on the territory of the country and, in addition to obvious economic benefits, have a devastating impact on the environment. On the one hand, it is impossible to deny the positive impact of the creation of free economic zones, as they help create jobs for the population, capital flows into the country, and the country's competitiveness on the world stage appears. But, on the other hand, such special zones imply deforestation, road construction, bridge laying, destruction of forest and water diversity in adjacent territories, which has a negative impact, as well as consequences for many decades, if at all has the property to restore.

It is worth noting the value of forest biological diversity in India, as plants influence the formation of enriched clean air, which is necessary for the normal functioning of the human body. The main reason for the loss of forest biological diversity is that its value is not fully

understood. For example, the decision to convert one hectare of forest rich in biological diversity into agricultural land or a construction site is usually based on the possibility of obtaining immediate benefits. While at the time of making such a decision, very little attention is paid to the invaluable ecological advantages that ecosystems represent.

In addition to the rich flora and fauna, the Indian forest has one of the largest heritages in the world – a large variety of medicinal plants. The Indian population regularly uses 8,000 plant species as medicines, and 90-95% of them are of forest origin. In the Indian medical system, official documentation is available for less than 2,000 of these plants. As for the remaining 6,000 species: all knowledge about their healing properties is transmitted orally and is considered traditional knowledge passed down from generation to generation. Modern medicine uses only 49 species of forest plants in India. Biological diversity is a kind of insurance against epidemic diseases, and besides, a knowledge bank about potential remedies for diseases such as cancer or AIDS. For example, the bark of the cinchona tree contains a substance that cures malaria. The critical fact is that in most cases society remains in the dark and does not even guess the extent of the loss when another plant species disappears from the face of the earth.

Despite the rapid industrialization, the forest tribes of India have hope. Exactly one year after the approval, on January 1, 2009, the Indian Parliament enacted the "Forest Rights Act", this Act grants the local population the right to declare their ownership of the land on which they live and work from generation to generation. "It is very important to give people the opportunity to stay in the territories where they have lived for generations. The integrity of the village is lost when its inhabitants leave. It is also a big loss for the forest. Losing its guardians, it becomes vulnerable and unprotected from development and destruction. In addition, public relations are being disrupted," says Dipankar Datta, director of the Concern Worldwide international aid agency operating in the region.

The economic development and “progress” of the country goes against the environmental agenda, since economic benefits are always more important, but they also have a downside. As a rule, SEZs are formed on the site of nature reserves, jungles, parks, farm plots. The environmental agenda is not a prerogative. Employers attracted to the zones can have significant benefits from well-structured and well-located zones. The creation and development of SEZs in India, meeting the needs of business, is necessary to multiply the portfolio of the economy and attract direct investment into the country.

Under such a system, land continues to be the property of the State. In India, however, private legal entities are involved in the development of the infrastructure of the Special Economic Zone. As a result, the land is acquired by the state and transferred to private developers.

The main discussion around the implementation of the policy of the special economic zone is caused by ill-considered and ruthless methods of land acquisition. Protests in the country against the methods of acquiring land for the creation of special economic zones increased. Then the government created a rule about how many zones could be industrial (very few), how much is devoted to housing construction (much more), etc. The rapid development of zones that could help exports was like the beginning of the idea of company cities with tax benefits that would lead developers to mega–profits.

Currently, the Indian economy requires huge investments in infrastructure projects, which can be domestic as well as foreign. The whole structure of the SEZ policy requires immediate attention in order to accelerate and strengthen the growth momentum, especially when the global economy is slowing down and foreign investors are monitoring investments. The decision to set a limit on the size of the land should not lead to a violation of equitable economic growth.

2.2. India in the global ecopolitical arena

Joint international efforts are required to solve cross-border and global environmental problems. Today, India is also a party to major international agreements in the field of environment and development, an active participant in international conferences, and also cooperates on environmental and development issues with many countries of the world.

Of the approximately three hundred-sided environmental agreements that exist today, India has signed more than 70. The most important recent agreements signed and ratified by India include the Cartagena Protocol on Biosafety to the Convention on Biological Diversity of 2000 and the Stockholm Convention on Persistent Organic Pollutants 2001. The commitments undertaken by India under these agreements have had a significant long-term impact on domestic environmental policy. In addition, the goals of these international agreements would be unattainable without the participation of the largest developing countries (OECD 2008).

Global environmental problems are inseparable from the worldview of the inhabitants of the Earth, every third of whom is an Indian today, and therefore we cannot but rejoice at the fact that there are significant philosophical ecological concepts in India. As already mentioned, in India they often turn to traditional ethics. Even more often, however, scientists and politicians turn to the ideas of Mahatma Gandhi. Thus, many texts quote him saying that "There is enough land to satisfy everyone's needs, but it is not enough to satisfy everyone's greed" (Tailor 2007, 167). Some authors turn to a different story. A Briton leaving India sarcastically asked Gandhi: "Mr. Gandhi, how long do you think it will take India to reach the standard of living of the British?" The answer was not long in coming: "Sir, in order for the British to be able to reach this level, it took more than half of all the resources of the Earth. How many planets does it take for India, with its size and population, to reach such a standard of living?" (Sudhakara 2008, 77).

Thus, the limited resources and the impossibility of repeating the path of developed countries are quite clearly realized by many representatives of Indian society. Nevertheless, one should not overestimate the role of different concepts in Indian society. Orientation to Western values and consumption patterns, the desire to achieve the standard of living of developed countries, a low level of environmental awareness – so far these factors are decisive. In addition, the environmental concepts themselves are primarily focused on the national interests of both countries, and therefore if India becomes an environmental superpower in the near future, it will be only by the degree of its influence on global environmental policy, and not as a result of assuming global environmental responsibility.

Economic, political and cultural processes of globalization have a significant impact on the state of the environment and environmental policy of India. At the same time, foreign direct investment in environmentally friendly industries and the "green industry" of India has a positive impact on the state of the environment. "Environmental protectionism", pressure from international organizations, consumption patterns in developed countries – all this forces the Indian government to tighten environmental legislation, increase requirements for export-oriented industries and support the introduction of new technologies.

Targeted foreign investments in environmental projects by international organizations and developed countries, in turn, increase the possibilities of environmental regulation. The country's attitude to environmental problems is also changing in the course of political and cultural globalization. International non-governmental organizations are playing an increasingly important role in India. India has great influence among developing countries. Finally, India has significant political weight in the global arena. This country cannot become an environmental superpower in the near future, as the current eco-political course, development priorities and national environmental concepts do not allow it to assume global environmental responsibility.

At the end of the above, I would like to draw a conclusion. The process of globalization is developing rapidly and opens up a lot of new opportunities for us, helps countries and ourselves to develop for the better. Through globalization, the countries of the world are joining forces in the struggle for collective security, and environmental security is one of the most important conditions for human life in the XXI century. India is directly and indirectly exposed to such a problem, and a good point is that the government of this country is aware of the criticality of the situation and implements programmes to prevent this problem.

III AIR QUALITY MEASURES

1. Measures to improve air quality in India in the past and present

Undoubtedly, poor air quality cannot remain without the attention of the authorities. In the previous chapter we referred to some measures already taken in India, and in this section we will look at them in more detail. First of all, it is worth noting the legislative framework in this area. Legislative measures can be taken at different levels, starting from local, urban, regional and ending with continental and global.

In general, the fundamental concepts of environmental laws and treaties are the following (Bhave and Kulkarni 2015, 260):

1. The polluter is responsible for the costs of pollution.

2. Everyone should be treated equally and not discriminated against.

3. Proactive measures should be taken to prevent harm to the environment, even if scientific evidence is not conclusive.

4. All parties must take responsibility for environmental concerns, but based on different circumstances.

5. Future generations' rights to the environment must be taken into account.

Thus, the principles of responsibility and environmental justice and equality are at the heart of environmental legislation. Also, an important aspect is taking care of nature, people, and in particular, future generations.

Even before the independence of India (1947), some laws and acts were adopted regarding the problem of air pollution. Here they are (Ibid 260):

1. The Oriental Gas Company Act, 1857

2. Indian Penal Code, 1860

3. Indian Explosive Act, 1884

4. The Bengal Smoke Nuisance Act, 1905

5. The Bombay Smoke Nuisance Act, 1905

6. The Indian Boilers Act, 1923

7. Indian Petroleum Act, 1934

8. The Motor Vehicles Act, 1939

We can see that since about the middle of the 19th century, the legislative framework in the field of environmental protection began to emerge in India. In the 20th century, an increase in the number of legislative acts can be observed.

Since the independence, India has become an independent entity in the international arena. The list of legislative acts has expanded significantly. We will give a list and briefly describe them below.

1. The Factories Act, 1948, focuses on air pollution indirectly and specifically addresses the health of labor in regard to proper ventilation and managing factors such as dust, fumes, and humidity.

2. The Industrial (Development and Regulation) Act, 1957, grants the central government power to investigate scheduled industries or industrial undertakings, with a focus on saving natural resources and regulating production and development.

3. The Mines Act, 1952, addresses air pollution concerns related to ventilation, dust, fire, inflammable and poisonous gases, and precautions to prevent events like spontaneous ignition, underground fires, and coal dust.

4. The Inflammable Substances Act of 1952 aimed to promote safety by identifying and regulating dangerous flammable substances in accordance with the Petroleum Act of 1934, indirectly addressing air pollution.

5. The Atomic Energy Act of 1962 solely focused on controlling atomic energy and radioactive substances to ensure health and safety.

6. The Air (Prevention and Control of Pollution) Act of 1981 was created for preventing, controlling, and reducing air pollution. This act designated powers and responsibilities to boards for addressing related matters. The decision to establish this act was made during the United Nations Conference on the Human Environment in 1972, which India attended. The goal was to take steps to preserve natural resources, including air quality and pollution control.

7. The Environment (Protection) Act of 1986, which began to take effect on May 23, 1986, was established to safeguard and enhance the environment and related issues. This act serves as the foundation for several other rules and regulations, such as the 1995 Notification on lead-free petrol and catalytic converters for vehicles in metropolitan cities.

8. The Motor Vehicle Act of 1988 pertains to managing emissions from vehicles and establishing standards for emissions.

9. The Ozone Depleting Substances (Regulation and Control) Rules of 2000 deal with banning the use of ozone depleting substances, monitoring and reporting of ozone depleting products, and regulating their import, export and sale.

10. The Noise Pollution (Regulation and Control) Rules of 2000 classify the ambient air quality standards for noise based on land use and time (day or night).

Among the listed acts and rules, the very first directly aimed at protecting against air pollution was The Air (Prevention and Control of Pollution) Act of 1981.

It is worth noting separately the activity of Central Pollution Control Board (CPCB). It appeared in 1974 as Central Board for the Prevention and Control of Pollution and in 1988 it was renamed to its current name (Radhika 2012).

The list of its functions comprises:

1. Provide the Central Government with advice on any issue about the prevention and control of pollution and the improvement of air quality.

2. Develop and execute a program nationwide to prevent, control or reduce air pollution.

3. Coordinate state activities and resolve conflicts among them.

4. Provide guidance and support to State Pollution Control Boards (SPCBs) and conduct and sponsor investigations and research on air pollution and its prevention, control, and reduction.

5. Organize the training of individuals involved in air pollution prevention, control, or reduction programs.

6. Gather, organize, and publish technical and statistical data involving air pollution and measures developed to prevent or control air pollution. Develop manuals, codes, or guides related to air pollution prevention, control, or reduction.

7. Establish air quality standards.

8. Collect and distribute information concerning air pollution and related topics.

9. Carry out any other prescribed responsibilities.

CPCB has managed to achieve some success in terms of protecting the environment. For instance, to address plastic waste, it has created guidelines for its disposal. The CPCB plays an important role in developing environmental standards, guidelines, and laws, as well as assessing the impact of pollutants on the environment, including air, water, land, and natural resources. The main activity of the organization is in regulatory and advisory functions.

Various ministries of India are involved in solving the problem of poor air quality. Below we present a table with the relevant ministries and the initiatives presented by them.

Table 4. Recent air pollution related policies in place or discussed within Indian ministries and agencies.

Ministry	**Air pollution related policy**
Ministry of Agriculture	Policies to promote the varied use of crop residue to prevent burning.
Ministry of Earth Sciences	System of Air Quality and Weather Forecasting And Research (SAFAR) to inform, forecast, and increase awareness. National Air Quality Index (NAQI) qualitative scale of six pollutants.
Ministry of Environment, Forest and Climate Change	National Clean Air Programme (NCAP).

	Increase share of electricity generation from renewable sources. Stricter emission standards for desulphurisation. De-NOx technologies in power generation. Improved industrial energy efficiency. Reduce PM emission intensity. Measure multiple air pollutants and meteorology through the CPCB. Enforce Indian National Ambient Air Quality Standards (NAAQS). The New Environment Protection Amendment Rules. Continuous emission monitoring systems. Implementation of environment impact assessments on industry. Enforce the banning of agricultural and trash burning through the National Green Tribunal Act. Emission standards for the brick manufacturing industry.
Ministry of Finance	Estimate the cost of health impact from air pollution exposure. Provide clean gas for cooking to 50 million households by 2019.
Ministry of Health and Family Welfare	New targets aimed at the most significant exposure reductions. Tackle total pollution, considering both ambient and household.
Ministry of Heavy Industries and Public Enterprises	Faster adoption and manufacturing of hybrid and electric vehicles.
Ministry of Human Resource Development	Ensure regular check-ups for non-communicable diseases of children.

	Include the health impacts of air pollution in the school curriculum
Ministry of Labour and Employment	Ensure regular check-ups for non-communicable diseases of workers. Strengthen hospital capacity to cater for non-communicable diseases.
Ministry of Micro, Small and Medium Enterprises	Zero Effect, Zero Defect campaign to increase efficiency, pollution control, and use of renewable energy.
Ministry of New and Renewable Energy	Launched the NBCI in 2009 to provide 10.5 million improved cook stoves by 2022, primarily to rural households. Increase in solar and electric lighting. Support Integrated Rural Energy Programme on household pollution. Develop a national policy for clean biofuels.
Ministry of Petroleum and Natural Gas	PAHAL scheme directly pays subsidies into people's banks. Ujjwala to provide gas connections. The *Give it Up* scheme to persuade middle-class households to give up their fuel subsidies to redirect them to poor households. Provide 10 million PNG connections by 2019.
Ministry of Power	National Mission for Enhanced Energy Efficiency. DDUGJY to provide electricity to rural households. Improved energy efficiency through Perform, Achieve, and Trade. The Fly Ash Utilisation Policy. Promote improved cook stoves.
Ministry of Road Transport and Highways	Growth in public and electric transport. Tighter vehicle emission standards.

	Bharat VI standards reducing emissions from buses and trucks.
Ministry of Rural Development	Promote clean air guidelines
Ministry of Steel	Reduce anthropogenic dust emissions.
Ministry of Urban Development	Disincentives for diesel generators. Enforcement of the ban on trash burning.
Ministry of Women and Child Development	Promote awareness of air pollution from solid fuel use.

Source: Conibear 2019, 35-36

A total of 17 ministries are involved in this issue. At the same time, the largest number of initiatives comes from Ministry of Environment, Forest and Climate Change as well as from various ministries dealing with energy issues.

There are also a number of international agreements/treaties that have been signed by India and the provisions of which India should adhere to (Bhave and Kulkarni 2015, 261-262). For instance:

1. The Montreal Protocol, signed by India in 1992, stemmed from the United Nations Environment Programme's World Plan of Action on the Ozone Layer in 1977. The plan called for in-depth international research and monitoring of the ozone layer, leading to the development of a global framework convention on stratospheric ozone protection. In my opinion, this is one of the most significant agreements since the beneficial effect of stratospheric ozone is indisputable (we wrote about it earlier).

2. In 1986, the Helsinki Protocol was created, calling for a 30% reduction in sulphur emissions/trans boundary fluxes as a solution to control one of the leading air pollutants. As of 1987, twenty-one ECE countries were parties to this protocol, and by 1993, they had reached the goal of the Sulphur Protocol.

3. United Nations framework convention on climate change (UNFCCC), signed by India on November 1, 1993, is a global agreement on environmental issues that was negotiated during the "Earth Summit" which took place in Rio de Janeiro from June 3-14, 1992. The treaty's purpose is to establish a stable amount of greenhouse gases in the atmosphere to avoid negative effects on the climate system caused by human activity. It was available for signatures starting May 9, 1992, and went into effect on March 21, 1994. Up until 2014, 192 countries have agreed to follow this agreement.

4. Stockholm Convention on Persistent Organic Pollutants was signed by India in 2002. It is a worldwide agreement that aims to regulate and decrease the use of harmful chemicals that persist and accumulate in the environment and living organisms. Such toxins pose a risk to

human health and the environment. The Convention necessitates that governments take steps to eliminate or minimize the discharge of these pollutants into the environment.

As we can see, there are a huge number of regulations and laws in the legislative framework of India, but the most of them were signed about 20 years ago. However, an important recent development is the growth of judicial activity in the field of enforcement of environmental legislation. This is reflected in an increase in environmental-related public court cases, which have led the courts to take serious steps, such as ordering the closure of polluting plants (Shablin et al. 2022, 81).

2. Measures in Delhi and other cities

In the previous section, we reviewed the measures taken in relation to the whole country. And now in separate sections we will describe what actions are being taken and planned in Delhi, Kolkata and Mumbai.

2.1. Delhi

The list of stakeholders within the air quality management system in Delhi and in other cities includes judiciary, ministries involved directly and indirectly, government agencies involved both directly and indirectly, academic and research institutes, non-governmental organisations, media houses, associations, international agencies/bilateral organizations, India Inclusive (India Inc.) and websites (Radhika 2012).

The Ministry of Environment Forests has put in place a National Environmental Policy in 2006 that is comprehensive and guided by principles such as safeguarding the environment as development is pursued, setting standards for environmental quality, the principles of precautionary and "polluter pay", acting preventively, promoting economic efficiency, and supporting fairness. The policy's measures to control pollution and manage air quality include enhancing monitoring and enforcement of emissions standards for both non-point and point sources, devising air pollution action plans for cities, encouraging research and development, creating a national strategy for energy conservation and urban transport (Ibid).

To combat short-term instances of severe pollution in Delhi National Capital Region (NCR), the Supreme Court mandated the creation and execution of a Graded Response Action Plan (GRAP) by the government in November 2016. The Union environment ministry officially announced the GRAP in January 2017, which consists of a series of actions that increase depending on the severity of the air pollution in the city. When the level of PM concentration increases to a more hazardous extent, the government has the right to implement strict rules and regulations, such as prohibiting the use of firecrackers and generators, disallowing construction in specific regions, and even shutting down schools. These measures must be cumulatively followed to address an emergency level of pollution. However, the enactment of these measures

is impeded by the involvement of multiple parties with different responsibilities (De Vito et al. 2018, 448).

Actions according to GRAP were taken during severe air pollution conditions in November 2017 (Ibid 448). The measures were also applied in 2019 and 2020, but they showed their inefficiency since the level of pollutants in the atmosphere remained at an extremely high level (Kurinji, Khan, and Ganguly 2021, 14).

The policies of GRAP have changed over time. Central Pollution Control Board (CPCB) at first presented Stage-1 and Stage-2 of the plan. Then CPCB decided to introduce Stage-3 (Haobijam 2022). It comprises the actions that will be listed below:

1. The frequency of vacuum and mechanized sweeping of roads should be increased.

2. Roads need to be sprinkled with water and dust suppressants every day before peak hours to ensure proper dust disposal.

3. Public transport services should be intensified.

4. The construction and demolition of specific projects should be strictly prohibited, including railways, airports, hospitals, public projects, sanitation projects, and related activities.

5. All activities related to excavation and drilling, structural construction, demolition, loading and unloading of construction materials, transferring of raw materials, cutting and fixing of flooring materials, piling work, grinding activities, water proofing work, and road construction and repair are strictly prohibited, apart from the categories mentioned above.

In addition, the local population should follow some recommendations:

1. Choose an eco-friendly way to travel to work such as carpooling, taking public transit, using a bike or going on foot.

2. If possible, choose to work from home.

3. Avoid using coal and wood for heating.

4. Providing heaters (in winter) to security personnel to prevent open burning

5. Try to reduce the number of trips. Go on errands on foot if it is possible.

In the industrial sector a number of actions have been implemented, including the use of emission standards, relocating facilities, limiting the use of coal, and installing filters (Verma and Nagendra 2022). Additionally, several measures have been put in place for the transportation sector, such as emission standards, reducing sulphur content in diesel fuel, banning lead in gasoline, discarding old vehicles, and upgrading public transportation by substituting all diesel buses with natural gas buses. In Delhi, thermal power plants have ceased using coal-burning boilers over the last ten years.

In Delhi and the wider capital region, the use of pet coke and furnace oil in industry has been prohibited since 2017, and emission standards have been established for the main

industries. Nevertheless, enforcing these regulations is a major obstacle. Crop residue burning in neighboring states during the post-harvest season is a significant source of pollution, as there is little time between harvesting and sowing. Various measures have been introduced to address this problem, including remote sensing, training, and incentives for farmers, as well as fines and promotion of agricultural mechanization. However, it is difficult to understand the efficacy of policies due to the varying sources of pollution and the exponential growth of vehicles (Ibid).

2.2. Kolkata

In order to highlight the measures carried out in Kolkata, we turn to Comprehensive Air Quality Action Plan for Kolkata (Air Quality Monitoring Committee 2019).

The Department of Transport has already issued an order restricting the use of commercial vehicles (buses, minibuses, taximeters and others) aged 15 years in the Kolkata Metropolitan Area. The process of eliminating vehicles is carried out automatically by e-Vahan Software, which is administered by the National Informatics Centre (NIC). The software identifies the vehicles and locks them in the database to prevent any future transactions, such as tax payments, permit renewals or other actions.

Kolkata Traffic Police has implemented several solutions to ensure the flow of traffic in Kolkata improves. The traffic signals have been upgraded and automated using SIEMENS controllers and GPRS network system. Currently, a majority of crossroads have undergone this change.

The idea of coordinating traffic signals can result in shorter waiting times for vehicles at intersections and a decrease in vehicle emissions. One common technique is to synchronize traffic lights along major roads to create a "green wave" that speeds up travel times. Implementing a green wave could potentially decrease air pollutant emissions by 10-40% under optimal conditions, depending on factors such as traffic flow and signal timing.

Transport Department uses a vehicle equipped with a special device called the Remote Sensing Device (RSD), which can remotely evaluate the amount of pollution being emitted by moving vehicles. This vehicle is frequently used in various areas of Kolkata to inspect the pollution level of vehicles passing by and then notifies the defaulting vehicles through notices issued by the Director's office of the Transportation Directorate.

The authorities of West Bengal have made a decision to introduce electric buses in Kolkata as a measure to lower the amount of pollutants generated by vehicles. And if in 2019 the number of new buses was equal to 80, at present it is planned to launch 1,180 new buses within two years (Sharma 2022).

Also, Kolkata Municipal Corporation has introduced a measure such as daily spraying of water at important transport junctions in Kolkata during the peak winter months (from October to February) to reduce the content of PM in the air.

Air pollution in Kolkata has become complicated due to a variety of sources such as industries, vehicles, generators, fuel burning, dust, and construction. The Source Appointment Study has been proposed to understand the sources and how much they contribute to the poor air quality in the city using measurements and receptor modeling. With the results, a plan to manage the air quality will be developed, including identifying the sources, assessing their impact, prioritizing those that need to be addressed, evaluating options, and implementing appropriate action plans.

2.3. Mumbai

A GRAP has been developed for Mumbai as well as for Delhi for cases of significant deterioration of air quality. The measures included are (Divyastuti 2022):

1. The roads in the areas with heavy traffic should be frequently swept and sprinkled with water to ensure control of dust.

2. Garbage and dust need to be disposed of in designated locations while open burning of garbage is strictly prohibited.

2. Proper disposal of demolition and construction waste is required and any site that violates this rule will be shut down.

4. The ban on open burning of biomass and municipal solid waste must be enforced.

5. The flow of traffic needs to be smooth and GRAP must continuously monitor pollution hotspots.

6. Polluting vehicles will face large fines and non-essential truck traffic will be diverted, reducing heavy goods vehicles by 50%, except for those carrying essential items or providing essential services.

7. Ban on fireworks and non-compliant diesel generators.

One of the newest strategies suggested by Brihanmumbai Municipal Corporation (BMC) is planned for 2023-24 (Mumbai Live 2023). It consists of 7 steps:

1. Building and demolishing in a way that is environmentally conscious and not harmful.

2. Ways to reduce the amount of dust on roads.

3. Transportation methods which are ecologically satisfactory.

4. Techniques to manage waste sustainably.

5. Urban projects that involve environmentally friendly and sustainable landscaping.

6. Efficient monitoring.

7. Educating and informing the public about sustainability and environmental conservation.

It will be held as part of the Clean Air Mumbai Initiative that is also planning to focus on three specific goals such as decreasing the amount of pollution in different industries, establishing a monitoring system in different levels within the city, distribution of planning responsibilities and raising public awareness about the state of health to lower individual exposure (Ibid).

It is noteworthy that this strategy came out Maharashtra Chief Minister Eknath Shinde decided to install air purifiers throughout the city in February 2023. Air purifiers have already been set up, despite the criticism of some Indian politicians who consider these measures a waste of money.

3. Possible solutions at macro level and micro level

Measures that can have a positive impact on air quality can be taken both at the macro level (at the state level) and at the micro level, that is, at the individual level. It is best if these levels work together, striving for a common goal.

We will look at measures at both levels that can improve air quality in India in the long term. Since the air quality situation is similar in the analyzed cities, the measures will be similar

The first and the most obvious action that every person in India can do is to use public transport whenever it is possible instead of using a car. The fewer vehicles there are on the roads, the fewer emissions into the air will be. But the authorities must ensure good uninterrupted operation of transport for this. Also, if possible, it is worth walking more, especially for short distances.

Obviously, local population should abandon burning firecrackers during celebrations. For instance, people living in the towns of Kollukudipatti and Singampunari in the Sivaganga district of Tamil Nadu have long abandoned it (Patel 2018). Although the primary reason for this behavior is not to avoid deterioration of air quality, but it is a good example of caring about nature and it shows the positive influence of the older generation on the younger. The local population is worried about animals, which can be frightened by loud noises, and this can disrupt their usual way of life. The abandonment of the use of firecrackers occurred several decades ago at the initiative of more senior residents. And as a result, it is difficult for the new generation to imagine that once firecrackers were a constant element of celebrations. It is a good idea to replace this common element of Indian celebrations with some other more environmentally friendly one.

On an individual level, people can also improve the environment by growing trees. This measure can help to increase the amount of oxygen and to reduce the concentration on carbon dioxide. Besides, this may promote the unification of people, generating a sense of community.

It is also worth giving preference to more environmentally friendly energy sources, such as solar and wind power. However, the use of this measure is complicated by the high cost. Thus, in this matter, the support of the state for the poor is important. One more measure is proper waste disposal as it can reduce the amount of open burning, but the authorities must also provide the necessary conditions for this.

However, various individual measures must be applied together; otherwise they will not have a positive effect in the long term. Also, more global measures on the part of the state are needed.

First of all, the authorities can encourage and support the use of public transport by the local population. But it is necessary to ensure the continuous operation of transport and the convenience of the schedule. Then it will be convenient for the population to use it. Also, if possible, a system of incentives for refusing to use personal transport can be applied.

More serious control over industrial enterprises is needed. Strict standards for the operation of industrial facilities should be developed. Fines or other more stringent measures should be applied for their violation.

Educational activities on the part of the state and environmental organizations can help people more quickly realize the need to change their habitual behavior. Some steps are being taken in this direction, for example, awareness-raising activities have already begun to be implemented in some schools in India (Pti 2022). Efforts to raise awareness involve organizing initiatives such as planting trees within school campuses, advocating for the usage of school buses, abstaining from using personal vehicles, and establishing pedestrian-only areas near school campuses.

There is an interesting point of view about why already existing measures do not bring the desired result (The Wire 2021). It is likely that the Indian government tends to oversimplify the problems. Out of all the countries in the Indian subcontinent, India has conducted the most extensive research till now. This research includes studying variations in space and time, describing and apportionment of PM sources.

Between 2007 and 2010, several organizations such as the National Environmental Engineering Research Institute (NEERI), The Energy and Resources Institute (TERI), Automotive Research Association of India (ARAI), and some other research organizations conducted a series of extensive studies on source apportionment for six Indian cities: Delhi, Chennai, Kanpur, Bangalore, Mumbai, and Pune (Ibid). These studies contributed to the

integration of source apportionment science into mitigation programs. As a result, researchers and experts have highlighted the importance of source apportionment science in informing policies and taking mitigation actions. Several academic institutions conducted about 73 studies on source apportionment between 2001 and 2017. However, the concentration of air pollutants responsible for deteriorating urban air quality has remained consistent over the past forty years. Despite the big number of policies, implementation capacity is quite low in India.

It is likely that the low effectiveness of the measures is associated with the need to analyze various sources of pollution in a complex, not separately; therefore, the measures taken do not bring the proper result. In addition, the situation is complicated by insufficient financial resources in the regulatory agencies responsible for the development of measures and their implementation.

In recent years nature-based solutions (NbS) are becoming increasingly popular in addressing environmental issues, in particular climate change and air pollution. They are cost-effective and offer environmental, social, and economic benefits. NbS provide sustainable options for mitigating the negative effects of climate change and pollution, improving the health and well-being of urban residents, and benefiting biodiversity in a resource-efficient manner (Menon and Sharma 2021, 4).

Nature-based methods can be a cost-effective and sustainable solution for reducing exposure to particle and gaseous pollution in urban areas. They help monitor air quality and mitigate air pollution. Certain species such as lichens, algae, and trees can be used as bio-indicators for measuring air quality. In addition, some plant species are able to decrease air pollution through bioaccumulation and deposition processes. The ability of these plant species to cope with pollutants varies based on their sensitivity and tolerance to different types of stress. The Air Pollution Tolerance Index (APTI) was developed by Singh and Rao to evaluate the resistance of plants to air pollutants. Plants that have a high APTI value can help reduce air pollution, while those with a low APTI value can be used for monitoring pollution levels due to their sensitivity. However, various other aspects including canopy structure, habitat type, and economic value need to be considered based on specific needs (Ibid).

Nowadays researchers use the term Green Infrastructure (GI) to refer to the incorporation of vegetation, such as parks, green roofs and walls, into city landscapes (Barwise and Kumar 2020). This has been found effective in reducing air pollution through processes such as dispersion and deposition as well as mitigating and adapting to climate change. WHO has recommended a minimum of 9 square meters of green space per person to improve quality of life. Some countries, like the UK and Malaysia, have adopted standards to ensure availability of green spaces, but India lacks such regulations. However, the Ministry of Urban Development's

2014 Urban Greening Guidelines outlined steps to integrate green spaces into urban planning. Rapid urbanization has resulted in a decline in green cover in major Indian cities. While some cities like Delhi have made efforts to restore greenery, most other cities have seen a decrease. Urban green spaces can be planned by restoring existing areas or designing new ones as parks, gardens, urban forests, roadside avenues or vertical greening systems (Menon and Sharma 2021, 4).

Vertical Greening Systems (VGS) are structures in which vegetation is allowed to grow and spread over a wall or building (Ibid). Green facades and walls are seen as a way to combat urban heat islands by passively cooling the temperature. Also, VGS can help in energy conservation through its ability to provide thermal insulation created by shade, plant evapotranspiration, and insulation from multiple layers. Depending on the type of plants, these systems are capable of reducing the level of air pollution. Particular climbing plant species with a high APTI rating have been singled out as being the most appropriate for constructing VGS for mitigating air pollution (Price et al., 2015).

The living root bridges grown by rural communities in Meghalaya (India) are the most famous and unique example of functional residential architecture (Schlaefli 2020). This measure is also within the framework of green-based solutions. The bridges have exceptional strength in extreme climatic conditions, minimal material and maintenance costs, no environmental damage, their load-bearing capacity is gradually increasing, and also they have medicinal properties for the surrounding soil, water and air. Due to their qualities, they represent an unusual innovative model for infrastructure solutions and further application of these properties in construction.

Living structures, such as this traditional vine bridge in India, serve as a source of inspiration for creating completely new materials, and are also good practice in improving green technologies and air quality.

Figure 14. Conscious Concrete

An unprecedented class of materials provides the foundation for this kind of self-aware infrastructure - and researchers around the world have been busy investigating their mysteries for the past few years. One example is concrete with an inner sense of self. Mixed with carbon fibers, carbon nanotubes and nickel powder, this material autonomously monitors its condition to provide information about cracks, humidity, or unusually high loads. This data is extracted from the structure by applying voltage and constant measurement of electrical resistance (Ibid 2020). This confirms the extraordinary development in technology and can become a solid foundation for further eco-friendly construction.

Living in an animated environment is a new area of research that scientists have started, and at this stage there are more questions than answers. One big question is how to ensure security and stability when infrastructures live their own lives. Another is how living creatures will react to an artificially created environment consisting of living organisms.

In conclusion of this section, we would like to note that the new century requires a rethinking of existing technologies. In this sense, nature-based solutions can serve as an excellent replacement for existing environmentally harmful technologies.

4. India's energy efficiency policy as a key opportunity to achieve air quality improvement goals.

Currently, India is among the largest energy consumers in the world, but nevertheless, the population of India is characterized by a low level of consumption of high-quality energy of about 880 kWh per person per year. At the same time, it is possible to maintain one of the highest GDP growth rates in the world, which currently stands at more than 7% per year (Reva 2019, 97)[27].

Further growth in India's population and GDP is expected to generate even more abundant energy demand and, as a result, increase CO_2 emissions. As you know, CO_2 emissions have an extremely negative impact not only on changes in air quality, but also lead to an increase in carbon dioxide concentrations on a global scale, therefore, gas insulation increases worldwide, which is the cause of global warming on earth.

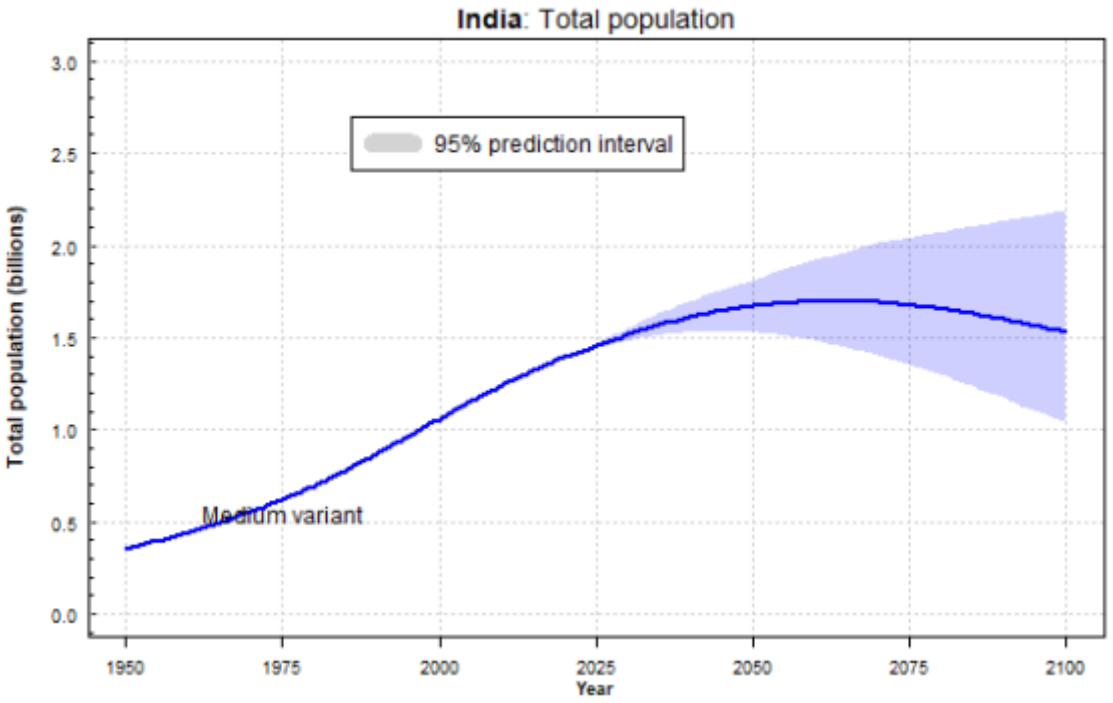
In this section, we will consider energy efficiency in India, the introduction of electric vehicles now, as well as in the future, in order to analyze the dynamics of changes affecting air quality. Let us consider an approach based on current energy conservation policies to understand the future development of India's complex energy system.

At the moment, it is impossible not to note the increasing role of India as one of the key consumers of energy resources. India, home to about 20% of the world's population, uses only 6% of the world's primary energy. The population is expected to grow in the future and

[27] Here and further statistical information is taken from the article by Reva (unless otherwise indicated).

socio-economic development will improve, so the demand for energy is expected to grow. Today, energy resources are considered crucial for achieving India's ambitions in the field of development, supporting a growing economy, delivering electricity to rural areas, satisfying the need for greater mobility and infrastructure development needed to meet the needs of the most populous country in the world. We are going to demonstrate this statement on a graph below.

Graph 1. Population and share of urbanization



Source: UN. (2022). UN Population Trends[28].

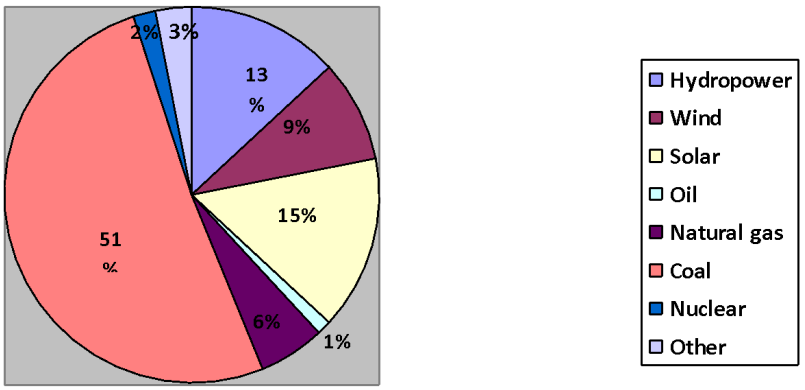
As shown in the graph, the population is expected to increase every year in India, which means energy resources are considered the most important indicator in the development of the country, as well as the direction of the paradigm in relation to the environment. Today, energy is considered crucial to achieving India's development ambitions, supporting a growing economy, delivering electricity to rural areas, meeting the needs for greater mobility, and developing the infrastructure needed to meet the future needs of the most populous country in the world. However, according to the analytical data published on the EIA website in India, coal occupies the prominent role in energy consumption due to the still low availability of electricity and its unequal distribution between urban and rural areas. This trend is reflected on the chart presented as of 2020.

As shown in Figure 14, the main inflow of electricity as of 2022 in India was provided by coal (52%), solar energy (15%), hydropower 13%, wind energy (10%), gas 6%. The data indicate a positive trend over the past few years. The share of renewable energy is increasing. It

[28] http://www.un.org/en/develop ment/desa/population/theme/trends/index.shtml

is worth noting that the Government of India has set the goal of compensating coal with renewable energy sources in order to reduce emissions into the atmosphere to solve the acute problems with air pollution and by 2030, India will try to achieve 50% of the use of renewable energy sources.

Figure 15. India`s installed electricity generating capacity by type (2022)



Source: Indian Ministry of Power

Energy security and sustainability are mutually enhanced, since India's energy imports are mainly based on fossil fuels, the goal of affordability will be contrary to the goal of sustainability, since fossil fuels are the cheapest source of energy. Integrated energy planning is extremely important to ensure that the country achieves an accurate balance in achieving these goals. It is assumed that India will contribute more than any other country to the projected growth of global energy demand, approximately 25% of the total volume. Urbanization will be a key factor reflecting this trend, as by 2040, the urban population of India is expected to increase by 315 million people, or about 48% of the total population, which is equivalent to the population of the United States of America. The growth rate of GDP is one of the main drivers of energy demand in the country. India is expected to become one of the fastest growing economies in the world in the near future; India's GDP is expected to grow by an average of 7.4% until 2042.

It is worth considering that coal will continue to remain dominant among all other commercial energy sources in India in the foreseeable future due to its price advantage over other energy sources. In addition, compared to other fuels such as oil and natural gas, which are mainly imported due to the limited availability of domestic resources, coal is abundantly available domestically. Efforts to reduce oil imports and improve energy security are already

underway. The intensity of energy emissions, is likely to grow, this is mainly due to two reasons: the shift in demand for cooking from traditional biomass to more advanced fuel and technological binding to liquid fuels (gasoline and diesel) is likely to continue in the transport sector, although the growth of electric vehicles increases its position, but is insufficient to replace gasoline and diesel cars.

India's ratification of the COP21 agreement in December 2015 is associated with goals including a promise to reduce the intensity of emissions by 2030 GDP by 33-35% compared to the 2005 level, in addition, there is a plan to ensure by 2030 the generation of 40% of electricity without the use of fossil fuels and the creation of additional carbon absorption in the amount of 2.5 to 3 billion tons of CO_2 equivalent (Co_2). All this entails new restrictions on the prospects for high growth rates of the Indian economy.

In order to achieve the emission intensity of the GDP target and compensate for this increase in the intensity of energy emissions, India will have to reduce its energy intensity of GDP by 45% compared to 2005 levels. Based on the existing problem, two ways should be proposed for reducing emissions:

Increasing efficiency = energy efficiency

I. Household appliances: Setting energy efficiency standards for household appliances

II. Construction: Adoption of the Energy Efficient Construction Code

III. Industry: Scheme (PAT)3 Perform, Achieve and Trade

Renewable energy

I. Wind energy

II. Solar energy

III. Geothermal energy

The data show that in the period from 2005 to 2010, the intensity of emissions GDP decreased by about 4%. During this period, India's GDP grew by about 6%, and total emissions increased by 4.7%. It is interesting to note that the two-component indicators are the intensity of energy emissions and the energy intensity of GDP decreased by 2.38% and 2.43%, respectively (Table 5).

Table 5 - Recent trends in India's key climate indicators.

Parameter	2005	2010	Average annual growth (%)	Decrease (%)
Emission intensity GDP (kg CO_2 /Rupee 2010)	0.024	0.019	-4.7	21

Intensity of energy use (TW\h/Rupee of 2010)	0.12	0.1	-2.4	14
Intensity of energy emissions	0.21	0.18	-2.4	11

Source CEA 2016, GoI, 2015c, MoEFCC 2015.

It should be noted that in the 1990s, India had a higher level of intensity of fossil fuel use, and efficiency levels were low in several production sectors; with constant technological improvements, a sharper decrease in the intensity of GDP emissions was reported until 2000 with a 9% increase.

Between 2000 and 2017, the growth of economic activity in India could potentially more than double energy consumption without taking into account the impact of energy efficiency improvements and structural changes. Almost 70% of such changes in energy consumption were related to industry and the service sector, where a significant increase in output has more than tripled since 2000. Improving energy efficiency in India since 2000 has avoided an additional 6% increase in energy consumption in 2017. The increase in efficiency was achieved mainly due to industry and services. The efficiency improvement also prevented CO_2 emissions of about 145 million tons and an increase in fuel imports by 5% in 2017.

The Energy Conservation Act, passed in 2001 and amended in 2010, provides a framework for India's energy efficiency policy. The Act is supported by the National Energy Efficiency Mission, one of eight missions under the National Climate Action Plan 2008. The National Energy Efficiency Mission is in the process of being transformed into a roadmap for a sustainable and holistic approach to national energy efficiency.

Table 6. Electricity production, billion kWh

2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22	9 months 2022-23
1 336,0	1 432,0	1 509,0	1 607,9	1 646,8	1 533,3	1 651,2	1 070,8

Source: Central Electricity Authority of India

Electricity generation in India in 2021.22 amounted to 1651.2 billion kWh (+7.7% by 20.21). In the structure of production, thermal power plants accounted for 78.1%, hydroelectric power plants — 10.4%, renewable energy — 8.7%, nuclear power plants - 2.8%.

India is one of the world leaders in the field of wind energy. As of March 2021, the total installed capacity of the country's wind power plants was 40.9 million kW, of which most is located in Tamil Nadu. According to this indicator, India ranks 4th in the world (about 6% of the

world's WPP capacity). The Indian Wind Energy Association estimates India's wind energy potential at 48.6 million kilowatts. The installed capacity of solar energy in India in the first half of 2022 reached 57 million kW. Among the Indian states, Rajasthan is the leader, in which 13 million kW of solar power plants have been installed. In May 2022, the first solar-wind power plant was commissioned in the west of India near Jaisalmer (Rajasthan).

A hybrid power plant that uses the potential of two main renewable energy sources — wind and solar - allows the new 390 MW plant to solve the problem of interruptions in electricity generation depending on the weather and time of day. In 2022, 14 GW of solar power plants were commissioned in India. According to the draft "Indian Electric Power Development Plan" (Draft National Electricity Plan), the share of solar energy in India's electricity production will reach 23% by 2032, and the total share of solar and wind energy 35%. At the same time, the installed capacity of solar generation by this date should be 333.5 gigawatts. The Government of India has set a goal to increase the total capacity of renewable energy sources to 450 GW by 2030.

Given the scale of demand in the country and the availability of cheap coal, coal will remain the main source of electricity, followed by other cost-effective sources such as hydropower, gas, nuclear and renewable energy. However, when using coal to generate electricity, a gradual transition to clean coal technologies can be observed. This is reflected in the increase in the efficiency of coal in the near future, despite the increase in the level of its use. As for solar and wind power, without any significant cost improvement, the addition of power from these renewable sources is limited.

Table 7. Solar and wind energy costs based on IES data

Cost components	Solar panels	Wind-driven generators
Investment costs	1043 $/kV	1149 $/kV
Fixed costs	20 $/kV	16 $/kV
Normalized costs	2.9 rupee/kW\h	2.2 rupee/kW\h

Source: India’s Energy and Emissions Outlook: Results from India Energy Model 1.

These goals could have been seen as ambitious a few years ago, but with the fall in the cost of solar and wind energy, as well as the cost of storing batteries, they are within reach. Reducing exhaust emissions from urban transport is crucial to addressing climate change. According to the International Council for Clean Transportation, approximately 84,000 premature deaths were caused by air pollution from exhaust emissions in India in 2020. Since the number of cars on the roads in India doubles every 8-10 years, CO_2 emissions cause even more pollution. The transport sector has the highest energy saving potential - about 40% in 2030,

which is largely due to the ambitious introduction of electric vehicles and the transition from private to public transport. The Government of India, thanks to its schemes, has accelerated the introduction and production of hybrid and electric vehicles, with the aim of achieving 30% penetration of electric cars by 2030. The scheme creates incentives for demand for electric vehicles and calls for the introduction of Western technologies and stations in urban centers.

If these targets are met by 2030, they will provide savings of up to 474 million tons of oil equivalent and 846 million tons of net CO_2 emissions over their lifetime. Housing construction (including cooking) provides about 30% of the estimated savings. This is largely due to the transition of almost 300 million people from traditional biomass to efficient furnaces running on liquefied petroleum gas and liquefied petroleum gas and the introduction of ultra-efficient appliances. Industries have demonstrated a modest savings potential is about 25%. This is due to the fact that such large industries as cement and aluminum production are already using the world's best practices and technologies, mainly due to the competitiveness of the industry.

Mass purchases can expand markets for energy-efficient products, which is already happening successfully in India. Volume purchases create sufficient demand to achieve economies of scale by making effective products affordable at or below the cost of traditional products. The manufacturer's ability to supply products for wholesale purchases encourages other manufacturers to follow this example.

Energy Efficiency Services Limited (EESL), an Indian state-owned "super" energy service company, has radically lowered the price of LEDs available on the market and helped create jobs in local to meet the need for energy-efficient lighting. The cost of LEDs is currently less than 1 US dollar (about 60 rupees), which is 80% less than in the first round of purchases in 2014. Thanks to the Uniti Jyoti by Affordable Plans for ALL (UJALA) program, EESL has replaced more than 308 million lamps with LED without the need for any subsidies.

Mass purchases do create problems, which include generating demand on a sufficient scale, agreeing on the right terms of the contract and managing the production of the product. By solving these problems, companies involved in wholesale purchases will continue to transform markets by improving access to more energy-efficient products. In general, the analysis shows that with the strict implementation of the current policy, India can achieve the required reduction in energy intensity by 2030.

In order to better understand the possible future development of the Indian energy sector China could provide some useful insights. China is usually criticized as being the world's bigger emitter and Chinese cities were often in the headlines for intense air pollution. Unfortunately, China is penalized by the metrics used to define the countries pollution, because China is compared for instance to the US which has an almost five times smaller population. The same is

true for India. Developed nations have a much stronger per capita emissions fingerprint compared to China and even more to India. In addition, many European and American companies delocalize to India and China to exploit lower labor costs and also less strict environmental regulations. A large part of this production is then reimported to developed nations. In this regard part of Chinese and Indian emissions could be considered as European and American ones since these companies are producing for the developed countries. Adopting per capita metrics of emissions for instance and eliminating these distortions would be useful to show the real amount of emissions and the responsibility of each county for climate change.

The delocalization process and globalization brought the majority of world manufacturing capacity to China. The country has seen a drastic rise in environmental problems and worsened air pollution. The Chinese government adopted an ambitious plan to improve the country's environmental reputation by investing in new technologies. Currently China is installing almost half of the world's new renewable capacity every year. Chinese new solar and wind installations are bigger than the European and American combined. In addition China is becoming a world leader in the production of electric vehicles and accounts for about 60% of world photovoltaic production. At the beginning of 2023 the market share of electric vehicles in China has reached an astonishing 35% with a 95% growth year on year. India, with its growing population, rising education standards could follow the Chinese model in this regard.

The chapter has already pointed out the importance of coal for Indian energy security. The coal industry provides also many jobs in the Indian economy while high-tech production of solar power and Electric vehicles would have to compete with other players in this case mainly low cost and highly efficient Chinese manufacturers. Behind the phasing out of coal stay also geopolitical and political considerations which are not only related to the climate change or air pollution issue. Developed countries have the problem that they already have a developed energy and electricity infrastructure and often it is more costly to adapt existing networks than to build new ones. In this regard many future, sustainable and green cities are namely built in China and India from scratch. India instead of passing through the so called "bridge fuels" like natural gas could organize, plan and build its future energy networks directly on renewable energy. If the Chinese case is significant for India, with all the differences that exist, Indian energy transition could go faster compared to estimates of just some years ago thanks to a more rapid adoption of new energy technologies. However, neither China nor India have already reached the peak of their emissions because the energy needs are still growing faster than the reduction of energy intensity and adoption of renewable energy. China and India economies could still absorb huge amounts of new oil, coal and gas production worldwide.

5. Environmental Humanities with relation to air pollution problem

In India, the problem of contamination and the increase in the amount of waste, caused by economic growth, urbanization and population growth, is urgent. The Indian government is making a lot of efforts to solve environmental problems: at present, environmental legislation is developing in the country, environmental authorities at all levels of government are functioning, and various political instruments are being used. But unfortunately, measures do not lead to the desired results. Perhaps it is time to look at the problem in a different way? Environmental humanities can help us to take a fresh look at the problem.

Describing the comprehensive relationship between environmental humanities and nature, I would like to quote a female ecologist, Heather Davis, associate professor of Culture and Media at the New School in New York, who views nature through the prism of the female image, pointing out that nature is an integral part of man himself. Quoting the writer, it can be noted how subtly she feels and empathizes with nature, its changes and large-scale pollution.

"Breathing in contemporary times reveals a deep vulnerability to the outside world."[29]

The author's essay, which has gained popularity in the ecological community, is called "Breathing space", the author poetically denies human alienation from nature. In her work, she tells us that we breathe the environment and it nourishes us. There is a subtle relationship between man and nature, because our lungs inhale oxygen, transforming it into carbon dioxide, and thus changing the environment. Currently, the existing boundaries between ecology and man are increasingly blurred, due to the developing progress, modernization, technology development, as well as new scientific discoveries. According to many environmental experts, today's division into nature and culture is an irrational dichotomy, since a person is not above the dirty entanglements of environmental disasters, but on the contrary, is an integral part of nature and the source of their occurrence.

In my opinion, it is especially important in modern society to find a connecting thread between the humanities, art and modern scientific research concerning human healthy life on the planet, a way of eco-friendly existence with nature. This is not an answer, but an important step. Now more and more universities are interested in research, popularization, and establishing a link between environmental humanities in human life, as evidenced by many practical programs and scientific articles in this field. We can highlight the main results of such studies: visual art, literature, poetry, documentaries, lectures by various scientists. In addition to an expanded informative base, today there is an opportunity to conduct environmental discourse, criticizing, creating, and offering. Ecological discourse reaches its relevance on a par with philosophy, sociology and art theory. All discussion events not only consider and celebrate the current

[29] The quote is taken from the website https://hyperallergic.com/414831/environmental-humanities/

environmental situation, but also take actions in the form of developing programs for the future, forming their own point of view and pursuing the goal of changes for the better.

It is the environmental humanities that help to combine scientific rigor and creative practice, which are so necessary for thinking about how to live well on the affected planet. The humanities about the environment allow us to refresh the sad facts about how acute the environmental agenda is and to enter the social discourse in a new way so that existing problems are analyzed and understood by an increasing number of people. This disciplinary activity carries a lot of speculative, productive research, exposing the truth, as well as showing the fragmentation of knowledge, challenging short-sighted individuals, depoliticizing science and emphasizing the art of ecological wisdom. The humanities of environmental sciences are actively developing and we can highlight programs at various universities around the world, including UCSC, the famous University in Santa Cruz, USA, UNSW in Sydney, the modern Aarhus University in Denmark, mainly aimed at the development of the Anthropocene with invited outstanding environmental scientists, the University of New Mexico program is widely known in the scientific community “Art and Ecology” as a pedagogical platform for art and ecology.

Outside the West, in the Global South, the environmental direction also does not stand still, the Southern Humanities University of Cape Town is famous for its humanitarian programs and is a large scientific community outside the West and is strong in the study of ecology. The programs described above prove that the scientific community is seriously thinking about the importance of pressing issues of our time and is striving to attract the public for familiarization, cooperation and the development of team projects to prevent various kinds of environmental disasters. Robin Wall Kimmerer, an important environmental scientist in the scientific community, is of the opinion that interdisciplinary study is necessary to understand the connection between “culture” and “man”. The topics she works on are: non-human intelligence, interspecies communication, symbiotic relationships and more. These approaches could give an opportunity to take a fresh look at today's problems, to find ways to exist in the world that would not be so painful and destructive.

Many of Kimmerer's studies show the reader the spirit of humanitarian development in solving environmental problems. I would like to quote a wonderful phrase from Kimmerer's book called: "Weaving from fragrant grass.” This book conveys the true wisdom of indigenous peoples, as well as scientific knowledge and teachings about plants. Thus, the author narrates: “Not only the earth has been destroyed, but, more importantly, our relations with the earth.” In my opinion, this reasoning very clearly conveys the disturbed relationship between man and nature, man needs to get closer to the earth through research, which will be considered both from a scientific and cultural point of view. Convergence is necessary for us to fill in the gaps that

cold statistics and facts leave. It is important for a person to remember that no matter how successful the path of his development and progress is, he is only a part of the earth, which means he does not stand at the top of management, but only co-creates the world.

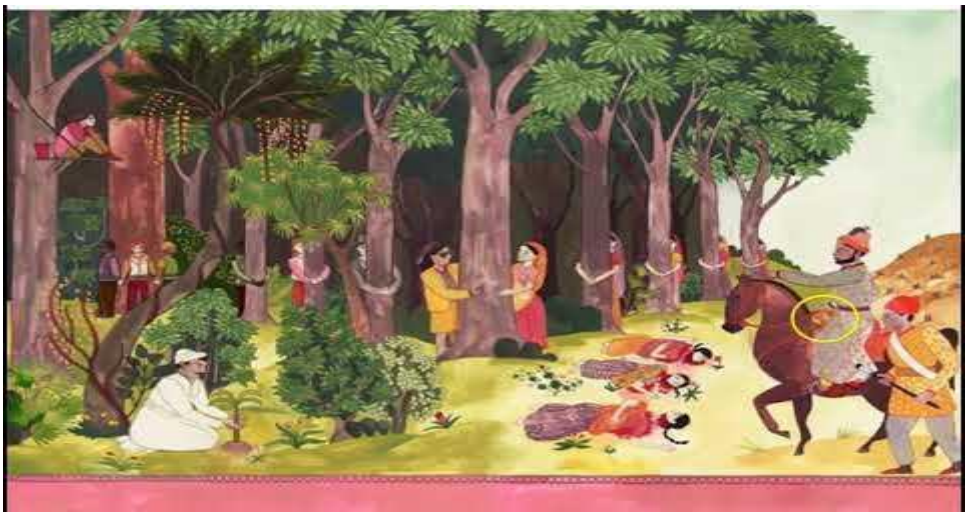
We would like to note that one of the reasons for air pollution is the low level of development of ecological consciousness, characteristic of both the general population and officials. More conscious and knowledgeable residents can educate other people about the need to change their habits and choose a more environmentally friendly model of behavior. Especially in this regard, representatives of the older generation can help, since the authority of the elders is very great in India. Of course, environmental humanities can be an excellent guide in raising the environmental awareness of the population.

One should not ignore the philosophical aspects of the relationship between man and nature. We would like to describe from a philosophical point of view the movement of Chipko women in India, who protected the forest with their bodies[30]. The Chipko movement has become famous in 1973, when a group of women from the village of Mandal in the Himalayas in India has embraced trees to prevent them from being cut down. When the loggers came, the women, led by Gaura Devi, surrounded the trees and chanted: “This forest is our mother's home; we will defend it with all our might.” If you plunge into the past, then this movement started with an even earlier event that happened in 1783 in Hijal, Rajasthan, in India. People sacrificed their lives for Hijri trees, which were considered sacred in the community. The terrible events began when Amrita Devi of the Bishnois faith, which prohibits the cutting of trees, protested against the royal entourage, who arrived to burn the trees to lime for the construction of a new palace. Amrita refused to pay the bribe demanded for the tree, saying that “If the tree is saved even at the cost of someone's head, it is worth it”, and was killed for her brave act. Then even more people stood up to protect the trees, resulting in the death of 363 people, before the Maharaja ordered them to stop cutting down trees.

[30] Here and further information about the Chipko movement is taken from https://www.tottenhamtrees.org/chipko-movement.html

Figure 17. Women performing Chipko.

Figure 18. Amrita Devi saving trees by Cari Vander Yacht.



The described example speaks of the high consciousness of people, courage and fearlessness even for their own lives. It demonstrates an extraordinary love for nature, comparable to a mother's love for her child. Chipko's appeal was unique. The movement was co-operated, formed and popularized by such diverse groups as local journalists and reporters from all over the world. It has gained great popularity among mass activists, environmentalists, Gandhian supporters, spiritual leaders, politicians, practitioners of social change of people. The feminist movement popularized Chipko, pointing out that poor rural women travel long distances to collect fuel and forage, and thus are the first victims of forest destruction. Gandhi's supporters emphasized the importance of the Chipko movement through symbolic protests such as prayers,

fasting and padayatras (ritual processions). In addition, Chipko is synonymous with the growth of environmental journalism in India and around the world.

In India, the media created by Chipko have directly included the idea of forest conservation in the political and public agenda for the country. In the early 1980s, the Prime Minister of India, Mrs. Indira Gandhi, ordered a 15-year ban on cutting down trees at an altitude of 1000 meters above sea level in the Himalayan forests (she believed that Chipko personified "moral conscience" India). Subsequently, this decree was extended to the tree-covered forests of the Indian Western Ghats and the Vidhya mountain ranges. It is incredible that it started spontaneously, with a simple hug of a tree! This demonstrates that people united by the power of the spirit and deeply established in their own strength are able to influence the change of nature. Defending the forest in a militant way, brave and heroic women were able to achieve legislative protection, even though it happened a long time later. Despite the line of progress, the race to increase profits, the growth of the economy and the endless enrichment of man as a whole, it is worthwhile for the public to look at the legal, ethical and ideological side of the problem.

Many Indian scholars touch in their works and appeal to the statements of the great Mahatma Gandhi. In India, unlike China, considerable attention is paid to traditional ethical teachings that can help a person overcome greed and passion for consumption. Indian researchers also turn to religious ecological concepts. Some public figures even suggest abandoning the Western system (in the broadest sense of the word) and returning to the Indian tradition. Significant Indian scientists are interested in the knowledge and ideas of indigenous peoples about the environment, which can be used, for example, in matters of biodiversity preservation.

At present science starts to overlap with various forms of art: paintings, music and literature. A stunning example of the synthesis of science and art is Jaipur Litfest (Lavakare 2021)[31]. At this event in 2016, three scientists discussed air pollution through the prism of mournful memoirs that were written as a personalized narrative about the human costs of air pollution. This piece of art showed how toxic air affects not only our bodies, but also our minds.

This is not the only example of presenting environmental problems in a creative form. The term "ecological art", or "eco-art", refers to a set of different genres of fine art in which the artist addresses the topic of the relationship between man and nature. Such directions include not only modern trends like environment, land and science art, but also, for example, classical landscape painting and even rock paintings - attempts by primitive man to capture and comprehend the world around him. Putting aside oil and watercolor, modern artists use discarded

[31] Information is taken from here https://scroll.in/article/989790/decoding-science-how-art-can-help-in-communicating-the-harms-of-air-pollution-in-india

plastic, waste paper and other garbage as materials. New Zealand artist Rosalie Gascoigne, who created collages from waste, was one of the first to use it in her work[32].

Modern artists not only pay attention to environmental problems, but also show by their example how a person can solve them. In 1982, the German artist Joseph Beuys organized the project "Seven thousand Oaks", in which he and the locals were going to plant seven thousand trees on the road from the German city of Kassel to Russia[33]. Boyce died in 1986, and the artist's undertaking was completed by his friends and relatives. In 2021, Boyce would have turned 100 years old. In memory of him, a tree planting campaign was launched in several German cities this spring.

In the conclusion, we would like to note that in India, the recommendations for improving the effectiveness of environmental policies are mainly technical and economic in nature. Ecopolitical course of the government of the society is not rejected; we hear only appeals to a more efficient use of existing tools, as well as their expansion. Environmental problems in general and air quality in particular are seen as problems of inadequate management, and not as a systemic crisis of the existing economic and political order. To the main question of the modern environmental discourse about whether it is possible to achieve sustainable development, that is, to find a compromise between the desire for economic growth and limited natural resources, without radical political and economic transformation Indian scientists give a positive response.

The position of environmental economics considering environmental problems in terms of economic efficiency and ecological modernization concept, which asserts that the problems of modern society are management shortcomings and not a systemic crisis of capitalism, is strong in Indian science. In such a theoretical context, it does not seem surprising that the majority of proposals for improving the effectiveness of environmental policies are reduced to the need to develop legal and economic instruments, modernize existing institutions and improve technologies.

The ecological problem should also be considered as a living organism of the country, which breathes and lives with its inhabitants, has its own diseases and problems, which expects to be treated compassionately, given a chance for recovery and life, because one should not forget that a person still does not stand at the top of nature management, is not its Creator and cannot reverse the processes started. Nature was conceived as a kingdom where all living creatures develop according to their own laws, without human participation, and thrive in their biodiversity.

[32] https://www.artgallery.nsw.gov.au/collection/artists/gascoigne-rosalie/
[33] https://publicdelivery.org/joseph-beuys-7000-oaks/

The public bears a great burden of responsibility for its activities, industrial growth, industrialization, globalization, capitalism, unconscious consumption with all the negative consequences of these epochal milestones of human development. Often, one should look at the side of the problem philosophically, from an ethical and moral point of view, from a different angle in order to assess the scale of what is happening and understand that there is no other such planet. Postponing the problem of air pollution today, without putting it under the scope for a solution, people do not think about their tomorrow.

CONCLUSIONS

The thesis throughout the chapters has tried to show the complexity of the air pollution problem in India and that there are no quick solutions on the horizon. India is facing a series of tradeoffs and difficult choices between different noble and important goals, and it has a long way to go in achieving good air quality.

Based on the analysis, we can conclude that the problem of air pollution in India has acquired not a local, but a global character; therefore it should be treated as an international issue. We do not know how much the problem of air pollution in India affects residents of other countries, but by conducting a survey we found out that 70% of the surveyed Delhi residents are dissatisfied with the air quality in their city. However, positive trends have already been outlined, for example, towards the use of renewable energy sources. Also, in judicial practice, the cases of termination of the activities of enterprises that do not comply with environmental standards have been observed.

We cannot deny the positive impact of globalization and rapid economic growth in the country, as these processes have helped to lift millions of people out of poverty, but at the same time, it has put a lot of pressure on ecosystems. The growth of unsustainable consumption has affected air pollution, water scarcity and waste generation. This practice poses a significant danger to human health and the entire environment. In addition, automobile pollution, industrial emissions, and the burning of fossil fuels contribute significantly to respiratory and lung diseases. When making production decisions, if possible, priority should be given not to economic benefits, but to environmental well-being and population`s needs.

Economic growth in itself is not enough if it does not involve all the population layers, especially the poorer classes. While the developed world, with a stable or even shrinking population, could take relatively fast and effective measures to fight air pollution the same is hardly true for India. With a booming population and rapidly expanding cities the fight against air pollution is a real challenge. Economic growth is of vital importance for India to create jobs for a growing population and to exit the poverty trap. If in the case of the developed world economic growth is a matter of living standard, in India it is a matter of survival.

There is a link between the level of income of the population and the level of exposure to pollution. The richer the population, the less pollution it can be exposed to. While the wealthier population can afford air purifiers and more secure homes, the poor are particularly vulnerable to air pollution. Thus, the problem of air pollution is closely related to the problem of environmental injustice.

The ineffectiveness of many of the measures taken indicates the need to reconsider the old approaches. Green-based solutions seem to be an excellent environmentally-friendly alternative, perfectly fitting into the idea of a harmonious relationship between man and nature.

Basically, awareness and adaptation are two key steps towards preserving the environment. In our work, we have shown excellent examples of how art helps to raise awareness of environmental issues, and its potential is inexhaustible and powerful. Art does not solve problems, but they are solved by people inspired by it. Every resident of India can and should do their part to curb the consequences of these environmental problems and provide future generations with a healthy place to live on.

We would like to emphasize that the fight against the problem of climate change in general, as well as changes in air quality in India, can change for the better if appropriate actions are taken. On the part of the government, a strict legislative framework for industrial enterprises that emit pollutants into the atmosphere and water of India is needed along with popularization of the problem in society in the form of advertising and prohibition of smoking in public places. A good idea would be the government's proposals for greening cities, as well as rural areas, which will increase forest cover and biodiversity. The government should invest in and promote sustainability in all sectors of industry to encourage change. It is worth noting that awareness of the population to waste is also important. First of all, this is the sorting of garbage, its disposal only in specially designated places. Individuals should practice the art of “green” life, applying an eco-friendly approach to life. Particular attention should be paid to the ban on the use of firecrackers. Traditions associated with harm to the environment are unacceptable; therefore, it is a good idea to replace them with safer ones.

In my opinion, an interesting continuation of our research could be a comparison in the historical trend. It is obvious that there is a gap due to the fact that corrective measures relate to a certain period and cannot trace its subsequent development in the future with great improvements that sooner or later take place. Such a study is necessary to analyze the environmental situation and assess the current dynamics against the background of previous years. A good basis could be the consideration of such parameters as the human development index (HDI), the level of awareness of the population on environmental issues, assessment of the introduction of environmental humanities in society, social movements and environmental strikes. It is important to assess the dynamics of development and the trend of structural changes taking place in nature and society.

BIBLIOGRAPHY

1. Air Quality Monitoring Committee. 2018. Comprehensive Air Quality Action Plan for Kolkata.

2. Ayad, Hicham, Pradeep Mishra, Binita Kumari, Soumik Ray, Florian Marcel Nuţă, Rajani Gautam, Daniel Balsalobre-Lorente, Alina Cristina Nuţă, and Cristina Gabriela Zamfir. 2023. "The Spillover Effects of Uncertainty and Globalization on Environmental Quality in India: Evidence from Combined Cointegration Test and Augmented ARDL Model." Frontiers in Environmental Science 11 (March 1, 2023). https://doi.org/10.3389/fenvs.2023.1144201

3. Barwise, Yendle, and P. Senthil Kumar. 2020. "Designing Vegetation Barriers for Urban Air Pollution Abatement: A Practical Review for Appropriate Plant Species Selection." Climate and Atmospheric Science 3, no. 1 (March 2, 2020). https://doi.org/10.1038/s41612-020-0115-3

4. Beggiora, Stefano. 2009. "India e Nordest. Il Mercato Del Terzo Millennio."

5. Bhave, Prashant D., and Nikhil Nitin Kulkarni. 2015. "Air Pollution and Control Legislation in India." Journal of the Institution of Engineers (India) 96 (3): 259–65.

6. British Deputy High Commission Kolkata. n.d. "Roadmap for Low Carbon and Climate Resilient Kolkata."

7. Ciumasu, Ioan and Naela, Costica. 2010. "Impacts of Air Pollution on the Ecosystem and Human Health: A Sustainability Perspective."

8. Conibear, Luke Alexander. 2019. "Ambient Air Quality and Human Health in India."

9. Cummings, Lucas E., Justin D. Stewart, Radley Reist, Kabindra M. Shakya, and Peleg Kremer. 2021. "Mobile Monitoring of Air Pollution Reveals Spatial and Temporal Variation in an Urban Landscape." Frontiers in Built Environment. https://doi.org/10.3389/fbuil.2021.648620

10. Das J. 2020. "Hotspot Detection, Traffic Pollution and Asthma Incidence in and around Kolkata, India." https://doi.org/10.29011/2574-7754.100537

11. Deng, Chuxiong, Si Tian, Zhiwei Li, and Ke Li. 2022. "Spatiotemporal Characteristics of PM2.5 and Ozone Concentrations in Chinese Urban Clusters." Chemosphere 295 (May): 133813. https://doi.org/10.1016/j.chemosphere.2022.133813

12. Devi, M. Renuka. 2017. "Globalisation impact on Indian economy and culture." International Journal of Applied Research 3.

13. De Vito, Laura, Graham Parkhurst, Anil Namdeo, S.M. Shiva Nagendra, Sunil Gulia, Sanjiv Goyal, Margaret Bell, et al. 2018. Air Pollution in Delhi: A Review of Past and Current Policy Approaches. Ecology and the Environment. WIT Press. https://doi.org/10.2495/air180411

14. Fenger, Jes. 2009. "Air Pollution in the Last 50 Years – From Local to Global." Atmospheric Environment 43 (1): 13–22. https://doi.org/10.1016/j.atmosenv.2008.09.061

15. Gayer, Anna, Łukasz Adamkiewicz, Dominika Mucha, and Artur Badyda. 2018. “Air Quality Health Indices - Review.” MATEC Web of Conferences 247 (January): 00002. https://doi.org/10.1051/matecconf/201824700002.

16. Greenpeace. Southeast Asia. 2021. “Greenpeace Southeast Asia analysis of the cost to the economy due to air pollution”

17. Gupta, Sunil, and Suresh Pandian Elumalai. 2019. “Exposure to Traffic-Related Particulate Matter and Deposition Dose to Auto Rickshaw Driver in Dhanbad, India.” Atmospheric Pollution Research 10 (4): 1128–39. https://doi.org/10.1016/j.apr.2019.01.018.

18. Gurjar, Bhola R., Luisa T. Molina and Chandra Shekhar Prasad Ojha. 2010. “Air Pollution : Health and Environmental Impacts.”

19. Gurjar, Bhola R., Khaiwal Ravindra, and Ajay Singh Nagpure. 2016. “Air Pollution Trends over Indian Megacities and Their Local-to-Global Implications.” Atmospheric Environment 142 (October): 475–95. https://doi.org/10.1016/j.atmosenv.2016.06.030

20. Guttikunda, Sarath K., Rahul Goel, and Pallavi Pant. 2014. “Nature of Air Pollution, Emission Sources, and Management in the Indian Cities.” Atmospheric Environment 95 (October): 501–10. https://doi.org/10.1016/j.atmosenv.2014.07.006

21. Guttikunda, Sarath, and Nishadh KA. 2022. “Evolution of India's PM2.5 Pollution between 1998 and 2020 Using Global Reanalysis Fields Coupled with Satellite Observations and Fuel Consumption Patterns.” Environmental Science: Atmospheres 2, (6). https://doi.org/10.1039/d2ea00027j

22. Haque, Md. Senaul, and R. P. Singh. 2017. “Air Pollution and Human Health in Kolkata, India: A Case Study.” Climate 5, no. 4. https://doi.org/10.3390/cli5040077.

23. IQAir. 2021. World Air Quality Report 2021.

24. Kanchan, Kanchan, Amit Kumar Gorai, and Pramila Goyal. 2015. “A Review on Air Quality Indexing System.” Asian Journal of Atmospheric Environment 9 (2): 101–13. https://doi.org/10.5572/ajae.2015.9.2.101.

25. Karmakar, J. 2020. “Air Pollution in Kolkata: Emerging Challenges and Dynamics.” Journal of Atmospheric Science Research. https://doi.org/10.30564/jasr.v3i4.2231

26. Kaur, Rajveer, and Puneeta Pandey. 2021. “Air Pollution, Climate Change, and Human Health in Indian Cities: A Brief Review.” Frontiers in Sustainable Cities 3 (August). https://doi.org/10.3389/frsc.2021.705131.

27. Khan, M. K., Brauer, M., Cropper, M. L., Balakrishnan, K., Mathur, P., Dey, S., Turkgulu, B., Kumar, G. R., Khare, M., Beig, G., Gupta, T., Krishnankutty, R. P., Causey, K., Cohen, A., Bhargava, S., Aggarwal, A. N., Agrawal, A., Awasthi, S., Bennitt, F. B., . . . Dandona, L. 2021. Health and economic impact of air pollution in the states of India: the Global

Burden of Disease Study 2019. The Lancet Planetary Health, 5(1), e25–e38. https://doi.org/10.1016/s2542-5196(20)30298-9

28. Kurinji, L. S, Adeel Khan, and Tanushree Ganguly. 2021 Bending Delhi's Air Pollution Curve: Learnings from 2020 to Improve 2021 New Delhi: Council on Energy, Environment and Water.

29. Lim, Stephen S, Theo Vos, Abraham D. Flaxman, Goodarz Danaei, Kenji Shibuya, Heather Adair-Rohani, Mohammad A. AlMazroa, et al. 2012. "A Comparative Risk Assessment of Burden of Disease and Injury Attributable to 67 Risk Factors and Risk Factor Clusters in 21 Regions, 1990–2010: A Systematic Analysis for the Global Burden of Disease Study 2010." The Lancet 380 (9859): 2224–60. https://doi.org/10.1016/s0140-6736(12)61766-8

30. Maji, Kamal Jyoti, Dikshit, A. K., and Chaudhary, Ramjee. 2017. "Human Health Risk Assessment Due to Air Pollution in the Megacity Mumbai in India." Asian Journal of Atmospheric Environment, 11(2). https://doi.org/10.5572/ajae.2017.11.2.061

31. Mangaraj, Poonam, S.K. Sahu, Gufran Beig, and Ravi Yadav. 2022. "A Comprehensive High-Resolution Gridded Emission Inventory of Anthropogenic Sources of Air Pollutants in Indian Megacity Kolkata." SN Applied Sciences 4 (4). https://doi.org/10.1007/s42452-022-05001-3.

32. Manisalidis, Ioannis, Elisavet Stavropoulou, Agathangelos Stavropoulos, and Eugenia Bezirtzoglou. 2020. "Environmental and Health Impacts of Air Pollution: A Review." Frontiers in Public Health 8 (February). https://doi.org/10.3389/fpubh.2020.00014.

33. Marjit, Sugata, and Yu, Eden Siu-hung. 2018. Globalization and environment in India. ADBI Working Paper 873. Asian Development Bank Institute (ADBI), Tokyo

34. Menon, Jyothi U., and Sharma Richa. 2021. "Nature-Based Solutions for Co-Mitigation of Air Pollution and Urban Heat in Indian Cities." Frontiers in Sustainable Cities 3 (October 8, 2021). https://doi.org/10.3389/frsc.2021.705185.

35. Naughton, Barry. 2007. "The Chinese Economy: Transitions and Growth."

36. Nayak, Amar K. J. R., Kalyan Chakravarti, and Prabina Rajib. 2005. "Globalization Process in India: A Historical Perspective since Independence, 1947." South Asian Journal of Management 12 (1): 7.

37. Nordhaus, William D. 2007. "A Review of the Stern Review on the Economics of Climate Change." Journal of Economic Literature 45 (3): 686–702. https://doi.org/10.1257/jel.45.3.686.

38. OECD. 2008. OECD Environmental Outlook to 2030.

39. OECD. 2016. "The economic consequences of outdoor air pollution: policy highlights."

40. Price, Alexandra, Erick C. Jones, and Felicia Jefferson. 2015. “Vertical Greenery Systems as a Strategy in Urban Heat Island Mitigation.” Water Air and Soil Pollution 226 (8). https://doi.org/10.1007/s11270-015-2464-9.

41. Public Health Foundation in India. 2017. Air Pollution and Health in India: A review of the current evidence and opportunities for the future.

42. Reva, A.R. 2019. “India's Energy Efficiency Policy as a Key Opportunity to Achieve COP21 Goals.” Innovations and Investments19 (11).

43. Rogozhina, N.G. 2009. “New Trends in Environmental Policy of Developing Countries”.

44. Sablin, I.V. 2014. “Globalization and the Environment: Environmental Policy of India and China.” The Age of Globalization 14 (2).

45. Sawhney, Aparna. 2004. The New Face of Environmental Management in India. http://ci.nii.ac.jp/ncid/BA6789604X.

46. Shablin P. A., Eriashvili N. D., Osodoev O. P., and Ivanova Yu. A. 2022. “Environmental law of India: current aspects.” Criminological Journal 22 (1). https://doi.org/10.24412/2687-0185-2022-1-75-82.

47. Sharma, Disha, and Denise L. Mauzerall. 2022. “Analysis of Air Pollution Data in India between 2015 and 2019.” Aerosol and Air Quality Research 22 (2): 210204. https://doi.org/10.4209/aaqr.210204.

48. Stafoggia, Massimo. 2020. “Health Effects of Air Pollution : Innovative Approaches for Spatio-Temporal Evaluations.”

49. Spiroska, Jana, Asif Rahman, and Saptarshi Pal. 2011. “Air Pollution in Kolkata: An Analysis of Current Status and Interrelation between Different Factors.” SEEU Review 8 (1). https://doi.org/10.2478/v10306-012-0012-7

50. Sudhakara R. B. 2008. Environment, Development and the Role of Technology // Problems and Prospects of Environment Policy: Indian Perspective.

51. Sultana, Sharmin. 2022. “An exploration of detrimental pollutants causing air pollution in India.”

52. Tailor, N. D. 2007. “Environmental Change in India.”

53. TERI. 2015 Air Pollution and Health. Discussion Paper by the Energy and Resources Institute: New Delhi.

54. TERI. 2015. Environment Status Report of Mumbai Metropolitan Region (MMR).

55. Uday, Utkarsha, Lakshmi Deepak Bethineedi, Muhammad Hasanain, Behram Khan Ghazi, Arsalan Nadeem, Prashastee Patel, and Zaira Khalid. 2022. “Effect of COVID-19 on Air

Pollution Related Illnesses in India." Annals of Medicine and Surgery 78 (June). https://doi.org/10.1016/j.amsu.2022.103871

56. Verma, Nidhi, and S.M. Shiva Nagendra. 2022. "Long-Term Trend Analysis of Criteria Pollutants in Megacity of Delhi: Failure or Success of Control Policies." Urban Climate 45 (September): 101254. https://doi.org/10.1016/j.uclim.2022.101254

SITOGRAPHY

1. BM Global News. 2021. "Road Dust Responsible for 71% Emission Load of PM in Mumbai, Finds NEERI Study." https://bmglobalnews.com/2021/03/02/road-dust-responsible-for-71-emission-load-of-pm-in-mumbai-finds-neeri-study/ (accessed on May 2023)

2. "CAQI and AQI Air Quality Index. How to Calculate Them? | Air Quality Monitoring. Monitor in UK & Europe. Airly Data Platform and Monitors." n.d. https://airly.org/en/air-quality-index-caqi-and-aqi-methods-of-calculation/ (accessed on January 2023)

3. Chand, Prakash. 2021. "2021 Census of India : Facts, Important Questions for Competitive Exams." https://censusofindia2021.com/2021-census-of-india/ (accessed on March 2023)

4. "Climate Change Indicators: Greenhouse Gases | US EPA." 2022. US EPA. August 1, 2022. https://www.epa.gov/climate-indicators/greenhouse-gases (accessed on June 2023)

5. "Cross-Cutting Story 5: Co-Benefits of Addressing Climate Change and Pollution." n.d. European Environment Agency. https://www.eea.europa.eu/publications/zero-pollution/cross-cutting-stories/cross-cutting-story-5-co. (accessed on June 2023)

6. "Deforestation in the Amazon | Amazon Conservation Association." 2020. Amazon Conservation Association. April 30, 2020. https://www.amazonconservation.org/the-challenge/threats/ (accessed on June 2023)

7. "Delhi Air Quality Index (AQI) and India Air Pollution | AirVisual." 2020. Iqair.com. https://www.iqair.com/india/delhi (accessed on March 2023)

8. Divyastuti. 2022. "West Bengal's 'Graded Response Action Plan.'" GKToday (blog). December 2, 2022. https://www.gktoday.in/west-bengals-graded-response-action-plan/ (accessed on May 2023)

9. Duggal, Vishal. 2019. "Causes and Sources of Air Pollution." IndiaCelebrating.Com. https://www.indiacelebrating.com/environmental-issues/causes-and-sources-of-air-pollution/ (accessed on January 2023)

10. Financial Express. 2022. "Air Pollution 'satisfactory' in Kolkata after Diwali: Official." https://https://www.financialexpress.com/lifestyle/science/air-pollution-satisfactory-in-kolkata-after-diwali-official/2743885/ (accessed on May 2023)

11. Future of Humanity Institute - FHI. 2021. "Research Areas - Future of Humanity Institute." The Future of Humanity Institute. June 11, 2021. https://www.fhi.ox.ac.uk/research/research-areas/ (accessed on May 2023)

12. Glossary of Meteorology. 2012. https://glossary.ametsoc.org/wiki/Ambient_air (accessed on January 2023)

13. Hanzala, Aman. "A Comprehensive Study of Air Pollution in India." 2017. https://www.youthkiawaaz.com/2017/10/a-comprehensive-study-of-air-pollution-in-india/ (accessed on March 2023)

14. Haobijam, Gyane. 2022. "Graded Response Action Plan (GRAP): The Solution to Delhi's Air Pollution." AQI India (blog), November 1, 2022. https://www.aqi.in/blog/graded-response-action-plan-grap-the-solution-to-delhis-air-pollution/ (accessed on May 2023)

15. The Wire. "India's Air Pollution Mitigation Strategy Needs More Direction. " The Wire. 2021. https://thewire.in/environment/indias-air-pollution-mitigation-strategy-needs-more-direction (accessed on May 2023)

16. "India Air Quality Index (AQI) and Air Pollution Information | AirVisual." n.d. https://www.iqair.com/india (accessed on February 2023)

17. "India's Air Quality Is Seven Times Worse than WHO Guideline : IQAir World Air Quality Report 2022." n.d. Greenpeace India. https://www.greenpeace.org/india/en/press/15431/indias-air-quality-is-seven-times-worse-than-who-guideline-iqair-world-air-quality-report-2022/ (accessed on January 2023)

18. "How Is India Addressing Its Water Needs?" n.d. World Bank. https://www.worldbank.org/en/country/india/brief/world-water-day-2022-how-india-is-addressing-its-water-needs (accessed on June 2023)

19. "Joseph Beuys' Ambitious Plan to Plant 7000 Oaks." 2020. April 21, 2020. https://publicdelivery.org/joseph-beuys-7000-oaks/ (accessed on June 2023)

20. Lavakare, Jyoti Pande. 2021. "Decoding Science: How Art Can Help in Communicating the Harms of Air Pollution in India." Scroll.In, March 20, 2021. https://scroll.in/article/989790/decoding-science-how-art-can-help-in-communicating-the-harms-of-air-pollution-in-india (accessed on June 2023)

21. Mashal, Mujib, Emily Schmall, and Russell Goldman. 2021. “Why India’s Farmers Are Protesting.” The New York Times, November 19, 2021. https://www.nytimes.com/2021/01/27/world/asia/india-farmer-protest.html (accessed on May 2023)

22. “Mumbai Air Quality Index (AQI) and India Air Pollution | AirVisual.” n.d. https://www.iqair.com/india/maharashtra/mumbai (accessed on February 2023)

23. Mumbai Live. 2023. “BMC Budget 2023-24: 7-Step Strategy To Reduce Air Pollution in Mumbai,” February 4, 2023. https://www.mumbailive.com/en/environment/bmc-budget-2023-24-five-air-purifiers-proposed-in-crowded-areas-of-mumbai-76984 (accessed on May 2023)

24. Patel, Tanvi. 2018. “For Decades, 2 TN Villages Haven’t Burst Crackers on Diwali. The Reason Will Move You!” The Better India, October. https://www.thebetterindia.com/162644/tamil-nadu-diwali-crackers-news/ (accessed on May 2023)

25. Pti. 2022. “Delhi: DoE Tells Schools to Sensitise Students about Air Pollution, Climate Change.” The Times of India, December 21, 2022. https://timesofindia.indiatimes.com/education/news/delhi-doe-tells-schools-to-sensitise-students-about-air-pollution-climate-change/articleshow/96397022.cms (accessed on May 2023)

26. Radhika. 2012. “Stakeholder Analysis of Air Quality Management in India.” Air Quality Management in India, October 17, 2012. https://airqualityindia.wordpress.com/2012/10/15/aqm/ (accessed on May 2023)

27. Rajagopal, Krishnadas. 2021. “Supreme Court Brings Back Ban on Firecrackers in Delhi-NCR.” December 3, 2021. https://www.thehindu.com/news/national/sc-brings-back-ban-on-firecrackers-in-delhi-ncr/article62037015.ece (accessed on April 2023)

28. Rajshekhar, M. 2011. “Posco’s Orissa Project: Many Hurdles Lie Ahead despite Environment Ministry’s Approval.” The Economic Times. May 7, 2011. https://economictimes.indiatimes.com/industry/indl-goods/svs/metals-mining/poscos-orissa-project-many-hurdles-lie-ahead-despite-environment-ministrys-approval/articleshow/8189409.cms (accessed on May 2023)

29. “Rosalie Gascoigne | Art Gallery of NSW.” n.d. https://www.artgallery.nsw.gov.au/collection/artists/gascoigne-rosalie/ (accessed on June 2023)

30. Rosencranz Armin, and Raghuveer Nath. The Hindu God is no longer green. Policy Forum. 2017. https://www.policyforum.net/hindu-god-no-longer-green/ (accessed on April 2023)

31. Sharma, Monalisa. 2022. “West Bengal Government to Introduce CNG and Electric Buses to Combat Air Pollution.” October 30, 2022. https://www.officenewz.com/2022/10/30/west-bengal-government-to-introduce-cng-and-electric-buses-to-combat-air-pollution/ (accessed on May 2023)

32. Schlaefli S. 2020. “Living bridges” January 3, 2020. https://ethz.ch/en/news-and-events/eth-news/news/2020/01/biodegradable-bridges.html# comment (accessed on June 2023)

33. Shubhankar, Rawat. “India—Air Pollution Data Analysis.” Medium. Towards Data Science. 2019 https://towardsdatascience.com/india-air-pollution-data-analysis-bd7dbfe93841 (accessed on March 2023)

34. Slutsky, Rebecca. 2017. “Delhi’s Air Pollution and Its Effects on Children’s Health. Yale Global Health Review. ” https://yaleglobalhealthreview.com/2017/05/14/delhis-air-pollution-and-its-effects-on-childrens-health/ (accessed on May 2023)

35. The Economic Times. 2021. “Lancet study confirms air pollution in India can result in increased risk of pregnancy loss.” https://economictimes.indiatimes.com/magazines/panache/lancet-study-confirms-air-pollution-in-india-can-result-in-increased-risk-of-pregnancy-loss/articleshow/80164207.cms (accessed on April 2023)

36. The Global Economy. “India Overall Globalization” n.d. https://www.theglobaleconomy.com/India/kof_overall_glob/ (accessed on May 2023)

37. The Global Statistics.2023 “Poverty Rate in India Statistics 2022 | Poorest State in India.” May 19, 2023. https://www.theglobalstatistics.com/poverty-in-india-statistics-2021/ (accessed on May 2023)

38. Timmer, John. 2012. “Berkeley Earth Project Is Back to Re-Re-Confirm Earth Is Warming.” Ars Technica. July 30, 2012. https://arstechnica.com/science/2012/07/berkeley-earth-project-is-back-to-re-re-confirm-earth-is-warming/ (accessed on June 2023)

39. United Nations Climate Change. “Cities and Local Action to Combat Climate Change.” 2019. https://unfccc.int/topics/education-youth/youth/global-youth-video-competition/global-youth-video-competition-2019/cities-and-local-action-to-combat-climate-change (accessed on June 2023)

40. Varanasi, Anuradha. 2022. “Unraveling the Interconnections Between Air Pollutants and Climate Change.” State of the Planet.

https://news.climate.columbia.edu/2022/07/22/unraveling-the-interconnections-between-air-pollutants-and-climate-change/ (accessed on May 2023)

41. Varshney, Apekshita. 2021. "Smoggy, but unfazed: Mumbai needs to take air pollution more seriously than it does." https://citizenmatters.in/mumbai-delhi-air-pollution-particulate-matter-aqi-environment-12940 (accessed on May 2023)

42. World Health Organization. 2022. "Billions of People Still Breathe Unhealthy Air: New WHO Data." www.who.int. April 4, 2022. https://www.who.int/news/item/04-04-2022-billions-of-people-still-breathe-unhealthy-air-new-who-data (accessed on January 2023)

43. World Population Review. 2020. "World City Populations 2020." https://worldpopulationreview.com/world-cities (accessed on February 2023)

44. Wu, Jin, Derek Watkins, Josh Williams, Shalini Venugopal Bhagat, Hari Kumar, Jeffrey Gettleman, Rumsey Taylor, Leslye Davis, and Karan Deep Singh. 2021. "Who Gets to Breathe Clean Air in New Delhi?" The New York Times, November 11, 2021. https://www.nytimes.com/interactive/2020/12/17/world/asia/india-pollution-inequality.html (accessed on May 2023)