Software Impacts 16 (2023) 100506

Contents lists available at ScienceDirect

Software Impacts

journal homepage: www.journals.elsevier.com/software-impacts

Original software publication

AID-PRIGSHARE: Automatization of indicator development in green space health research in QGIS. Accompanying script to the PRIGSHARE reporting guidelines

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ARTICLE INFO

Keywords:
Green space
Sensitivity analysis
Indicator
GIS
Script
Automatization

ABSTRACT

In the interdisciplinary field of green space health research, there is a demand to reduce the effort to assess green space, especially for non-spatial disciplines. To address this issue, we developed AID-PRIGSHARE, an open-source script that automates over 400 QGIS processes to substantially reduces the time-intensive task of generating green space indicators. AID-PRIGSHARE calculates greenness, public green space, access to green infrastructure, and green space uses within distances of 100–1500 m around geolocations. This substantially reduces the effort for sensitivity analysis and may provide support for research that aims to understand the impact of different green space features and distances on health outcomes.

Code metadata

Current code version	*v1.0.0*
Permanent link to code/repository used for this code version	https://github.com/SoftwareImpacts/SIMPAC-2023-129
Permanent link to reproducible capsule	
Legal code license	GPL-3.0license
Code versioning system used	*Semantic Versioning Specification*
Software code languages, tools and services used	*Graphical Modeler in QGIS 3.22*
Compilation requirements, operating environments and dependencies	*QGIS 3.12 and above*
If available, link to developer documentation/manual	https://github.com/mcardinali-data/AID-PRIGSHARE/blob/main/README.md
Support email for questions	m.cardinali@tudelft.nl

1. Introduction

In quantitative research on the effects of green spaces on behavior, physical health, and mental health, researchers rely heavily on spatial indicators. Especially for the non-spatial disciplines, processing these spatial data is a significant hurdle for their research [1]. Furthermore, it is still largely unclear which distances and aspects of green spaces are relevant for the different impact pathways [1]. To this date, researchers often rely on artificial distances (often 300 m or 500 m) justified by policy documents, mostly independent of the pathway studied [2]. It is however likely that both the distance and aspect of green space that drives the assumed impact, differ significantly between pathways [3]. In the *Mitigation* pathway, the main aspect seems to be the potential of vegetation to reduce environmental stressors [4–7]. In the *Restoration* pathway, it is assumed that contact with nature triggers recreational function and stress reduction [8]. In the *Instoration* pathway, the inviting character of publicly accessible green spaces is theorized to increase physical activity and social exchange [9,10]. Sensitivity analyses that test different distances and green space indicators are therefore an important element for the research field [2,11]. To significantly reduce the effort required for this and to make it easier for non-spatial disciplines in particular, we have developed AID-PRIGSHARE [12]. AID-PRISGHARE is an open-source script that allows researchers to automatically generate a variety of green space indicators at several distances with minimal effort.

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https://doi.org/10.1016/j.simpa.2023.100506
Received 3 April 2023; Received in revised form 22 April 2023; Accepted 24 April 2023

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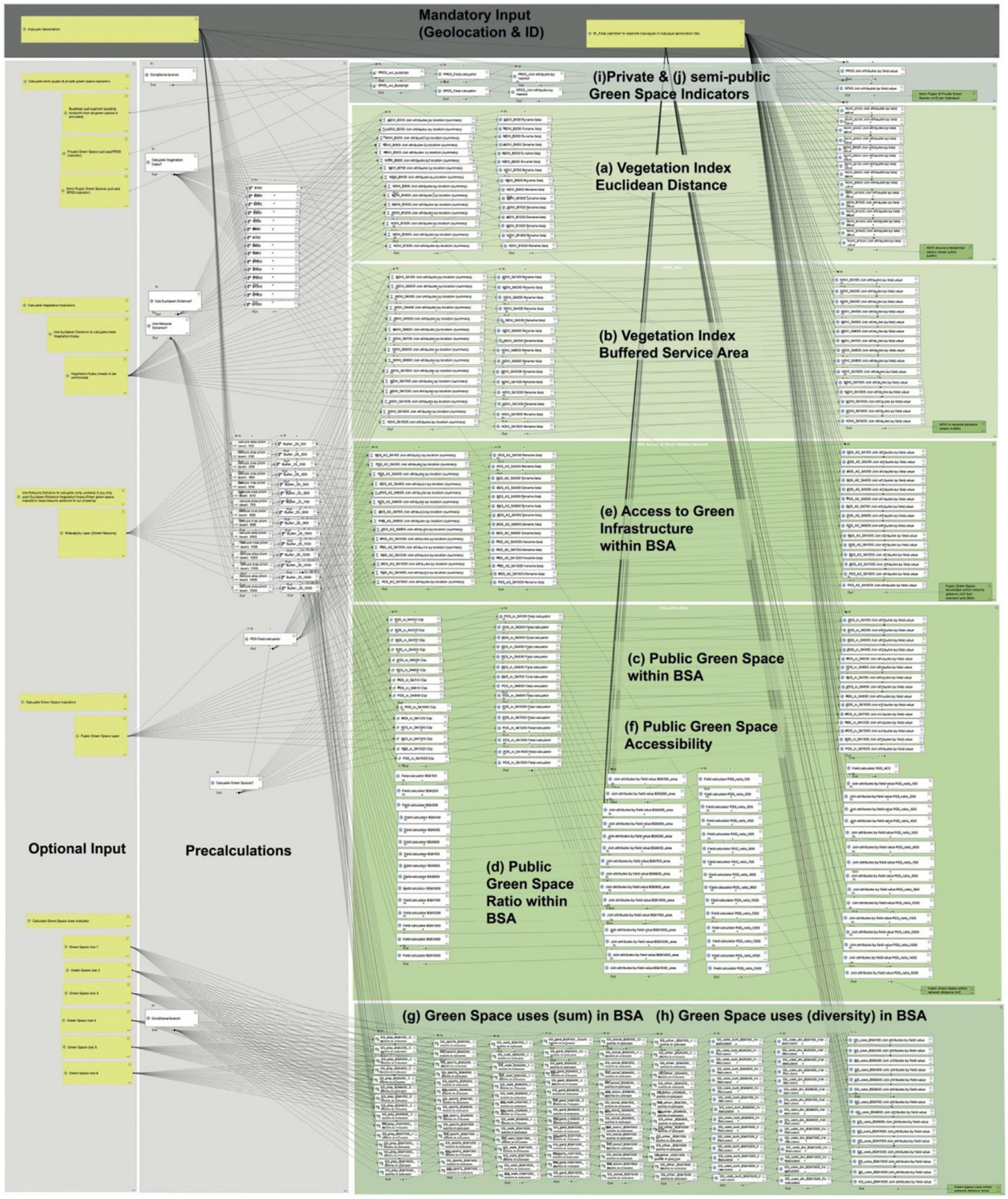

Fig. 1. Graphical overview of the model. A high-resolution image can be viewed at the GitHub repository [12].

2. Software features & architecture

AID-PRIGSHARE was developed within QGIS v3.22 [13] with the graphical modeler feature to automate specific repetitive processes that are necessary to compare different indicators and/or different buffers. Next to Euclidean buffers, 25 m buffered service areas (BSA) to calculate network distances are available. BSA are a more precise version of network distances, especially for smaller distances [14]. The algorithm will calculate the chosen indicators for distances between 100 m and 1500 m with 100 m increments. AID-PRIGSHARE allows the user to choose which of the following green space indicators should be generated by the algorithm:

(a) Mean vegetation index (e.g. NDVI) in Euclidean distance (−1 to 1)
(b) Mean vegetation index (e.g. NDVI) in BSA (−1 to 1)
(c) The amount of public green space within BSA (m^2)
(d) Public green space ratio (public green space/total buffer area) within BSA (0-1)
(e) Access to green infrastructure within BSA (m^2)
(f) Distance to the nearest public green space (rounded in steps of 100 m)
(g) The amount of green space uses (playgrounds, sports fields, gardening,..) within BSA (number)
(h) Diversity of green space uses within network distance (number)
(i) The amount of private green space of an individual (m^2))
(j) The amount of semi-public green space of an individual (m^2)

The architecture of the script combines the necessary steps to generate a specific indicator in a task chain that is repeated for every distance. See Fig. 1 for a graphical overview of the algorithm and Fig. 2 for the specific tasks chained together to generate the individual green space indicators. Next to the mandatory input of the geolocation of points (e.g. the home address of an individual surveyed) and corresponding ID field, the input is optional and depends on the requested tasks. The script uses Boolean operators to indicate which tasks should be performed. To reduce computation time, the script makes use of intermediate results and reuses them to create additional indicators.

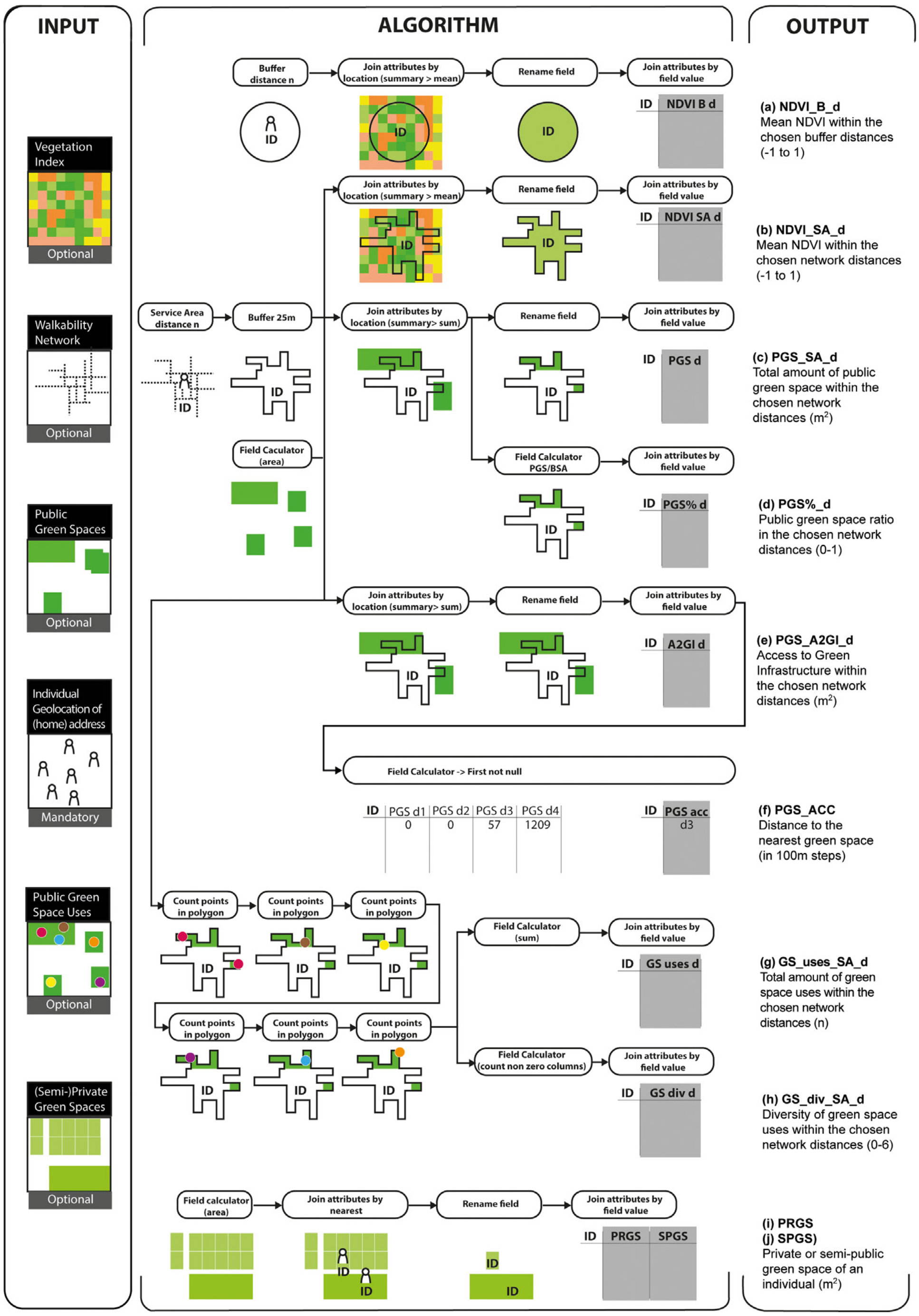

Fig. 2. Left to right flow diagram with specific tasks performed by the algorithm, depending on the user input.

3. Software demonstration with case study

Figs. 3, 4, and 5 demonstrate the application of the tool in a case study in Nantes Nord, France. In the first step, the necessary input layers were generated. The vegetation index is based on modified Copernicus Sentinel data [2019] processed by Sentinel Hub [15]. The spatial layers were downloaded from OpenStreetMap [16]. All layers have been checked individually for bias with the PRIGSHARE Reporting Guidelines [3]. The spatial data should cover an area at least 1500 m larger than the outermost points of the address layer as seen in Fig. 3 to cover accessibility within 1500 m. Then the AID-PRIGSHARE.model3 file can be executed from the browser panel within QGIS which will open the input mask (Fig. 4). After deciding on the indicators to be generated via the checkboxes and providing all necessary layers for those tasks below the accompanying checkbox, the script can be executed. For the approximately 400 addresses of this case study, the script will take about 8 hours to run. The computation time varies by the number of observations, spatial spread, and available computational power. The script adds the indicators requested to the attribute table of the geolocation layer. It will generate a new layer for every indicator, but not for every distance. See Fig. 5 for an example output of mean NDVI within Euclidean Distance.

4. Software impacts

The software paper presents “AID-PRIGSHARE”, a free and open-source script for QGIS. Our tool automates and combines over 400 steps to generate a variety of green space indicators, for multiple types of

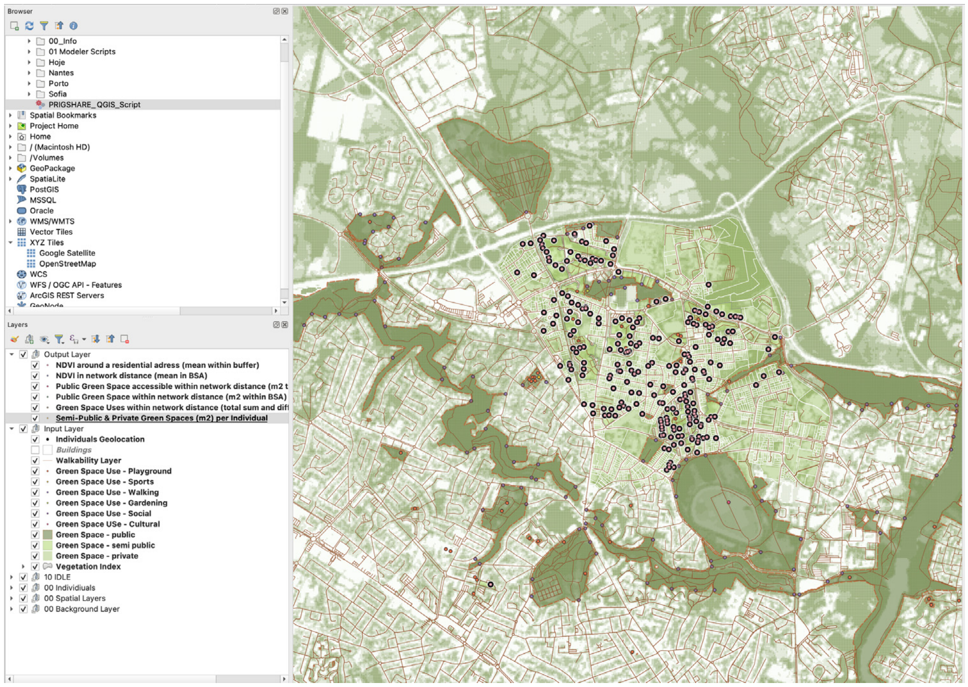

Fig. 3. Input layers of case study in Nantes Nord (France), after the risk of bias assessment with PRIGSHARE Reporting Guidelines [3].

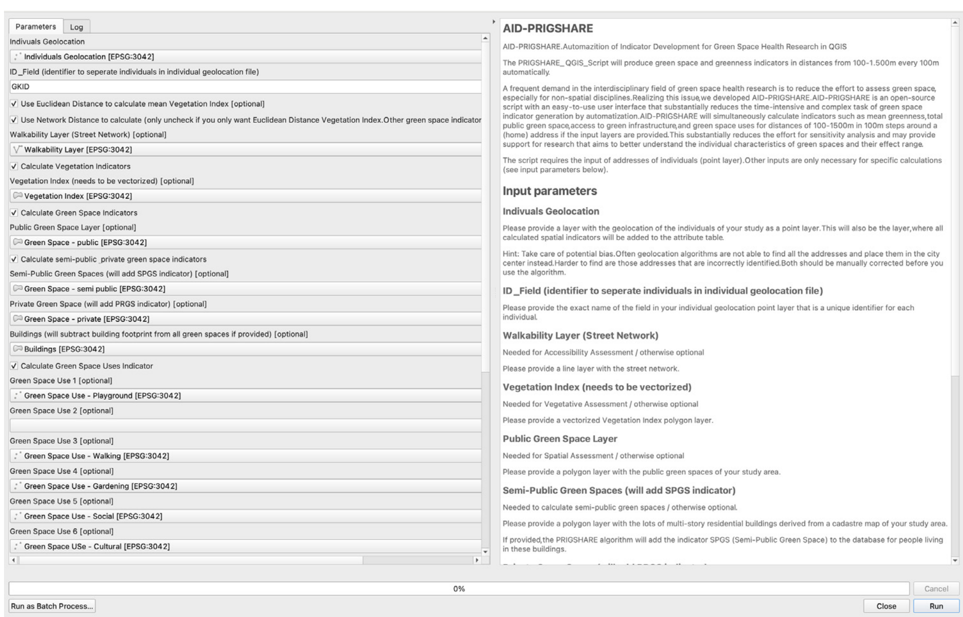

Fig. 4. User Interface with input mask on the left side and additional information on the right side.

indicators and distances ranging from 100 m to 1500 m, every 100 m in one algorithm (see Fig. 1). Currently, the required expert knowledge, the sheer amount of tasks, and the computation time that needs to be performed to be able to do a sensitivity analysis is a barrier in the field, especially for non-spatial disciplines [1]. In light of these challenges, AID-PRIGSHARE offers a promising solution. AID-PRIGSHARE has the potential to significantly impact the research field of green space and health by enabling a feasible spatial sensitivity analysis. This drastically reduces the effort needed to calculate these indicators and makes it feasible for researchers:

– to compare different types of green space indicators
– to analyze the area of effect of green space indicators on health outcomes by comparing different buffer sizes
– to make the variance visible that derives from chosen buffer types and distances

AID-PRIGSHARE is designed to be user-friendly and accessible. Especially for non-spatial disciplines and improve access to spatial indicators for research. It is designed in a way so that it can be executed by users with little prior knowledge. Although the validity of the output will depend on the validity of the input [3]. It has the potential to lead to a more interdisciplinary approach to research in this field, which can result in more comprehensive and nuanced findings. In

	NDVI_B100	NDVI_B200	NDVI_B300	NDVI_B400	NDVI_B500	NDVI_B600	NDVI_B700	NDVI_B800
1	0,492463	0,468375	0,442931	0,447288	0,436569	0,430593	0,42714	0,42044
2	0,438977	0,40252	0,42101	0,453189	0,45289	0,426027	0,412984	0,408015
3	0,485601	0,48124	0,486096	0,480122	0,483087	0,487096	0,494744	0,491576
4	0,432794	0,392449	0,404973	0,431058	0,433706	0,430832	0,423256	0,414912
5	0,443667	0,416935	0,41648	0,439237	0,447368	0,42063	0,413073	0,413965
6	0,310038	0,349382	0,366512	0,353851	0,357086	0,383131	0,403329	0,41776
7	0,401946	0,422735	0,407544	0,424974	0,438331	0,420339	0,413399	0,409444
8	0,39036	0,39566	0,416393	0,424684	0,418702	0,425033	0,433502	0,436218
9	0,428362	0,419548	0,451478	0,480274	0,484922	0,485493	0,48473	0,489685
10	0,393031	0,437821	0,474968	0,465815	0,43922	0,42288	0,417442	0,412487
11	0,442096	0,453203	0,439218	0,427341	0,419369	0,416371	0,42343	0,440111
12	0,442096	0,453203	0,439218	0,427341	0,419369	0,416371	0,42343	0,440111
13	0,586902	0,48245	0,477863	0,470323	0,47441	0,483796	0,496173	0,507818
14	0,378746	0,402897	0,428827	0,441332	0,450149	0,444894	0,435867	0,427007
15	0,452667	0,412946	0,401189	0,396603	0,412824	0,418146	0,412086	0,416379
16	0,356176	0,404328	0,3926	0,403978	0,424964	0,431515	0,432459	0,429138
17	0,455978	0,473154	0,443342	0,430347	0,431489	0,437504	0,441467	0,447785
18	0,404417	0,43149	0,463156	0,46626	0,444848	0,43077	0,420447	0,416718
19	0,4392	0,437366	0,471177	0,471074	0,442566	0,432621	0,418458	0,416017
20	0,413591	0,487187	0,494847	0,469246	0,433049	0,417642	0,416141	0,434344

	NDVI_B900	NDVI_B1000	NDVI_B1100	NDVI_B1200	NDVI_B1300	NDVI_B1400	NDVI_B1500
1	0,427555	0,440249	0,459879	0,476341	0,485412	0,498735	0,513067
2	0,415936	0,429087	0,443028	0,465248	0,484622	0,505043	0,516083
3	0,499902	0,505365	0,509256	0,514975	0,518513	0,520318	0,522964
4	0,417736	0,431101	0,452119	0,471206	0,485605	0,491317	0,495025
5	0,420268	0,434489	0,44748	0,465008	0,485399	0,504513	0,512025
6	0,433213	0,450741	0,466501	0,475012	0,481171	0,490018	0,497893
7	0,41391	0,423013	0,44375	0,465626	0,482525	0,500034	0,513336
8	0,443353	0,455093	0,466202	0,478073	0,482432	0,488602	0,498126
9	0,48946	0,491159	0,498833	0,505942	0,514529	0,522752	0,529647
10	0,419968	0,437839	0,457618	0,477343	0,486871	0,49021	0,491062
11	0,454376	0,462546	0,464987	0,471414	0,481145	0,489606	0,49945
12	0,454376	0,462546	0,464987	0,471414	0,481145	0,489606	0,49945
13	0,512137	0,50572	0,501596	0,500109	0,500976	0,500483	0,500753
14	0,42706	0,438637	0,454453	0,46782	0,483507	0,487591	0,487789
15	0,417281	0,425926	0,446445	0,465472	0,479786	0,495757	0,508361
16	0,431537	0,437263	0,451099	0,464541	0,475883	0,489132	0,494254
17	0,450396	0,459366	0,466374	0,48088	0,498808	0,515104	0,522671
18	0,419157	0,433878	0,457298	0,477687	0,485249	0,488246	0,489979
19	0,429872	0,445112	0,457169	0,469781	0,492683	0,508537	0,517208
20	0,453404	0,468581	0,475422	0,480129	0,482211	0,484058	0,485812

Fig. 5. Automated Indicator Generation of the AID-PRIGSHARE Open-Source Script with the input data from Nantes Nord (France).

addition, it might also enable post-hoc sensitivity analysis of already published studies to further explore the robustness of those findings and contribute to reducing and explaining the current heterogeneity in findings in green space health research. Overall, AID-PRIGSHARE has the potential to greatly benefit the research field of green space and health by streamlining research processes and facilitating interdisciplinary collaboration.

While AID-PRIGSHARE offers many benefits, it is important to also consider its current limitations. Currently, it is not possible to ask the algorithm to calculate only specific distances. Due to the approach using the graphical modeler, the software cannot make use of functions and loops which limits its capabilities and efficiency. In addition, there might be several other indicators worth exploring, that are not yet part of the algorithm. It is planned to add these features in future updates. Additionally, the software is on purpose not able to automatically download and preprocess the necessary input data, which might still be a hurdle for non-spatial experts. We decided to not integrate this feature, because this would lead to a risk that the necessary step of data verification of the green space data and its necessary adaptation to the research question could be skipped. The research field of green space health is known for a low signal-to-noise ratio [17]. Thus reducing the risk of bias and noise in the data set is a very important step in this field of research. For guidance in this process, we refer to the PRIGSHARE reporting guidelines [3].

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The work of Marcel Cardinali was supported by the European Union's Horizon 2020 research and innovation programme [grant number 776783]. The work of Mariëlle Beenackers was supported by the Netherlands Organization for Scientific Research (NWO) (grant number 09150161810158/VI.Veni.194.041) and the European Union's Horizon 2020 research and innovation programme (grant number 956780).

References

[1] I. Markevych, J. Schoierer, T. Hartig, A. Chudnovsky, P. Hystad, A. Dzhambov, S.de. Vries, M. Triguero-Mas, M. Brauer, M.J. Nieuwenhuijsen, G. Lupp, E.A. Richardson, T. Astell-Burt, D. Dimitrova, X. Feng, M. Sadeh, M. Standl, J. Heinrich, E. Fuertes, Exploring pathways linking greenspace to health: Theoretical and methodological guidance, Environ. Res. 158 (2017) 301–317, http://dx.doi.org/10.1016/j.envres.2017.06.028.

[2] S.M. Labib, S. Lindley, J.J. Huck, Spatial dimensions of the influence of urban green-blue spaces on human health: A systematic review, Environ. Res. 180 (2020) 108869, http://dx.doi.org/10.1016/j.envres.2019.108869.

[3] M. Cardinali, M.A. Beenackers, A. van Timmeren, U. Pottgiesser, Preferred reporting items in green space health research, guiding principles for an interdisciplinary field, Environ. Res. 228 (2023) 115893, http://dx.doi.org/10.1016/j.envres.2023.115893.

[4] M.H.E.M. Browning, A. Rigolon, O. McAnirlin, H.V. Yoon, Where greenspace matters most: A systematic review of urbanicity, greenspace, and physical health, Landsc. Urban Plan. 217 (2022) http://dx.doi.org/10.1016/j.landurbplan.2021.104233.

[5] T. Iungman, M. Cirach, F. Marando, E.Pereira. Barboza, S. Khomenko, P. Masselot, M. Quijal-Zamorano, N. Mueller, A. Gasparrini, J. Urquiza, M. Heris, M. Thondoo, M. Nieuwenhuijsen, Cooling cities through urban green infrastructure: A health impact assessment of European cities, Lancet 401 (10376) (2023) 577–589, http://dx.doi.org/10.1016/S0140-6736(22)02585-5.

[6] D.J. Nowak, S. Hirabayashi, A. Bodine, E. Greenfield, Tree and forest effects on air quality and human health in the United States, Environ. Pollut. 193 (2014) 119–129, http://dx.doi.org/10.1016/j.envpol.2014.05.028.

[7] T. Van Renterghem, Towards explaining the positive effect of vegetation on the perception of environmental noise, Urban For. Urban Green. 40 (2019) 133–144, http://dx.doi.org/10.1016/j.ufug.2018.03.007.

[8] G.N. Bratman, C.B. Anderson, M.G. Berman, B. Cochran, S.de. Vries, J. Flanders, C. Folke, H. Frumkin, J.J. Gross, T. Hartig, P.H. Kahn, M. Kuo, J.J. Lawler, P.S. Levin, T. Lindahl, A. Meyer-Lindenberg, R. Mitchell, Z. Ouyang, J. Roe, et al., Nature and mental health: An ecosystem service perspective, Sci. Adv. 5 (7) (2019) http://dx.doi.org/10.1126/sciadv.aax0903.

[9] L. Van Hecke, A. Ghekiere, J. Veitch, D. Van Dyck, J. Van Cauwenberg, P. Clarys, B. Deforche, Public open space characteristics influencing adolescents' use and physical activity: A systematic literature review of qualitative and quantitative studies, Health Place 51 (2018) 158–173, http://dx.doi.org/10.1016/j.healthplace.2018.03.008.

[10] C. Wan, G.Q. Shen, S. Choi, Underlying relationships between public urban green spaces and social cohesion: A systematic literature review, City, Culture Soc. (24) (2021) http://dx.doi.org/10.1016/j.ccs.2021.100383.

[11] Z. Davis, M. Guhn, I. Jarvis, M. Jerrett, L. Nesbitt, T. Oberlander, H. Sbihi, J. Su, M. van den Bosch, The association between natural environments and childhood mental health and development: A systematic review and assessment of different exposure measurements, Int. J. Hygiene Environ. Health 235 (May) (2021) http://dx.doi.org/10.1016/j.ijheh.2021.113767.

[12] M. Cardinali, M. Beenackers, A. van Timmeren, U. Pottgiesser, AID-PRIGSHARE (v1.0.0), 2023, http://dx.doi.org/10.5281/zenodo.7794368, [Python; QGIS 3.22].

[13] QGIS Development Team, QGIS Geographic Information System, 2023, QGIS Association. https://www.qgis.org.

[14] L.D. Frank, E.H. Fox, J.M. Ulmer, J.E. Chapman, S.E. Kershaw, J.F. Sallis, T.L. Conway, E. Cerin, K.L. Cain, M.A. Adams, G.R. Smith, E. Hinckson, S. Mavoa, L.B. Christiansen, A.A.F. Hino, A.A.S. Lopes, J. Schipperijn, International comparison of observation-specific spatial buffers: Maximizing the ability to estimate physical activity, Int. J. Health Geogr. 16 (1) (2017) 1–13, http://dx.doi.org/10.1186/s12942-017-0077-9.

[15] European Space Agency, Contains modified Copernicus Sentinel data [2019] processed by Sentinel Hub, https://scihub.copernicus.eu/dhus/#/home, 2021.

[16] OpenStreetMap contributors, Planet dump retrieved from, 2017, https://planet.osm.org, https://www.openstreetmap.org.

[17] T. Hartig, R. Mitchell, S. de Vries, H. Frumkin, Nature Health 35 (1) (2014) 207–228, http://dx.doi.org/10.1146/annurev-publhealth-032013-182443.