Plant more trees in cities and provide them space to grow big

Statement by the researchers of the GreenLung Project led by Dr. Somidh Saha
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“Climate change impacts are now clearly visible in cities of Germany. In southwest Germany, droughts in the upper Rhine valley are becoming frequent, lengthy, and hotter. Extreme heatwaves are becoming a common phenomenon risking plant, animal, human life, and infrastructure security. In addition, exceptional and torrential rainfalls are increasing the flooding vulnerability of cities near rivers because the enormous amount of water can move fast due to high impervious cover and favorable terrain conditions resulting in massive destruction. Unfortunately, we have already witnessed such destructions in the North Rhine Westphalia and Rhineland Palatinate in 2021. Having many trees inside cities can help mitigate heatwaves and floods impacts. However, trees inside the cities face double trouble. First, trees inside cities are losing their vitality, getting damaged or even die, due to climate change impacts and diseases. Second, due to urbanization and densification, the high demand for space inside cities is responsible for the decline of growing space. In a DLR (Deutsches Zentrum für Luft- und Raumfahrtsforschung) and BMBF-funded (Bundesministerium für Bildung und Forschung) GrüneLunge project (https://www.projekt-gruenelunge.de/), we aimed to develop strategies for increasing social-ecological resilience (capacity of urban forests to resist and recover climate change impacts) through inter- and transdisciplinary research. The scientists of different disciplines from KIT, DWD, FVA-Freiburg, urban horticulturists, and foresters from the City of Karlsruhe jointly worked on this project.

Our research had shown that recurrent events of drought significantly impacted the health of trees. We have discovered that the spring rainfall shortage had reduced annual growth. Heatwaves, drought, and diseases during the summer contributed to tree crowns' damage. The prolonged drought from spring to summer is one of the leading climate change-related stressors for urban tree health decline in our study region of Karlsruhe. We recommend that a permanent network of soil-moisture monitoring should be developed in cities for urban trees. It can help optimize water use in urban tree irrigation and develop a future digitalized AI-based climate-smart irrigation system.

A win-win situation would be that we get the highest possible benefits from urban trees and forests. However, we have found that significant trade-offs exist between different types of ecosystem services. For example, in a spatially explicit study, we have shown that significant trade-offs exist between the benefits of climate regulating services (e.g., cooling potential of trees, pollution removal capacity, soil erosion control capacity etc.) and supporting ecosystem services (e.g., floristic diversity, microhabitat diversity, microhabitat abundance). We recommend that cities increase the diversity of trees in streets and parks to reduce trade-offs between climate regulation and biodiversity conservation. In addition, high diversity of trees in urban areas help in risk management and risk mitigation. The monoculture of street trees should be avoided, and more societal dialogue with all stakeholders on tree species selection for urban areas is urgently needed. At the same time, old and big trees should be preserved as much as possible because we have found that old and big trees contribute more to climate regulation and increase biodiversity.

The result showed that native oak trees (*Quercus robur*) provided more biodiversity than their non-native oak trees (*Quercus rubra*); however, non-native oak trees were much healthier than native oak trees. We have quantified nine species of bats in Karlsruhe city and found more bats' activities near native oak trees than non-native oak trees. In the urban heat islands with very high drought vulnerability, diverse species of trees with high drought tolerance should be planted. Exotic species

with high invasiveness should be avoided. In the parks with a lower vulnerability to heatwaves and better soil conditions compared to the streets and city centers, the diversity and proportion of native species should be increased because native species are more likely to survive and provide the wanted ecosystem services.

We have also studied the influence of tree cover and composition to reduce heat stress during heatwaves in the city. We demonstrated that with an increase in green cover surface, air temperature declines during heatwaves. Notably, urban trees and forests significantly lowered the temperature during the night and early morning hours when we rest and then get ready for the day of work. We also found that areas with higher diversity of trees in the city have a lower temperature during heatwaves than those with lower diversity of trees under similar canopy cover conditions. The question of why the higher diversity of trees was correlated to a lower temperature during the heatwave is still under investigation and warranted us to develop models and experiments on understanding ecological and biophysical processes in urban areas. Our recommendation is to increase the overall green cover of the city, preserve the existing big trees, and plant more trees near vulnerable infrastructures such as hospitals, nursing homes, kindergartens, schools, and child day care units. We are currently implementing the results as a specific heat warning system for the city of Karlsruhe. Such heat warning system is one part of a future heat action plan.

Our research also demonstrated that appreciation of cultural ecosystem services from urban trees and forests increased significantly during the pandemic-related lockdown. People without access to private gardens or balconies visited more of the city's green spaces, such as parks and urban forests. We have found that the high demand for recreation from citizens from parks and urban forests during the pandemic and post-pandemic times, as well as the urgent need for sanitary intervention for dying trees and climate change adaptation measures, created double trouble for urban planners. On the one hand, more money and planning should be invested to increase the recreation demand. On the other hand, dying and moribund trees need to be removed, new trees need to be planted, and monitoring for trees needs to be increased to prevent accidents from falling branches or trees (German word verkehrssicherheit). Short and long-term intervention to convert urban parks, peri-urban and urban forests to more resilient diverse urban forests would also require time and protection from human disturbances, such as avoiding forest fire from careless human activities (e.g., barbequing in city parks and forests), garbage deposition, and trampling of forests. We have recommended initiating societal dialogue between the city administration, stakeholders, and citizens on balancing recreational demand, safety, sanitary interventions of unhealthy trees, and climate change adaptation measures.

Finally, we would like to stress that urban forests are artificial ecosystems created by the people, and we need a holistic approach to increase social-ecological resilience. In such an ecosystem, trees and animals will not react the same way to environmental stress as they do in their natural ecosystem. Therefore, we request the government and other agencies to increase research funding and give a long-term commitment to fundamental and applied research on urban forestry, urban horticulture, urban planning, landscape architecture, and urban ecology. The project results from project GrüneLunge can be applicable in the Upper Rhine Valley region of Germany. Therefore, more future research should be done in the other parts of Germany. This way, we can perhaps guarantee our future generation a habitable, healthy, inclusive, green, and resilient city for all.”

Further information:

https://www.projekt-gruenelunge.de/en/
https://www.itas.kit.edu/english/projects_saha18_grulu.php