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The food-water-climate nexus of green infrastructure: Examining ecosystem services trade-offs of peri-urban agriculture

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Emission reduction, heat mitigation, and improved access to water and food provision are increasingly critical challenges for urban areas in the context of global climate change adaptation and mitigation. The revival of local agricultural production is often lauded as a potential nature-based solution. However, an expansion of peri-urban agriculture (peri-UA) may entail significant trade-offs in the ecosystem services it provides.

This study explores the impacts on the food-water-climate nexus of different scenarios of peri-urban agricultural expansion in a semi-arid, Mediterranean climate, addressing local food provision, freshwater use, local temperature regulation, global climate change mitigation, and the trade-offs thereof. Examining four theoretical land-use scenarios in the Metropolitan Area of Barcelona, the study integrates estimates of food provision and irrigation water requirements based on georeferenced urban metabolism approach with the local atmosphere and biogenic carbon balance estimates produced through the combination of an atmospheric model with a satellite and meteorological-driven biosphere model.

Our study reveals that a 31.12 % (+17.27 km^2) and 115.08 % (+64.25 km^2) increase in the current peri-UA in the AMB, achieved by replacing natural non-forested and forest areas, results in an increase in local food production of 24.0 % (+16503 tons $year^{-1}$) and 85.8 % (+58940 tons $year^{-1}$), respectively. However, it would also increase the irrigation water requirements by 10.0 % (+3.2 hm^3) and 43.5 % (+14.1 hm^3), respectively. The analysis of the midday/midafternoon temperatures during a summer hot month reveals that peri-UA especially when it is irrigated can potentially reduce near-surface temperatures up to 0.7 °C with respect to a current scenario, however the air cooling affects principally located in rural regions with lower population density, while temperature reductions in the densest urban areas are minimal. If an expansion of Peri-UA goes at the expense of natural non-forested and forests areas, as in the scenarios we used, it has further the potential to disrupt the regional carbon balance, impacting the net ecosystem

productivity of the AMB green infrastructure and overall carbon stocks with reductions in the net ecosystem productivity of up to 18.5 % and reduce total carbon stocks by 3.3 %.

These findings, derived from an innovative and combined modelling approach, reveal significant trade-offs in ecosystem services associated with an expansion of peri-urban agriculture. It is likely that similar trade-offs would be observed with other nature-based solutions strategies. An integrated understanding of these trade-offs, facilitated by nexus approaches that combine different models, appears to be a promising direction for informing land-use decision-making in the context of urban climate adaptation and mitigation.