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Psycho-physical wellbeing as a technological-environmental design challenge

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Introduction: In performance-based approaches and quality assessment protocols used both in the technological design of architecture and the environmental design of the built habitat, the concept of psycho-physical wellbeing is usually defined in purely quantitative human-techno-centric or eco-techno-centric terms. However, in socio-technical-environmental realities in continuous transition, wellbeing extends to areas that cannot be confined within the notions of comfort or healthiness because it involves material and immaterial, cultural and technical, aesthetic and performative, real and virtual aspects.

Method: The aim of this article emerges from studies being conducted as part of *Ex-Mind* research. The working hypothesis is to broaden performance-based approaches in a technological-environmental sense to avoid reducing the goal of psycho-physical wellbeing just to the compliance with technical-constructive aspects. It could be possible combining the material and quantifiable dimensions with other aspects that extend the project to sensorial, perceptive, and emotional interactions. Important theoretical-scientific evidence is already emerging on this dichotomy to be overcome from areas of project evaluation responsive to the new paradigms of sustainability such as resilience, inclusive placemaking, and wellbeing according to the flourish model. Characteristics such as dimensions, proportions, shapes, colors, scents and immaterial aspects of spaces, for example, should be evaluated with respect to the complex physical and mental comfort conditions that they can produce.

Results: In the technological-environmental vision of the human habitat project, the objective of psycho-physical wellbeing should be a function of the dynamic balance between the constantly evolving users'/inhabitants' needs and the variability of context factors and agents. The concept of wellbeing therefore takes on a scalar and expanded declination. Considering the technological-environmental approach, a possible element of originality emerges in the integrated and balanced human-environmental centered vision aimed at broadening the framework of the qualitative-quantitative references of the project of the human habitat. This could be an alternative bio-psycho-socio-technological methodological vision starting from the determinants of wellbeing in a broad sense, including natural, cultural and socioeconomic environmental factors, social and collective networks of relationships and participation, individual behavioral, physical, and functional factors of people. Added to these determinants are the different technological-environmental interface systems with which the project is able to define, in a bio-psycho-socio-technological sense, multiple and variable regulatory conditions of wellbeing, at a building, urban, and territorial level.

Discussion: The possible outcomes of this alternative and integrated hypothesis are related to the reconnection with the production and regeneration processes of the built material, to the reorganization and reinvention of spatial and perceptual relationships between individuals, communities, technologies, environment, and to the integration of non-directly quantifiable subjective variables into the design of the built environment. The proposed integrated bio-psycho-socio-technological vision may open for developments concerning the expansion of the determinants of psycho-physical wellbeing through new performative descriptors and the definition of agile tools, procedures, and metrics to integrate wellbeing assessments, including consensus-based approaches.

KEYWORDS

technological culture of design, wellbeing, performance-based approach, architecture for 5 senses, materiality/immateriality

1 Introduction

The concept of people's psycho-physical wellbeing, if contextualized in the technological-environmental dimensions of the human habitat, finds its a-scalar and extended significant in the living space design. In fact, in contemporary socio-technical-environmental transitional realities, wellbeing extends itself to fields that can no longer be confined within the notions of comfort or healthiness (Morin, 2014). Instead, it involves, at the same time, material and immaterial, cultural, and technical, aesthetic and performative, real and virtual aspects. In the technological approach to human habitat design, this extended concept of wellbeing is particularly evident in the performance-based methodologies. Construction solutions tend to be defined in response to the end-users' needs. Design solutions are certainly measurable, if filtered using quantitative requirement sets, because they can be parameterized in their capability to guarantee performance. However, the performance-based approach often does not consider the non-measurable aspects concerning people. It just defines technical answers, often strongly focused on specific target-groups' needs.

The goal of psycho-physical wellbeing indeed is a function of a dynamic balancing act between the evolving users/inhabitants' needs and the variability of contextual factors and agents. Psycho-physical wellbeing thus pervades the technological requirements and performance of architectures from within, but it also involves the adaptability, resource availability and resilience conditions determined by the external environment.

This close relationship between the physical and material characteristics of built and natural systems and the immaterial ones of environmental spaces and flows, even if not directly tangible, can give the project new capabilities in managing and improving people's perception of habitats through the five senses (Pallasmaa, 1999). This approach, in fact, would lead to measuring the effects (performance) that technical-constructive choices (defined on needs and requirements) may have on users. At the same time, it would tend to redefine living space by also considering the effects that external environmental variables (which cannot be managed according to performance logics) entail in defining different degrees of the built environment livability. Psycho-physical wellbeing thus constitutes a transversal and essential element that can be found in the regulatory production aimed at orienting and determining the qualities of living space in a technical sense. However, it also emerges as a result of the use of technologies in a regulating and enabling sense that can lower or raise people's wellbeing conditions (WHO, 2013). For this twofold reason, psycho-physical wellbeing is today increasingly relativized with respect to the sensible use of building technologies, which from man-nature interfaces have turned into man-technology interfaces and, in recent years, also into interfaces between technology and technology (Floridi, 2014).

It is therefore necessary to update the performance-based approaches to avoid reducing the goal of psycho-physical wellbeing to responding only to technical-constructive aspects. It is needed to place alongside the material and quantifiable dimensions other aspects that extend the project to sensorial, perceptive, and emotional interactions. Therefore, it is important to integrate in the management design tools issues that have been neglected or traced back just to the physical-technical condition. The contemporary inhabiting scenario requires an ability in designing places for people (Hooks, 2023) that are healthy, both in physical and mental terms and, therefore, also compatible with maintaining the health of the planet. Characteristics such as size, proportions, shapes, colors, scents, and temperatures of spaces, for example, should be evaluated with respect to the complex of physical and mental comfort conditions they can produce (Mallgrave, 2015). This approach requires a strong interdisciplinary ability in managing aspects that can "produce" built or natural environments, real or virtual, capable of stimulating states of mind (happiness, serenity, kindness, etc.) and positive behaviors.

2 The human-centric performance reasons for wellbeing

In reiterating the centrality of the specific performance-based approach of technological-environmental design, it is important to highlight that this approach outlines the quality of the project, through requirements that specify properties and capabilities of technical objects and technological systems (which can then be verified through technical performances to satisfy the wellbeing needs). The so-called human-centered approaches (Design for All, Inclusive Design, Universal Design) which are performance-based, in fact, define wellbeing in

techno-centric terms, so they are human-techno-centric at the same time.

The contemporary panorama instead requires to "measure what matters" (Stiglitz et al., 2021) to identify the "minor damage" (Tiezzi and Marchesini, 1999) determinable with design choices and to achieve truly convenient results for the planet and people. According to this vision, lines of research should be pursued referring to the need to better understand the relationships between the people's physical and mental health and that of the planet by defining, for example, the principles according to which the class of demands for environmental protection does not constitutes limits to that of wellbeing (for people). It is undeniable, in fact, that this effect is produced when, for example, a drastic and exasperated search towards the maximum containment of energy consumption could produce environments that provide poor psycho-physical wellbeing benefits because they are characterized by excessive physical and visual separations between internal spaces and outdoor spaces or between built up and natural environments.

The envisaged field of investigation requires a critical analysis of place transformations, which can include, in a transdisciplinary way, the interaction with regenerating thoughts and a broader definition of wellbeing in the habitat. This means to propose a humanistic and cultural model able to amplify the understanding of the attractiveness of certain contexts and to consider humans and planet needs in a unified way. This requires a change in the traditional reductive approach to building systems, towards a more dynamic and adaptive perspective (Allen, 2017).

In this scenario, studies involving neuroscience (focused on the potential that places can have in expanding people thinking capabilities) represent an important tool, able to go beyond the limits of traditional design, and to consider the environment not only as a physical background but as an integral part of the human experience (Pallasma, 1999). One needs to go beyond the thermo-hygrometric, acoustic, and lighting characteristics, considering psychological healing effects and the mind extension capabilities in the assessment of what makes people feel good. This hypothesis provides for a profound understanding of the effects that the characteristics (especially formal, dimensional, chromatic, thermal, odoriferous, acoustic) of environments can produce on people's physical and mental comfort conditions. This understanding should also have to consider the variability of the response of the senses depending on whether we are referring to the perception of a real or virtual environment. Compared to the real dimension, in fact, the virtual one involves a greater extension of the mind capabilities through the more intense use of some senses compared to others. To give an example, if one enters a real environment characterized by a cold color (for example, light blue) and a very warm temperature, one can feel relaxed (due to the effects produced by the color) and warm (due to the effects produced by the temperature) while if enter a virtual environment with the same color, you will tend to perceive a low temperature since in our mind the coldness of the color can correspond to a low temperature.

The same reasoning could be done by comparing a warm color and low temperature real environment to a warm color virtual environment. These examples highlight how, in inhabiting a virtual space there is more space for imagination (future) and the memory of one's knowledge and experiences (past). On the other hand, living in a real space lead to giving priority to tangible characteristics and living in the present. To define new design approaches able to produce human-friendly habitats, another fundamental question to be investigated concerns the effects that are given by the sum of multiple sensory perceptions and the variability of the predominance of some senses over others. For example, if one enters a red painted room that gives off a scent of berries, one will probably perceive a sense of cheerfulness and joy while if the same room gives off a smell of blood one will probably perceive sensations such as anguish, fear, and discomfort. Therefore, the creative phases of the habitat design activity should, through interdisciplinary work, not only consider all the senses and mental dynamics that influence the perception of a space to be inhabited but also the possible relationships between the different senses and mental processes to allow the creation of habitats able to evoke positive emotions instead of being artificial and cold (Ruzzon, 2022).

3 The eco-centric performance reasons for wellbeing

The framework of the environmental reasons, influencing the definition of people's psycho-physical wellbeing, is not so different from the performance-based positions centered on the end-users. This approach is evident with respect to at least two-dimensional levels on the human habitat intervention within which psycho-physical wellbeing can manifest itself or be inhibited: the urban-territorial dimension and the building one. For both levels, from a design perspective, the current orientation continues to match the concept of wellbeing with the World Health Organization's definition of health as "a state of complete physical, mental and social wellbeing and not merely the absence of disease" (WHO, 1948). This definition is also referred to by successive documents that have addressed the relationship between the state of people's health and the goal of wellbeing (e.g., Ottawa/1986, Sundswall/1991, Jakarta/1997, UN Agenda 2030/2015) dwelling above all on policies, infrastructures, and the multidimensionality of the supportive environment for health. However, some still unresolved issues emerge from the original 1948 definition. The concept of physical wellbeing (visual, acoustic, thermal, olfactory, etc.) is easily framed within the parameters of environmental comfort but, for this reason, always brought back to a focus on the performance of technical objects' vision. The meaning of mental and social wellbeing, on the other hand, remains more nuanced, referring to the emotional-psychological components and cognitive capabilities with which an individual performs his functions in social and personal life, adapting to external environmental conditions and internal conflicts.

Moving in this direction, environment-centered approaches and systems of protocols and standards start from sustainability environmental priorities and also evolve toward new issues such as climate change, inclusion, smartness, resilience, healthiness, participation. Three reference areas can be considered among them.

GBC Quartieri Italia 2015 Main exemplificative voices referred to the wellbeing issues

	Voice/Theme	Requirement/Indicator	Measuring unit	Credits
LCS Localization and Connection of Site	Bicycle mobility	Positioning near bicycle paths Number of space for bicycles	MI (distance) Number of bicycle parking	1-2
	Proximity residence/working sites	Walkable distance from working sites	MI (distance)	1-3
OPQ Organization and Programming of Neighborood	Walkable streets	Distance facade/gateway Number gateway Percentage of glass facades	MI (distance), Mq (surface) Number of gates % glass facades	1-9
	Public space access	Percentage access	% number of access	1
	Access to recreational activities	Percentage of access	% number of access	1
	Street with trees/shadows	Percentage blocks with trees Percentage sidewalks with shadows	% blocks-sidewalks	1-2
	Acoustic climate	Sound levels during different hours	dB	1-2
IES Infrastructures and Sustainable Buildings	Reduction of heat island	Outdoor paved surface High reflection covers/green roofs	SRI (Sun Reflection Index)	1
	Sun orientation	Percent. buildings with good orient. Percent. blocks with good orient.	% buildings-blocks	1
	Reduction of light pollution	BUG (Backlight – Uplight - Glare) classification	Lightining device technical classification	1

GBC Home Italia V2 2022 Main exemplificative voices referred to the wellbeing issues

	Voice/Theme	Requirement/Indicator	Measuring unit	Credits
SS Site Sustainability	Proximity collective service/alternative mobility	Proximity of basic service Proximity to train/bus stop Proximity to bicycle paths Devices for bicycle mobility	MI (distance) Number of bicycle parking	3
	Rain water Green space	Percentage of new green spaces	% green spaces	4
	Heat island effect	Outdoor areas with shadows High reflection covers and Green roofs	SRI (Sun Reflection Index)	4
	Common and relational spaces	Relational outdoor spaces Relational indoor spaces	Mq (surface)	2-4
QI Internal Environmental Quality	Ventilation and humidity control systems	Mechanical ventilation Natural ventilation	Q (Appropriate air flow) Walkable/openable surface ratio	1-5
	Natural light	Natural light continuous illumination	D (Daylight factor)	1-2
	Acoustic	Acoustic classification	dB	2-3

BREEAM Communities 2012 Main exemplificative voices referred to the wellbeing issues

	Voice/Theme	Requirement/Indicator	Measuring unit	Credits
SC Social and economic wellbeing	Noise pollution	Rating/Background noise level	dB	1-3
	Delivery of services, facilities and amenities	Walking distance Safe and convenient pedestrian route	MI (distance) Speed limit of 30mph	1-7
	Microclimate	Microclimatic factors (temperature/thermal comfort, solar exposure, sky view and shadowing, air movement and wind speed, dust and pollution, acoustic environment)	Various quantitative measuring units	1-3
	Green infrastructure	Walking distance Accessible Natural Green Space	MI (distance) Hectare (surface)	1-4
	Light pollution	Specifications lighting design guide and installed products	Descriptions	1-3

BREEAM New Construction V6 2023 Main exemplificative voices referred to the wellbeing issues

	Voice/Theme	Requirement/Indicator	Measuring unit	Credits
HW Health and Wellbeing	Visual comfort	Glare control, daylighting, view out, exposure to sunlight, internal and external lighting	Various quantitative measuring units	1-7
	Indoor air quality	Minimising sources of air pollution Adaptability - potential for natural ventilation	Various quantitative measuring units	6
	Thermal comfort	Thermal comfort simulation Adaptability - for CC scenarios Thermal zoning and controls	PMV, PPD, RCP	3
	Acoustic performance	Acoustic parameters Acoustic testing	Various quantitative measuring units	4
	Accessibility	Safe access Inclusive and accessible design	MI (distance), Mq (surface), dedicated surfaces for accessibility	2
	Outdoor space	Size	MI (distance)	1
	Microbial contamination	Water system Humidification system	Various quantitative measuring units	1
	Radon	Radon levels	Bq	2

LEED v4.1 Existing Cities betha 202 Main exemplificative voices referred to the wellbeing issues

	Voice/Theme	Requirement/Indicator	Measuring unit	Credits
NS Natural System and Ecology	Green Spaces	Access to Green Spaces Urban Forest Cover	MI (distance) Prevision or Plan	1-2
	Light Pollution Reduction	Protect Night Sky Access	Implementation of BUG (Backlight – Uplight - Glare) Classific.	1
TR Transportation and Land Use	Safe, Multimodal Accessibility	Walking distance high frequency transit Percentage Pedestrian/Bicycle infrastructures	MI (distance) Prevision or Plan % infrastructure	1-2
QL Quality of Life	Social Services & Infrastructure	Community Needs Assessment Equitable Access to Social Infrastructure	Community Needs Assessment Initiative At least four social infrastructure assets	1-3
	Public Health	Public Health Metrics Protect Air Quality Protect Noise Quality	Various quantitative measuring units	1-3

LEED v5 BDC New 2024 Main exemplificative voices referred to the wellbeing issues

	Voice/Theme	Requirement/Indicator	Measuring unit	Credits
LT Location and Transportation	Active Travel Facilities	Bicycle Network Bicycle Storage	MI (distance) Number of bicycle parking	1-2
	Electric Vehicles	Projects with Parking/No Parking	% of total parking spaces	1-2
SS Sustainable Sites	Protect and Restore Biodiverse Habitat	Percentage of restored areas	% restored areas	1-2
	Accessible Open Space	Outdoor spaces	% of the total site area	1
	Heat Island Reduction	Tree Equity	High-Reflectance Roof SRI (Sun Reflection Index)	1-2
EQ Indoor Environmental Quality	Enhanced Air Quality	Additional Outdoor Air or Air Cleaning	Responsiveness to specific rules	1
	Occupant Experience	Customizable Environment Thermal Environment Sound Environment Lighting Environment Window Access Daylight simulation	Allow occupants choice and flexibility % of responsiveness to specific rules	1-6
	Connecting with Nature	Experience of Nature Space and Place	Without evaluation system	1
	Enhanced Building Accessibility□	Physical Accessibility Accident Prevention and Safety Wayfinding	Without specifical evaluation system	1
	Air Quality Testing and Monitoring	Indoor air quality	Responsiveness to specific rules	1-2

FIGURE 1
Comparison framework between three assessment protocols GBC, BREEAM and LEED that foresee specific items and procedures for calculating/measuring performance-based wellbeing in quantitative terms of technical-environmental physical comfort (engineering-plant wellbeing) or psychological-mental comfort (medical wellbeing). (Source: authors, through a re-elaboration from GBC, BREEAM and LEED protocols).

In a first field are the voluntary project certification protocols that operate on a building, urban or neighborhood/community scale, in which wellbeing can be traced in indoor or outdoor housing quality objectives referable to physical-chemical performance control variables that can be scored (e.g., BREEAM, Green Building Council, ITACA Synthetic, LEED). A second field links wellbeing to the compliance of indoor/outdoor spaces with universal performance standards. Wellbeing is generated by natural-human, process/product factors and agents that also connect directly with the Goals of the UN 2030 Agenda for Sustainability (e.g., ISO *Sustainable Cities* series 37,100 standards). The third field includes systems and networks that combine certification procedures with elements concerning the management process of planning or design. Quantitative performance indicators are integrated with qualitative aspects to define not only prescriptive but performative criteria (HQE-GBC Urban Planning, CIB-Performance Based Building/PeBBu Network, EUPolis Approach).

In all these application fields, the outdoor, natural, or man-made, indoor, or even virtual environment affects people's psycho-physical wellbeing mainly through technical devices, solutions, and components. The specific focus on the environmental aspects of the bio-physio sphere (biodiversity, energy, food resources, production/consumption cycles) leads to a biased declination of sustainability that, unfortunately, neglects the socio-sphere and the bio-psychological variables concerning people. Instead, maximum emphasis is placed on the technical and economic-productive sphere by focusing on technical objects of different origins. For example,: fully artificial (e.g., digital devices for smart environments, participatory processes, inclusive interaction); hybrids, such as building envelope systems that define habitable space within isolated high-performance capsules; natural, such as all green solutions, even nature-based, that do not confront the evidence, variability, with differences in the demands, behavior and non-homogenized practices of individuals and communities (Altomonte et al., 2020). Although successive versions followed the original health-sanitary definition that gave the more recent salutogenic meanings of a bio-psycho-social matrix (WHO, 2013), the concept of psycho-physical wellbeing continues to be tied to an interpretation of living space in terms of comfort and safety. Even the environment-centered performance-based design approaches, although based on the measurability of phenomenology interfering with the development and evolution of people's wellbeing, thus assume an eco-technocentric position. The issues of anthropic habitat design are reduced to the exclusive provision of increasingly high technical performance through an additional process of "facilitating" technical components that risk reducing people's adaptive, creative, and emotional capacities/abilities.

4 New frontiers for the performance-based approach

The dichotomy between human-centered and environment-centered performance-based approaches is no longer sufficient for dealing with the multiple transitional states (climatic, energetic, ecosystemic, technological, socio-economic, cultural) that the anthropogenic habitat is going through (Losasso, 2022). It is necessary to shift the sense of the built environment project measurability towards a sense of sustainable measurement of constructive interventions, to return to the synergy between technique, environment, and humanity that has always characterized the co-evolutionary history of the human species (Pievani, 2021). In this reference framework, wellbeing cannot be traced back only to technical-environmental physical comfort which, while placing the end user at the center of the project, defines responses of an engineering-plant matrix. Nor can wellbeing be declined exclusively by referring to the psychological-mental aspects that outline its connections with indicators and parameters of healthiness of living environments, in the medical-health sense.

The harmonization between assessment of technical-environmental physical comfort and medical-mental psychological wellbeing is one of the priority objectives of the *Ex-Mind* research[1].

Through a comparative analysis between some performance-based procedures addressing wellbeing at various scales, the orientation exclusively focused on quantitative physical-technical-environmental (engineering-plant comfort), or psychological-mental (medical-medical wellbeing) variables is evident. In a comparative framework (Figure 1), three protocols (GBC, BREEAM, LEED)[2] were taken into consideration. Among the many building, urban or territorial quality assessment forms, these three protocols include specific sections dedicated to the parametric evaluation and monitoring of wellbeing. The protocols follow an additive procedure in which the final assessment of the project quality results from the number of individual successful verifications achieved through the scorecard system.

The performance response is thus a function of the total number of credits received in responding to the individual assessments or calculation procedures for the different thematic sections.

The process of wellbeing improvement follows a linear logic[3], by thematic families, which provides for each section: an assessment item/theme, a specific requirement/indicator to be met quantitatively, a corresponding unit of measurement and resulting credits got through the quantitative assessment.

In these procedures, the recurring sections related to the aspects of wellbeing are:

1 The interdisciplinary project *Ex-Mind EXtended MIND models for the design of human environment* (coordination by Lorenzo Pignatti Morano di Custoza, G. d'Annunzio University of Chieti-Pescara - Italy) is funded by the European Community under the Erasmus Mundus Design Measures - Erasmus + program. The research integrates architecture, urban planning, neuroscience, cognitive studies and behavioral economics to develop an innovative vision of "wellbeing" based on new relationships between the human mind, behaviors, environment and architectural and urban spaces. The authors, starting from the performance-based methodological and design approaches of Technological and Environmental Design of Architecture, are investigating possible trajectories of harmonization between qualitative and quantitative assessments to guide design developments of the concept of wellbeing toward the definition of multi-sensory/multifactorial living space

2 Exemplificative voices of the framework (Figure 1) excerpted from GBC, BREEAM and LEED protocols are referred to: GBC Quartieri Italia 2015, GBC Home Italia V2 2022, BREEAM Communities 2012, BREEAM New Construction V6 2023, LEED v4.1 Existing Cities betha 2024, LEED v5 BDC New 2024. See also in references Green Building Council (2015), Green Building Council (2022), BREEAM (2012), BREEAM (2023), LEED (2024a), LEED (2024b).

3 Similarly articulated are the standards (e.g., ISO, EN, WELL) that regulate at an international level the assessment and control of wellbeing performance and in which the recurring assessment categories concern comfort (thermo-hygrometric, visual, acoustic, olfactory, spatial, motivational, psycho-perceptual, hygienic).

UN ARUP Resilience Framework Main exemplificative voices referred to the wellbeing issues

Dimension	Goals	Indicators	Main quality	Examples of qualitative questions about
Health & Wellbeing	Minimal human vulnerability	Adequate affordable energy supply Inclusive access to safe drinking water Effective sanitation	Flexible Inclusive/Robust Robust	Extension of affordable, safe, alternative energy supply Extension of safe, affordable, alternative water supply Extension of safe, effectiveness planning of sanitation
	Diverse livelihoods & employment	Inclusive labour policies	Resourceful Inclusive	Labour policies, standards and public aid for all
	Effective safeguards to human health & life	Emergency medical care	Resourceful Flexible	Extension of emergency medical services for major events
Infrastructure & Ecosystems	Reduced exposure & fragility	Effectively managed protective ecosystems Robust protective infrastructure	Resourceful Robust Integrated	Extension of physical integration/protective capabilities Adequacy of maintenance/update levels
	Effective provision of critical services	Diligent maintenance & continuity	Robust/Reflective	Monitoring and continuity planning of maintenance
	Reliable mobility & communications	Diverse and affordable transport networks Reliable communications technology	Redundant Flexible/Inclusive Integrated	Amount of affordable, public, optional transport networks Extension of diverse, updated infornations for ordinary and emergency situations
Leadership & Strategy	Effective leadership & management	Proactive multi-stakeholder collaboration	Reflective Inclusive	Participation in policy/decision making process
	Empowered stakeholders	Adequate education for all	Resourceful Inclusive	Accessible and affordable education levels
	Integrated developed planning	Consultative planning process Appropriate land use and zoning	Reflective Integrated	Integrated, long-term planning strategies Proactively planning strategies

Project for Public Space Main exemplificative voices referred to the wellbeing issues

Key attribute	Intangible	Correspondent quantitative measurement	Examples of qualitative questions about
Comfort & Image	Greenery Walkable	Sanitation rating Building conditions	Good first impression
	Sittable	Building condition	Seats convenient location/Choice of places to sit
	Attractive	Environmental data	Capability to feel safe
Access & Linkages	Proximity	Mode splits	Capability to see the space from a distance
	Connected	Mode splits/Transit usage	Good connection between place and adjacent buildings
	Accessible	Parking users patterns	Variety of transportation options
Sociability	Friendly	Evening use	Capability to favour meetings or to be easily used
	Welcoming	Street life	General capability to reflect ages and ethnic groups

Flourish Project Child 2020 Main exemplificative voices referred to the wellbeing issues

Human need	Core need	Main quality (only exemplificative)	Examples of qualitative questions about
Physical	Security	Positive contact with environment/Connection to nature	Feeling of safe and security Feeling to be healthy
Emotional	Relationship	Satisfaction/Emotional fulfilment	Capability to spend time connecting with other people Feeling to be not lonely
	Indipendence	Self regulation/Knowledge	Feeling to be supported as independent in the environment Local travel services enabling to access all the places Feeling to can currently manage without support of others
Mental	Engagement	Concentration/Optimism	Feeling to can easily access information about local activities or learning opportunities Feeling to be involved in the artistic, social and creative life of the community
	Fulfiment	Self expression/Joy	Feeling to be able to use knowledge, skills and resources

FIGURE 2
Comparison framework of three exemplificative tools considering psycho-physical wellbeing according to qualitative assessments combined with performance-based parametric controls. (Source: authors, re-elaboration through excerpts from *TRF/ARUP Resilience Framework*, *Project for Public Space Placemaking*, and *Flourishing Model*).

At the level of community, city or neighborhood assessment.

- Aspects concerning the location of the intervention site and the natural ecological context
- Aspects related to the organization and planning of the intervention.
- Socio-economic, service and public health aspects.
- Aspects relating to the provision of transport infrastructure.

At the level of building systems assessment.

- Aspects related to the sustainability of the intervention in the local context.
- Aspects relating to the proximity and endowment of transport infrastructures.
- Aspects relating to the thermal, acoustic and visual comfort of interior spaces.

For both levels, the measurement parameters tend to be linear variables (extents, distances), areal variables (areas), distribution percentages, specific technical indicators/indices or combinations thereof. However, in some cases, additions are beginning to be made in the direction of assessment also based on judgment categories (e.g., LEED v5 BDC New, *Connecting with Nature entries*, *Enhanced Building Accessibility*) (Kellert and Calabrese, 2015).

The framework 2 (Figure 2) compares three examples of project appraisal procedures responding to new sustainability paradigms such as resilience (TRF/ARUP, 2016), inclusive placemaking (PPS, 2022), and wellbeing according to the flourish model (Ellyatt, 2020; The Flourish Project, 2020; Clemence-Croome et al., 2021). These other procedures, in addition to performance-based parametric assessments, also include qualitative forms of wellbeing evaluation, determined through direct final user involvement processes[4].

These procedures are based on a polar articulation in which the final quality of the intervention is the outcome of an integrated vision between numerical checks and judgment evaluations expressed with respect to the various thematic fields (WGBC, 2021).

Each thematic field is articulated by: dimensions/attributes/needs, quantitative performance indicators and their units of measurement, qualitative assessment items/objectives (assessed through questionnaires, surveys, interviews, check lists, etc.), usually, color-range score for final assessment.

In these procedures, the recurring qualitative evaluation items related to the wellbeing concern:

The evaluation of wellbeing and physical health.

- The vulnerabilities of users in the field of resources (food, energy, water).
- The effectiveness of policies, rules and regulations.
- Measures to safeguard and assist people's health.
- Conditions of reception and perception of the safety of spaces.
- Conditions of affirmation, development and valorization of people.

The evaluation of infrastructure, access and emotional conditions.

- The adequacy of infrastructure maintenance and monitoring processes.
- The connectivity and connection options between spaces.
- The ability to generate relationships between people and their perceptive conditions of autonomy.

The evaluation of social, organizational and mental wellbeing aspects.

- The conditions of participation in decision-making activities and design of spaces.
- The capacity for short, medium and long-term planning.
- The conditions of coexistence of otherness and representation of diversities.
- The conditions of access to knowledge and cultural, artistic, recreational activities.

The new challenge is therefore to expand and specify the potential of performance-based approaches in a direction that is both technological and environmental, to integrate more descriptive and parametric variables. The design of the built habitat, in this sense, can be oriented towards the multiple human-environmental centered dimensions of people's psycho-physical wellbeing in the use of living space, at its various scales.

A field of possible human-environmental-centered synergic integration is outlined in redefining the built environment not as a relationship/opposition between parts and whole, product and process, but rather as a result of the co-evolutionary adaptation that people perform through the continuous construction of their habitat (Wylie, 1970). Influencing this adaptive position is the bio-psycho-social redefinition of the health concept (Dahlgren and Whitehead, 2007; WHO, 2013).

The human habitat is a creative and constructive expression of the overall system of socioeconomic, cultural, and environmental determinants. It constitutes the system of contextual environmental factors (landscape, cities, buildings, objects, virtual environments) that influences people's health and abilities. The built space and the building technologies to built-up the habitat assume enabling significance because they can emphasize people's responsive and adaptive capacities in terms of empowerment, participation, inclusion (RSM, 2013).

At the same time, the adaptive vision also integrally relocates the value of the resources constituting the anthropic habitat from an alternative perspective to the classical economy based on the variables of land, labor, and capital. The living space results from the continuous interaction between three forms of capital—natural, sociocultural, and built—that must be cared for, maintained, regenerated, and transformed because they are essential for the wellbeing and existence of humanity (Tucci, 2017). In this sense, the very sustainability of the human habitat relates to the maintenance of conditions of wellbeing. Moving from the consolidated environmental, economic, and social tripartition to a far more complex bio-psycho-socio-technological articulation, wellbeing is placed at the center of physical, psychological, social, environmental, and economic contextual variables. The production of human habitat value corresponds to the design capability to generate synergic and circular welfare conditions with the regeneration of the biosphere and socioeconomic resources (Folke et al., 2016; Ronchi, 2018).

Living space thus plays a central role in defining the conditions of interaction between the natural environment, individuals (with their needs, activities, diversity, behavior) and communities (degrees of participation, policies, collective practices). Various experiences are already moving in this direction, especially on an urban scale. They include the theme of the psycho-physical wellbeing of individuals and communities within a process of reviewing the performance and purpose of human habitat design, responding to the new paradigms of sustainability[5].

4 For the purposes of this essay, only a few illustrative qualitative variables referring to wellbeing have been selected in framework/Figure 2, without including the corresponding performance-based metrics

5 To cite few examples: the *City Resilience Index* (The Rockefeller Foundation-ARUP), in its four research dimensions (Health and wellbeing, Leadership and strategy, Economy and society, Infrastructure and ecosystems), among its 52 performance indicators integrates quantitative parameters (metrics) and sub-indicators of process adequacy (worst- and best-case scores). In the *Project for Public Spaces* procedures, performance evaluation referring to four key-attributes is provided for by combining measurement indicators and intangible value indicators

This convergence field thus delineates a redefinition of the project's compliance framework with requirements that are not only individual but also refer to a broader spectrum of value variables of a collective order. They are not limited to measuring objective data, but also open to contextual evaluations expressed on criteria of judgment.

Starting from the contemporary scenario, probably, for architecture and, more generally, for living environments, other values will have to be identified and recognized that go well beyond the square meters, the location, the quality of the finishes. Parameters, not necessarily tangible, capable of restoring sustainable, inclusive, and beautiful spaces (as also requested by the European Commission with the New European Bauhaus) will have to be focused on. To give an example, with specific reference to residential use, it is undeniable that a small sized accommodation equipped with all comforts and open spaces able to provide effective relationships between natural (greenery, sun, etc.) and built environments offers a better quality of life compared to a big sized property without external spaces and a whole series of features, able to provide psychophysical wellbeing benefits and sustainable conditions. New research perspectives can be recognized in investigations that concern the understanding of what really determines the value (not only economic but also environmental and social) of a habitat, the definition of the parameters able to produce this value and the identification of the skills needed to implement these developments.

5 The performative challenges of technological-environmental wellbeing

Compared to the usual contrast between human/techno-centric and eco/techno-centric approaches, the element of originality of the integrated and balanced human-environmental centered vision can be identified in the ability to broaden the framework of the qualitative-quantitative references of the project human habitat, while avoiding critical issues arising from the redundancy of data, parameters, and measurements. While maintaining its requirement-performance bases, the human-environmental centered vision opens to a technological-environmental reinterpretation of the wellbeing project also thanks to the support of different interdisciplinary contributions. The technical components that, in performance-based approaches today tend to take on an invasive and excessively technocratic/technocentric nature (Emery, 2011; Pope Francesco, 2015) with respect to human and environmental variables, are replaced by technological variables. These variables incorporate the multiple reasons and implications of the project into the design analyses and investigations processes. The concept of technical performance that is quantitatively and objectively measurable and linked to action (performance-based design), is assisted by a vision of housing performance referring to the result that can be qualitatively experienced by people (performative oriented design). The fundamental difference can be found in the evaluation of the effects of design decisions: based on efficiency, if they refer only to the technical performance of the project; traceable to effectiveness, if they refer to the performativity of the project, in the sense of ability to give form and space. The use of technical resources in the project of living wellbeing goes from the simple resolution of a problem, in facilitating terms, to an enabling condition (Emery et al., 2023; Ferraris, 2023; Tombesi, 2023). This new statement is thus able to generate people's and communities' new capacities for adaptation and development in tune with the environmental context. Design thus becomes a process of harmonizing the capabilities of the anthropic environment to generate conditions of psycho-physical wellbeing with respect to three fundamental dimensions. Firstly, through the reconnection with the production and regeneration process of the built material, architectural, environmental, historical, and cultural heritage, the project can act to recover, reuse, and reduce the consumption of natural and cultural capital. Conditions of psycho-physical wellbeing result from design actions that tend to determine multiple degrees of people's interactivity with the habitat, according to the variability of their needs, but without depending entirely on techniques. Secondly, by reorganizing and even reinventing the spatial and perceptual relationships between individuals, communities, technologies and the environment, the project can make the human habitat enabling, using technologies not to simplify or standardize behavior and habits. Psycho-physical wellbeing evolves as a function of the conditions people have to establish, recover and invent multiple degrees of co-evolutionary adaptivity with their environment, developing proactive capacities through the reasonable use of techniques.

Thirdly, the integration in the human environment project of variables that cannot be directly quantified, which can be framed in the sensorial, perceptive and emotional spheres, can contribute to raising the levels of living quality of the human habitat. Psycho-physical wellbeing is a function of the ability of living space to generate multiple forms of individual and widespread creativity by nurturing different levels of performance that are not limited only to the performance of objects and technical devices.

According to these three dimensions, the assessment of the project's capability to generate conditions of mental and physical wellbeing is in continuous transition. It, in fact, evolves as a function of quantitative variables that can be objectively determined and regulated. At the same time, however, it is subject to continuous individual and collective adaptive reactions that can only be identified and employed in the configuration of spaces through a qualitative assessment of subjective variables. The hybrid evaluation model that can be envisaged should therefore complement the linear performance-based procedures that consider individual thematic families of wellbeing according to an expert-oriented logic, with a parallel consensus-based approach that would provide guidance, feedback and information directly expressed by non-expert end users and inhabitants (Sharifi and Murayama, 2013; Manzini, 2015).

The co-presence of objective and subjective variables would allow an assessment of wellbeing conditions congruent with the bio-psycho-social framing model of people's health defined by the World Health Organization and, in parallel, could respond also to the performance-based framing models of the technological-environmental responsiveness of human habitats, because it considers:

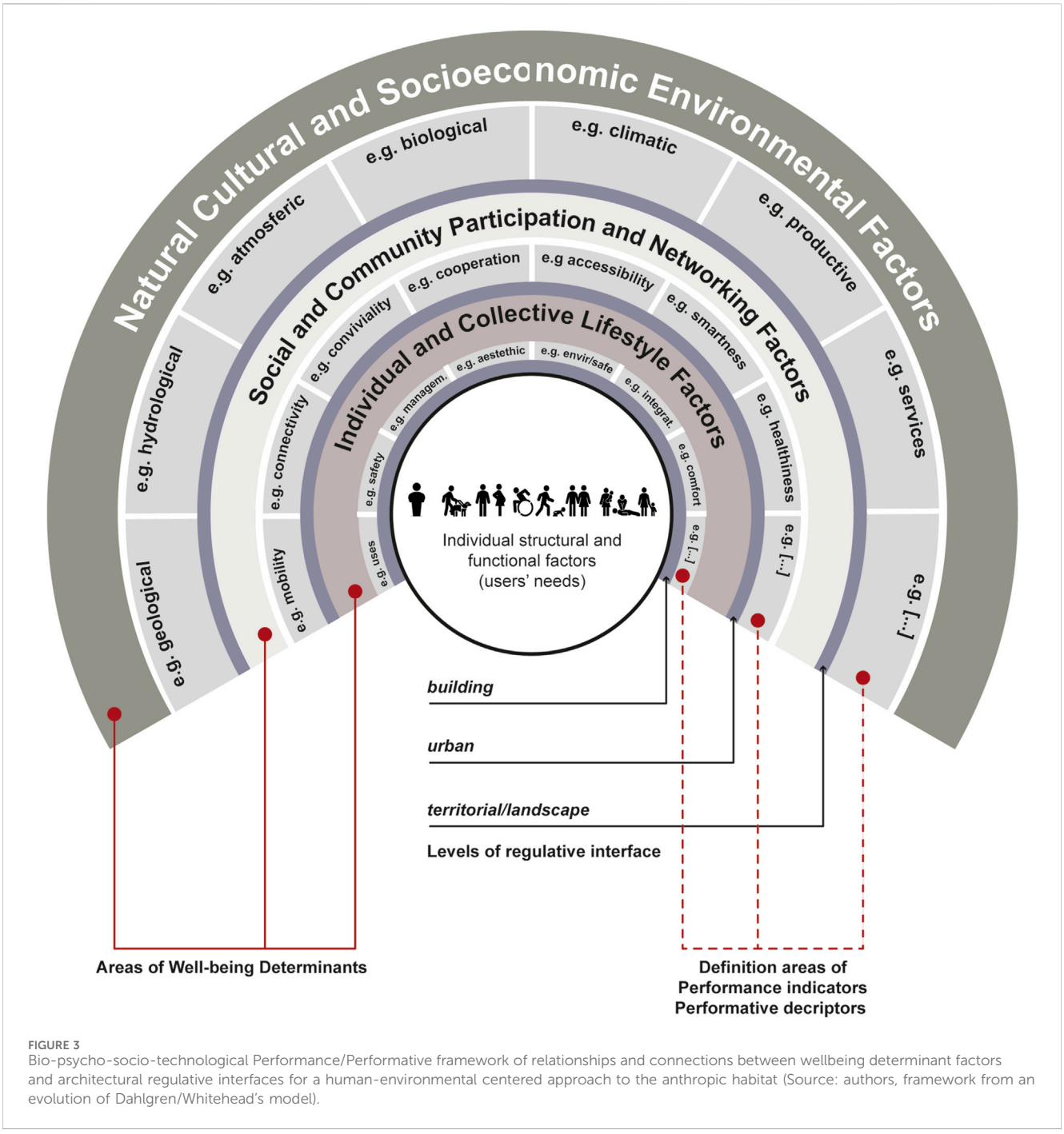

FIGURE 3
Bio-psycho-socio-technological Performance/Performative framework of relationships and connections between wellbeing determinant factors and architectural regulative interfaces for a human-environmental centered approach to the anthropic habitat (Source: authors, framework from an evolution of Dahlgren/Whitehead's model).

- The Bio components concerning the integrity of people's bodily functions and structures.
- The Psycho components concerning people's ability to perform daily activities.
- The Socio components related to the degrees of people's participation in community life.
- The Techno components as the ability of techniques to enable functions/reactions in people.

The hybrid bio-psycho-socio-technological model that is hypothesized would allow for the integration of the health-map scheme developed by Göran Dahlgren and Margaret Whitehead (Figure 3). This model already lends itself to be used for design at the various scales of human habitat through interaction with the multiplicity of actors involved in the transformation processes of the built environment (Barton and Grant, 2006; Grant, 2023). In fact, the hybrid bio-psycho-socio-technological assessment model could help integrate the determinants of health (natural, cultural and socio-economic-environmental, social and collective participation/networking, individual and collective lifestyle) with the idea of habitable built space as a regulatory interface acting on multiple levels (built, urban, spatial/landscape). Through a cross-cutting

consideration of technical components with respect to the three contextual dimensions—bio-topological, socio-anthropological, and eco-technological—recurrent in the built habitat design (Guazzo et al., 2003) at any scale, it is possible to hypothesize a human-environmental centered reorientation framework of performance-based approaches even in a consensus-based sense to act on people's psycho-physical wellbeing (Graham and White, 2016; Dyar et al., 2022):

- In a responsible way, with respect to the different determinants that influence the definition and achievement of wellbeing goals at individual and community level.
- In a responsive way, with respect to different interface architectures between people, communities, and artifacts to meet global/local and personal/collective wellbeing needs.

The proposed model thus places alongside the bio-psycho-social vision of the determinants of wellbeing an integrative vision of the different interface technological-environmental systems with which the project is able to define, in a bio-psycho-socio-technological sense, multiple and variable regulatory conditions of wellbeing. Technological-environmental determinants and systems can be quantitatively measured through the broad spectrum of indicators commonly used for the assessment of the optimal conditions and performance requirements necessary to guarantee the wellbeing goals.

This aspect therefore does not negate the performance-based assessment procedures of protocols such as BREEAM, GBC, LEED. At the same time, the determinant and technological-environmental variables will have to be conceptualized through qualitative and evidence-based descriptors, referable to case-studies, criteria, models, best practices, specifically defined to orient the project towards those specific performance capacities necessary to respond adaptively to the demands of wellbeing. In addition to focusing on these needs, the specific requirements able to allow their satisfaction could and should be considered as important parameters for defining new market values of living spaces that go well beyond the extension of square meters, location and all values considered so far.

6 Conclusion

The question concerning how much the architectural design, in its various dimensions and spheres of intervention, can have an impact on improving people's conditions of psycho-physical wellbeing also requires a reinterpretation of the performance-based logics. Architecture, as an expression of people's process of adaptation to changes in the natural and artificial habitat, is asked to develop transversal and a-scalar ways of designing and building, assuming a connotation that is both technological and environmental. It will be essential to focus on the conditions of contextualization, the availability of data and survey sources, and the levels of complexity of intervention. The human habitat design will have to take on a technological character, because architecture is in any case linked to the factors of technical development that characterize its links with production processes and the manipulation of the anthropic habitat, as it has always happened in the evolutionary history of the human species. It will necessarily also be environmental, because it will have to establish relations of global and local relevance with the materials, heritages, local histories and cultures, and natural resources that define its sense of belonging to places and territories.

Consequently, the human-environmental centered convergence will also entail necessary and inescapable reinterpretations and modifications of the performance-based approaches in the project. The proposed integrated bio-psycho-socio-technological vision, of which this paper is the first theoretical and conceptual advancement of *EX-Mind* research, opens a hybridization of performance-based design and evaluation approaches with subjective and qualitative elements that are difficult to generalize and standardize. Future developments of the proposed model will address two aspects. The first aspect can be summarized in the opportunity to expand the areas of psycho-physical wellbeing determinants by referring to new families of performative descriptors to be placed alongside the more established and objective performance indicators. New determinant areas of wellbeing assessment could be identified within some families of experiential variables emerging from experiments in *flourishing design* and *biophilic design*:

Area of variables related to the direct experience of nature and space.

- Integration of spaces with nature, greenery, landscape.
- Availability of viewpoints and observation.
- Accessibility to different forms of mobility.
- Identifiability and functional effectiveness of built habitat layouts.
- Perception and availability of natural elements (air, light, water, soil, etc.).

Area of variables related to the indirect experience of nature and space.

- Correlation with styles, forms, artifacts and languages characteristic of the context.
- Perception of and correlation with the chromatic characters of the context.
- Availability/accessibility of information about the natural/artificial context of intervention.
- Recognizability of technical characters related to local building cultures.
- Availability of transitional spaces to other natural and artificial systems/spaces.

The second aspect will involve defining the agile tools, procedures and metrics to be used to integrate objective and performance-based wellbeing assessments with consensus-based evaluations regarding subjective factors. This other aspect also underlies the further challenge of comparative assessment of psycho-physical wellbeing, between universally parameterizable expert viewpoints and diffuse design by non-expert actors. A middle-out evaluation logic should therefore tend to bring together top-down and bottom-up needs, experiences, positions, and solutions in a bidirectional evaluative vision. Assessments aimed at the measurability of the project in a quantitative and performance sense of systems or parts of the project will have to be flanked by a continuous search for new levels of qualitative description of the project's performance capabilities. This substantial innovation does not deny the performance-based foundations of technological design, but rather broadens its responses in a direction that also opens the performative components of natural/artificial space that influence wellbeing.

From this perspective, the interdisciplinary dimension, which involves an interaction between the disciplines of architecture and

those of neuroscience, psychological and social sciences, should consist not only in moments of comparison between different skills but should have a clear role in the preparation of design support tools.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below.

Author contributions

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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