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Supplementary Material

Filling in the spaces: Compactifying cities towards accessibility and active transport

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1. Evaluation of active travel probability

Evaluation of active travel probability from origin-to-destination (OD) follows the methodology of [1]. The discussion below summarizes the methodology and follows that reference closely. Based on the OD distance, a probability for carrying out the trip in active mode, i.e., either by walking or cycling, is calculated as follows.

First, trip probability for individual walking and cycling modes is modelled via a log-logistic distribution:

$$p(x) = \frac{1}{1 + \exp(a + b \ln x)} \quad (1)$$

where a, b are parameters and x the network distance for the respective travel mode. Log-logistic parameter values depend on destination type and can be obtained indirectly from the negative exponential law for the walk mode of Yang and Diez-Roux [2] by calculating the distances for which the Yang and Diez-Roux law yields 10% and 90% walk probabilities, inserting these benchmarks in eq. (1), and solving for a, b for each destination type. This yields the parameters shown in Table S1 below. Trip probabilities for the cycling mode are derived assuming that users typically spend a similar time buffer in cycling trips as in walking trips [3]. However, since the distance ridden by a bicycle is longer due to its higher speed, the effect on (1) is that, for cycling, the trip probability is given simply by changing the distance by $x \to x \cdot \frac{v_{\text{walk}}}{v_{\text{cycle}}}$. Using the walking speed of Tobler [4] and cycling speed of Parkin and Rotheram [5] yields a ratio of circa $\frac{v_{\text{walk}}}{v_{\text{cycle}}} \approx 0.233$.

The second step in obtaining an active trip probability requires combining walking and cycling probabilities into one single probability. This is done considering three distance regimes: short, long, and medium distances, defined respectively as distances for which walk probability < 50%, < 10%, and in-between [1]. For short distances one has the choice to either walk or use a bicycle and the active trip probability, p_{A}, can be modeled by $p_{\text{A}} = 1 - (1 - p_{\text{W}})(1 - p_{\text{C}})$, with p_{W} and p_{C} obtained applying eq. (1) for distances x and $0.233x$ respectively, as prescribed above. Extending this reasoning for all distances would lead to an excessively optimistic trip probability for long distances [3,6], so in that the simplifying assumption is made that all active trips are done cycling. Finally, trips in the medium range are modelled by a linear interpolation between the short and long distance expressions. The mathematical expression for the unified active trip probability is given in eq. (2) below:

Table S1. Log-logistic parameters for walking.

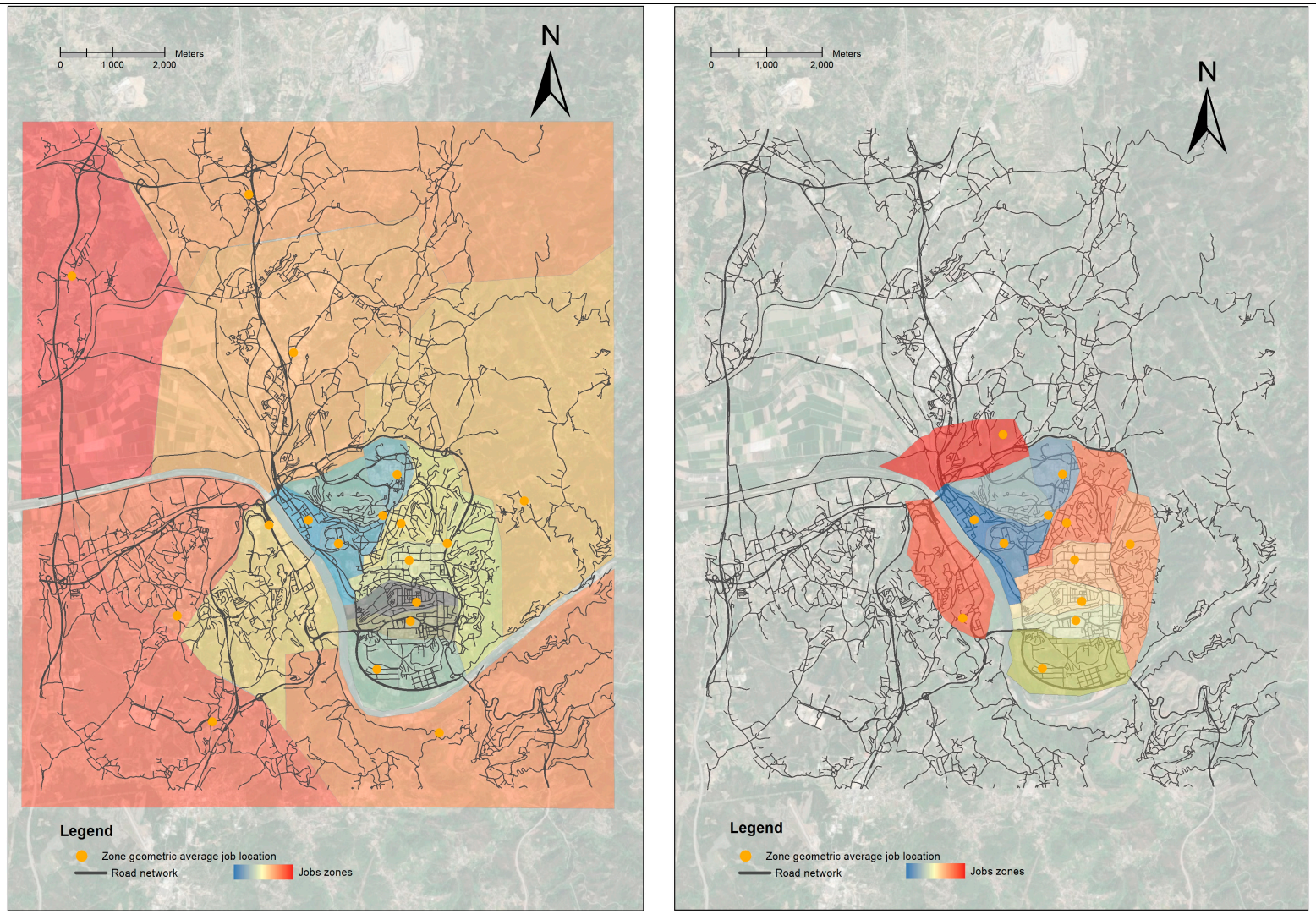
Destination type	a_j (distance: km)	b_j (distance: km)
Post offices	1.19225	1.83021
Sports facilities	0.05574	1.83013
Cultural organizations	1.00344	1.82990
Universities and institutes	1.07775	1.82989
Elderly care centres	1.19225	1.83021
Churches	1.00344	1.82990
High Schools	1.07775	1.82989
Shopping centres	1.19225	1.83021
Entertainment sites	1.00344	1.82990
Primary healthcare services	1.19225	1.83021
Pharmacies	1.19225	1.83021
Restaurants	1.46215	1.83009
Parks and green areas	1.00344	1.82990
Kindergartens	1.46215	1.83009
Primary schools	1.46215	1.83009
Middle Schools	1.46215	1.83009
Grocery stores	1.19225	1.83021
Supermarkets	1.19225	1.83021
Bakeries and pastries	1.46215	1.83009
Jobs	0.89627	1.83017

$$p_{\mathrm{A}}(x) = \begin{cases} 1-(1-p_{\mathrm{W}})(1-p_{\mathrm{C}}) & p_{\mathrm{W}} \geq 0.50 \\ p_{\mathrm{C}} + \dfrac{1-(1-p_{\mathrm{W}})(1-p_{\mathrm{C}})-p_{\mathrm{C}}}{0{,}5-0{,}1}(p_{\mathrm{W}}-0{,}1) & 0.10 \leq p_{\mathrm{W}} \leq 0.50 \\ p_{\mathrm{C}} & p_{\mathrm{W}} \leq 0.10 \end{cases} \quad (2)$$

Because p_{W} and p_{C} depend on destination type j, the active trip probability in the manuscript reads $p_{\mathrm{A}j}(x)$ to reflect this dependence. For further details and motivation, the reader is referred to [1].

References

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2. Yang Y., Diez-Roux A. (2012). Walking distance by trip purpose and population subgroups, American Journal of Preventive Medicine, 43, 11-9. https://doi.org/10.1016/j.amepre.2012.03.015
3. Ton, D., Duives, D., Cats, O., Hoogendoorn-Lanser, S. & Hoogendoorn, S. (2019). Cycling or walking? Determinants of mode choice in the Netherlands, Transportation Research Part A, 123, 7-23. https://doi.org/10.1016/j.tra.2018.08.023
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5. Parkin, J. & Rotheram, J. (2010). Design speeds and acceleration characteristics of bicycle traffic for use in planning, design and appraisal, Transport Policy, 5, 335-341. https://doi.org/10.1016/j.tranpol.2010.03.001
6. Rijsman, L., van Oort, N., Ton, D., Hoogendoorn, S., Molin E. & Teijl, T. (2019). Walking and bicycle catchment areas of tram stops: factors and insights, 2019 6th International Conference on Models and Technologies for Intelligent Transportation Systems (MT-ITS), pp. 1-5, https://doi.org/10.1109/MTITS.2019.8883361



(**a**) (**b**)

Figure S1. Job zones: (**a**) Coimbra; (**b**) Compact Coimbra.

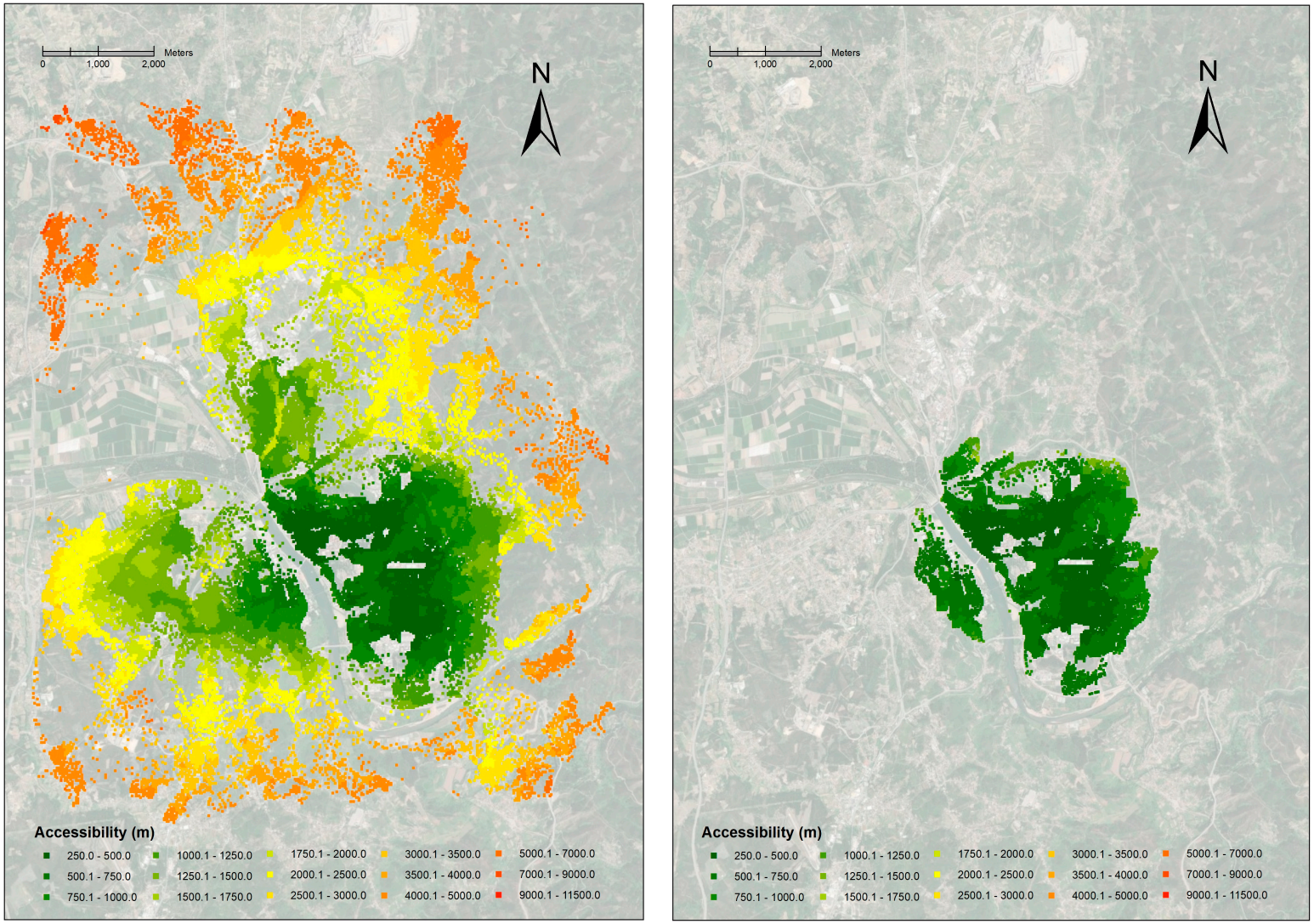


Figure S2. Accessibility to urban facilities (m): (**a**) Coimbra; (**b**) Compact Coimbra.

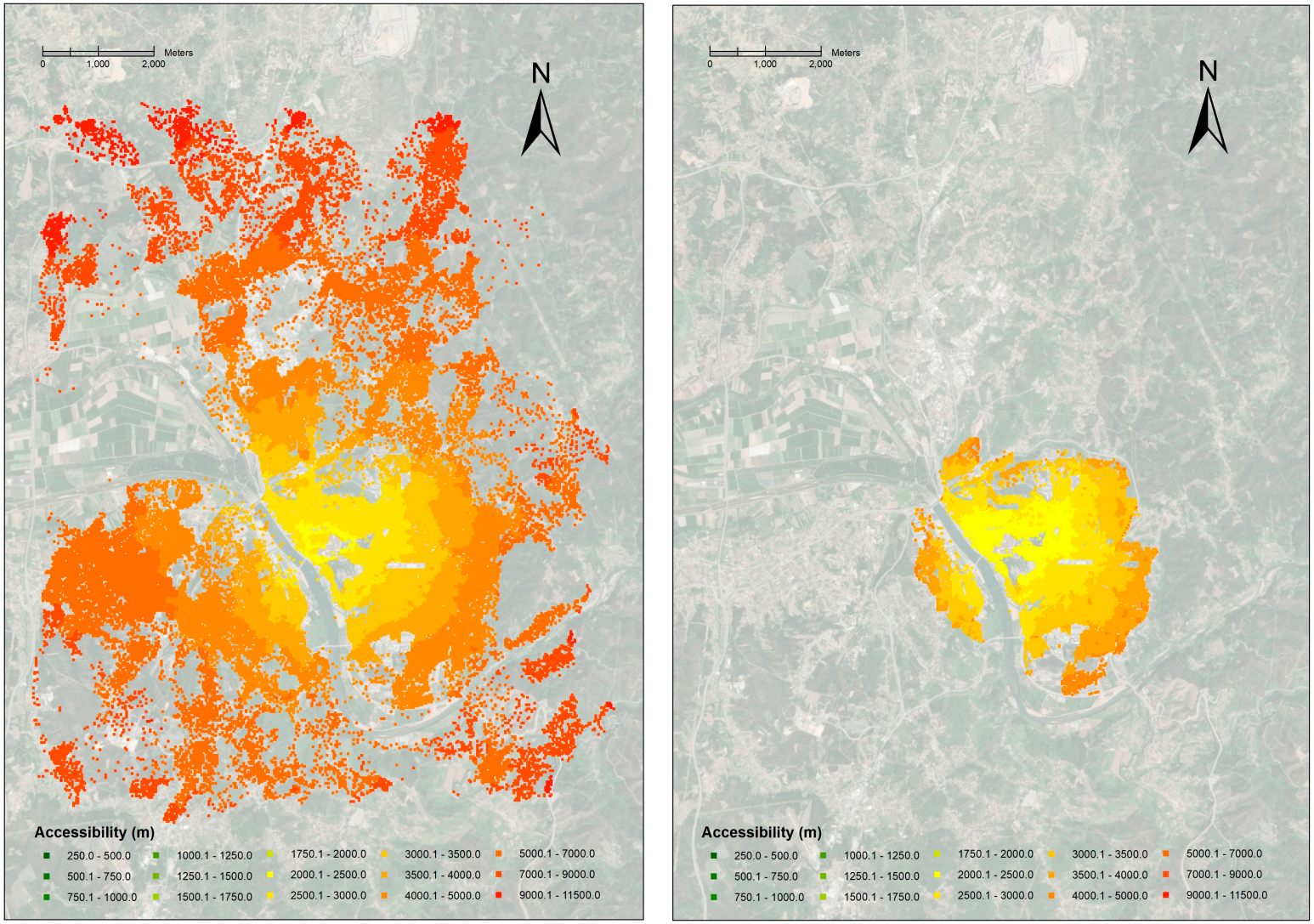
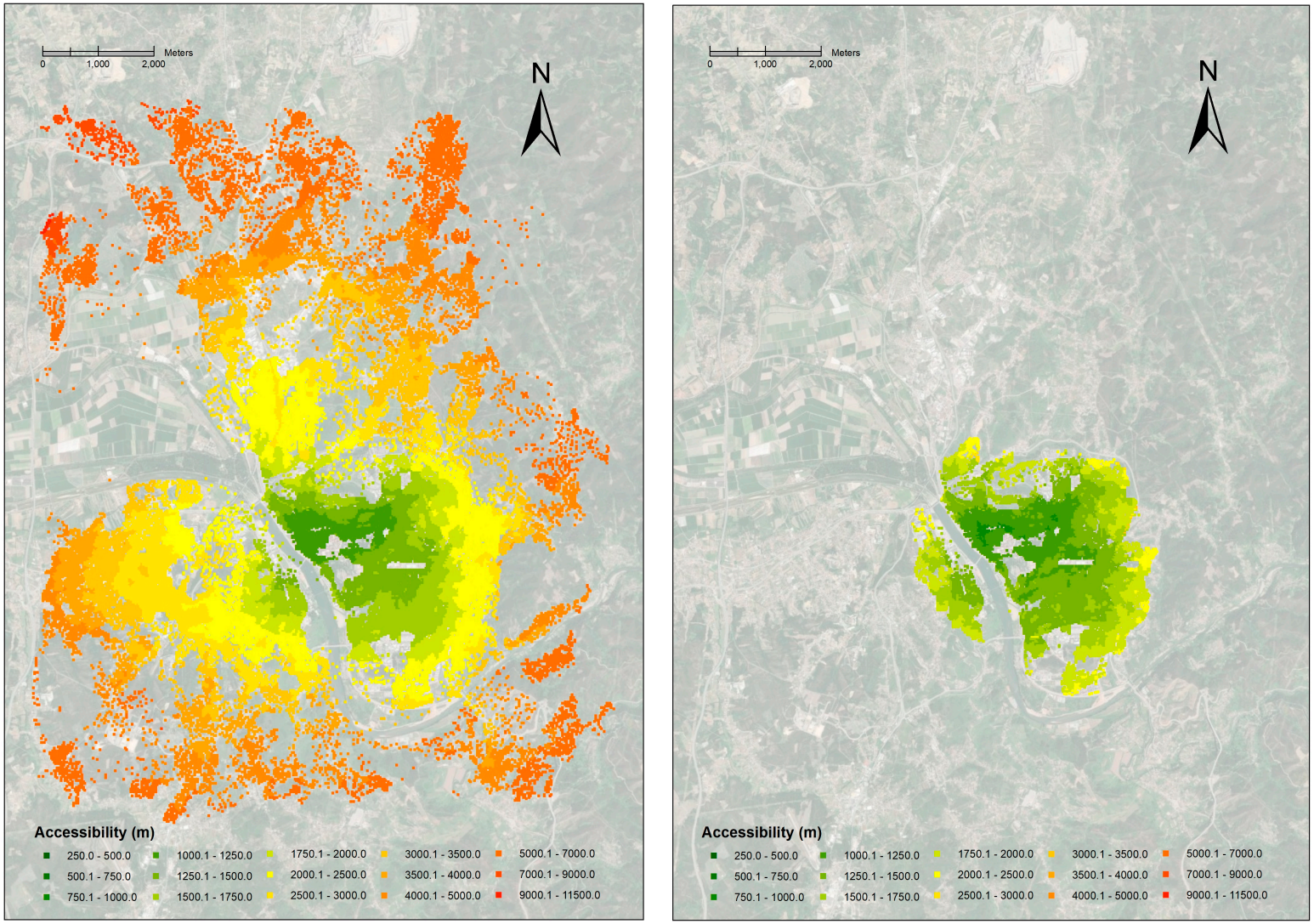


Figure S3. Accessibility to jobs (m): (**a**) Coimbra; (**b**) Compact Coimbra.



(**a**) (**b**)

Figure S4. Total accessibility [facilities plus jobs] (m): (**a**) Coimbra; (**b**) Compact Coimbra.

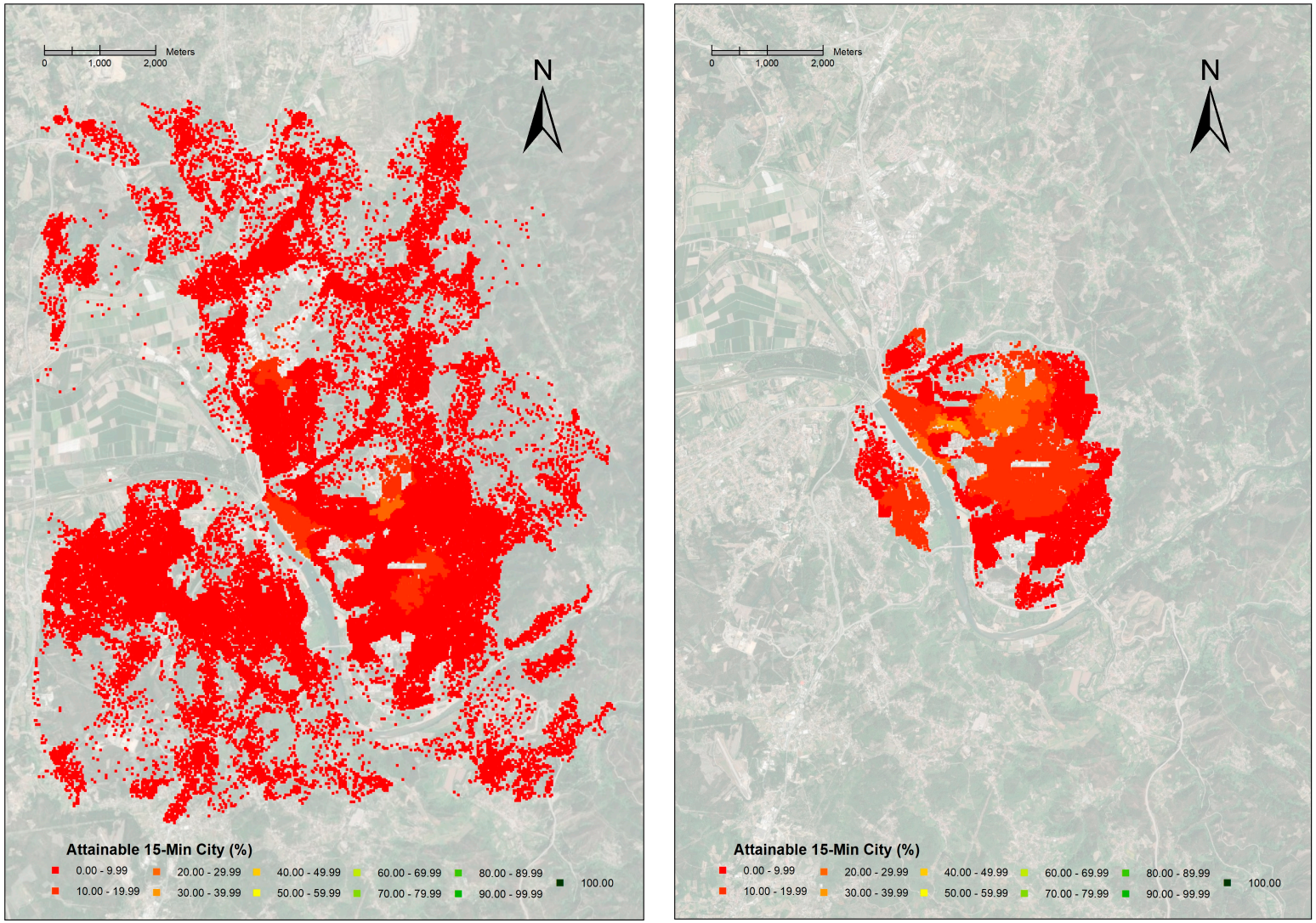


Figure S5. 15-Minute City by walking [jobs only] (%): (**a**) Coimbra; (**b**) Compact Coimbra.

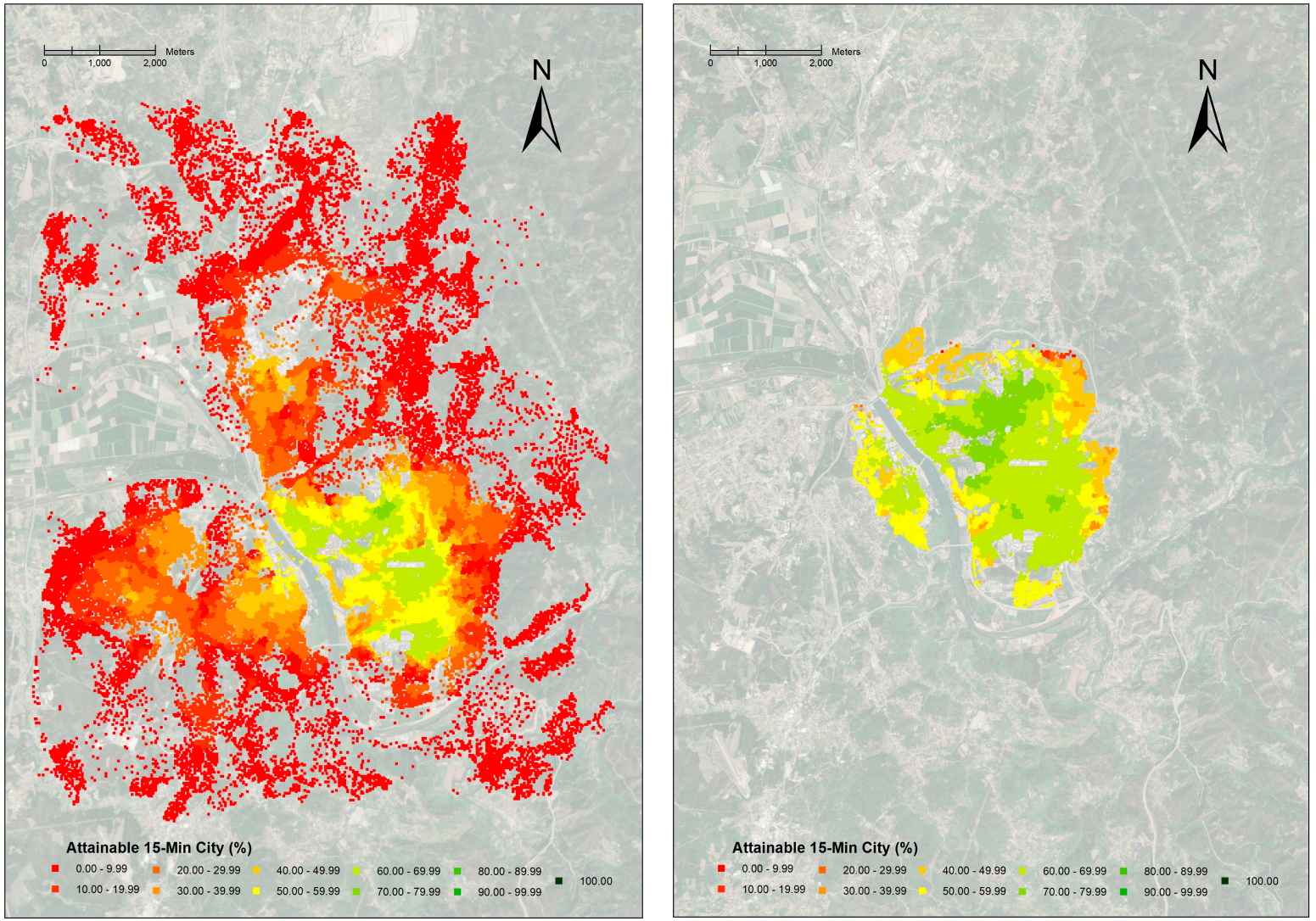
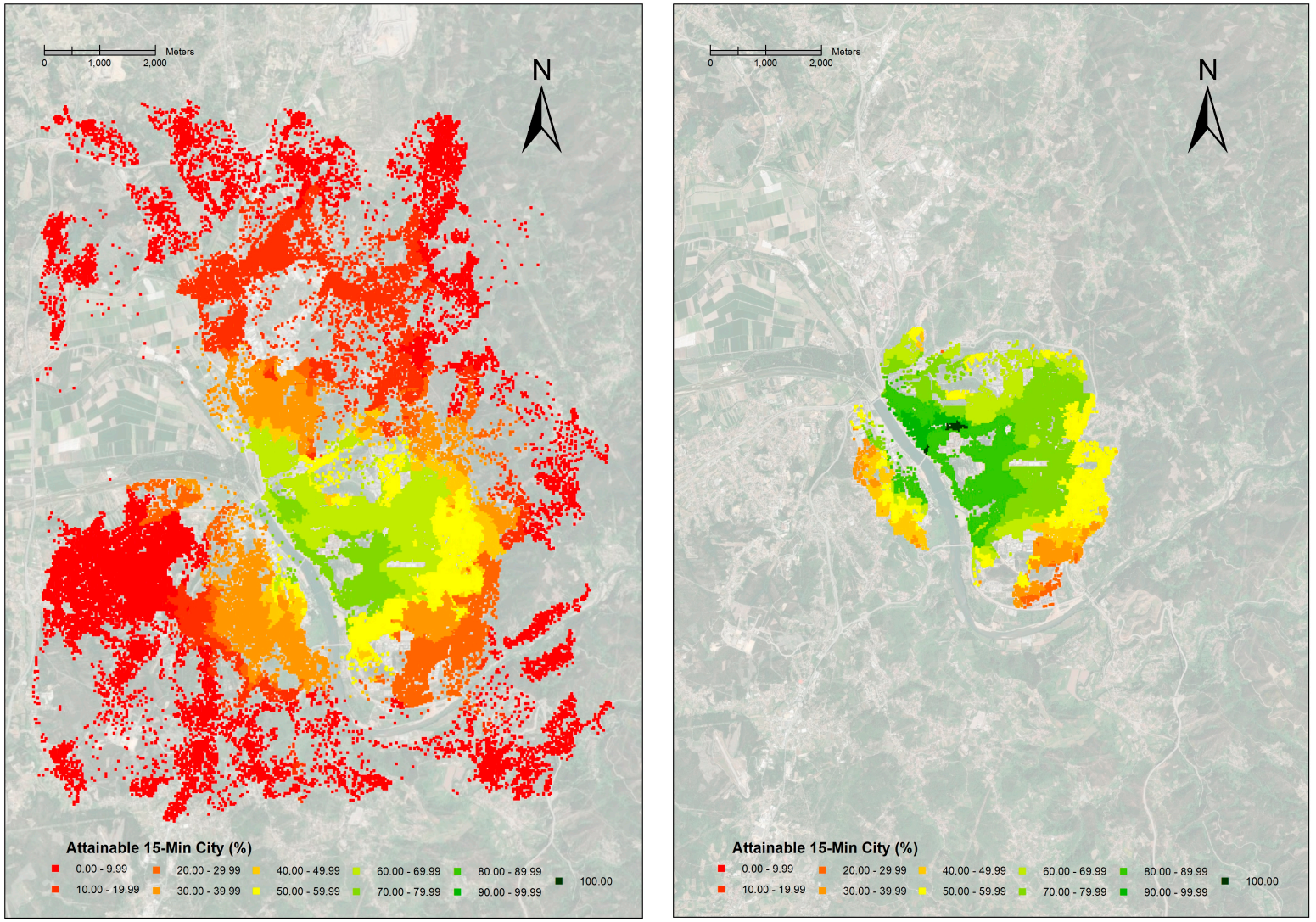


Figure S6. 15-Minute City by walking [facilities plus jobs] (%): (**a**) Coimbra; (**b**) Compact Coimbra.



(**a**) (**b**)

Figure S7. 15-Minute City by active modes (walking/cycling) [jobs only] (%): (**a**) Coimbra; (**b**) Compact Coimbra.

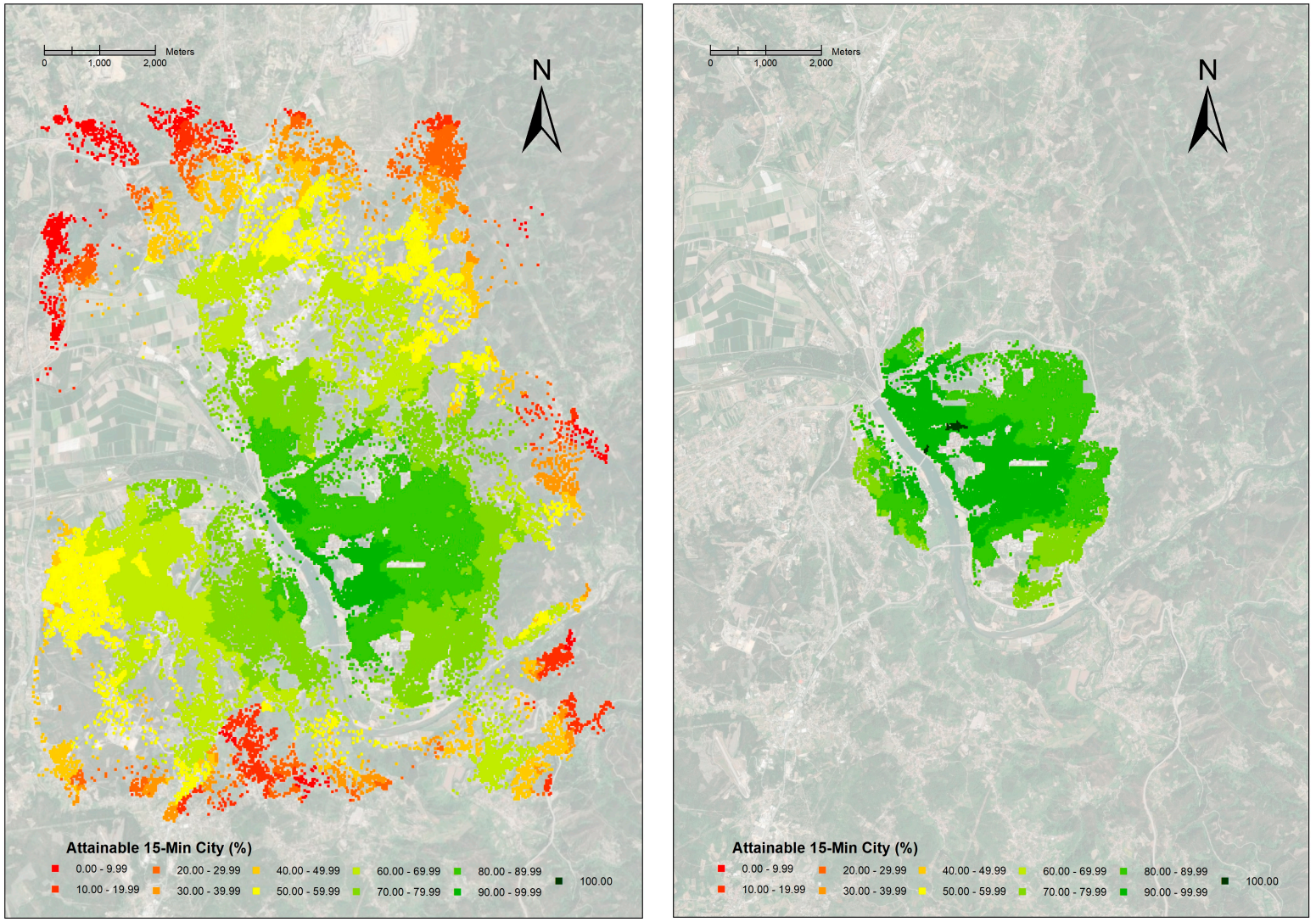


Figure S8. 15-Minute City by active modes (walking/cycling) [facilities plus jobs] (%): (**a**) Coimbra; (**b**) Compact Coimbra.

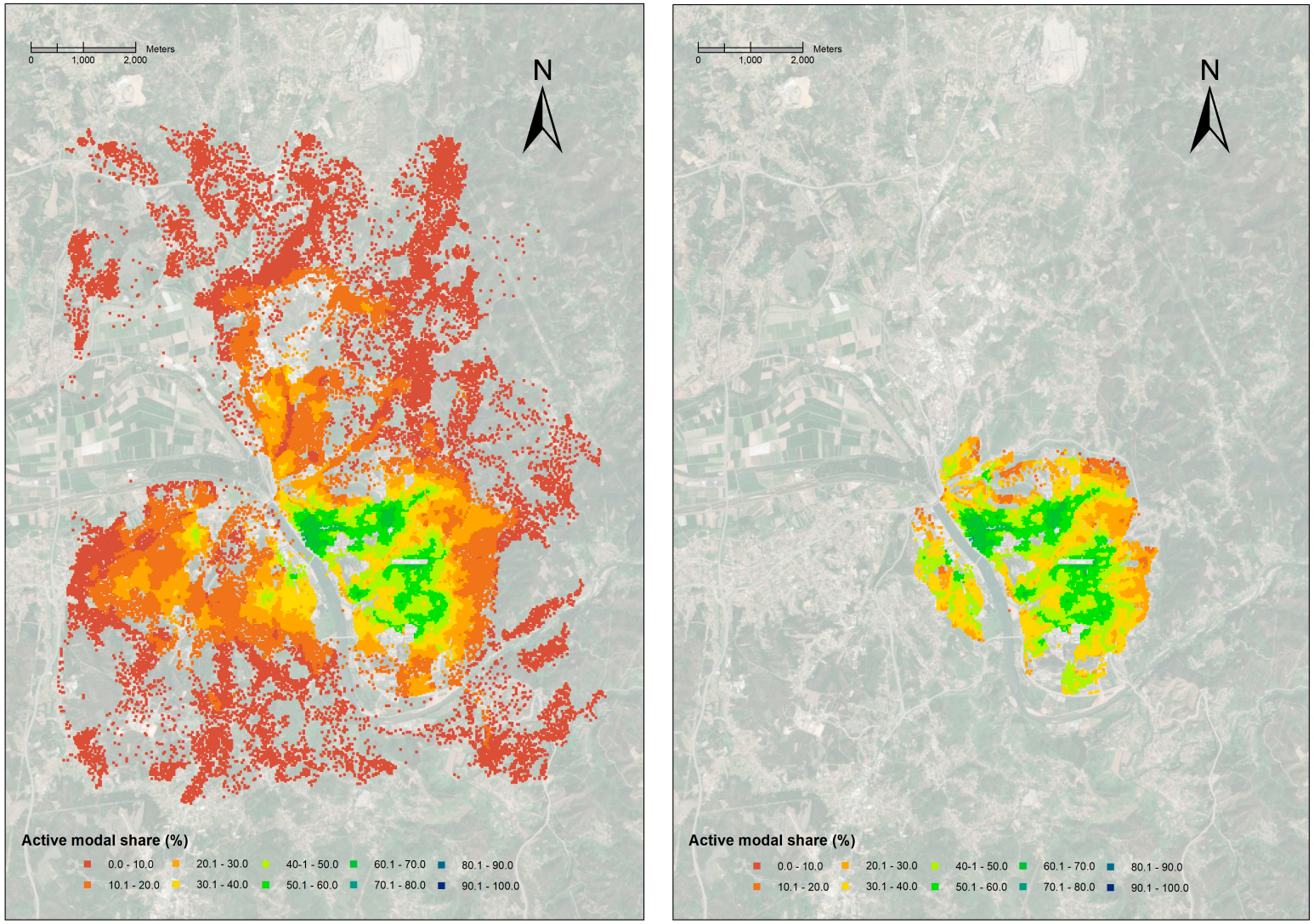


Figure S9. Walk modal share to facilities (%): (**a**) Coimbra; (**b**) Compact Coimbra.

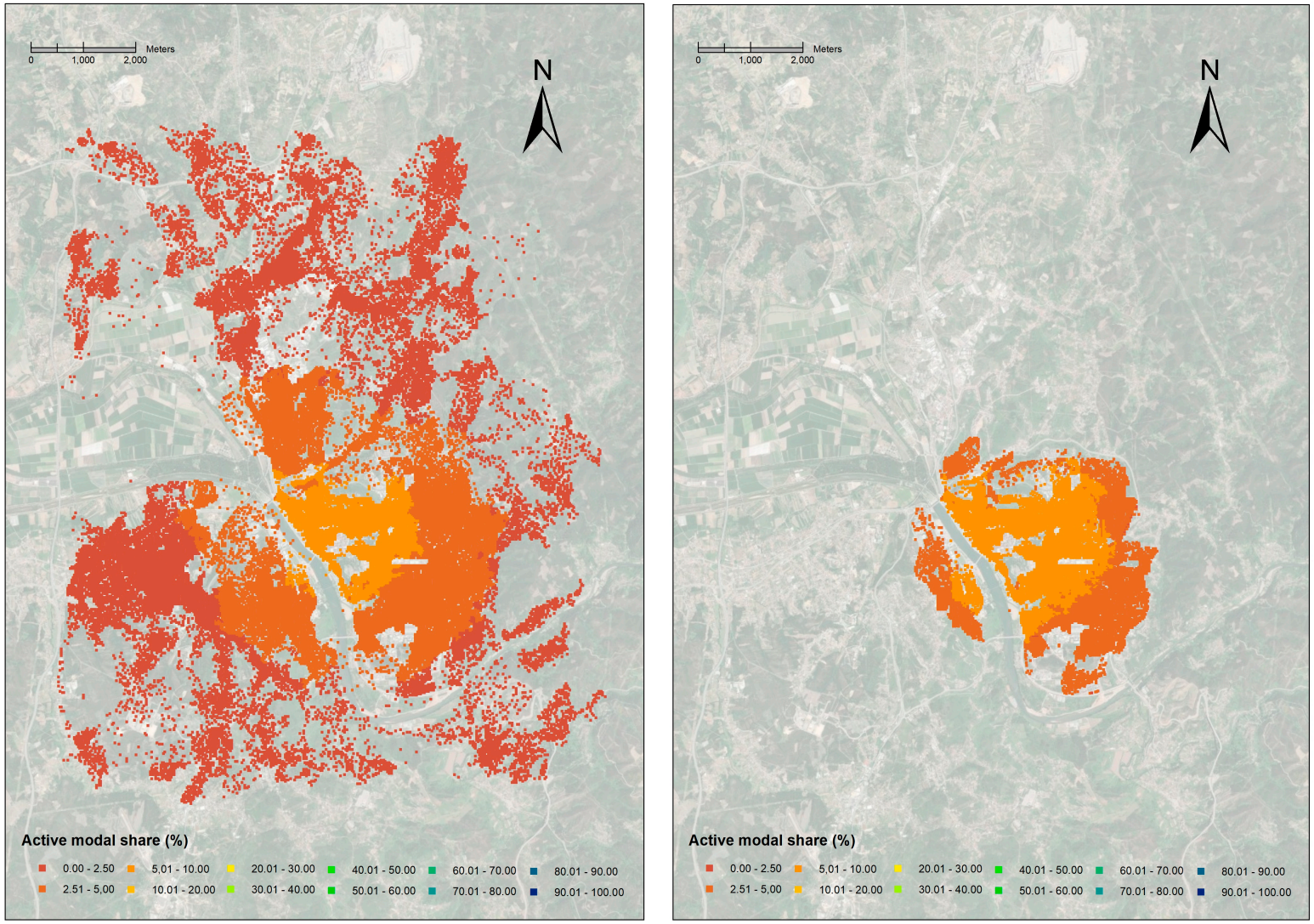
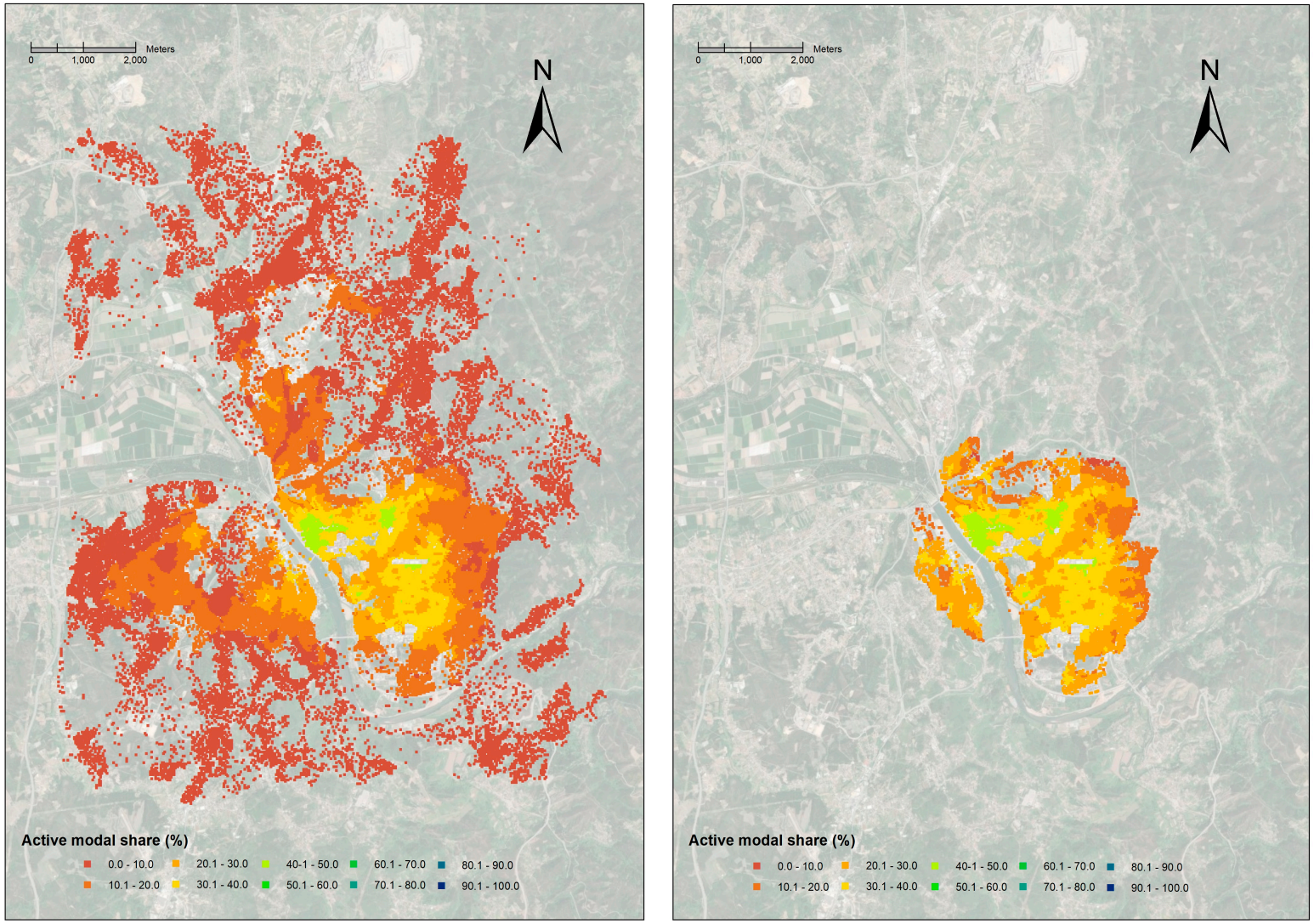
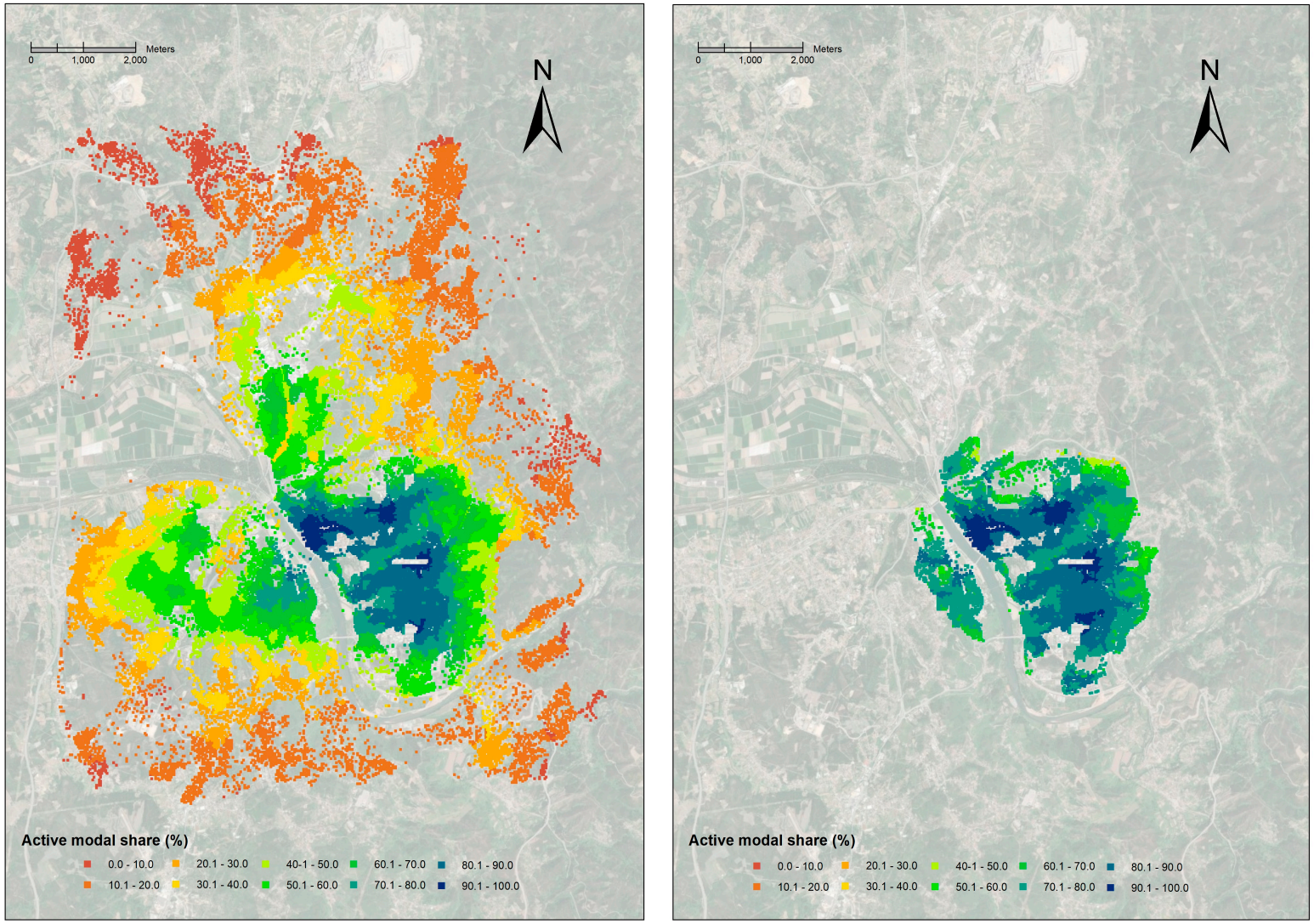


Figure S10. Walk modal share to jobs (%): (**a**) Coimbra; (**b**) Compact Coimbra.



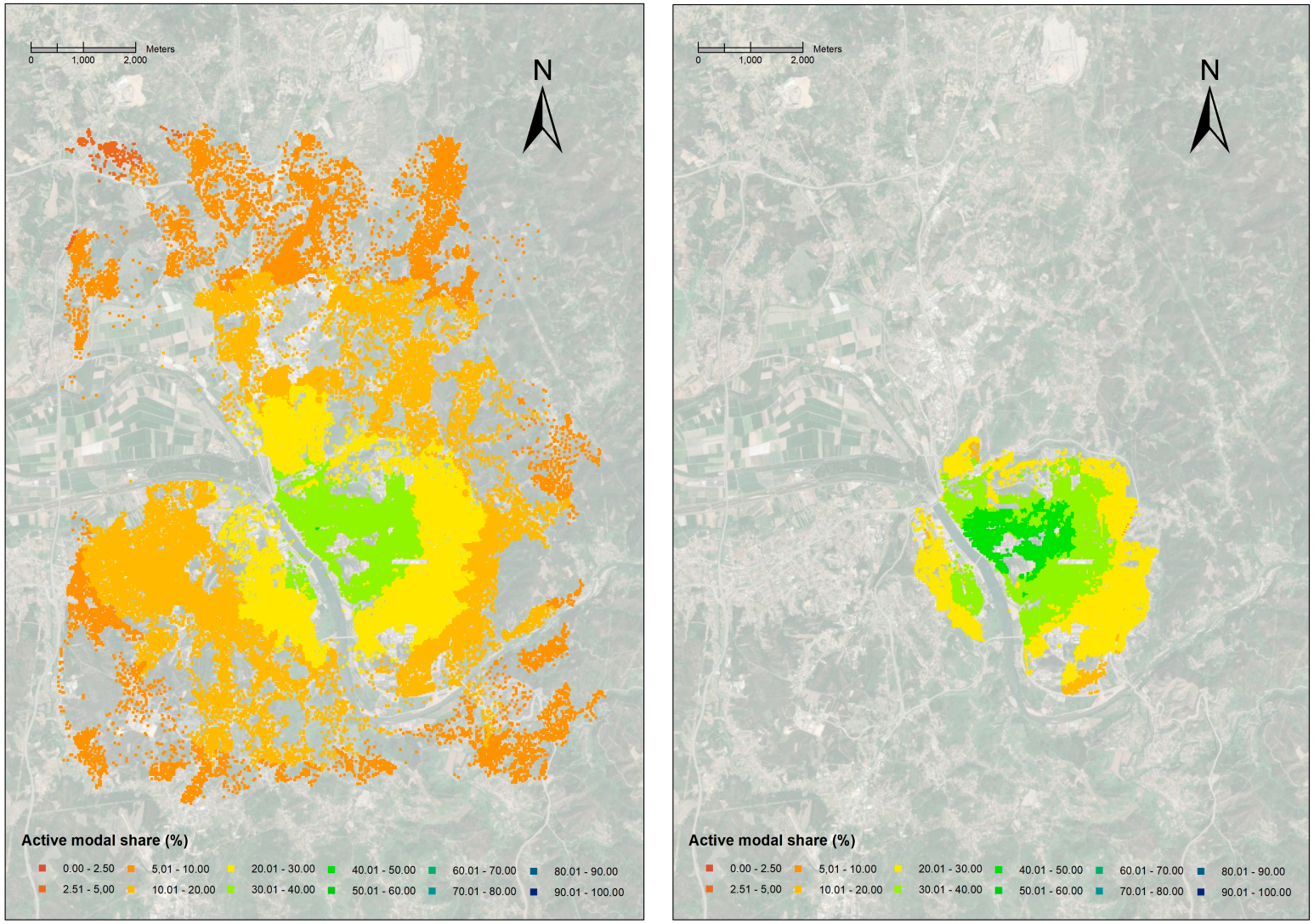
(**a**) (**b**)

Figure S11. Walk modal share to facilities plus jobs (%): (**a**) Coimbra; (**b**) Compact Coimbra.



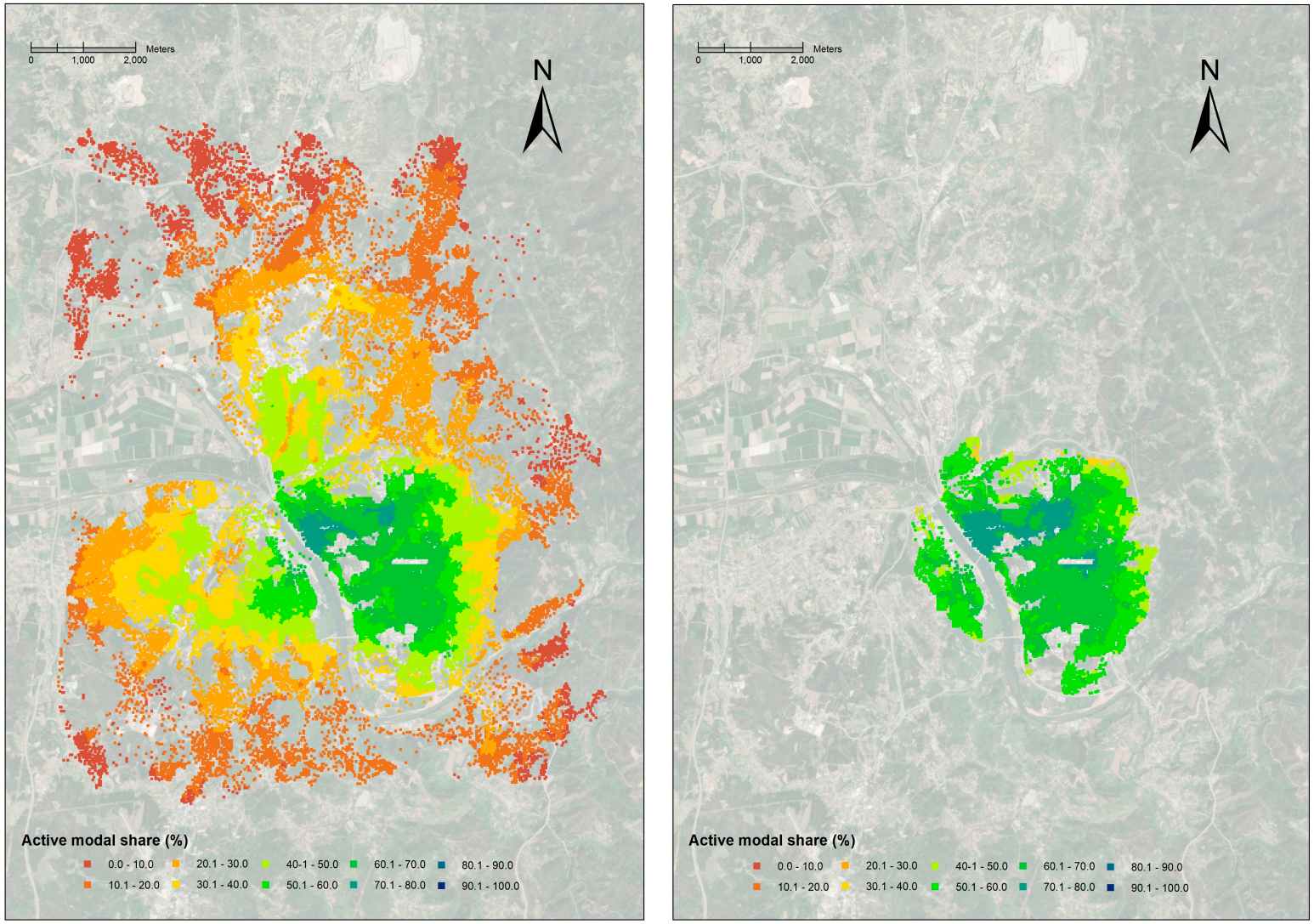
(**a**) (**b**)

Figure S12. Active modal share (walking/cycling) to facilities (%): (**a**) Coimbra; (**b**) Compact Coimbra.



(**a**) (**b**)

Figure S13. Active modal share (walking/cycling) to jobs (%): (**a**) Coimbra; (**b**) Compact Coimbra.



(**a**) (**b**)

Figure S14. Active modal share (walking/cycling) to facilities plus jobs (%): (**a**) Coimbra; (**b**) Compact Coimbra.

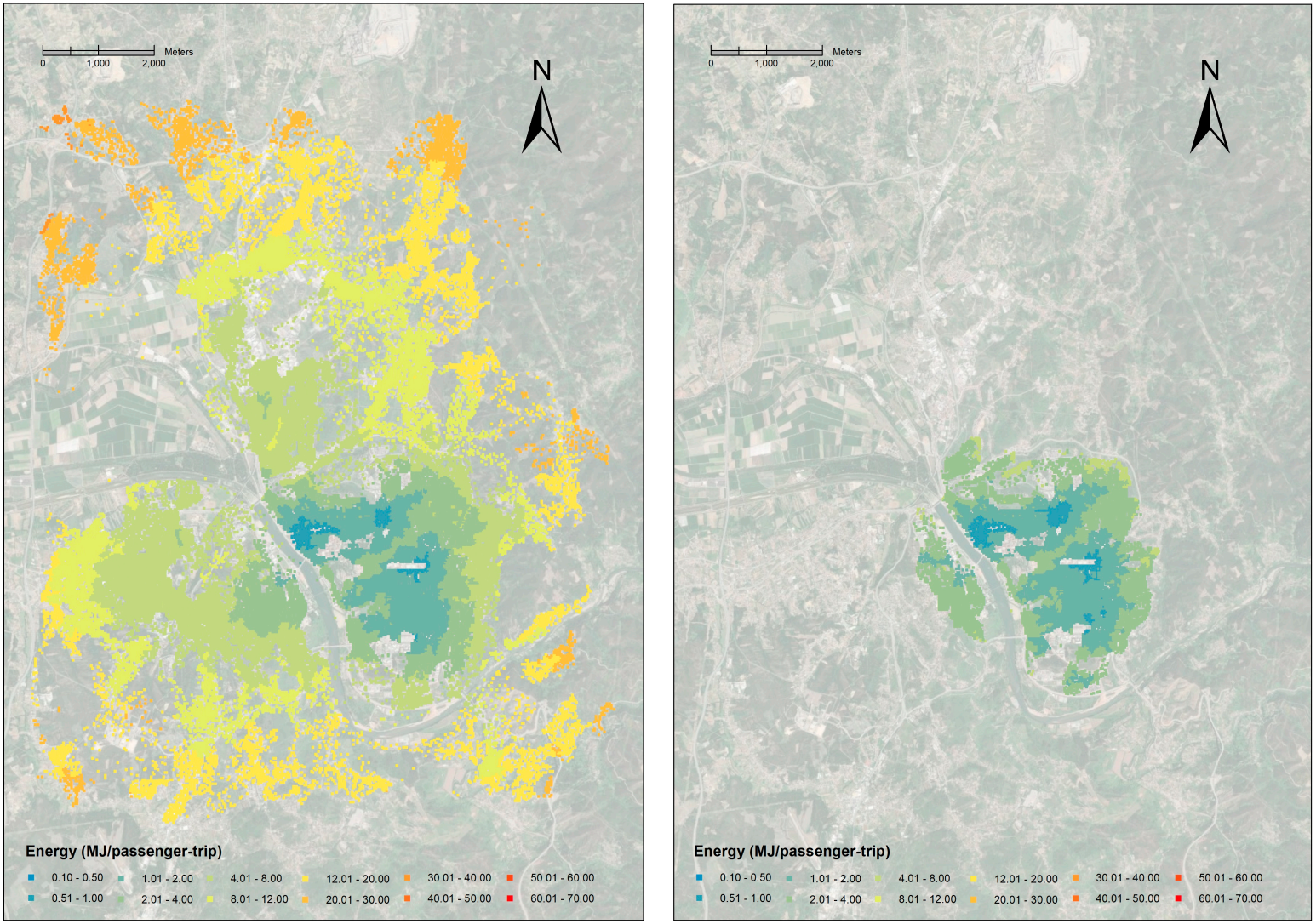


Figure S15. Transport energy spending to facilities [active: walk only] (MJ/passenger.trip): (**a**) Coimbra; (**b**) Compact Coimbra.

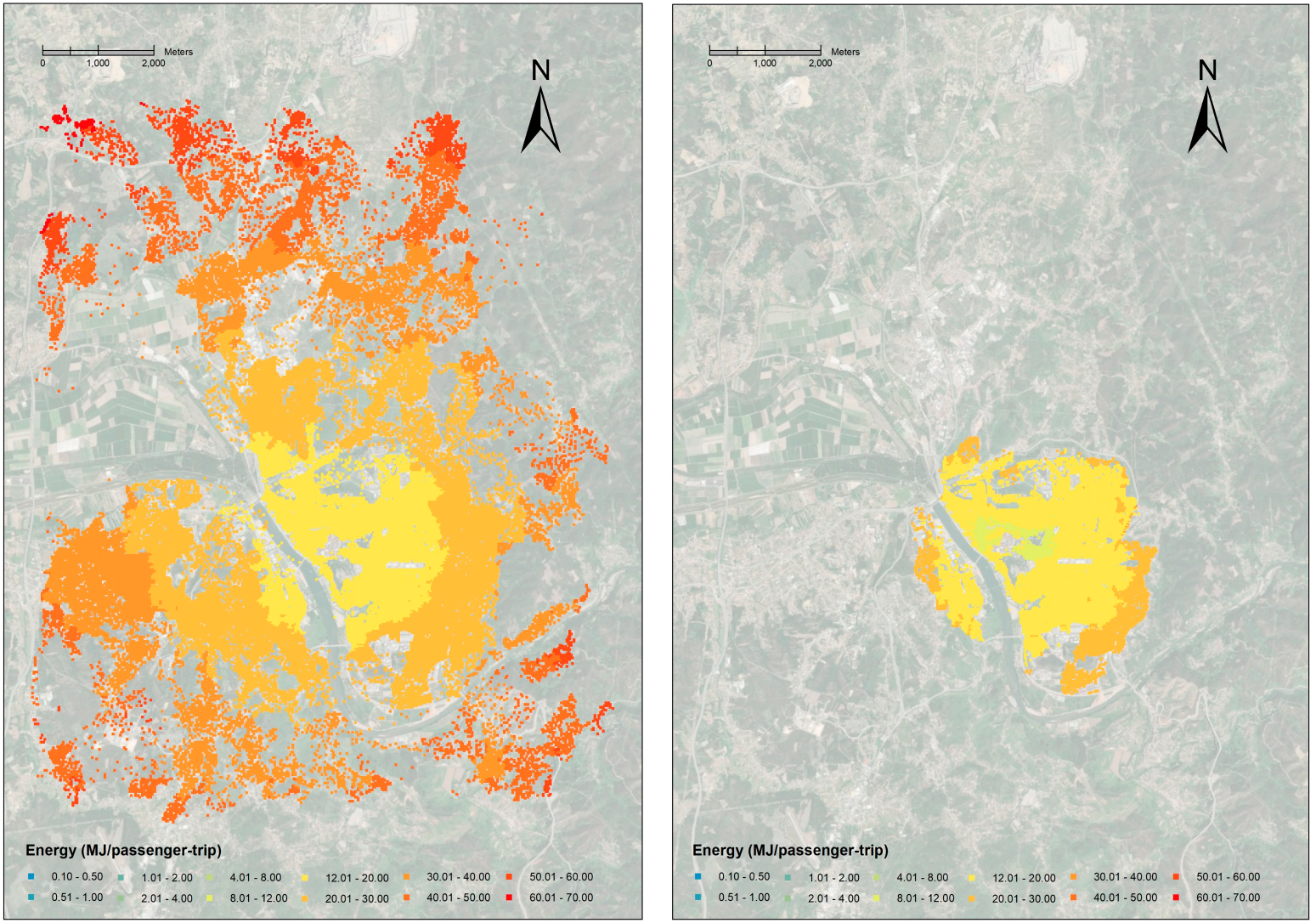


Figure S16. Transport energy spending to jobs [active: walk only] (MJ/passenger.trip): (**a**) Coimbra; (**b**) Compact Coimbra.

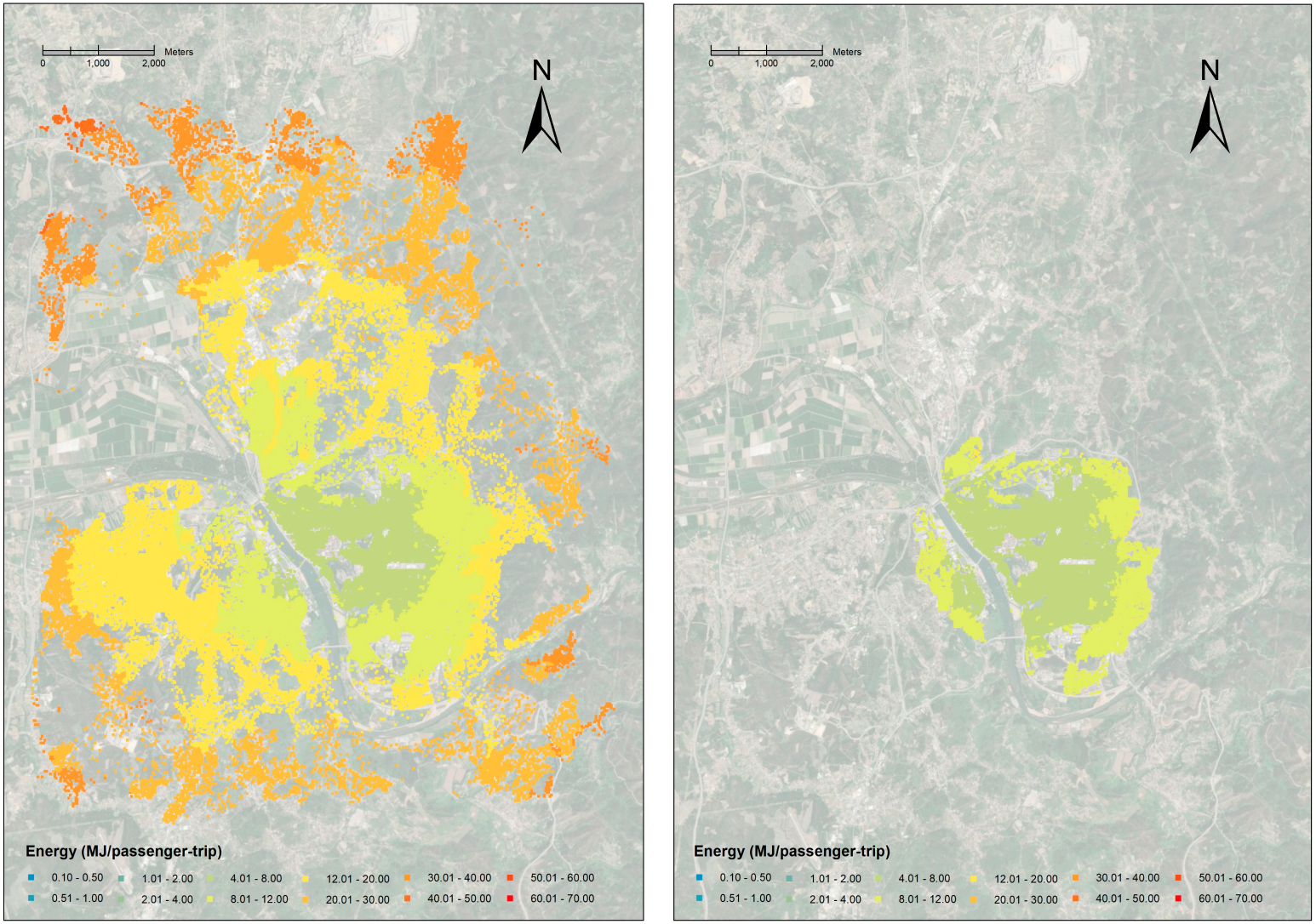


Figure S17. Transport energy spending to facilities plus jobs [active: walk only] (MJ/passenger.trip): (**a**) Coimbra; (**b**) Compact Coimbra.

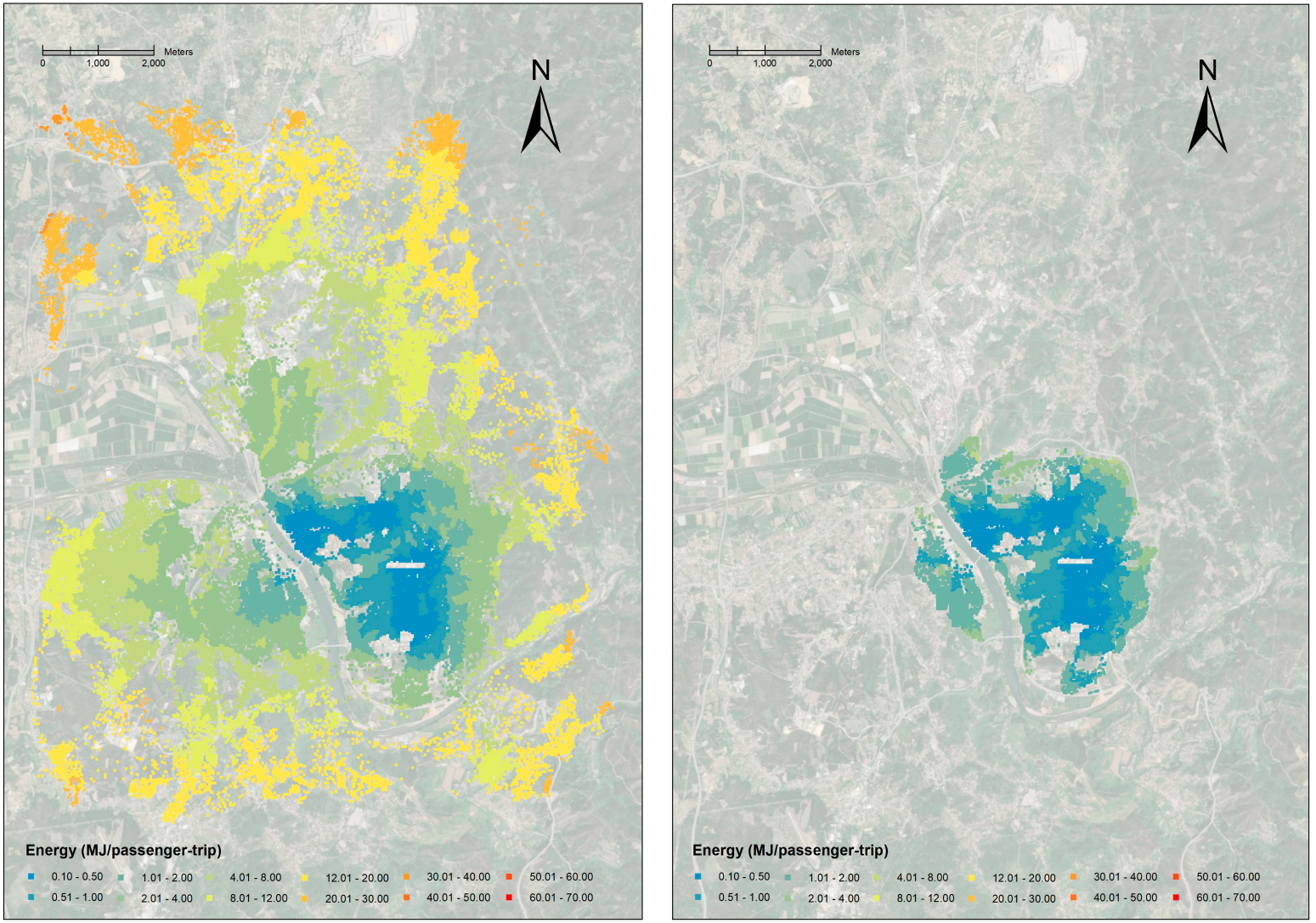


Figure S18. Transport energy spending to facilities [active: walking/cycling] (MJ/passenger.trip): (**a**) Coimbra; (**b**) Compact Coimbra.

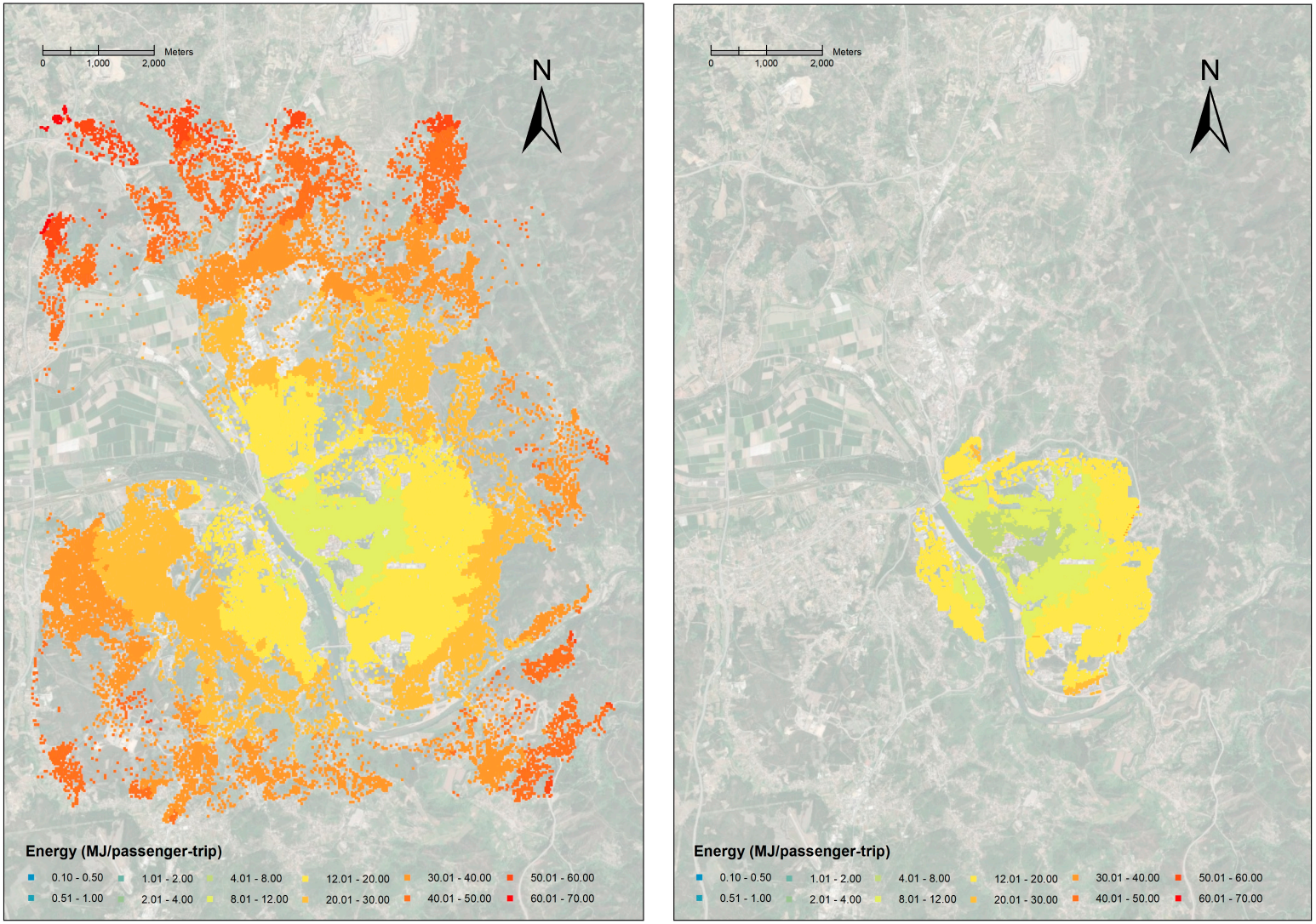


Figure S19. Transport energy spending to jobs [active: walking/cycling] (MJ/passenger.trip): (**a**) Coimbra; (**b**) Compact Coimbra.

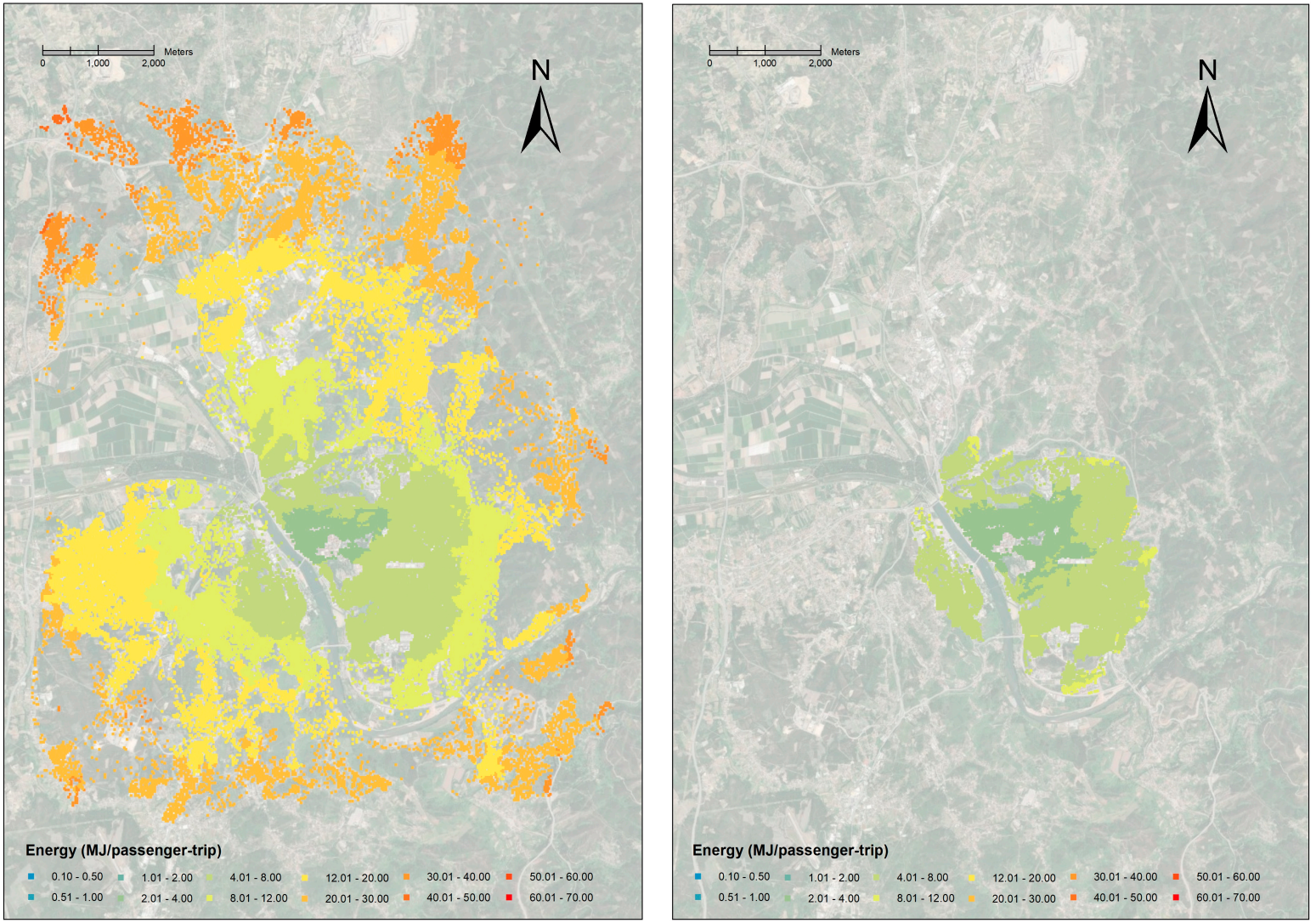


Figure S20. Transport energy spending to facilities plus jobs [active: walking/cycling] (MJ/passenger.trip): (**a**) Coimbra; (**b**) Compact Coimbra.