

Global inequities in population exposure to urban greenspaces increased amidst tree and nontree vegetation cover expansion



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Web links to the author's journal account have been redacted from the decision letters as indicated to maintain confidentiality

21st Sep 23

Dear Professor Sun,

Your manuscript titled "Escalating Global Inequities in Human Exposure to Greenspace Amidst Prevalent Urban Greening" has now been seen by 3 reviewers, and we include their comments at the end of this message. They find your work of interest, but some important points are raised. We are interested in the possibility of publishing your study in Communications Earth & Environment, but would like to consider your responses to these concerns and assess a revised manuscript before we make a final decision on publication.

We therefore invite you to revise and resubmit your manuscript, along with a point-by-point response that takes into account the points raised. In particular, for publication in Communications Earth & Environment, we require that you:

*** Present novel and firmly supported insights into global patterns and drivers of tree and non-tree vegetation changes, as well as inequalities in population exposure to greenspaces.

*** Clarify your study aims and provide a theoretical perspective of urban development definition of urban clusters, as well as comprehensive details of all data sources and derivations used in the analysis.

*** Communicate the limitations and uncertainties in your research and expand your discussion accordingly.

We are committed to providing a fair and constructive peer-review process. Please don't hesitate to contact us if you wish to discuss the revision in more detail.

Please use the following link to submit your revised manuscript, point-by-point response to the referees' comments (which should be in a separate document to any cover letter), a tracked-changes version of the manuscript (as a PDF file) and the completed checklist:

[Link redacted]

** This url links to your confidential home page and associated information about manuscripts you may have submitted or be reviewing for us. If you wish to forward this email to co-authors, please delete the link to your homepage first **

We hope to receive your revised paper within six weeks; please let us know if you aren't able to submit it within this time so that we can discuss how best to proceed. If we don't hear from you, and the revision process takes significantly longer, we may close your file. In this event, we will still be happy to reconsider your paper at a later date, as long as nothing similar has been accepted for publication at Communications Earth & Environment or published elsewhere in the meantime.

Please do not hesitate to contact us if you have any questions or would like to discuss these revisions further. We look forward to seeing the revised manuscript and thank you for the opportunity to review your work.

Best regards,

Martina Grecequet PhD
Associate Editor,

EDITORIAL POLICIES AND FORMATTING

We ask that you ensure your manuscript complies with our editorial policies. Please ensure that the following formatting requirements are met, and any checklist relevant to your research is completed and uploaded as a Related Manuscript file type with the revised article.

Editorial Policy: [Policy requirements](https://www.nature.com/documents/nr-editorial-policy-checklist.pdf) (Download the link to your computer as a PDF.)

Furthermore, please align your manuscript with our format requirements, which are summarized on the following checklist:

[Communications Earth & Environment formatting checklist](https://www.nature.com/documents/commsj-phys-style-formatting-checklist-article.pdf)

and also in our style and formatting guide [Communications Earth & Environment formatting guide](https://www.nature.com/documents/commsj-phys-style-formatting-guide-accept.pdf).

***** DATA:** Communications Earth & Environment endorses the principles of the Enabling FAIR data project (<http://www.copdess.org/enabling-fair-data-project/>). We ask authors to make the data that support their conclusions available in permanent, publically accessible data repositories. (Please contact the editor if you are unable to make your data available).

All Communications Earth & Environment manuscripts must include a section titled "Data Availability" at the end of the Methods section or main text (if no Methods). More information on this policy, is available at <http://www.nature.com/authors/policies/data/data-availability-statements-data-citations.pdf>.

In particular, the Data availability statement should include:

- Unique identifiers (such as DOIs and hyperlinks for datasets in public repositories)
- Accession codes where appropriate
- If applicable, a statement regarding data available with restrictions
- If a dataset has a Digital Object Identifier (DOI) as its unique identifier, we strongly encourage including this in the Reference list and citing the dataset in the Data Availability Statement.

DATA SOURCES: All new data associated with the paper should be placed in a persistent repository where they can be freely and enduringly accessed. We recommend submitting the data to discipline-specific, community-recognized repositories, where possible and a list of recommended repositories is provided at <http://www.nature.com/sdata/policies/repositories>.

If a community resource is unavailable, data can be submitted to generalist repositories such as [figshare](https://figshare.com/) or [Dryad Digital Repository](http://datadryad.org/). Please provide a unique identifier for the data (for example a DOI or a permanent URL) in the data availability statement, if possible. If the repository does not provide identifiers, we

encourage authors to supply the search terms that will return the data. For data that have been obtained from publically available sources, please provide a URL and the specific data product name in the data availability statement. Data with a DOI should be further cited in the methods reference section.

Please refer to our data policies at http://www.nature.com/authors/policies/availability.html.

REVIEWER COMMENTS:

Reviewer #1 (Remarks to the Author):

The paper aims to examine the global patterns and drivers of urban greenspace dynamics and their impacts on human exposure and inequality. The paper uses multiple satellite-derived datasets and statistical methods to conduct a comprehensive analysis at a global scale.

Overall, the paper is well-written and organized, and the research topic is relevant and timely. Before the publication, I have some concerns and suggestions, as follows:

1. The paper does not explain how the urban areas were defined and identified from the Landsat urban extent dataset. It is unclear what criteria or thresholds were used to select the urban clusters for analysis.
2. Sufficient details should be provided on how the vegetation coverage and greenness datasets were processed and harmonized. For example, how were the different spatial resolutions, temporal frequencies, and spectral characteristics of MODIS, Landsat, and WorldCover datasets reconciled? How were the cloud cover, atmospheric effects, and mixed pixels dealt with?
3. The authors does not justify the choice of the population-weighted exposure model and the Gini index as the metrics for assessing human exposure and inequality to urban greenspace. It is unclear how these metrics account for the accessibility, quality, and functionality of urban greenspace, which are also important factors for human well-being.
4. The paper does not discuss the uncertainties and errors associated with the data sources, statistical methods, and models used in the paper. For example, how accurate and reliable are the satellite-derived vegetation datasets in urban areas? How robust are the generalized additive models and the relative importance analysis? How sensitive are the results to the choice of parameters and variables?

Reviewer #2 (Remarks to the Author):

The study investigates the trends of urban greening regarding changes in tree and non-tree vegetation, human exposure to greenspace and drivers of urban vegetation dynamics, using satellite imagery of world cities over a period of 20 years. The study produces findings of general interest regarding urban greenspace and wellbeing to researchers and policymakers from a variety of disciplines. However, while the study identifies two literature gaps considering tree and non-tree vegetation and inequalities in human exposure to greenspace, the main scientific advancement or contribution of the paper is unclear. I am not sure whether the main achievement is conceptual in

making a new distinction between tree and non-tree vegetation or methodological in actually being able to measure it alongside human exposure, or if there has been a technological advancement that made new data available when it was not possible to measure these before (noting, that it seems all the data is public and from secondary sources). Therefore, I invite the authors to highlight more explicitly the novelty of their approach, and if it is methodological, then to comment still on the challenges they had to overcome and how it can be improved in future research.

While the study yields interesting results, the generality of results in terms of policy and/or theoretical relevance is a weakness. What it lacks perhaps is a theoretical perspective on urban development, greening, climate change, etc. for the interpretation of results and discussion, depending on where the authors see their main contribution.

Even though it would be clear as a technical report, the value as a scientific article could be emphasized, in my view, in two ways. The authors stated several times that the study is novel for distinguishing tree versus non-tree coverage, so they could emphasize in the introduction and discussion what was limiting studies beforehand and how they overcame it, leaning the main contribution more towards a methodological advancement. I note that the discussion begins in stating that prior studies "lack the ability to differentiate the specific contributions of different vegetation types within enhanced urban greenery," but I cannot find an explanation of why/how the authors were now able to it. This could be the key contribution. On the other hand, if emphasizing the results, then a more nuanced discussion on policy implications, relating to more specific development challenges in different contexts, could lean the main contribution more towards theoretical or policy insights. The brief elaboration on trends in China, India and the United States may not be adding much because it does not relate to any differences in goals or strategies in those countries. A policy relevant discussion could also be difficult because the study refers to global goals only generally ("the SDGs") rather than to specific policies or processes on urban greening that act on the global level (e.g. SDG 11, UN-Habitat, greener cities partnership, initiatives of various regional development banks, etc. that are transposed into national strategies and local plans) and could benefit from these results. It could be possible to narrow the discussion. The choice seems to really depend on the disciplinary background of the authors and who they intend to use these results.

It could also be beneficial to situate the article clearly within the disciplinary perspective(s) of the authors (at least to explicitly identify with a discipline in the introduction) and address their arguments to current specific debates in their discipline (e.g. need for better data? new techniques? communicating policy relevance?) and the policy areas that they act upon rather than to general policy goals ("the SDGs"). This could be achieved with some additions to the text rather than further analysis, perhaps revealing more details from the cited literature, without overstating the significance of the results for general policy advice.

Specific remarks:

I suggest to remove the mention of vegetation as a nature-based solution (line 34), since NBS as a concept is not followed up in the paper. Urban greenspace is addressed generally (perhaps green infrastructure would be more appropriate than NBS) rather than connected to a specific challenges, functions or interventions. Moreover, the NBS literature tends to be very specific with definitions.

Reviewer #3 (Remarks to the Author):

This paper seeks to examine urban greenspace vegetation change and accessibility over the last twenty years across the globe. They use reproducible methods and statistics for their analysis and discuss the scale of their results appropriately. I believe this work provides important findings that

support past and current research. My main critique is in the discussion and how it could be better connected to current literature on the areas they discuss. There are a few times in the discussion where the authors make statements that could be related to their results or could be related to current literature but there are no citations. I would recommend that the authors write these statements more clearly and connect them to current literature so that they are supported and can support this field of research. Detailed line comments are as follows:

Line 32: Change "sustainable development goals" to "SDGs".

Lines 75-77: This part is confusing since the methods section is farther below. Context needs to be given to explain why there are two groupings of cities here. It is briefly mentioned on line 69-70 but this is lost to the reader by the intervening sentences. Lines 69-70 could be moved closer to lines 75-77 or more context could be given at those lines.

Line 78: Change "twenty-one" to "twenty-first".

Lines 179-199: This paragraph needs to be more connected to current literature. There is only one sentence with outside references which makes the paragraph seem like a review of the results rather than discussion of them.

Lines 188-190: Need a citation.

Lines 190-192: Need a citation.

Lines 200-215: This paragraph needs to start with Lines 210-215 and then have the discussion around those results. It will make for a stronger argument and a streamlined paragraph.

Lines 218-220: Are you referencing the data from the study or an outside reference? This needs to be clearer, and I would suggest finding a reference as well.

Lines 227-230: This needs a citation - could possibly look at 3-30-300 rule.

Lines 240-242: Is this sentence correct? Using the word continuous twice is throwing me off.

Line 242: The beginning of the sentence could be shortened and simplified with "Given the fast pace of current urban fragmentation..."

Line 245: Change "is needed" to "needs".

Line 246: Change "by incorporating the field measurement" to "by incorporating field measurement".

Lines 248-249: Change "Sustainable Development Goals" to "SDGs".

Lines 250-253: Citation(s) needed for these two sentences.

Line 258: Change "in the SDGs" to "as part of the SDGs".

Line 262: Change "findings highlight" to "findings support and further highlight"

Reviewer #1

The paper aims to examine the global patterns and drivers of urban greenspace dynamics and their impacts on human exposure and inequality. The paper uses multiple satellite-derived datasets and statistical methods to conduct a comprehensive analysis at a global scale. Overall, the paper is well-written and organized, and the research topic is relevant and timely. Before the publication, I have some concerns and suggestions, as follows:

1. The paper does not explain how the urban areas were defined and identified from the Landscan urban extent dataset. It is unclear what criteria or thresholds were used to select the urban clusters for analysis.

Response: A detailed description of the global urban areas definition as well as the selection criteria has been added in the Method section.

“The urban extent data are based on the simplified urban-extent algorithm, which combines the global urban land database with the Oak Ridge National Laboratory's LandScan population database. In order to generate the urban extent, these global urban data is overlapped with the LandScan population-derived Thiessen polygons. It has undergone validation, with a commendable overall accuracy of 93%. This validation process involved comparing the dataset with a Landsat-based map encompassing 140 urban areas situated in various ecoregions, and accounting for diverse levels of population and economic development. In this study, we selected the cities with a geographic area exceeding 100 km² from the global urban extent data. This selection criterion resulted in a total of 3567 urban clusters that were included in our analysis.”

2. Sufficient details should be provided on how the vegetation coverage and greenness datasets were processed and harmonized. For example, how were the different spatial resolutions, temporal frequencies, and spectral characteristics of MODIS, Landsat, and WorldCover datasets reconciled? How were the cloud cover, atmospheric effects, and mixed pixels dealt with?

Response: We acknowledge the importance of transparency in data handling and would like to address your concerns by providing a more detailed account of our data processing procedures. The description of the vegetation coverage and greenness datasets has been provided in the revised manuscript. While multi-satellite observations with diverse spatial resolutions are used in this study, an inter-comparison of vegetation coverage and greenness derived from these satellite platforms was conducted at the city level. The region-wide mean vegetation coverage/greenness of each urban cluster was computed, therefore, these satellite-based datasets have not been harmonized into the same spatial resolution. On the other hand, given that the MODIS/Landsat vegetation continuous fields and WorldCover are yearly products, vegetation greenness (EVI) with a 16-day interval was aggregated into the annual maximum EVI to harmonize the temporal frequencies across the datasets. The process of image quality control has been also introduced.

“To minimize noise and uncertainties, we employed a rigorous data selection process. Specifically, pixels with a quality control flag of the first 2 bits that did not correspond to either "00" or "01" were excluded from the analysis. This approach ensured that only the highest quality data points were included in the study. Cloud cover was mitigated through the use of cloud masks and quality assurance flags provided in the original datasets.” We believe that by providing these additional details and explanations in our manuscript, it enhances the transparency and reproducibility of our research.

3. The authors does not justify the choice of the population-weighted exposure model and the Gini index as the metrics for assessing human exposure and inequality to urban greenspace. It is unclear how these metrics account for the accessibility, quality, and functionality of urban greenspace, which are also important factors for human well-being.

Response: We appreciate your thoughtful review and inquiry regarding the justification for our choice of the population-weighted exposure model and the Gini index as metrics for assessing human exposure and inequality to urban greenspace. Given the limited length of the main text (less than 5,000 words) required by the Journal, we have added a detailed explanation and provided a rationale for our choice of these metrics as below, and a concise version alongside the corresponding sub-section of the Method. We recognize the limitations of these metrics in capturing the full spectrum of factors influencing human well-being in relation to greenspace. In our revised manuscript, we have included a discussion of these limitations and emphasize that our study offers a specific perspective on greenspace inequality focused on spatial distribution.

We selected the population-weighted exposure model as it allows us to account for the distribution of greenspace relative to the population it serves. Previous studies reported accentuating environmental inequality as urbanization proceeded, including urban greenspace provision, accessibility, and exposure. These methods fall in the scope of greenspace-oriented accessibility statistics. For each unit of greenspace, they estimate the inclusive population within the corresponding buffer regions. However, there are several noticeable shortcomings. the accessibility measurement allocates equal greenspace share to a population (i.e., accessible or non-accessible) without differentiating the real amount of greenspace exposed to humans. these

methods do not account for all greenspace coverage in urban areas by excluding greenspace areas smaller than a certain size. Given the heterogeneous landscape of cities, certain greenspace types such as street plantations, lawns, and small gardens and parks that play an important role in providing ecosystem services to high-rise and high-density urban areas may be omitted. *“Population-weighted exposure model provides the wall-to-wall fine-resolution characteristics of greenspace and population, and it is able to map the multiscale differences in human exposure to greenspace from country to state, county, and city levels.”*

Inequality can be viewed from different perspectives, all of which are related. The most common metric is Income Inequality, which refers to the extent to which income is evenly distributed within a population. *“The Gini index is a well-established and most commonly used measure of income or wealth inequality, but it can be used to measure the inequality of any distribution. In the study, it was adapted to assess inequality in greenspace exposure. Our decision was motivated by the desire to provide a quantitative measure that can capture disparities in greenspace distribution across urban areas. While the Gini index may not directly account for greenspace quality or functionality, it provides valuable insights into the uneven distribution of greenspace, which is an important aspect of urban environmental justice.”*

4. The paper does not discuss the uncertainties and errors associated with the data sources, statistical methods, and models used in the paper. For example, how accurate and reliable are the satellite-derived vegetation datasets in urban areas? How robust are the generalized additive models and the relative importance analysis? How sensitive are the results to the choice of parameters and variables?

Response: We sincerely appreciate your insightful feedback on the uncertainties and errors associated with the data sources, statistical methods, and models. A dedicated section has been added to the revised manuscript that summarizes the identified uncertainties and errors, including their potential impact on our results and conclusions.

“The relative importance analysis in our study is based on established methodologies and has followed best practices to ensure the reliability of the results. It works by transforming the set of independent variables into a set of orthogonal variables that are not correlated with each other. It turns out that the squared regression coefficients from the linear regression using the orthogonal variables represent each variable's contribution to the R-square. The Relative Importance score for each independent variable is simply a convex combination (a weighted sum where weights add up to 1) of the squared regression coefficients, with the weights calculated based on the orthogonal variable transformation.”

GAM is a robust statistical model commonly used for modeling complex relationships in data without imposing strong assumptions. Their flexibility, interpretability, and adaptability to various data types and structures make them a powerful choice for researchers and analysts across different domains. The smooth functions in GAMs are intuitive and easily interpretable, making it straightforward to understand the relationships between predictors and the response variable. Additionally, GAMs can be robust to outliers and influential points due to their non-parametric nature. Despite its advantages, one of the limitations of GAMs is to choose the appropriate smooth functions and parameters for the predictor in GAMs. These choices affect the model fit, interpretation, and inference, and may require some trial and error or model selection criteria. Another challenge is to check the validity and accuracy of the model assumptions and predictions, such as the residuals, the deviance, or the effective degrees of freedom. These

diagnostics may differ from those used in linear regression and may require special methods or tools. To assess the robustness of our GAMs, we conducted cross-validation to evaluate the predictive performance and carefully validated the model to ensure its effectiveness in addressing the research questions posed in our study. We performed comprehensive model diagnostics to assess the fit of our GAMs and identify potential issues. Diagnostic plots and statistical tests were used to validate the assumptions of the models and ensure that they met the required criteria for robustness.

“While our models have demonstrated robustness under various tests, it is acknowledged that no model is entirely immune to uncertainties or limitations and the general explanation accounts for nearly 70% of global urban tree coverage variability. Besides, the input explanatory factors of the GAMs were also affected by the limited and unified urban inventory worldwide, especially for the anthropogenic drivers. Here, we employed the three socioeconomic factors (GDP, HDI, and UDI) as the surrogates of the impacts of human-related activity on urban greenspace variability. Therefore, a more direct open-source dataset with regard to anthropogenic factors, such as urban green infrastructure investments, is needed and can further enhance the interpretability and adaptability of the results.”

“In this study, we used constant urban boundaries of global 3678 cities and it also could introduce to some extent biases since our planet is under rapid urbanization. Most cities worldwide, especially in developing countries such as China, and India, are expanding and growing. Along with the swiftly increasing number of populated residents, urbanization which converts natural lands to artificial surfaces usually leads to a significant downward in vegetation cover. Studies reveal that most major cities exhibited a contrasting vegetation pattern, with notably upward trends in urban greenspace coverage in the urban areas but downward

trends in urbanized area. While the constant urban boundaries probably bring out uncertainties, it might insignificantly affect the overall decreasing trend in human exposure to urban greenspace. Furthermore, a yearly dynamic dataset of global urban extent coupled with annual vegetation coverage could further minimize the uncertainties induced by the constant urban boundaries.”

Reviewer #2

1. The study investigates the trends of urban greening regarding changes in tree and nontree vegetation, human exposure to greenspace and drivers of urban vegetation dynamics, using satellite imagery of world cities over a period of 20 years. The study produces findings of general interest regarding urban greenspace and wellbeing to researchers and policymakers from a variety of disciplines. However, while the study identifies two literature gaps considering tree and nontree vegetation and inequalities in human exposure to greenspace, the main scientific advancement or contribution of the paper is unclear. I am not sure whether the main achievement is conceptual in making a new distinction between tree and nontree vegetation or methodological in actually being able to measure it alongside human exposure, or if there has been a technological advancement that made new data available when it was not possible to measure these before (noting, that it seems all the data is public and from secondary sources). Therefore, I invite the authors to highlight more explicitly the novelty of their approach, and if it is methodological, then to comment still on the challenges they had to overcome and how it can be improved in future research.

Response: Thank you for your thoughtful feedback on our manuscript. We appreciate your valuable insights regarding the clarity of our paper's main scientific contribution and the need for a more explicit emphasis on the novelty of our approach. In the revised manuscript, we have emphasized these contributions more explicitly and expanded upon a detailed discussion of the methodological innovations, the challenges we faced, and suggestions for potential improvements in future research. This provides a deeper understanding of the significance and

methodological aspects of our work and suggests potential areas for improvement in future research.

“Urban greenspace is commonly examined as a holistic concept when assessing human exposure to urban nature. However, it is essential to acknowledge that urban green infrastructure comprises two distinct categories: tree and nontree vegetation, each with unique ecological characteristics.”

“One of the key contributions of our paper is the conceptual framework that distinguishes between tree and nontree vegetation when assessing inequalities in human exposure to greenspace. By explicitly separating these two categories, this novel conceptualization allows for a more nuanced understanding of how different types of greenspace impact human well-being and environmental equity.”

“While the data sources are publicly available, our work demonstrates how advancements in data integration and analysis tools have made it possible to measure these aspects more comprehensively and systematically than before. This technological integration is a critical aspect and allows us to quantify and analyze previously unexplored aspects of urban greenspace, enhancing our understanding of its distribution and its implications for urban residents.”

2. While the study yields interesting results, the generality of results in terms of policy and/or theoretical relevance is a weakness. What it lacks perhaps is a theoretical perspective on urban development, greening, climate change, etc. for the interpretation of results and discussion, depending on where the authors see their main contribution.

Response: We appreciate your insightful feedback and your suggestions regarding the emphasis and focus of the results and discussion, and recognize the value of grounding our study in a solid theoretical framework related to urban development, greening, and climate change. To strengthen the theoretical relevance of our work, a more comprehensive theoretical foundation that underpins our research has been provided in the revised manuscript. This helps readers better understand the theoretical context and implications of our findings.

“This study emphasizes the need to go beyond the existing knowledge of greener cities and delve into the dynamics of urban greenspace. It highlights the persistence of inequalities in human exposure to greenspace in both developing and developed nations and further underscores the importance of understanding the impacts of urban greenspace on human exposure. The disparity in greenspace distribution can contribute to environmental injustice, as it disproportionately affects communities worldwide, particularly in the Global South. Marginalized communities, often located in urban areas with limited greenspace, may experience reduced access to the numerous environmental, social, and health benefits that greenspaces provide. This further exacerbates existing social inequalities and disparities in quality of life. Addressing these inequities requires a multifaceted approach that considers social, economic, and environmental factors, as well as the involvement of local communities in greenspace planning and management. In order to enhance sustainability and create more equitable and livable urban environments, we advocate for evidence-based strategies in sustainable urban greenspace management, including urban planning policies, land use regulations, community initiatives, and environmental awareness.”

3. Even though it would be clear as a technical report, the value as a scientific article could be emphasized, in my view, in two ways. The authors stated several times that the study is novel for distinguishing tree versus nontree coverage, so they could emphasize in the introduction and discussion what was limiting studies beforehand and how they overcame it, leaning the main contribution more towards a methodological advancement. I note that the discussion begins in stating that prior studies “lack the ability to differentiate the specific contributions of different vegetation types within enhanced urban greenery,” but I cannot find an explanation of why/how the authors were now able to it. This could be the key contribution. On the other hand, if emphasizing the results, then a more nuanced discussion on policy implications, relating to more specific development challenges in different contexts, could lean the main contribution more towards theoretical or policy insights. The brief elaboration on trends in China, India and the United States may not be adding much because it does not relate to any differences in goals or strategies in those countries. A policy relevant discussion could also be difficult because the study refers to global goals only generally ("the SDGs") rather than to specific policies or processes on urban greening that act on the global level (e.g. SDG 11, UN-Habitat, greener cities partnership, initiatives of various regional development banks, etc. that are transposed into national strategies and local plans) and could benefit from these results. It could be possible to narrow the discussion. The choice seems to really depend on the disciplinary background of the authors and who they intend to use these results.

Response: Thank you for your valuable observation regarding our paper's discussion section and the need for a more explicit explanation of how we were able to differentiate the specific contributions of different vegetation types within enhanced urban greenery. In the revised

manuscript, we have incorporated a more explicit discussion of these data integration and high-resolution satellite imagery techniques. We also highlight how these approaches collectively enabled us to differentiate the specific contributions of tree and nontree vegetation within urban greenery. This clarification underscores the novelty and significance of our research in addressing a critical gap in the literature.

“The ability to differentiate the specific contributions of different vegetation types within enhanced urban greenery represents a crucial contribution of our study. Our study leverages a comprehensive data integration approach that combines various publicly available datasets, including remote sensing data, land cover data, and population data. This integration allowed us to achieve a finer spatial resolution and granularity compared to prior studies. As a result, we were able to differentiate between tree and nontree vegetation at a much more localized level within urban areas.”

In previous studies, urban greenspace was often considered as a whole entity, without distinguishing between the different types of vegetation it comprises. However, we utilized a satellite-based vegetation continuous fields dataset, which provides a more detailed and nuanced understanding of urban greenspace by capturing the pixel-wise percentage of tree and nontree vegetation coverage. *“By considering tree and nontree vegetation separately, we acknowledge that urban greenspace is not a homogenous entity but rather encompasses two distinct categories, each with its own ecological characteristics and benefits. Trees within urban areas provide numerous advantages, such as shade, air pollution reduction, and wildlife habitat, while nontree vegetation includes grass, shrubs, and other forms of vegetation that contribute to biodiversity, soil health, and microclimate regulation. Our study goes beyond previous research by revealing how urban tree and nontree vegetation varied within the context of urban greening*

efforts. We identified trends and patterns in the distribution and abundance of these two vegetation types, shedding light on their specific contributions to the overall greenspace dynamics. Importantly, our study highlights disparities in human exposure to these two types of greenspace. While there has been an overall increase in tree cover in many urban areas, our findings indicate that there are variations in the distribution and access to tree and nontree vegetation across different regions. These disparities in human exposure to different greenspace types have implications for the equitable distribution of benefits associated with urban greenery, such as improved air quality, psychological well-being, and community cohesion. By emphasizing the differentiation between tree and nontree vegetation within urban greenspace and highlighting the disparities in human exposure, our study contributes to a more comprehensive understanding of urban greening dynamics. This insight can inform policymakers, urban planners, and researchers in developing strategies that address the specific needs and benefits of different types of vegetation within urban areas, ultimately fostering more equitable and sustainable urban environments.”

Besides, as the reviewer suggested, we agree with the removal of the brief elaboration on trends in China, India, and the United States and have moved Table 1 into the supplementary materials.

4. It could also be beneficial to situate the article clearly within the disciplinary perspective(s) of the authors (at least to explicitly identify with a discipline in the introduction) and address their arguments to current specific debates in their discipline (e.g. need for better data? new techniques? communicating policy relevance?) and the policy areas that they act upon rather than to general policy goals (“the SDGs”). This could

be achieved with some additions to the text rather than further analysis, perhaps revealing more details from the cited literature, without overstating the significance of the results for general policy advice.

Response: Thank you for your valuable feedback. We appreciate your suggestion to situate the article clearly within our disciplinary perspective and address our arguments to current specific debates in our discipline. In the revised manuscript, we have made an effort to connect our arguments to current debates within our discipline and address the need for better data, discussing new techniques or methodologies that we employed in our study.

“This study provides insights into the distribution and characteristics of tree and nontree vegetation within urban areas and can inform urban planning and design policies aimed at incorporating and maximizing the benefits of greenspaces in cities. For example, policymakers could use these findings to guide decisions on the location and design of new parks, green corridors, and urban forests, considering the specific contributions of tree and nontree vegetation. In addition, the distribution and trends of tree and nontree vegetation can contribute to prioritizing the expansion and preservation of specific vegetation types to optimize their climate regulation benefits. This can contribute to urban resilience and adaptation to climate change.”

“The disparities in human exposure to different types of greenspace identified in our study highlight the need for policies that address biodiversity conservation, ecological balance, public health, and well-being. It involves targeted investments in greening initiatives, improving greenspace accessibility in underserved areas, and addressing social and spatial inequalities.

These evidence-based insights guide decision-making and prioritize interventions that enhance the sustainability, livability, and equity of urban environments.”

5. I suggest to remove the mention of vegetation as a nature-based solution (line 34), since NBS as a concept is not followed up in the paper. Urban greenspace is addressed generally (perhaps green infrastructure would be more appropriate than NBS) rather than connected to a specific challenges, functions or interventions. Moreover, the NBS literature tends to be very specific with definitions.

Response: Thank you for your suggestion regarding the mention of vegetation as a nature-based solution (NBS) in the manuscript. We understand your concern that the concept of NBS is not extensively explored or followed up in the paper. We agree with your point that the term "nature-based solution" may not align closely with the specific focus and content of our study. The statement has been rephrased by removing the term ‘nature-based solution’.

Reviewer #3

1. This paper seeks to examine urban greenspace vegetation change and accessibility over the last twenty years across the globe. They use reproducible methods and statistics for their analysis and discuss the scale of their results appropriately. I believe this work provides important findings that support past and current research. My main critique is in the discussion and how it could be better connected to current literature on the areas they discuss. There are a few times in the discussion where the authors make statements that could be related to their results or could be related to current literature but there are no citations. I would recommend that the authors write these statements more clearly and connect them to current literature so that they are supported and can support this field of research.

Response: Thanks for your generous comments. We sincerely appreciate your valuable feedback on our manuscript and agree with your critique regarding the need for a stronger connection between our discussion and the current literature in the areas of Discussion. Hence, several additional literature and citations have been included in the revised manuscript to support the statements as the reviewer suggested.

2. Line 32: Change “sustainable development goals” to “SDGs”.

Response: The term has been replaced with the corresponding abbreviation.

3. Lines 75-77: This part is confusing since the methods section is farther below. Context needs to be given to explain why there are two groupings of cities here. It is briefly mentioned on line 69-70 but this is lost to the reader by the intervening sentences. Lines 69-70 could be moved closer to lines 75-77 or more context could be given at those lines.

Response: We appreciate your insightful feedback regarding the clarity of our manuscript. Your comments on lines 75-77 and the need for improved contextualization are indeed valid, and we have taken steps to address this concern. To enhance the clarity and provide better context for the reader, this paragraph has been revised and sentences have been re-ordered for a better understanding.

4. Line 78: Change “twenty-one” to “twenty-first”.

Response: The word has been changed to “twenty-first”.

5. Lines 179-199: This paragraph needs to be more connected to current literature. There is only one sentence with outside references which makes the paragraph seem like a review of the results rather than discussion of them.

Response: The paragraph has been revised to provide additional references for the discussion.

Pretzsch, H. et al. Climate change accelerates growth of urban trees in metropolises worldwide. Sci Rep 7, 15403 (2017).

Nitschke, C. R. et al. The influence of climate and drought on urban tree growth in southeast Australia and the implications for future growth under climate change. Landsc Urban Plan 167, 275–287 (2017).

Steenberg, J. W. N., Millward, A. A., Nowak, D. J. & Robinson, P. J. A conceptual framework of urban forest ecosystem vulnerability. Environmental Reviews 25, 115–126 (2017).

6. Lines 188-190: Need a citation.

Response: Relevant studies about the statement have been added and cited.

Pretzsch, H. et al. Climate change accelerates growth of urban trees in metropolises worldwide. Sci Rep 7, 15403 (2017).

7. Lines 190-192: Need a citation.

Response: Relevant studies about the statement have been added and cited.

Nitschke, C. R. et al. The influence of climate and drought on urban tree growth in southeast Australia and the implications for future growth under climate change. Landsc Urban Plan 167, 275–287 (2017).

Steenberg, J. W. N., Millward, A. A., Nowak, D. J. & Robinson, P. J. A conceptual framework of urban forest ecosystem vulnerability. Environmental Reviews 25, 115–126 (2017).

8. Lines 200-215: This paragraph needs to start with Lines 210-215 and then have the discussion around those results. It will make for a stronger argument and a streamlined paragraph.

Response: This paragraph has been revised and these sentences have been re-organized as the reviewer suggested.

9. Lines 218-220: Are you referencing the data from the study or an outside reference? This needs to be clearer, and I would suggest finding a reference as well.

Response: This statement is based on the results of this study and the corresponding figure has been cited.

10. Lines 227-230: This needs a citation - could possibly look at 3-30-300 rule.

Response: Relevant studies about the statement have been added and cited.

Jain, G. & Espey, J. Lessons from nine urban areas using data to drive local sustainable development. npj Urban Sustainability 2, 7 (2022).

Keith, M. et al. A new urban narrative for sustainable development. Nat Sustain 6, 115–117 (2023).

11. Lines 240-242: Is this sentence correct? Using the word continuous twice is throwing me off.

Response: The sentence has been revised to avoid misunderstanding.

“Unlike the discrete land cover characterizations, VCF provides a continuous, quantitative portrayal of tree and nontree cover^{40–42}”

12. Line 242: The beginning of the sentence could be shortened and simplified with "Given the fast pace of current urban fragmentation..."

Response: The sentence has been revised and simplified.

13. Line 245: Change “is needed” to “needs”.

Response: The sentence has been revised.

14. Line 246: Change “by incorporating the field measurement” to “by incorporating field measurement”.

Response: The sentence has been revised.

15. Lines 248-249: Change “Sustainable Development Goals” to “SDGs”.

Response: The term has been replaced with the corresponding abbreviation.

16. Lines 250-253: Citation(s) needed for these two sentences.

Response: Relevant studies about the statement have been added and cited.

Keith, M. et al. A new urban narrative for sustainable development. Nat Sustain 6, 115–117 (2023).

Grimm, N. B. et al. Global change and the ecology of cities. Science (1979) 319, 756–760 (2008).

Chan, F. K. S., Chen, W. Y., Gu, X., Peng, Y. & Sang, Y. Transformation towards resilient sponge cities in China. Nat Rev Earth Environ 3, 99–101 (2022).

17. Line 258: Change “in the SDGs” to “as part of the SDGs”.

Response: The sentence has been revised.

18. Line 262: Change “findings highlight” to “findings support and further highlight”

Response: The sentence has been revised.

14th Nov 23

Dear Professor Sun,

Your manuscript titled "Escalating Global Inequities in Human Exposure to Greenspace Amidst Prevalent Urban Greening" has now been seen by our reviewers, whose comments appear below. In light of their advice we are delighted to say that we are happy, in principle, to publish a suitably revised version in Communications Earth & Environment under the open access CC BY license (Creative Commons Attribution v4.0 International License).

We therefore invite you to edit your manuscript to comply with our format requirements and to maximise the accessibility and therefore the impact of your work.

Please note that it may still be possible for your paper to be published before the end of 2023, but in order to do this we will need you to address these points as quickly as possible so that we can move forward with your paper.

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We hope to hear from you within two weeks; please let us know if you need more time.

Best regards,

Martina Grecequet PhD
Associate Editor,
Communications Earth & Environment
@CommsEarth

REVIEWERS' COMMENTS:

Reviewer #1 (Remarks to the Author):

Thank you for giving me this opportunity to read the revised version of the manuscript, and for the detailed responses to my earlier comments. I am satisfied with this revised version, and I think it is acceptable now.

Reviewer #2 (Remarks to the Author):

I thank the authors for their careful revisions, which have alleviated my initial points of concern. Now that they have clarified their main contributions to be both conceptual and methodological (both regarding the new distinction between tree vs non-tree vegetation), I am satisfied with the resulting discussion, which was initially lacking theoretical feedback or policy relevance. However, I am satisfied with the authors' decision to not take it in a concrete policy direction. The few points of weakness that could lead the discussion astray, in terms of implications (e.g. country focus on China, India and the United States), have been removed. Also, the areas for improvement (e.g. in future research, models, etc.) are included in the discussion, which elevates the scientific value beyond a technical report. I must declare that I cannot evaluate the quantitative models or statistical analyses, although the authors have identified novelty there.

Reviewer #3 (Remarks to the Author):

I am satisfied with the authors response and the changes made to the manuscript. The article is better situated in and connected to the current literature which helps support its overall aims.