IOCUS 2026 Conference
The 1st International Online Conference on Urban Sciences
20–22 May 2026 | Online
MDPI

Urban Breathing Systems:
A Spatial Assessment of Green-Recreational Spaces as Health Acupuncture for Physical and Mental Well-Being in Chennai City

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INTRODUCTION & AIM

Does urbanization allow people to breathe within rapidly transforming cities? Rapid urbanization in Global South cities has reduced accessible green spaces, increasing environmental stress and health vulnerabilities. In Chennai, unequal distribution of recreational spaces and high-density development have intensified thermal discomfort and declining well-being. The study conceptualizes urban green–recreational spaces as "Urban Breathing Systems" that support environmental comfort and public health (Wolch et al., 2014; Gong et al., 2024). Using GIS and SEM-based analysis, the study examines the relationship between green accessibility and urban health indicators.

The study aims to evaluate the role of urban green–recreational spaces as "Urban Breathing Systems" in improving environmental comfort and public health in Chennai City.

METHOD

The study adopts five phases as shown in Fig. 1: Phase I examines urban health and environmental challenges through the concept of "Urban Breathing Systems"; Phase II integrates satellite, GIS, survey, and health datasets using spatial and statistical methods; Phase III analyses green accessibility, thermal conditions, and health indicators through spatial and SEM-based assessment; Phase IV proposes health-oriented green infrastructure and urban resilience strategies; and Phase V develops an evidence-based framework linking green infrastructure and public health outcomes.

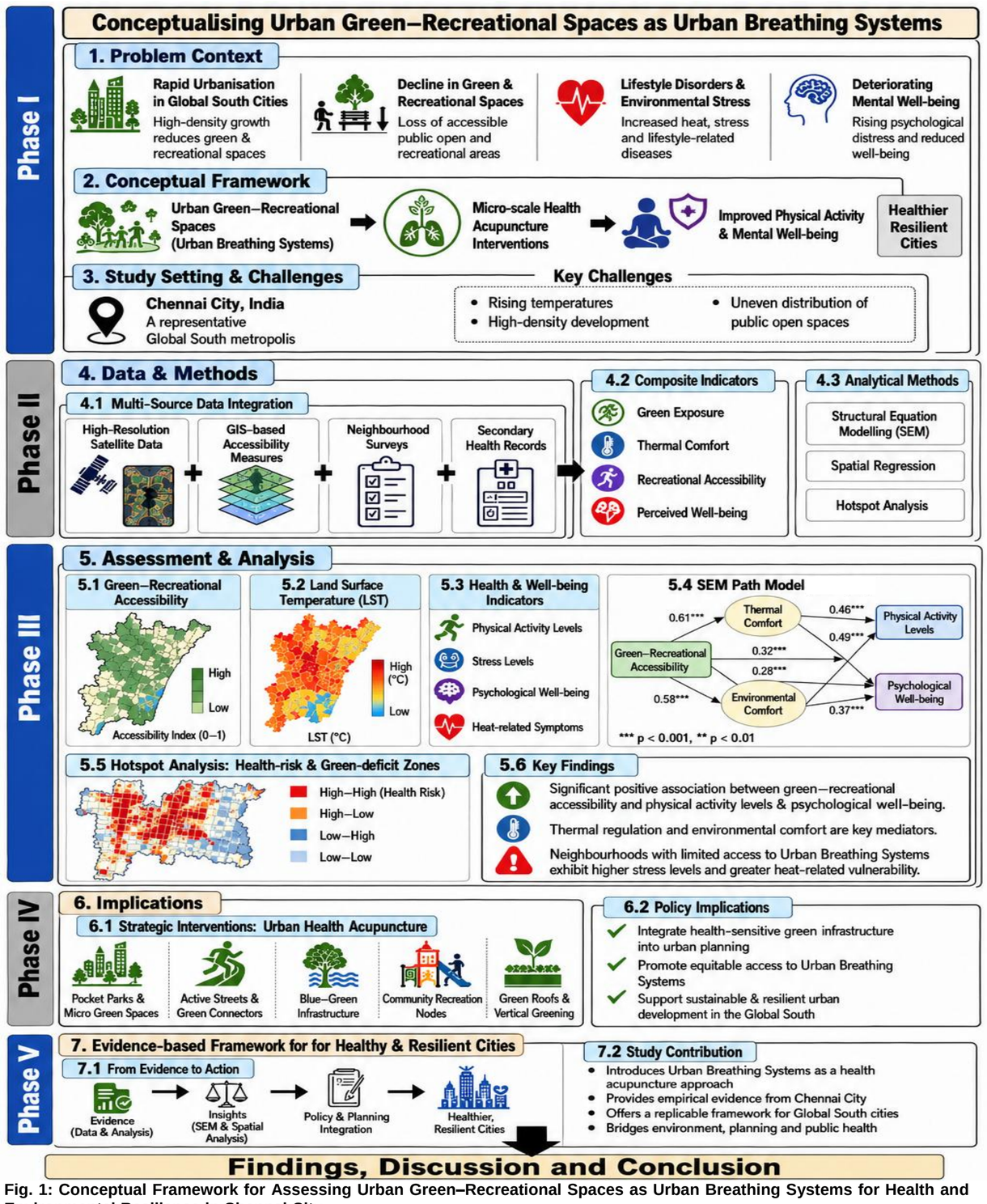
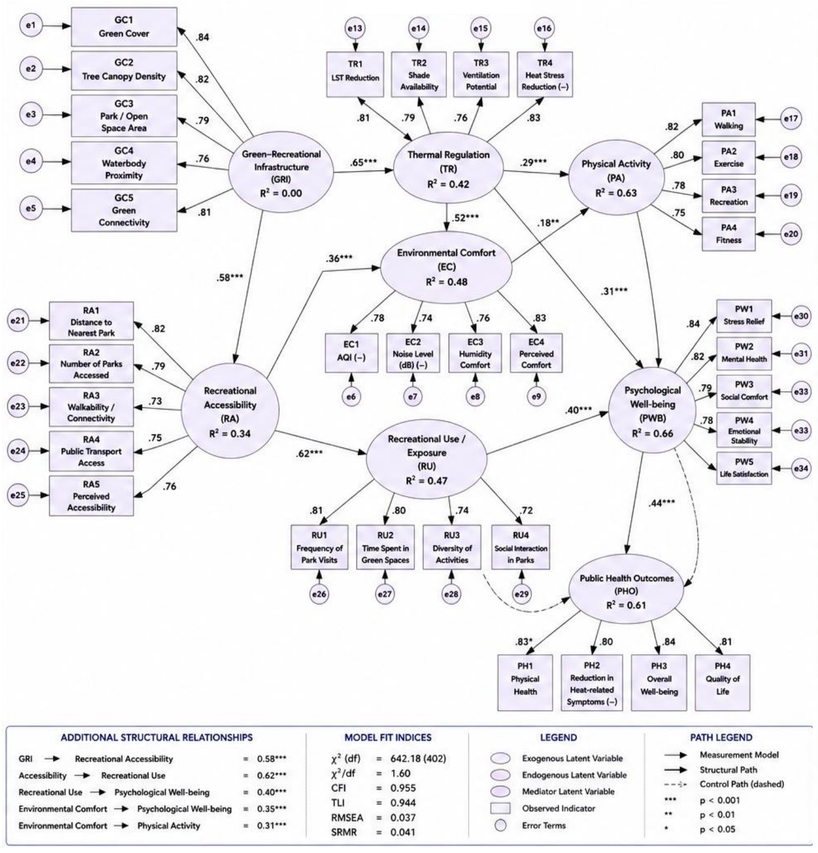


Fig. 1: Conceptual Framework for Assessing Urban Green–Recreational Spaces as Urban Breathing Systems for Health and Environmental Resilience in Chennai City

RESULTS & DISCUSSION

The SEM results (Fig. 2) demonstrate that Green–Recreational Infrastructure (GRI) has a significant positive influence on Thermal Regulation (β = 0.65) and Recreational Accessibility (β = 0.58), indicating that increased green cover, tree canopy density, park availability, and ecological connectivity substantially improve urban environmental conditions. Thermal Regulation further contributed to Environmental Comfort (β = 0.52) and Physical Activity (β = 0.29), highlighting the role of cooling capacity and thermal stress reduction in supporting healthier urban environments. The spatial assessment maps (Fig. 3) reveal clear spatial disparities across Chennai City. Wards with higher green cover and park accessibility, particularly along peripheral and ecologically connected zones, exhibited improved cooling capacity, enhanced environmental comfort, and better psychological well-being. The Recreational Accessibility Index and Psychological Well-being Index further indicate that accessible green spaces encourage recreational use, physical activity, social interaction, and stress reduction. The Composite Urban Health Risk Index identified major high-risk clusters concentrated within environmentally deficient urban zones characterized by low green infrastructure, high thermal exposure, and limited recreational opportunities.



Constructs	Indicator	Factor Loading Initial	Factor Loading Revised	Construct Reliability	AVE
Green–Recreational Infrastructure (GRI)					
GC1	Green Cover	0.842	0.840	0.924	0.668
GC2	Tree Canopy Density	0.821	0.820		
GC3	Park / Open Space Area	0.792	0.790		
GC4	Waterbody Proximity	0.762	0.760		
GC5	Green Connectivity	0.808	0.810		
Thermal Regulation (TR)					
TR1	LST Reduction	0.813	0.810	0.912	0.653
TR2	Shade Availability	0.794	0.790		
TR3	Ventilation Potential	0.758	0.760		
TR4	Heat Stress Reduction (–)	0.825	0.830		
Environmental Comfort (EC)					
EC1	AQI (–)	0.784	0.780	0.918	0.637
EC2	Noise Level (dB) (–)	0.742	0.740		
EC3	Humidity Comfort	0.761	0.760		
EC4	Perceived Comfort	0.831	0.830		
Recreational Accessibility (RA)					
RA1	Distance to Nearest Park	0.820	0.820	0.910	0.594
RA2	Number of Parks Accessed	0.791	0.790		
RA3	Walkability / Connectivity	0.733	0.730		
RA4	Public Transport Access	0.752	0.750		
RA5	Perceived Accessibility	0.756	0.760		
Recreational Use / Exposure (RU)					
RU1	Frequency of Park Visits	0.808	0.810	0.890	0.588
RU2	Time Spent in Green Spaces	0.803	0.800		
RU3	Diversity of Activities	0.739	0.740		
RU4	Social Interaction in Parks	0.723	0.720		
Physical Activity (PA)					
PA1	Walking	0.824	0.820	0.901	0.630
PA2	Exercise	0.802	0.800		
PA3	Recreation	0.782	0.780		
PA4	Fitness	0.747	0.750		
Psychological Well-being (PWB)					
PW1	Stress Relief	0.835	0.840	0.934	0.646
PW2	Mental Health	0.814	0.820		
PW3	Social Comfort	0.786	0.790		
PW4	Emotional Stability	0.778	0.780		
PW5	Life Satisfaction	0.812	0.810		
Public Health Outcomes (PHO)					
PH1	Physical Health	0.825	0.830	0.920	0.663
PH2	Reduction in Heat-related Symptoms (–)	0.803	0.800		
PH3	Overall Well-being	0.843	0.840		
PH4	Quality of Life	0.808	0.810		

Note: (–) indicates inverse relationship (higher values indicate lower heat, pollution, stress, etc.).

Fig. 2: Relationship Between Urban Green–Recreational Infrastructure, Environmental Conditions, and Public Health Outcomes

The significant path relationships indicate that green–recreational infrastructure substantially influences thermal regulation, environmental comfort, recreational accessibility, and psychological well-being across Chennai City. Spatial assessment identified environmentally vulnerable wards characterized by low vegetation cover, inadequate park accessibility, and high thermal stress, particularly within dense built-up urban cores. In contrast, wards with higher ecological connectivity, improved cooling capacity, and accessible recreational spaces demonstrated lower health risk levels and enhanced environmental resilience. The Composite Urban Health Risk Index further highlighted spatial inequalities in the distribution of health-supportive urban infrastructure across Chennai City.

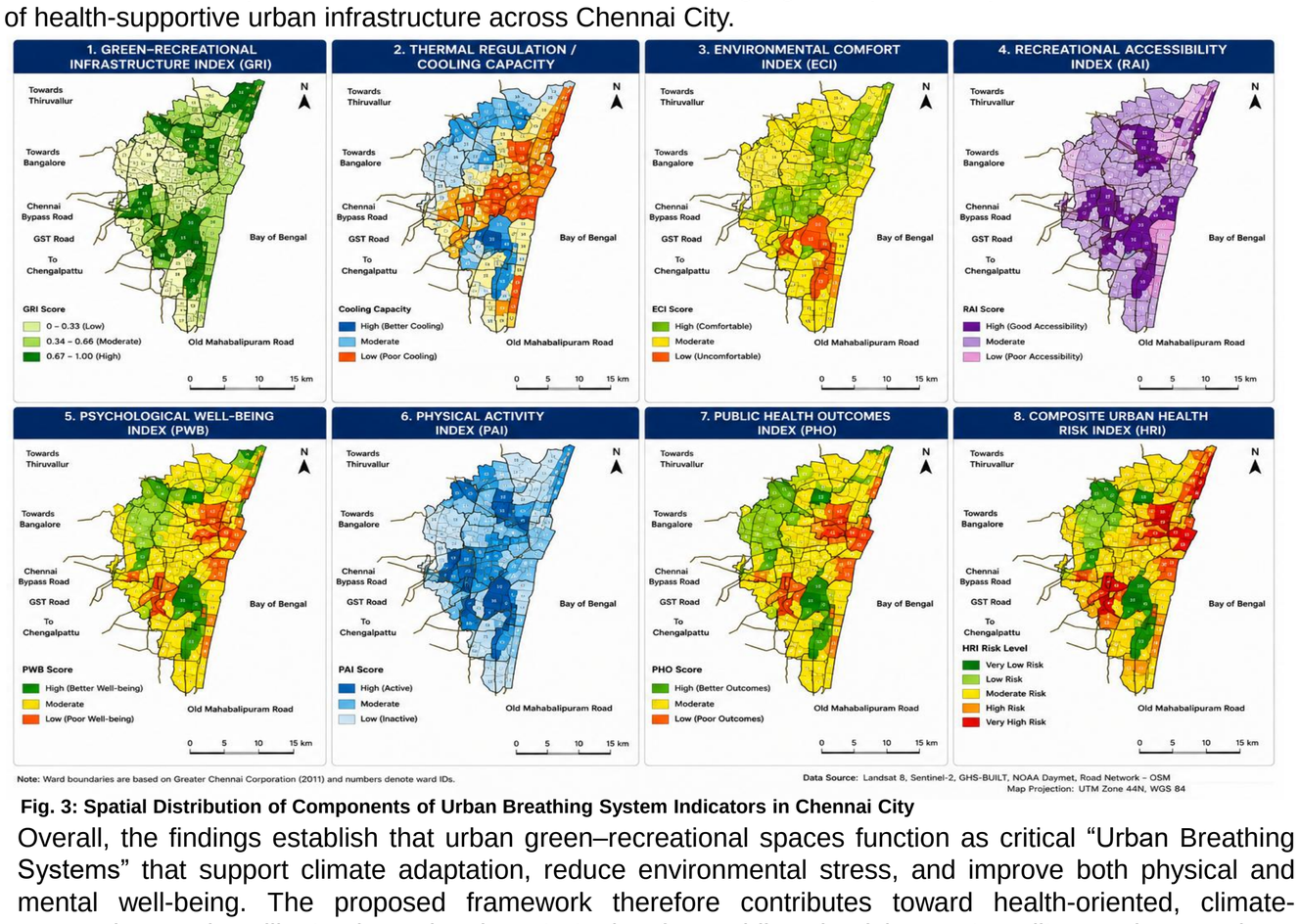


Fig. 3: Spatial Distribution of Components of Urban Breathing System Indicators in Chennai City

Overall, the findings establish that urban green–recreational spaces function as critical "Urban Breathing Systems" that support climate adaptation, reduce environmental stress, and improve both physical and mental well-being. The proposed framework therefore contributes toward health-oriented, climate-responsive, and resilient urban planning strategies for rapidly urbanizing metropolitan regions such as Chennai City.

CONCLUSION

The integrated GIS–SEM framework effectively quantified the spatial relationship between green–recreational infrastructure, thermal regulation, environmental comfort, recreational accessibility, and public health outcomes across Chennai City. The results confirmed that variations in green cover, cooling capacity, and accessibility significantly influence psychological well-being and urban health vulnerability.

FUTURE WORK / REFERENCES

Future studies may integrate real-time environmental sensors, AI-based health prediction models, and high-resolution mobility datasets to improve urban health risk assessment. The framework can also be expanded for comparative analysis across different metropolitan regions and climate-sensitive urban corridors.

1. Wolch, J. R., Byrne, J., & Newell, J. P. (2014). Urban green space, public health, and environmental justice: The challenge of making cities 'just green enough'. Landscape and Urban Planning, 125, 234–244. https://doi.org/10.1016/j.landurbplan.2014.01.017
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