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Hotter Cities, Hotter Nights: How Urban Growth Amplifies Global Warming in Hanoi and Ho Chi Minh City

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Hotter Cities, Hotter Nights: How Urban Growth Amplifies Global Warming in Hanoi and Ho Chi Minh City

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Abstract
Vietnam's two largest cities, Hanoi and Ho Chi Minh City (HCMC), are growing faster than almost anywhere in Southeast Asia. At the same time, global warming is pushing background temperatures steadily upward. When these two forces meet in a dense, concrete-covered megacity, their effects do not simply add up: they reinforce one another, producing heat events more intense, more frequent, and more dangerous. To capture this combined effect, we ran very high-resolution climate simulations that explicitly represent both future warming and expansion of urban areas for both cities. The results clearly show that the way cities grow, e.g., how dense, how green, how built-up, will partly shape how hot and how livable they become. Managing the physical urban footprint is therefore a frontline adaptation strategy in coping with climate change

Keywords
Climate change, urbanization, urban heat island, climate extremes, megacities

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Résumé
Les deux plus grandes villes du Vietnam, Hanoï et Hô Chi Minh-Ville (HCMV), connaissent une croissance urbaine parmi les plus rapides d'Asie du Sud-Est. Dans le même temps, le réchauffement climatique entraine une hausse progressive de la température. Lorsque ces deux dynamiques se conjuguent dans une mégapole dense et largement minéralisées, leurs effets ne sont pas simplement additifs : ils se renforcent mutuellement, entraînant des épisodes de chaleur plus intenses, plus fréquents et plus dangereux. Afin de tenir compte de cet effet combiné, nous avons réalisé des simulations climatiques à très haute résolution représentant explicitement à la fois le réchauffement futur et l'expansion des zones urbaines dans les deux villes. Les résultats montrent clairement que la manière dont les villes se développent, c'est-à-dire leur densité, leur couverture végétale et l'étendue des surfaces bâties, façonnera en partie leur niveau de chaleur et leur habitabilité. La maîtrise de l'empreinte physique des villes constitue donc enjeu majeur dans les stratégies d'adaptation au changement climatique.

Mots-clés
Changement climatique ; urbanisation ; îlot de chaleur urbain ; extrêmes climatiques ; mégapoles.

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Highlights

- To evaluate the combined effects of climate change and urbanization on extreme heat conditions in Hanoi and Ho Chi Minh City, we carried out new climate simulations at a very high spatial resolution, across different climate scenarios.
- Results show a steady increase in future temperature, with urban contribution representing approximately 25–30% of the total local warming, which increases the frequency and duration of extreme-heat days. Furthermore, the hotter the day, the larger the urban penalty.
- To protect lives and livelihoods from increasingly severe heat extremes, reducing the urban heat island effect should be made an explicit objective of climate-resilient urban planning in Vietnam's megacities.

1. Context and motivation

Hanoi and HCMC are the two economic engines of Vietnam, concentrating population, assets, and growth. Both are characterized by an extremely high density of impervious surfaces, a prevalence of high-rise "tube houses", and a marked lack of urban greenery, which are ideal conditions for an intense urban heat island (UHI). Yet their climates differ. Hanoi has a humid subtropical climate with hot, monsoon-driven summers, while HCMC is tropical and hot year-round, allowing us to compare how urban pressures play out across contrasting backgrounds. To evaluate the combined effects of climate change and urbanization, we carried out new climate simulations at a very high spatial resolution, that can explicitly account small-scale rainfall dynamics and the heterogeneity of the urban surface, making them best suited to assessing urban heat (Nguyen-Xuan *et al.* in prep.).

2. Methods

- **The climate model**

We used a regional climate model (Nguyen-Xuan, Nguyen-Le and Ngo-Duc 2025) to dynamically downscale a CMIP6 global climate model to a 3 km spatial resolution for both cities, under the high-greenhouse gas (GHG) emission scenario SSP5-8.5 — a pathway chosen to reveal the upper end of the risk. Three 30-year periods were analyzed: a Reference period (1985–2014), the Near Future (2025–2054), and the Far Future (2070–2099).

- **Isolating the urban effect**

To separate global warming from urbanization, we ran two parallel sets of future simulations: one using urban land-use maps consistent with the SSP5 pathway ("updated urban") and the other freezing the city at its historical (1985–2014) footprint ("reference urban"). The difference between the two isolates the net contribution of urban expansion alone. The evolving urban maps were built from global 1 km projections of population and urban land (Gao and O'Neill 2020).

- **Measuring extremes and the urban heat island**

We computed standardized climate-extreme indices for daily maximum and minimum temperature, capturing the intensity, frequency, and duration of extreme heat. UHI intensity was estimated with a spatially continuous method correcting for elevation and avoiding the bias of choosing a single rural reference station.

3. Results

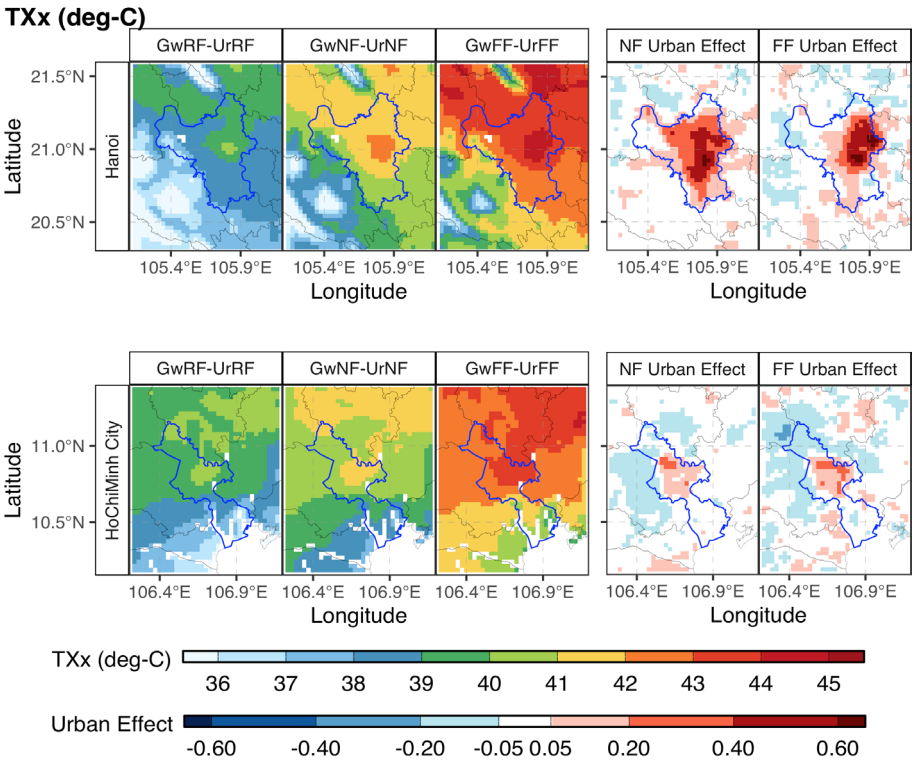
- **Strong warming in both cities**

Daily mean temperatures rise by about 1–1.8 °C in the Near Future and by about 3°C to over 3.6°C in the Far Future. The maximum value of daily maximum temperature in the city centre is projected to rise substantially in both cities. In Hanoi, increases of 1–2°C and 4–5°C are projected for the near and far future, respectively, while in HCMC, the corresponding increases are 1–2°C and 3–4°C (Fig.1).

- **Urbanization adds a local "thermal base load"**

The city itself contributes roughly 0.3–0.5 °C to the rise of daily mean temperatures, exceeding 0.5°C in the densest districts. Hence, the urban contribution represents approximately 25–30% of the total local warming. Crucially, this extra heat increases the frequency and duration of extreme-heat days (Fig.2). The urban fabric also lifts the temperature of the hottest nights: the core UHI intensity reaches median values of 1.5–2°C during the nocturnal peak. After dark, concrete and asphalt release the heat stored during the day and stop the city from cooling.

Figure 1. Spatial distribution of the maximum value of daily maximum temperature (°C) in Hanoi (top) and HCMC (bottom).



Note on figure 1: The first 3 columns display the climatological means for the Reference (GwRF-UrRF), Near Future (GwNF-UrNF), and Far Future (GwFF-UrFF) periods. The last two columns display the isolated urban effect, calculated as the difference between the "Real urban" and "Reference urban" simulations for the Near Future (NF Urban Effect) and Far Future (FF Urban Effect).

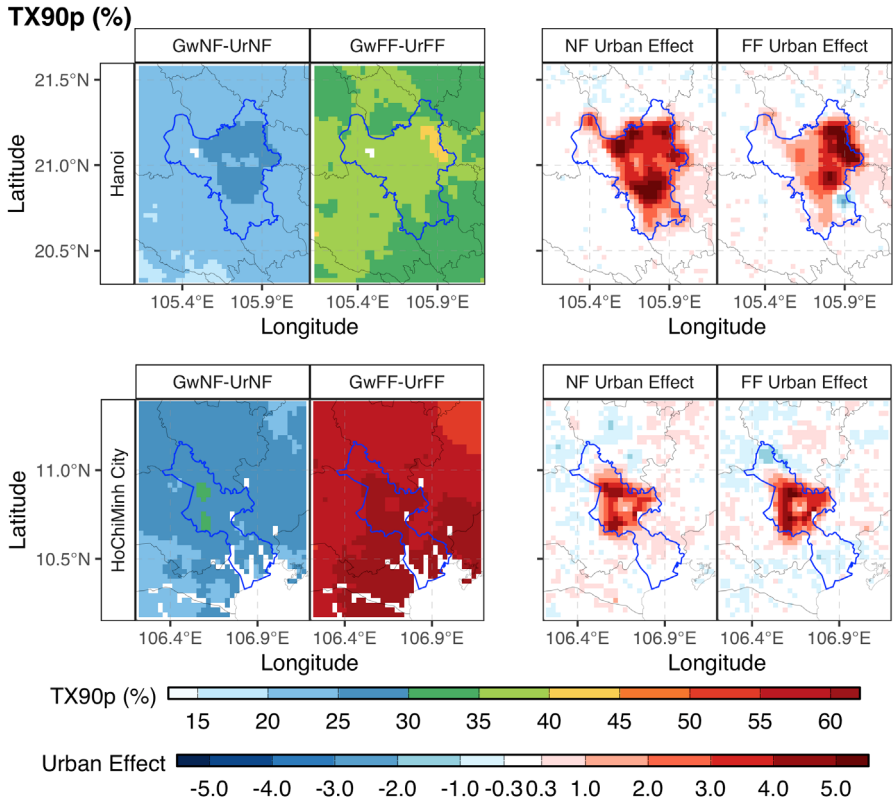
- **A dangerous synergy on the hottest days**

The urban heat island does not stay constant but intensifies when the weather is most extreme. During heatwaves we find a positive coupling between background temperature and UHI intensity: the hotter the day, the larger the urban penalty. Hence, adaptation plans that assume a fixed UHI simply added to future warming will underestimate the true risk.

- **Limitations**

There are substantial discrepancies between the urban scenarios used for Hanoi and the recently approved Capital Master Plan, which foresees far greater and continued growth than the global dataset. Therefore, the urban contribution to heat simulated here for Hanoi should be regarded as a conservative lower bound. The same caution applies to HCMC. In addition, our assessment is based on a single climate model and therefore does not capture the range of projections across climate models. Future work should assess this model uncertainty to provide a more robust estimate of future local warming levels.

Figure 2. Spatial distribution of the percentage of days when the daily maximum temperature surpasses the 90th percentile of the reference period (%) in Hanoi (top) and HCMC (bottom).



Note on figure 2: The first 2 columns display the climatological means for the Near Future (GwNF-UrNF) and Far Future (GwFF-UrFF) periods. The last two columns display the isolated urban effect, calculated as the difference between the "Real urban" and "Reference urban" simulations for the Near Future (NF Urban Effect) and Far Future (FF Urban Effect).

4. Implications

Without deliberate management, **the combination of global warming and urban growth will make both cities markedly hotter**, with the heaviest burden falling on dense, low-income, and poorly ventilated neighborhoods. Rising night-time temperatures are especially concerning: without cool nights, the body cannot recover, compounding health risks for the elderly, the chronically ill, and outdoor workers

Relying on global climate projections or static urban maps alone underestimates the real risks facing Vietnam's megacities. High-resolution modeling that represents urban growth provides a far more realistic basis for adaptation planning.

The direction of the urban effect is robust, but its precise magnitude and timing depend on the urban-growth scenario and should be tested against local plans in future high-resolution simulations. Hanoi's Master Plan aims to develop it as a green city and reduce population density in the city center — both of which could help mitigate the UHI effect. On the other hand, the substantial population growth and extensive urban expansion will likely increase the number of people exposed to urban heat. Furthermore, UHI mitigation is not identified as a specific planning objective, which represents an important gap in the city's climate adaptation framework.

Recommendations

Above all, the severity of future heat ultimately depends on global greenhouse-gas mitigation. But the choices Vietnamese cities make now, e.g., about how dense, how green, and how built-up they become, will decide how much of that warming is amplified, or buffered, at street level. Protecting lives and livelihoods in Vietnam's megacities under intensifying heat requires coordinated, flexible action across sectors. Priority measures include (but are not limited to):

- **Assess the impacts of urban plans and UHI mitigation measures on outdoor heat**: support high-resolution climate simulations and robust urban observation networks, and use dynamic urban-growth scenarios to guide long-term, city-specific adaptation. In particular, given that the effectiveness of pedestrian-level cooling strategies depends strongly on local climate and urban form, interventions should be assessed through modelling and field measurements before being scaled up.

- **Manage the physical urban footprint**: control impervious-surface expansion, protect and expand green and blue spaces, mandate minimum green space ratios, cool/reflective roofs and heat-sensitive zoning, and preserve ventilation corridors to limit urban heat island formation

- **Embed adaptation in city planning and governance**: integrate both heat and flood risk into master plans, building codes, and provincial budgets; ensure consistency with the National Adaptation Plan (NAP) and Nationally Determined Contributions (NDC).

- **Protect health and vulnerable groups**: establish heat-health early-warning systems and action plans, expand surveillance of heat-related illness, prepare hospitals for extreme-heat events, and target outreach to the elderly, outdoor workers, and dense low-income districts — with explicit attention to night-time heat.

- **Build climate-resilient energy**: plan for surging cooling demand and strengthen grid reliability during heatwaves.

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