The AIRFRESH approach as tool to estimate the role and potentiality of urban greening in improving city life quality

Dr Alessandra De Marco[1,2], Maily Anna Maria Nguyen[3], Beatrice Sorrentino[1], Dr Mario Jorizzo[1]

1 Italian National Agency for New Technologies, Energy and Sustainable Economic Development (ENEA), Via Anguillarese 301, 00123 Rome, Italy,

2 INCDS, Marin Dracea Institute, Romania

alessandra.demarco@enea.it; beatrice.sorrentino@enea.it; mario.jorizzo@enea.it

3 Fondazione Italia-Vietnam ETS, Bologna, Italy

maily.nguyen@fondazioneitaliavietnam.org

Abstract

In the recent years, the question on how urban and peri-urban forests may modify both air quality and surface climate conditions within the cities is receiving growing attention by scientists and policymakers (Sicard et al., 2022; Manzini et al., 2023). In fact, it is well known how the exposure to high concentrations of air pollutants, mainly tropospheric ozone (O_3), nitrogen dioxide (NO_2) and fine particulate matter ($PM_{2.5}$), leads to premature mortality, with millions of people dying every year from cardiovascular and pulmonary diseases caused by exposure to high levels of air pollution (Zhang et al., 2017). Moreover, extreme climatic conditions, like heat waves or cold spells, are responsible for a broad range of health effects ranging from dehydration to heatstroke or, more in general, to the worsening of preexisting cardiovascular and respiratory diseases that could lead to fatal outcomes, mainly among the elderly (WHO, 2021).

Within the AIRFRESH project (LIFE19 ENV/FR/00086), which aims to estimate the air pollution removal capacity of urban forests by planting some selected trees species in two cities, i.e., Florence (Italy) and Aix-en-Provence (France), we have developed a modeling framework which allows simulating air quality from coarse regional scale (i.e., Europe) to urban scale (1 x 1 km) and assess changes in urban air quality and meteorological conditions due to different reforestation strategies.

The modelling approach has large potential of replication in highly polluted areas of the world, such as South-East Asia, where the opportunity of improving periurban vegetation to ameliorate air quality and climate conditions is a critical issue to be investigated.

Main content

In the last years, ENEA in the Division Anthropic Impacts of Climate Change (SSPT-IMPACT), is active in international cooperation to support technology and knowledge transfer initiatives within the framework on action against climate change. In this context, we signed a MOU with the Italian Vietnamese Foundation for strengthening scientific and research collaborations applied to the production sectors and land management with Vietnam. Thanks to this collaboration, in addition to participating in this important initiative, we hope to start effective initiatives with Vietnamese partners.

Air pollution has emerged as a critical public health crisis, with a staggering impact that results in approximately 4.2 million premature deaths globally each year, and half a million within the European Union alone. As we look toward 2030, the rapid urbanization anticipated and over 80% of the EU's population is expected to live in cities, thus intensifies this challenge. Cities face deteriorating air quality that severely affects human health, diminishes quality of life, and threatens the vital ecosystem services provided by urban forests. The economic consequences are equally significant, with costs estimated between 330 and 940 billion euros annually, which amounts to 3-9% of the EU's GDP. (Kotz et al., 2024)

In southern Europe, particularly in south-eastern France and Italy, the risk from ozone (O3) pollution is among the highest in the EU. Cities such as Florence and Aix-en-Provence experience some of the worst levels of ozone and particulate matter (PM2.5 and PM10), regularly surpassing EU safety limits. This elevated pollution not only exacerbates environmental degradation but also leads to serious health issues, including premature deaths and frequent hospitalizations for cardiovascular and respiratory conditions (Fuller et al. 2022).

In response to these pressing issues, the LIFE AIRFRESH project aims to tackle air pollution through a strategic enhancement of urban green spaces. Specifically, the project focuses on the role of urban forests and shrubs in mitigating air pollution in Florence and Aix-en-Provence.

The project is implementing and analysing reforested test areas in both cities, and will provide actionable recommendations for reforestation policies, including guidance on optimal tree species and planting practices, to help these cities meet legislative air quality standards.

The project is employing a comprehensive approach that integrates field observations with advanced geographic information systems (GIS) and sophisticated modelling techniques to achieve several key objectives. This multifaceted strategy will enable us to quantify and map the air-purifying benefits provided by existing urban forests and their effectiveness in sequestering atmospheric carbon.

Modelling plays a pivotal role in this approach, offering crucial insights into the impact of reforestation efforts on air quality. Through detailed simulations, we analysed how different tree species and planting configurations influence the reduction of pollutants and overall improvement in air quality. These models not only help to optimize the design and management of urban green spaces but also provide predictive capabilities for future scenarios.

One of the most valuable aspects of this modelling effort is its potential for broader application beyond the immediate project sites. The methodologies and frameworks developed can be exported and adapted for use in other cities, particularly in highly polluted urban areas around the world. For example, the modelling techniques can be implemented in Southeast Asian cities, which often face severe air quality challenges due to rapid industrialization, high population density, and extensive vehicular emissions.

By applying these advanced modelling techniques to cities with high levels of air pollution, we can assess the effectiveness of different reforestation strategies in mitigating air pollution and improving air quality. The insights gained from these models can inform local policies and reforestation efforts, tailored to the specific needs and environmental conditions of each city. This approach not only enhances the ability to manage and reduce urban air pollution globally but also contributes to the development of best practices and guidelines for green infrastructure that can be adapted to diverse urban environments.

We evaluate the environmental and health and economic benefits of newly reforested areas, assessing their contribution to meeting air quality and climate change mitigation targets. This involves not only understanding the direct improvements in air quality but also examining the broader socio-economic impacts of cleaner urban air. By highlighting the economic advantages of reforestation, including potential reductions in healthcare costs and improvements in overall urban resilience, the project underscores the value of investing in green infrastructure.

Key outcomes of the LIFE AIRFRESH project include the creation of a web-based catalogue of best practices and a comprehensive list of tree species suitable for enhancing air quality in each city. Detailed maps illustrate the distribution of ecosystem services and the projected improvements in air quality resulting from reforestation efforts. Each reforested area is expected to achieve measurable reductions in pollution levels during the growing season. Additionally, these areas are projected to sequester approximately 2 tonnes of carbon per hectare.

At the moment we planted around 1,000 trees distributed in the two pilot cities, which will contribute to increased urban biodiversity and improved air quality and temperature control. Through the rehabilitation of these green spaces, we aim to

foster healthier urban environments that enhance both human well-being and ecological balance.

To assess the economic impact of vegetation on premature mortality due to temperature with a modelling tool, a scenario was created by eliminating the current vegetation. The economic savings, obtained by comparing this scenario with the control scenario, due to the reduction in costs caused by the decrease in mortality rates, amount to 4.08 billion euros in Florence and 1.26 billion euros in Aix-en-Provence. These results underscore the importance of urban vegetation in mitigating the negative effects of climate change and protecting public health.

The LIFE AIRFRESH project will play a vital role in shaping future urban planning and policy by contributing to local climate and air quality plans, as well as supporting broader EU environmental policies and smart city initiatives. Our recommendations will be incorporated into ten urban master plans by 2030, aiding cities across Europe in enhancing their green infrastructure and maximizing the benefits of urban forests. Through these efforts, LIFE AIRFRESH will not only advance our understanding of urban reforestation's impact but also drive meaningful changes towards cleaner, healthier cities.

References

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