Nature Environment and Pollution Technology
An International Quarterly Scientific Journal
p-ISSN: 0972-6268
(Print copies up to 2016)
e-ISSN: 2395-3454
Vol. 22 No. 4 pp. 2103-2110 2023
Original Research Paper
https://doi.org/10.46488/NEPT.2023.v22i04.035
Open Access Journal

Production of a Database on Short-Lived Climate Pollutants (SLCP) and the Elaboration of Projection Scenarios of these Emissions Using the LEAP Software - The Case of Morocco

Y. Kasseh†, A. Touzani and S. EL Majaty
Mohammedia School of Engineers, Avenue Ibn Sina B.P 765, Agdal, Rabat 10090, Morocco
†Corresponding author: Y. Kasseh; youssefkasseh.emi@gmail.com

Nat. Env. & Poll. Tech.
Website: www.neptjournal.com

Received: 11-03-2023
Revised: 24-04-2023
Accepted: 28-04-2023

Key Words:
Greenhouse gas emissions
Air quality index
Short-lived climate pollutants
Climate change mitigation
Sustainable development goal

ABSTRACT

Short-lived climate pollutants (SLCPs) have significant effects on climate, human health, and the environment. In Morocco, steps are being taken to reduce SLCP emissions, but effective policymaking requires a thorough understanding of emission sources and trends. In this paper, we present a study on the production of a database on SLCP emissions in Morocco, as well as the development of scenarios to project these emissions using LEAP software. The results of this analysis allow us to better understand the emissions sources and evaluate the impact of different emission reduction policies.

INTRODUCTION

Short-lived climate pollutants (SLCPs) are gases and particles that remain in the atmosphere for a short period but have a significant impact on climate, air quality, and human health The main SLCPs are methane, black carbon, HFCs, PFCs, and SF6. SLCP emissions are mainly caused by human activities such as fossil fuel combustion, agriculture, and chemical production and consumption. According to the United Nations Environment Programme (UNEP), SLCPs account for about one-third of global warming and are responsible for 7 million premature deaths each year worldwide. In Morocco, a recent study by the Ministry of Environment found that SLCP emissions increased by nearly 70% between 1990 and 2014, with a projected 5% annual growth by 2030 (Saidi et al. 2023). This alarming trend can be attributed to the country's rapid economic growth, increasing population, rapid urbanization, and increased industrialization (Al Wachami et al. 2023).

Morocco is committed to reducing its greenhouse gas emissions in line with the Paris Climate Agreement. It adopted a National Sustainable Development Strategy (NSSD) 2017 to guide its emission reduction efforts (Kasseh et al. 2023). Morocco also joined the CCW in 2014, demonstrating its strong commitment to managing and reducing short-lived pollutants (Ministry of Energy and Mines - Kingdom of Morocco, 2020). The Kingdom of Morocco joined the Sustainable Development Goals (SDGs) program in 2015 after participating in its development with the United Nations. Morocco considers the SDGs as levers to structure its development model and achieve its sustainable development objectives (Dettner & Blohm 2021).

However, national climate action faces challenges related primarily to limited funding and technology transfer (Liya & Jianfeng 2018). These challenges have been exacerbated by the combination of climatic elements, notably the drought experienced by the country, with the COVID-19 pandemic, which has taken a heavy human toll and constituted an additional financial burden (Sun et al. 2022). To face the challenges related to climate and health crises, Morocco advocates the adoption of a development model oriented toward sustainability and the resilient development of populations and territories (Boulakhbar et al. 2020).

It is also important to note that some air pollutants, such as black carbon, tropospheric ozone, or HFCs in particular, which contribute to climate change, are not considered in mitigation plans or the NDC. These pollutants, which are the subject of this study, are called "short-lived air pollutants" and have been the subject of particular attention since 2012 in the framework of a Climate and Clean Air Coalition (CCAC) (Duan et al. 2022).

The proposed paper fills a gap in producing a database on SLCPs in Morocco and developing scenarios to project these emissions using LEAP (Liya & Jianfeng 2018). In addition, the paper addresses the challenges Morocco faces in climate action, including limitations in financing and technology transfer, exacerbated by the COVID-19 pandemic and the drought that has affected the country. Ultimately, the paper proposes a solution to address these challenges by promoting a sustainable and resilient development model for Morocco.

Therefore, this paper is structured around three key issues. Firstly, the elaboration of an SLCP database, indeed, to define efficient air pollution control policies and, in the absence of structuring of data by activity and by sector, seemed to us relevant for the continuation of the study. Secondly, the realization of an inventory of emissions of SLCP and air pollutants, which are generally associated with them, is the 1st inventory of emissions in polluting gases and/or SLCP by groups of activities in Morocco. Finally, this work will provide projection scenarios of these emissions using the LEAP-IBC software. These results are presented for the selected base year and the emission projection horizon (2014 and 2040).

MATERIALS AND METHODS

Inventory of GHG, SLCP and Pollutant Gases

A first inventory of GHGs, SLCPs, and polluting gases has been carried out in Morocco. Activities were classified into two categories: energy and non-energy. Gases emitted by activities in the energy category are mainly from combustion, while emissions in the non-energy category are generated by the decomposition of raw materials (such as the production of lime and cement), fugitive emissions (such as the production of PVC or paints) or biochemical reactions (such as the methanization of waste).

The emissions of a given gas (Qgaz) are calculated as follows:

For energy activities: $Qgaz = G \times Ie \times Fe$

G: Characteristic size of the activity

Ie: energy consumption per unit of the characteristic quantity

Fe: emission factor of the energy used

For non-energy activities: $Qgaz = G \times Fe$

G: Characteristic size of the activity

Fe: emission factor of the energy used

The results of our study are presented and analyzed in the following paragraphs. We have included in our analysis the greenhouse gases, which are also part of the polluting gases. We have presented the greenhouse gas emissions for each activity to compare our results with those of the BUR2, which includes the revised emissions of the Third National Communication. The results for each activity are organized as follows:

- Cumulative greenhouse gas emissions expressed in $tEqCO_2$
- Total emissions of polluting gases modeled by LEAP
- Emissions and analysis of short-lived gases (SLCP)

Tool Used

A GHG emissions analysis for Morocco was conducted using LEAP software. LEAP, or Long-range Energy Alternative Planning System, is a widely used software tool for energy policy analysis and GHG mitigation assessments developed by the Stockholm Environment Institute (SEI) (Dettner & Blohm 2021).

LEAP is an integrated modeling tool that can be used to track energy consumption, production, and resource extraction in all sectors of an economy. It can be used to account for GHG emissions sources and sinks in both the energy and non-energy sectors. In addition to tracking GHGs, LEAP can also be used to analyze local and regional pollutant emissions and to perform cost-benefit assessments of scenarios (Gebremeskel et al. 2023).

LEAP is not a model of a particular energy system but rather a tool that can be used to create models of different energy systems, each of which requires its particular data structures. It supports a range of different modeling methodologies. On the demand side, it offers bottom-up/end-use accounting techniques and top-down/macro modeling. On the supply side, it offers a range of accounting and simulation methodologies and has optimization modeling capabilities.

LEAP's modeling operates at two conceptual levels. LEAP's built-in calculation formulas at the first level support all non-controversial energy accounting and emissions calculations. At the second level, the user enters spreadsheet-like expressions that can be used to specify time-varying data or to create multi-variable models (Fig. 1).

LEAP-IBC was the preferred tool for estimating emissions of gaseous pollutants and SLCPs and modeling their impacts.

Several activities emit polluting gases or SLCPs due to fossil or alternative energy consumption. We present the emissions of the three families of gases: i) Air pollutants, ii) Short-lived pollutants, and iii) Greenhouse gases. The independence between these three families is illustrated in Fig. 2.

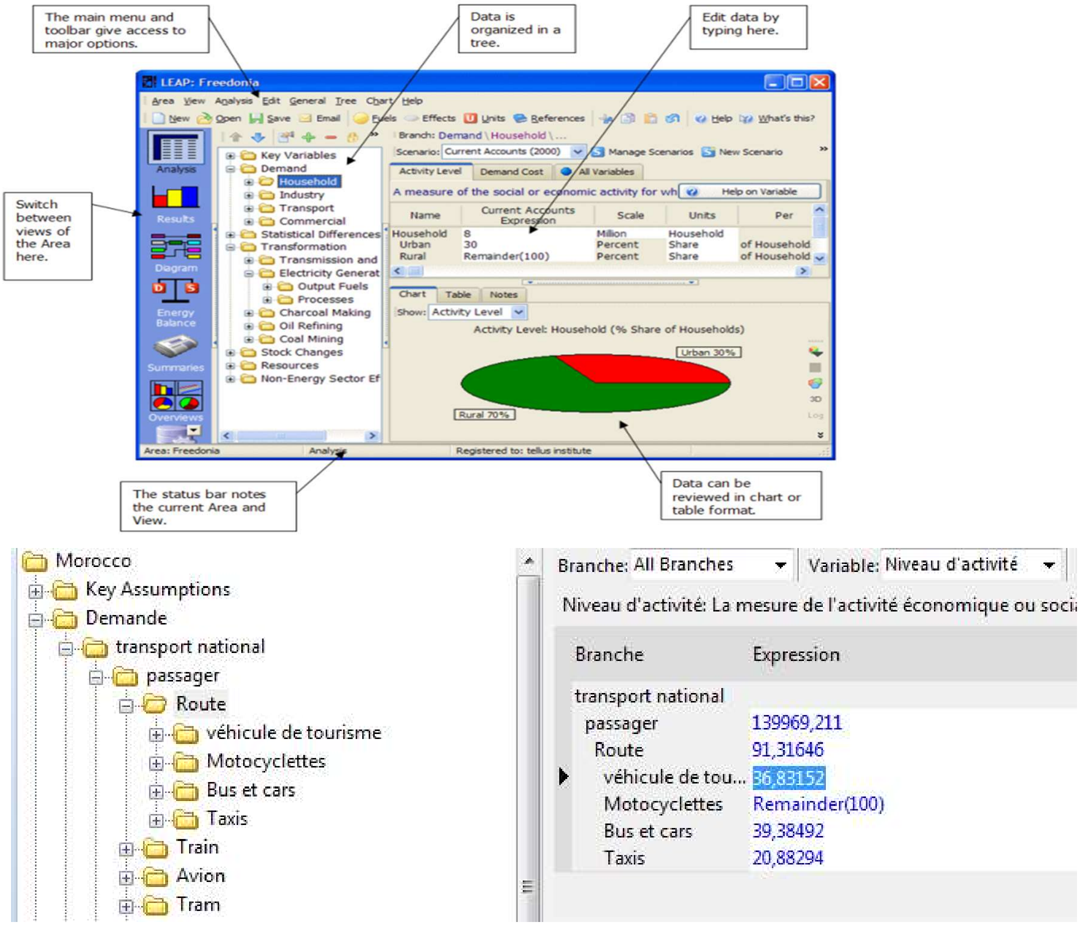

Fig. 1: General view of the LEAP software interface.

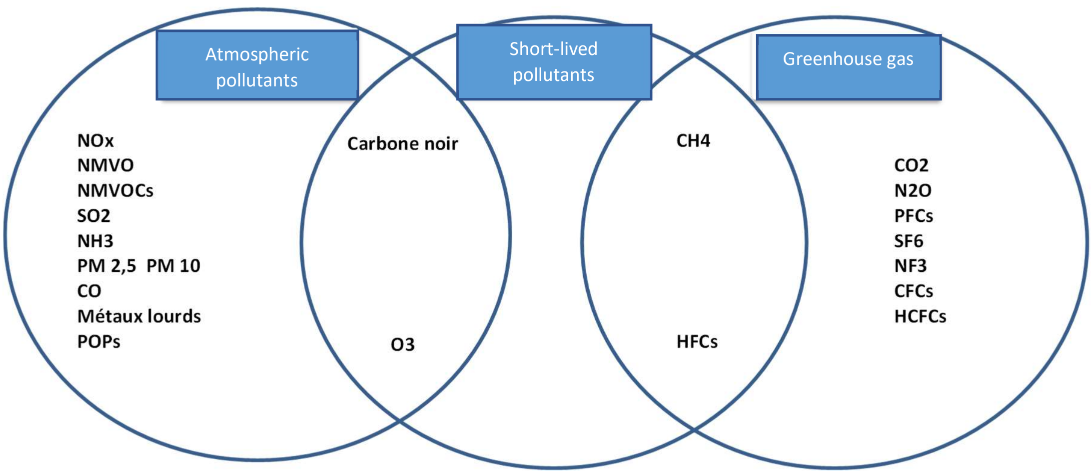

Fig. 2: Independence of the three gas families.

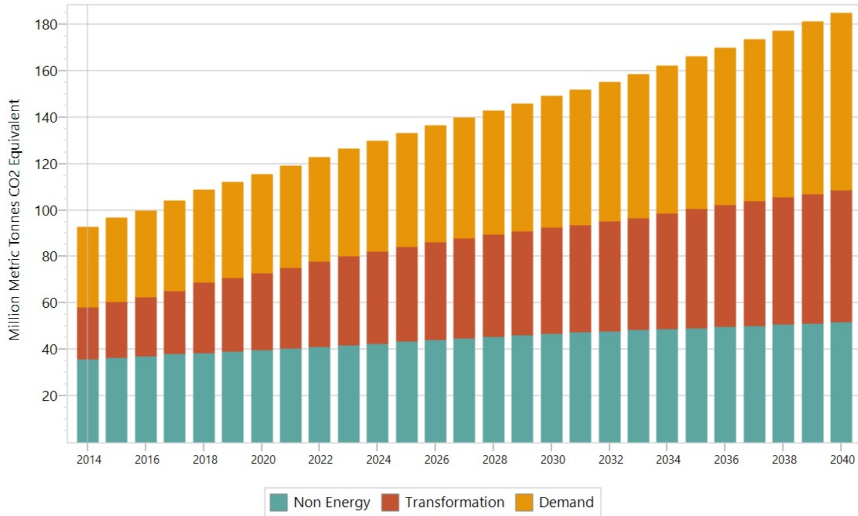

Fig. 3: Global GHG emissions.

RESULTS AND DISCUSSION

Summary of Emissions in Morocco

Global GHG emissions: The GHG emissions at the level of Morocco (BAU) evolved from 92.44 Million tons of CO_2 equivalent in 2014 to 184.63 Million in 2040. The non-energy sector represented 38.8% in 2014, followed by the demand sector at 37.1% and the transformation sector at 24.0%. (Fig. 3).

By fuel type, the non-energy part represents 38.8%, followed by diesel at 19.4%, coal at 17.0%, LPG at 6.9%, and heavy fuel oil at 5.1%. The rest of the fuels contribute with percentages < 5%. (Fig. 4). The graphs (Fig.5, Fig. 6) show the emissions by sub-sector and by activity.

In comparison with the TCN and the CDN, we can notice that our baseline is between the emissions of the TCN and the CDN. The evolution of the GHG of the TCN seems exaggerated from 2030.

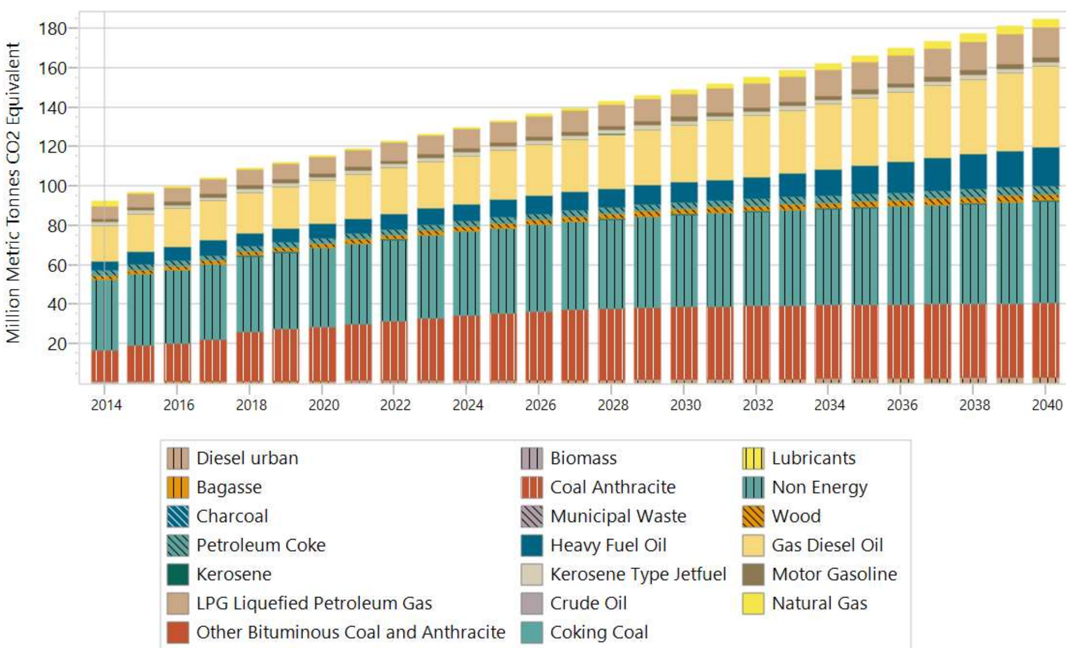

Fig. 4: Global GHG Emissions by fuel type.

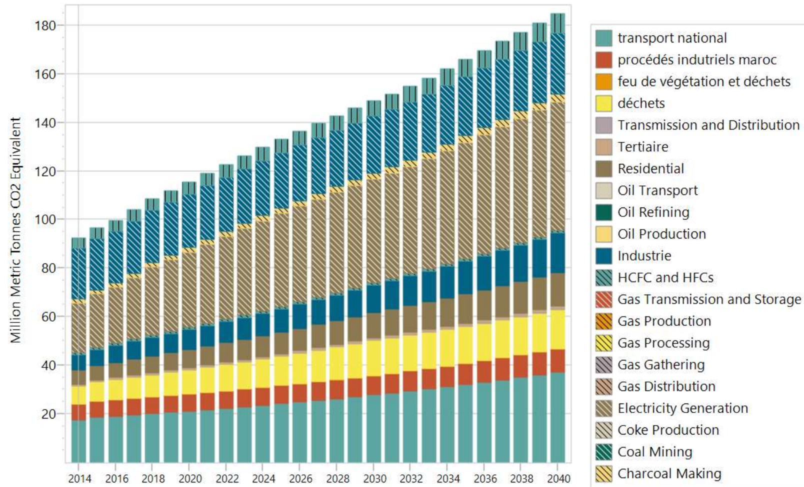

Fig. 5: Overall GHG emissions by sub-sector.

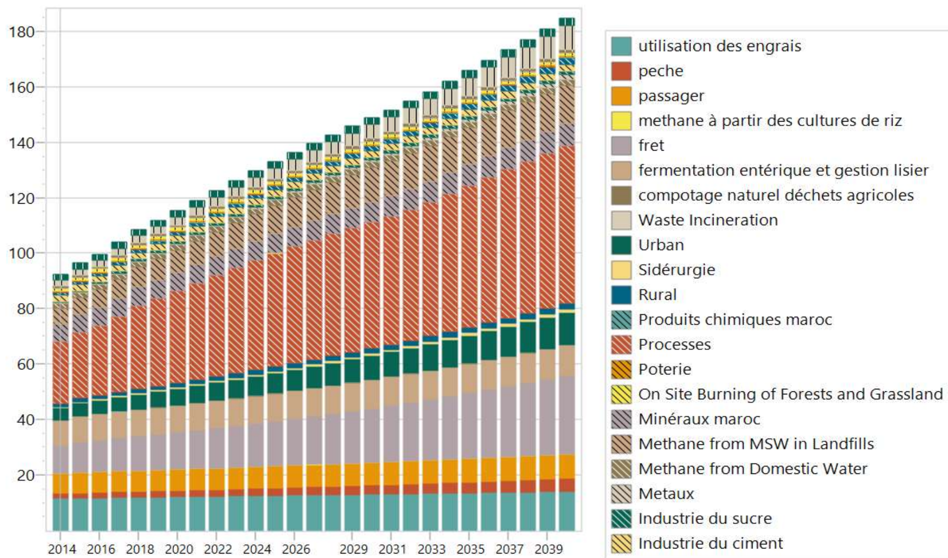

Fig. 6: Global GHG emissions by activity.

Note that the NDC does not consider emissions from HCFCs and HFCs, which is considered in our baseline (Fig. 7).

The details of the emissions of the 3 basic lines are summarized in the Table 1:

Global SLCP emissions: Overall, SLCP (Methane and Black Carbon) emissions changed from 899,907 tons in 2014 to 1,480,746 tons in 2040. Methane represents more than 99.25% of the total emissions. (Fig. 8)

Global emissions of polluting gases: The overall emissions of pollutant gases evolved from 26.63 Million tons in 2014 to 45.54 Million tons in 2040. NMVOCs represent more than 46.3%, followed by PM10 with 41.2%, PM2.5 with 4.3%, and CO with 3.7%. The other pollutants contribute with a percentage of < 1%. (Fig. 9).

CONCLUSIONS

A trend analysis of air quality (AQI) and GHG emissions in the energy sector was conducted for Morocco. The results showed that total GHG emissions have increased over the years due to economic growth and increased energy consumption. However, there has been a downward trend for some air pollutant criteria in some Moroccan cities in recent years, likely due to emission control measures and the implementation of environmental policies. Morocco has committed to a target of reducing its GHG emissions

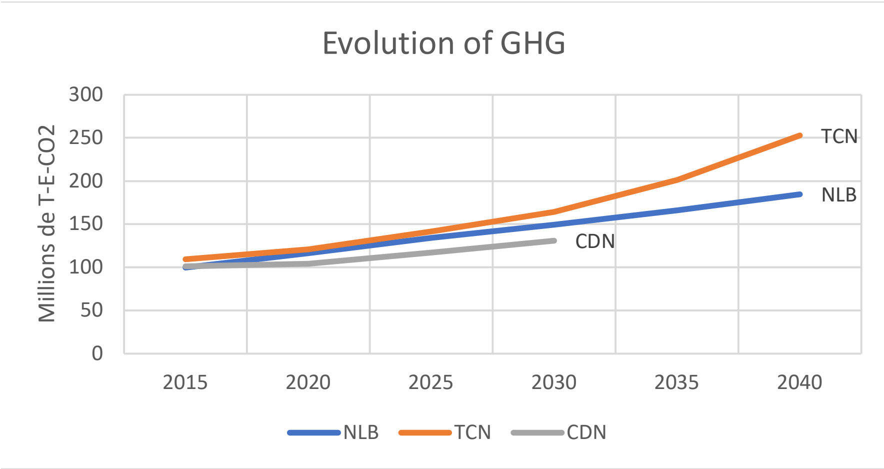

Fig. 7: Comparison of baseline with TCN and CDN.

Table 1: Evolution of GHG emissions of the 3 scenarios, NLB, TCN, and CDN (in Millions of tons CO_2 equivalent)

TCN	2010	2015	2020	2025	2030	2035	2040
Households	5,98	8,68	10,25	11,94	13,94	16,03	18,52
Industry	6,87	7,77	8,45	9,15	10,05	11,09	12,44
Transportation	13,86	18,25	23,88	30,39	38,69	49,27	62,76
Tertiary	0,38	0,46	0,58	0,72	0,90	1,15	1,47
Agriculture and fisheries	4,16	4,86	5,67	6,57	7,61	8,83	10,23
Processing	19,86	23,87	22,43	26,25	25,52	29,72	33,44
Non-energy Industrial processes	9,29	9,29	10,46	11,42	12,42	13,60	14,98
Non-energy Agriculture	22,02	22,60	23,37	27,83	36,55	52,19	79,29
No energy Forestry	4,51	4,34	4,25	3,85	3,07	1,82	0,00
No energy waste	7,03	9,13	11,34	13,61	15,64	17,64	19,66
Total	**93,94**	**109,26**	**120,67**	**141,72**	**164,38**	**201,36**	**252,81**
NLB	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
Households		5,97	7,46	8,94	10,34	12,05	13,72
Industry		9,07	10,43	11,98	13,9	16,33	19,4
Transportation		18,53	19,25	21,96	25,05	28,73	33,09
Tertiary		0,39	0,45	0,52	0,6	0,69	0,8
Agriculture and fisheries		4,51	4,7	5,21	5,78	6,45	7,24
Processing		24,8	34,04	42,04	46,86	52,56	58,41
Non-energy Industrial processes		6,66	7,03	7,46	8	8,69	9,61
Non-energy Agriculture		20,97	21,91	22,73	23,55	24,37	25,2
No energy Forestry		0,01	0,01	0,01	0,01	0,01	0,01
No energy waste		7,91	9,98	12,14	14,44	15,23	16,04
No energy HCFCs and HFCs		0,94	0,93	0,92	0,9	0,9	0,89
Total		**99,76**	**116,19**	**133,91**	**149,43**	**166,01**	**184,41**
CDN	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**
Total		**100,96**	**103,9**	**117,34**	**130,78**		

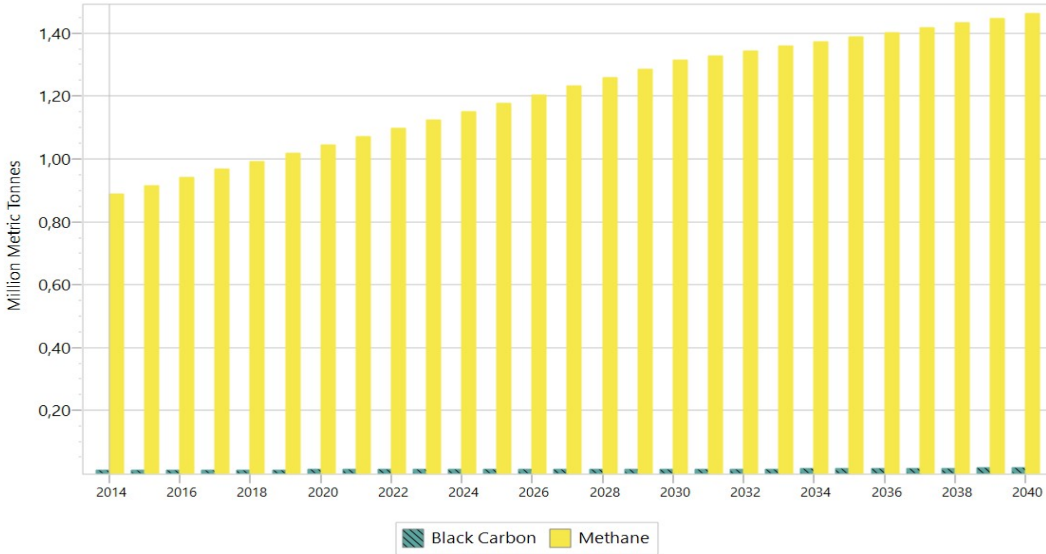

Fig. 8: Global SLCP emissions.

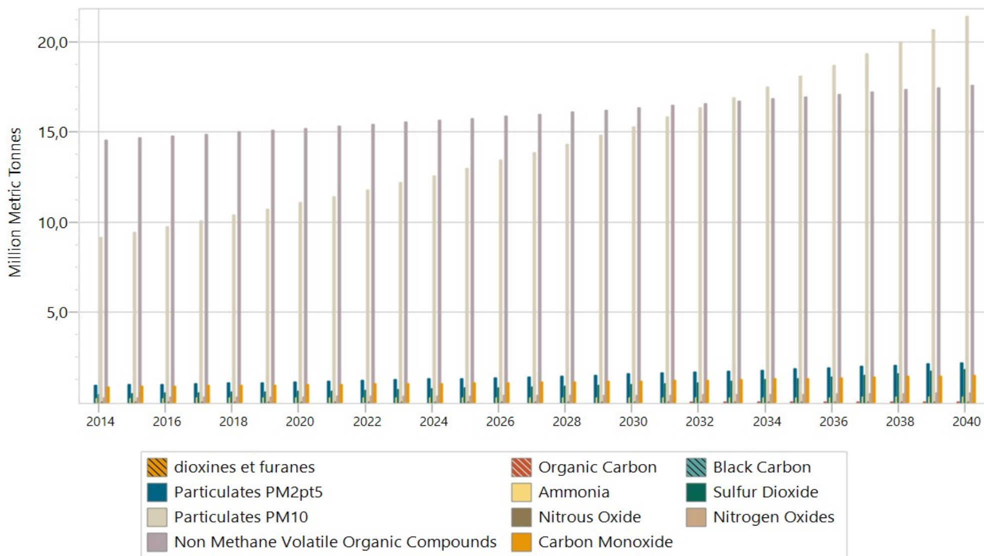

Fig. 9: Global air pollutant emissions.

by 17% by 2030 from 2010 levels in accordance with the Paris Agreement on Climate Change. To achieve this goal, the Moroccan government has implemented several policies, including the National Energy Strategy, which aims to increase the share of renewable energy in electricity generation and promote energy efficiency in all economic sectors. Morocco must continue to implement effective policies and measures to reduce GHG emissions and improve air quality. This requires international cooperation to facilitate technology and knowledge transfer, as well as financial investments to support sustainable development initiatives. By meeting its GHG emission reduction targets, Morocco can contribute to the global fight against climate change while improving the quality of life of its population.

REFERENCES

Al Wachami, N., Louerdi, M., Iderdar, Y., Boumendil, K. and Chahboune, M. 2023. Chronic obstructive pulmonary disease (COPD) and air pollution: The case of Morocco. Mater. Today Proceed., 72: 3738-3748. https://doi.org/10.1016/j.matpr.2022.09.249

Boulakhbar, M., Lebrouhi, B., Kousksou, T., Smouh, S., Jamil, A., Maaroufi, M. and Zazi, M. 2020. Towards a large-scale integration of renewable energies in Morocco. J. Energy Storage, 32: 101806. https://doi.org/10.1016/j.est.2020.101806

Dettner, F. and Blohm, M. 2021. External cost of air pollution from energy generation in Morocco. Renew. Sustain. Energy Trans., 1: 100002. https://doi.org/10.1016/j.rset.2021.100002

Duan, H., Hou, C., Yang, W. and Song, J. 2022. Towards lower CO2 emissions in iron and steel production: Life cycle energy demand-LEAP based multi-stage and multi-technique simulation. Sustain. Prod. Consump., 32: 270-281. https://doi.org/10.1016/j.spc.2022.04.028

Gebremeskel, D.H., Ahlgren, E.O. and Beyene, G.B. 2023. Long-term electricity supply modeling in the context of developing countries: The OSeMOSYS-LEAP soft-linking approach for Ethiopia. Energy Strat. Rev., 45: 101045. https://doi.org/10.1016/j.esr.2022.101045

Kasseh, Y., Touzani, A. and Majaty, S. 2023. Exemplarity of the state for the energy efficiency of buildings institutional: A case of Morocco. Nat. Environ. Pollut. Technol., 22(1): 169-177. https://doi.org/10.46488/NEPT.2023.v22i01.015

Liya, C. and Jianfeng, G. 2018. Scenario analysis of CO_2 emission abatement effect based on LEAP. Energy Proced., 152: 965-970. https://doi.org/10.1016/j.egypro.2018.09.101

Ministry of Energy and Mines-Kingdom of Morocco 2020. National Energy Efficiency Strategy Horizon 2030.

Saidi, L., Valari, M. and Ouarzazi, J. 2023. Air quality modeling in the city of Marrakech, Morocco, using a local anthropogenic emission inventory. Atmos. Environ., 293: 119445. https://doi.org/10.1016/j.atmosenv.2022.119445

Sun, X., Wang, P., Ferris, T., Lin, H., Dreyfus, G., Gu, B.H., Zaelke, D. and Wang, Y. 2022. Fast action on short-lived climate pollutants and nature-based solutions to help countries meet carbon neutrality goals. Adv. Clim. Change Res., 13(4): 564-577. https://doi.org/10.1016/j.accre.2022.06.003

ORCID DETAILS OF THE AUTHORS

Y. Kasseh: https://orcid.org/0000-0001-7776-5034
A. Touzani: https://orcid.org/0000-0002-5987-455X
S. El: https://orcid.org/0000-0002-4408-4969