Environmental Strategies for Air Pollution Mitigation in Industrial Areas Using the Clean Development Mechanism (CDM)

Rawan Ashraf Zaghloul

Master's Degree Candidate, Environmental Planning, Faculty of Urban Planning Cairo University, Cairo, Egypt. rawanashrafzaghloul@gmail.com

Tarek Abou El-Seoud

Professor, Environmental Planning, Faculty of Urban Planning Cairo University, Cairo, Egypt. tarek.seoud@cu.edu.eg

Seham Mostafa Qutb

Lecturer, environmental Planning and infrastructure, Faculty of Urban Planning Cairo University, Cairo, Egypt. seham.mostafa87@gmail.com

Abstract:

Abstract a series of environmental hazards as an impact of air pollution and climate change, as an example, the heat waves of over 40°C in Egypt and Greece and the burning forests in Turkey as well as the floods in Germany. (https://ec.europa.eu/clima/change/consequences_en). Developed countries and the early industrializers created their wealth and reached their high standards of living pumping into the atmosphere huge amount of Green House Gases (GHG) long before the world understood the consequences of climate change. Whereas developing countries are now faced by too many restrictions when it comes to industrialization as to keep the GHG gas level maintained. Putting these countries in a situation of not being able to achieve any progress (Hegazy 2014) (Ministry of State for Environmental Affairs 2010).

The Kyoto Protocol has come up with the Clean Development Mechanism (CDM) that aims to the cooperation between both rich and poor countries in order to achieve sustainable development in developing countries. As Egypt is one of the developing countries, there is a challenge whether it can achieve sustainable development while working on the development process the country is now implementing (Gerden 2018)

So, this paper aims to develop new urban strategies to achieve sustainable development using CDM methods and technologies and air dispersion models for air pollution simulation and prediction, that would help in reducing the current air pollution problem and avoid it in the future. The study also aims to test the validity of the clean development mechanism (CDM) based adaptation urban strategies on the Egyptian case, along with solving the gap between the current Egyptian urban regulation system and strategies and the current air pollution rates in Cairo

Keywords:

Climate Change, Air Pollution, Environmental Strategies, Clean Development Mechanism (CDM), Air Dispersion Modelling, Cairo.

Paper received 25th August 2021, Accepted 9th October 2021, Published 1st of November 2021

1. Introduction

Climate change is one of the major issues facing the world nowadays. And effectively taking actions on climate change rely on understanding the complexity and uncertainties of future climate change and related risks in cities. Under the framework of sustainable development, following related national green development strategies and polices, taking advantages of science, technology, finance and governance in cities, to actively tackle urban climate change issues, such as enhanced adaptation and mitigation measures, properly selecting development pathways will greatly enhance climate resilience in cities (Climate and Res 2019).

There is a fundamental unfairness to the climate change problem where there are uneasy relations between rich and poor nations. Developed countries and the early industrializers – Japan, north America, Europe and others- created their wealth and reached their high standards of living pumping into the atmosphere huge amount of GHG long before the world understood the consequences of climate change or even started to deal with it as an issue (Sena 2018) (Ministry of State for Environmental Affairs 2010). Whereas developing countries are now faced by too many restrictions when it comes to industrialization as to keep the GHG gas level maintained. There will also be new costly technologies that must be adopted so that less damage is caused in the future, these are

additional burdens that developing countries will not afford as they are struggling to give their citizens better lives. Putting these countries in a situation of not being able to achieve any progress.

Most industrial countries suffer from high rates of air pollution due to dust and carbon dioxide as well as fine particulate matters.

Table 1 : the amount of carbon dioxide emissions in Egypt and other countries of the world during (1990_2010) The unit (million tons)

Countries	1990	1995	2000	2004	2008	2010	Rate of change (1990- 2010) %
America	4821.2	10.2	5961.9	6049.4	6302.3	6104.2	26.6
England	579.7	569.6	580.1	587.3	590.2	591.6	2.05
Indonesia	214.0	303.0	365.6	378.3	381.4	434.5	103.04
France	364.0	351.1	357.7	373.7	378.5	380	4.4
Australia	278.6	312.4	337.7	336.8	341.7	356.6	28.0
Egypt	75.5	95.1	138.7	158.2	170.3	182	**141.06**
Morocco	23.5	30.3	34.3	41.2	44.2	46.1	96.2
Jordan	10.2	13.6	15.5	16.5	18.4	19.8	94.12

It is clear from (**Table 1**) that Egypt occupies the first place among all the states mentioned in the table where the rate of increase in those emissions reached 141.06% in 2010 in comparison with 1990 in which it amounted to about 75.5 million tons (Mokhtar et al. 2015).

Greater Cairo, Egypt, is one of the cities suffering from very high rates of pollutants, specifically particulate matters PM 2.5 and PM 10 (See Figure 1), also its contribution to the global greenhouse gas (GHG) emissions is 0.57% (Nakhla, Hassan, and Haggar 2013). This have caused negative health impacts on citizens along with social and economic costs. Around 20,000 People died in Egypt in 2017 as a result of ambient PM2.5 air pollution in Greater Cairo, and the estimated cost of these social effects was 2.5% of Egypt's Gross Domestic Product (GDP) where the cost of ambient PM2.5 air pollution was highest with a percent of 1.35% of GDP, estimate of 47 billion Egyptian Pounds (Larsen 2019). The major causes of air pollution are the huge urban development happening throughout the past decades, urban areas around the industrial zones are certainly considered of the most affected areas by industrial air pollution. These urban areas exceed the daily PM 2.5 and PM10 limit – 10 µg/m3 – as specified in the World Health Organization (WHO).

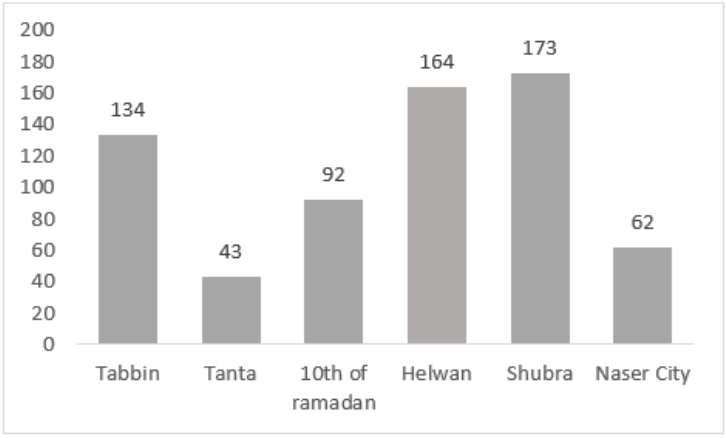

Figure 1 PM10 daily emission rates of different Egyptian cities (µg/m3)

There are various reasons and perspectives of why Cairo is vulnerable to air pollution, as a start, unformal urban areas have been formed within the industrial zones the due to the high number of workers and low residential areas. Then from the metrological perspective, where Egypt's air temperature and wind direction are stable most of the year which enables air pollutants to reach the surface. Which by order causes the exceedance in $PM_{2.5}$ and PM $_{10}$ rates (Ministry of Environment 2018) (World Health Organization 2005).

The formation and levels of dust and small particles are more characteristic in Egypt than presently found in industrialized countries. Some of the sources for these pollutants, such as industries, open-air waste burning, and transportation, were also well-known problems in most countries only 10 to 20 years ago. Another important source for particulate matter is the windblown dust from the arid areas. These particles are however to be found in the larger particle fraction (See Figure 2). (Edenhofer, O., Pichs-Madruga, R., Sokona, Y.,

Minx, J.C., Farahani, E., Kadner, S., Seyboth, K. 2015) (Karakosta and Psarras 2013).

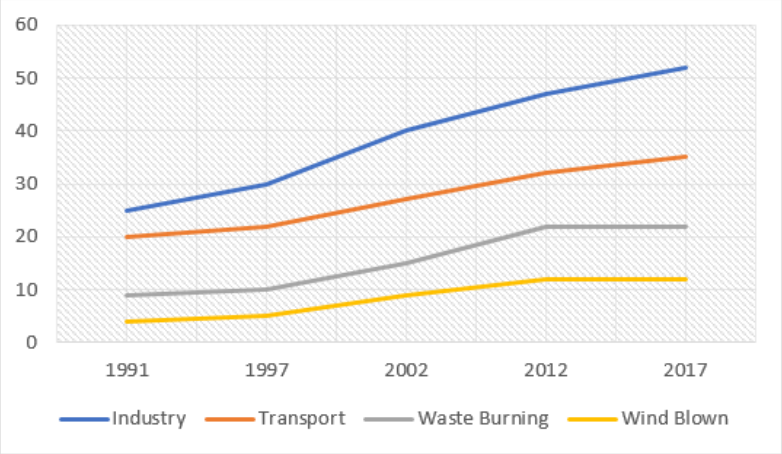

Figure 2 GHG emission projection for all sectors (in 1000 Gg of CO2 equivalent)

On the basis of these rough assumptions for all sectors, the total GHG emissions of Egypt are expected to raise to 345% above 1990 levels until 2017, a projected increase typical for developing countries. (Barakat, El-din, and Elewa 1999). PM_{10} concentrations can exceed daily average concentrations during 98% of the measurement period and the Exceedances are highest in industrial areas (Safar and Labib 2010). These levels can be found also in areas where local sources do not impact the measurements. Further measurements will be used in the research to quantify the relative importance of the different sources relative to a background level that varies depending upon the area characteristics.

Although there are currently available strategies in Egypt concerning air pollution, they only focus on urban planning policies without dealing with air pollution prediction, in order to develop adaptation and mitigation strategies to solve the pollution problem.

Examples of current procedures in Egypt:

- Egyptian authorities have taken measures to reduce vehicle emission rates and change relative user costs using policies that are consistent with evidence on the appropriate economic instruments for controlling air pollution.
- Other potential measures include congestion charges, economic instruments, such as taxes or subsidies, and regulatory instruments, such as emission standards have been taken.

The previous studies imply the need for international cooperation in tandem with local, national, and regional policies on many distinct matters. International cooperation can contribute by defining and allocating rights and responsibilities with respect to the atmosphere. Which gives rise to opening up of markets, and the creation of incentives to encourage private firms to develop and deploy new technologies and households to adopt them (Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Minx, J.C., Farahani, E., Kadner, S., Seyboth, K. 2015). And it is approved by the ministry of environmental affairs in Egypt that there must be ways of predictions and evaluation of air pollution to maintain the problem and also to develop mitigation and adaptation strategies, just as confirmed in 'Egypt's Position to Climate Negotiations Matching with African and Arab Group Positions 2016".

Several environmental approaches and models have appeared around the globe to solve the air pollution problem, to develop ways of prediction for pollution rates and to develop mitigation strategies. One of the most important environmental approaches targeting the air pollution problem is the clean development mechanism (CDM), CDM is a flexible emission reduction mechanism carried under the Kyoto Protocol and the United Nations framework convention on climate change (UNFCCC), the (CDM) aims to accomplish overcharging goals of the (UNFCCC) – Namely to prevent dangerous interference with climate change. (UNFCCC 1992) (Gerden 2018). CDM also allows industrialized countries to meet part of their commitment of greenhouse gases reduction in developing countries, that contribute to the reduction of air pollution while enhancing sustainable development in these host countries.

And although several CDM projects where registered in Egypt, the majority of the projects focus on Renewable Energy, Waste Management, Transport and Fuel Switching, and the projects concerning the industrial sector only focuses on N2O emissions. (Egyptian Environmental Affairs Agency registered CDM projects in Egypt 2018).

So, this study will focus on implementing different CDM strategies and projects in Cairo to test the validity of CDM on reducing $PM_{2.5}$ and PM_{10} causing the air pollution problem in industrial

areas, which will also develop new urban strategies concerning and prioritizing air quality in the future.

1.1. Scope of work

All simulations and air quality models will be practiced upon the South Cairo urban area for its very high air pollution concentrations that exceed the national baseline concentrations. The simulation model is built for the time zone of 15 June 2021 and it measures the concentrations of air pollutants along with air dispersion and diffusion contour maps according to collected metrological data, environmental, social, and urban variables, pollution data is measured by (Dust Meter – Model AQ 9600) for PM_{10} and $PM_{2.5}$ measurements also the air AERMOD software will be used for developing the air dispersion models and the analysis process of the pollution concentration data and the areas affected.

2. Methodology

As mentioned before CDM is an agreement negotiated under the (UNFCCC), Kyoto Protocol, that allows industrialized countries to meet part of their commitment of greenhouse gases reduction in developing countries, that contribute to the reduction of air pollution while enhancing sustainable development in these host countries.

2.1. Practical framework

The research mainly focuses on discussing the urban air pollution problem in south Cairo and developing an urban planning guide to overcome this problem and help in the process of prevention and reduction of emissions through using the clean development mechanism (CDM), as follows:

1. Identifying the problem and its causes.
2. Determining the research objectives and scope of work.
3. Collecting Metrological, urban, environment, and social data of the study area (south Cairo).
4. Examining the Egyptian current regulatory planning guide.
5. Evaluating the Current air quality state Using simulation systems and soft-wares (AERMOD, GIS, SCREEN3). (A)
6. Examining previous similar studies and collecting data.
7. Develop a theoretical framework of urban strategies and policies to create a new planning guideline that put air pollution prevention and reduction into account.
8. The evaluation of air quality state after applying the planning guide of CDM strategies using the same soft-wares and simulation systems. (B)
9. Comparing both Cases (A) and (B).
10. Evaluating the developed Planning Guide and its contribution to reducing air pollution.
11. Air quality monitoring and guidance.

After the determination of the study's scope of work and objective, metrological, urban, environment, and social data will be collected - which will later be the AERMOD software input data – for the study area. Then the current Egyptian regulations will be examined to determine the areas of concern and the areas that are not included in the Egyptian strategic plan.

After examining the current state of air pollution concentrations, CDM practices for projects and strategies will be examined to develop a theoretical framework of policies and strategies used to combat air pollution and urban strategies will then be applied to the study area.

This will later be tested by simulating the CDM application of strategies on the study area by predicting pollution concentrations and areas of dispersion using AERMOD software, then environmental planning guidelines will be developed for future use in urban development in order to maintain air quality, combat air pollution and reduce emissions in the urban environment.

This will also help in controlling the emissions causing air pollution, solve the air pollution problem caused by factories and urban areas and achieve sustainable development goals which are providing a high quality of life and combating climate change.

Table 2 : Practical Framework

Develop a framework of policies and strategies used to combat air pollution through CDM mitigation measures
Analytical baseline study of the study area (South Cairo) Environment, Social and Urban Studies
Evaluation of the Current air quality state and regulating system using AERMOD simulation models
The application of the air pollution mitigation measures (theoretical framework) on the study area.
Examination of the theoretical framework with air quality modelling (AERMOD) and simulation.
Modification of the theoretical framework
Results (emission reduction)
Developing environmental adaptation strategies

2.2. Theoretical Framework

Urban Planning Policies and air Pollution.

The role of urban planning is to manage the spatial organization of cities for efficient allocation of urban infrastructure and land use. Depending on

how it is applied, urban planning can improve air quality in the long run by strategic locations of polluting sources and exposed population, and by encouraging a city structure that would minimize pollution emissions. (Alain Bertaud 2014) (Aziz 2014).

There are a variety of urban planning strategies to improve air pollution that can be implemented at a local level

Table 3: Urban air pollution abatement Strategies

Strategy		Policy
1	Prevent Emissions	Remove source of emissions
		Prevent release of pollutants
2	Reduce Emissions	Minimize the source of pollution
		Improve traffic flow
		Reduce peak emissions
3	Enhancing Air Circulation	Promote penetration of winds
		Avoid special confinement
4	Removing Pollutants from the Air	Planting landscape filters
		Use special coating and construction materials to absorb the pollutants

Based on different CDM plans in the existing knowledge and previous case studies; The following policies are suggested to be implemented in the study area as a mean of emission reductions.

Table 4: Clean Development Mechanism Urban Planning Policies

Strategy	**Policy**
develop a Climate smart city	emission reduction and air pollution mitigation strategies
	the use of Renewable energy in the development process
	Urban form for better dispersion of pollutants
	Balanced Land use plan
Urban Ecological Restoration	Urban Management through excessive implementations of green zones
	Vegetation works as filters
	Building materials and pollutant absorption
Green Industry Hub cities	heading towards Environmental Green Industries
expansion of Green Traffic	Introducing Green transport to the city
	Supporting environmentally friendly transportations.
	Design streets to accommodate alternative transport modes
	Discourage private car use
developing Green Governance	Spreading awareness campaigns about the importance of reducing air pollution

2.3. Methodology of environmental impact prediction of air pollution

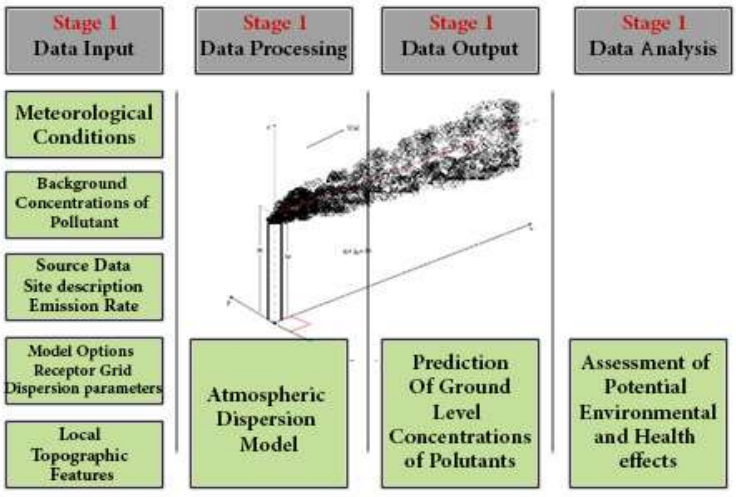

Figure 3 Stages of environmental impact prediction of air pollution

2.4. Summary description of the used model.

Table 5: description of the simulation software for air dispersion modelling.

Model name	Model type	Recommendation for regulatory use	Pollutant type	In put Requirement	Model output	developer
AERMOD	Steady-state Gaussian plume model	• Point, volume, and area sources • Surface, near-surface, and elevated releases • Rural or urban areas; • Simple and complex terrain. • Continuous toxic air emissions	Primary pollutant	Source data, Dispersion data, receptor and terrain data, meteorological data, and down wash related information	• 1h,24h and yearly concentration; • Wet and dry deposition	American Metrological Society (AMS)and US-EPA

3. Results

By predicting the state of air quality and pollution after applying the Clean Development Mechanism (CDM) Urban strategies under the United Nations framework convention on climate change (UNFCCC), and by evaluating the current state of air pollution, appeared the following:

The Current urban policies do not consider air pollution prevention or even reduction, which worsens the air quality state in south Cairo, causing an increase in emission rates that are far above the regulated limitations by 10 to 100 times, thus, worsening the quality of life. And through applying the CDM urban strategies, there was a significant decrease in the rate of emissions. Along with, helping to stay within the limitations and regulatory system, the CDM also creates a sustainable climate-smart city through combatting air pollution and offering a high quality of life.

Figure (4)

simulation of air pollution (PM10) concentrations according to the current urban strategies

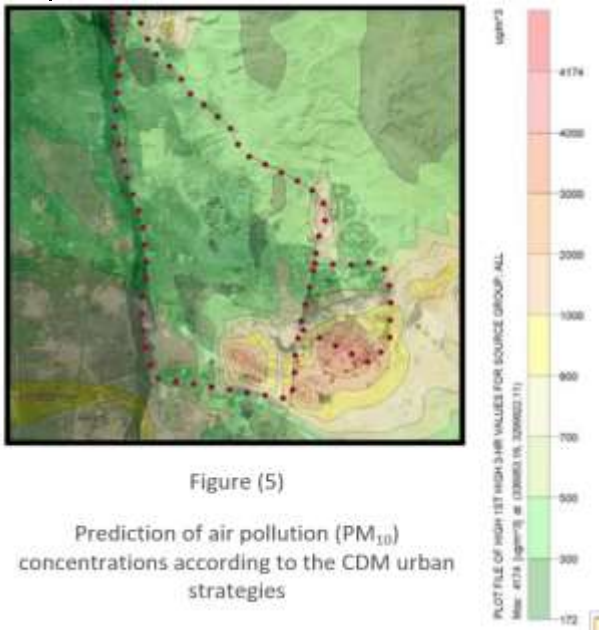

Figure (5)

Prediction of air pollution (PM_{10}) concentrations according to the CDM urban strategies

4. Discussion

This study encourages the implementation of environmental air pollution reduction strategies and policies in Cairo, the used model predicts the amount of emission reduced by applying CDM planning guidelines. And table 6 shows the impact of CDM urban strategies on reducing air pollution where the impacts are measured based on the validity of application on Cairo current urban environment.

Table 6 : Impact of CDM urban strategies on reducing air pollution in South Cairo

Strategy	Policy	Impact on Air Pollution
Develop a Climate smart city	Emission reduction and air pollution mitigation strategies	High
	The use of Renewable energy in the development process	High
	Urban form for better dispersion of pollutants	Medium

	Balanced Land use plan	medium
Urban Ecological Restoration	Urban Management through excessive implementations of green zones	High
	Vegetation works as filters	High
	Building materials and pollutant absorption	Medium
	Roof gardens on government property /private building	High
Green Industry Hub cities	Heading towards Environmental Green Industries	Medium
	Relocate headquarters of governmental institutions	High
	Establish new green area/pocket parks	High
Expansion of Green Traffic	Introducing Green transport to the city	High
	Minimize on-street parking	Low
	Design streets to accommodate alternative transport modes	Medium
	Discourage private car use	Low
Developing Green Governance	Spreading awareness campaigns about the importance of reducing air pollution	Medium
	Implement the necessary measures to reduce air pollutants from the source	High

5. Conclusions

The study provides a flexible planning guideline for urban planners that would help in achieving sustainable cities with no emissions and good air quality based on the clean development mechanism, also maintaining a high quality of life, as two main sustainable development goals – combat climate change and provide a good quality of life-, by evaluating these policies through urban air quality simulation and prediction.

6. References

1. Barakat, Y. F., A. Saad El-din, and M. K. Elewa. 1999. “Clean Development Mechanism Benefits , Opportunities and Implementation in Egypt.” 1–6.
2. Climate, Adv, and Change Res. 2019. “Climate Change and Sustainable Development for Cities.” 1995. doi: 10.1360/N972018-00911.
3. Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Minx, J.C., Farahani, E., Kadner, S., Seyboth, K. 2015. Climate Change 2014 Mitigation of Climate Change Summary for Policymakers and Technical Summary, Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Vol. 40.
4. Egyptian Environmental Affairs Agency. 2018. “Registered Egyptian CDM Projects.” 20(June 2011):3.
5. Gerden, Tomaž. 2018. “The Adoption of the Kyoto Protocol of the United Nations Framework Convention on Climate Change.” Prispevki Za Novejso Zgodovino 58(2). doi: 10.51663/pnz.58.2.07.
6. Hegazy, Ibrahim Rizk. 2014. “Urban Strategies and Environmental Policy: Towards Urban Sustainability within the Egyptian Context.” Environmental Development 11:190–207. doi: 10.1016/j.envdev.2014.05.002
7. Ministry of State for Environmental Affairs. 2010. “Egypt National Environmental, Economic and Development Study (NEEDS) for Climate Change Under the United Nations Framework Convention on Climate Change (UNFCC).” 58.
8. Karakosta, Charikleia, and John Psarras. 2013. “Understanding CDM Potential in the Mediterranean Basin: A Country Assessment of Egypt and Morocco.” Energy Policy 60:827–39. doi:
9. Larsen, Bjorn. 2019. ARAB REPUBLIC OF EGYPT : COST OF ENVIRONMENTAL DEGRADATION: AIR AND WATER POLLUTION. Alain Bertaud. 2014. “The Spatial Organization of Cities : Deliberate Outcome or Unforeseen Working Paper 2004-01 The Spatial Organization of Cities : Deliberate Outcome or Unforeseen Consequence ? University of California at Berkeley.” (March).
10. Aziz, Noha Ahmed Abd El. 2014. “Air Quality and Urban Planning Policies The Case of Cairo City CBD.” 17(1):1–13.
11. Barakat, Y. F., A. Saad El-din, and M. K. Elewa. 1999. “Clean Development Mechanism Benefits , Opportunities and Implementation in Egypt.” 1–6.
12. Climate, Adv, and Change Res. 2019. “Climate Change and Sustainable Development for Cities.” 1995. doi: 10.1360/N972018-00911.
13. Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Minx, J.C., Farahani, E., Kadner, S., Seyboth, K. 2015. Climate Change 2014 Mitigation of

Climate Change Summary for Policymakers and Technical Summary, Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Vol. 40.
14. Egyptian Environmental Affairs Agency. 2018. "Registered Egyptian CDM Projects." 20(June 2011):3.
15. Gerden, Tomaž. 2018. "The Adoption of the Kyoto Protocol of t He United Nations Framework Convention on Climate Change." Prispevki Za Novejso Zgodovino 58(2). doi: 10.51663/pnz.58.2.07.
16. Hegazy, Ibrahim Rizk. 2014. "Urban Strategies and Environmental Policy: Towards Urban Sustainability within the Egyptian Context." Environmental Development 11:190–207. doi: 10.1016/j.envdev.2014.05.002.
17. Karakosta, Charikleia, and John Psarras. 2013. "Understanding CDM Potential in the Mediterranean Basin: A Country Assessment of Egypt and Morocco." Energy Policy 60:827–39. doi: 10.1016/j.enpol.2013.05.078.
18. Ministry of Environment. 2018. Egypt's First Biennial Update Report to the United Nations Framework Convenstion on Climate Change.
19. Ministry of State for Environmental Affairs. 2010. "Egypt National Environmental, Economic and Development Study (NEEDS) for Climate Change Under the United Nations Framework Convention on Climate Change (UNFCC)." 58.
20. Mokhtar, Soheir, Nagwa El Agroudy, Fatima Ahmed Shafiq, Heba Yassin, and Abdel Fatah. 2015. "The Effects of the Environmental Pollution in Egypt." International Journal of Environment 04(01):21–26.
21. Nakhla, Dalia Adel, Mohamed Galal Hassan, and Salah El Haggar. 2013. "Impact of Biomass in Egypt on Climate Change." Natural Science 05(06):678–84. doi: 10.4236/ns.2013.56083.
22. Safar, Zeinab, and Mounir W. Labib. 2010. "Assessment of Particulate Matter and Lead Levels in the Greater Cairo Area for the Period 1998-2007." Journal of Advanced Research 1(1):53–63. doi: 10.1016/j.jare.2010.02.004.
23. Sena, A. 2018. Ministry Of The Environment, Understanding Climate Change, A GUIDE TO THE KYOTO PROTOCOL.
24. UN. 1992. United Nations Framework Convention. Vol. 62220.
25. World Health Organization, WHO. 2005. "WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide: Global Update 2005." 1–21. doi: 10.1016/0004-6981(88)90109-6.

Citation: Rawan Zaghloul et al. (2021), Environmental Strategies for Air Pollution Mitigation in Industrial Areas Using the Clean Development Mechanism (CDM), International Design Journal, Vol. 11 No. 6, (November 2021) pp 217-224