sustainability

Supplementary materials

Table S1. Description of the sustainability indicators.

Category	No	Indicators	Max/ Min	Unit of Measuring	Description
Environmental sustainability dimension					
Land use considerations	q_{el1}	Appropriate site selection	Max	Points	The selected site for housing development project should meet municipal regulations, environmental context and reflect the particular needs of the population. Qualitative indicator assessed in 10-point scale by experts: 1 = site is not appropriate for the housing project, 10 = site is perfectly selected, meets all the above-mentioned requirements.
	q_{el2}	Developing damaged areas	Max	Points	The project helps revive the damaged area. Qualitative indicator assessed in 10-point scale by experts: 1 = project is not developed in the damaged area, 10 = project is implemented in the damaged area, advanced conversion solutions applied.
	q_{el3}	Landscape design	Max	Points	Quality of landscape design. Qualitative indicator assessed in 10-point scale by experts: 1 = lowest quality landscape solutions, 10 = highest quality landscape solutions (compatible with nature, includes flower and rock gardens, etc.).
	q_{el4}	Ecosystem preservation	Max	Points	The project aims at preserving a natural ecosystem. Qualitative indicator assessed in 10-point scale by experts: 1 = no ecosystem preservation solutions, 10 = the project is strongly focused on ecosystem preservation.
	q_{el5}	Quality of outdoor environment	Max	Points	Qualitative indicator assessed in 10-point scale by experts: 1 = the poorest outdoor environment, 10 = the highest level outdoor environment (private courtyard, children's playground, fitness equipment, etc.).
	q_{el6}	Housing density	Max	Number/ km^2	Density of houses in the district /neighborhood. Higher density is preferred.
	q_{el7}	Infrastructure efficiency	Max	Points	Qualitative indicator assessed in 10-point scale by experts: 1 = undeveloped infrastructure, 10 = perfectly developed infrastructure (roads, sidewalks, street lighting, etc.)
Water efficiency considerations	q_{ew1}	Quality of potable water	Max	Points	Quality of potable water assessed according to the results of toxic, indicatory and microbiological laboratory experiments. Qualitative indicator assessed in 10-point scale: 1 = the lowest quality of potable water, 10 = the highest quality of potable water.

Category	No	Indicators	Max/ Min	Unit of Measuring	Description
	q_{ew2}	Implementation of alternative water resources	Max	Points	Implementation of alternative water resources (e.g. reuse of rain and grey water). Qualitative indicator assessed in 10-point scale by experts: 1 = no alternative water solutions, 10 = advanced alternative water solutions.
	q_{ew3}	Water conservation	Max	Points	Water conservation solutions. Qualitative indicator assessed in 10-point scale by experts: 1 = no water conservation solutions, 10 = advanced water conservation solutions.
Energy and atmosphere considerations	q_{ee1}	Energy efficiency of housing	Max	Points	Energy efficiency class directly influences energy savings and economy of heating costs. Assessed in points according to the class: A++ class = 6 points; A+ class = 5 points; A class = 4 points; B class = 3 points; C class = 2 points; lower class = 1 point.
	q_{ee2}	Lighting efficiency	Max	Points	Lighting efficiency directly influences energy consumption. Qualitative indicator assessed in 10-point scale by experts: 1 = the lowest lighting efficiency, 10 = the highest lighting efficiency (use of natural lighting, LED bulbs, etc.).
	q_{ee3}	Renewable energy use	Max	Points	Renewable energy solutions (i.e. photovoltaics, wind energy). Qualitative criterion assessed in 10-point scale by experts: 1 = no renewable energy solutions, 10 = advanced renewable energy solutions.
	q_{ee4}	Greenhouse gas emission	Min	Tons/year	Greenhouse gas emission from heating. Calculated according to national standards.
Materials and waste management	q_{em1}	Use of materials with low environmental impact	Max	Points	Qualitative criterion assessed in 10-point scale by experts: 1 = environmentally friendly materials are not used, 10 = high quality environmentally friendly materials used.
	q_{em2}	Use of regional/local materials	Max	Percentage	Use of local materials in construction. Percentage of local materials used in construction of the building.
	q_{em3}	Materials and products reused	Max	Percentage	Percentage of reused materials in construction of the building.
	q_{em4}	Availability of waste management facilities	Max	Points	Qualitative indicator assessed in 10-point scale by experts: 1 = no waste management facilities, 10 = high quality waste management facilities, including recycling facilities.
Indoor environmental quality	q_{ei1}	Thermal comfort and control	Max	Points	Qualitative indicator assessed in 10-point scale by experts: 1 = thermal comfort does not satisfy norms, no control opportunities, 10 = the highest level thermal comfort, advanced control solutions.
	q_{ei2}	Indoor air quality (IAQ) solutions	Max	Points	Refers to the air quality within and around a building, especially as it relates to the health and comfort of building occupants. Source control, filtration and the use of

Category	No	Indicators	Max/ Min	Unit of Measuring	Description
					ventilation to dilute contaminants are the primary methods for improving indoor air quality in most buildings. Qualitative indicator assessed in 10-point scale by experts: 1 = the lowest IAQ, no improvement solutions, 10 = the highest level IAQ, advanced improvement solutions.
	q_{ei3}	Lighting comfort	Max	Points	Qualitative indicator assessed in 10-point scale by experts: 1 = the lowest lighting comfort, 10 = the highest lighting comfort (satisfies requirements, natural lighting is used, advanced lighting solutions, etc.).
	q_{ei4}	Visual comfort	Max	Points	Visual comfort depends on the interior design solutions and aesthetics. Qualitative indicator assessed in 10-point scale by experts: 1 = the lowest visual comfort, partial finishing, 10 = the highest visual comfort, design by famous designers, etc.
	q_{ei5}	Aural comfort	Max	Points	Building walls and floor systems have to be designed with sufficient sound absorption capability to sustain suitable acoustical quality for occupants and neighbors. Qualitative indicator assessed in 10-point scale by experts: 1 = the lowest aural comfort, 10 = the highest aural comfort.
External pollution	q_{ep1}	Pollution by NO2	Min	μg/m^3	Measured according to the national pollution maps.
	q_{ep2}	Pollution by CO	Min	μg/m^3	Measured according to the national pollution maps.
	q_{ep3}	Noise pollution	Min	dB	Measured according to the national noise maps.
	q_{ep4}	Pollution reduction considerations	Max	Points	Pollution reduction solutions in the project design. Qualitative indicator assessed in 10-point scale by experts: 1 = no pollution reduction solutions, 10 = advanced pollution reduction solutions.
Innovation and design process considerations	q_{ed1}	Innovation in design	Max	Points	Innovative solutions in design, application of "smart house" systems, etc. Qualitative indicator assessed in 10-point scale by experts: 1 = the lowest innovativeness, 10 = the highest innovativeness.
	q_{ed2}	Environmentally friendly design	Max	Points	Eco-friendly design is an approach to design buildings with special consideration for the environmental impacts. Qualitative indicator assessed in 10-point scale by experts: 1 = no eco design solutions, 10 = advanced eco design solutions.
	q_{ed3}	Quality of facilities /equipment	Max	Points	Quality of internal equipment, including heating and cooling equipment and home appliances. Qualitative indicator assessed in 10-point scale by experts: 1 = no equipment, 10 = advanced energy efficient

Category	No	Indicators	Max/ Min	Unit of Measuring	Description
					equipment.
	q_{ed4}	Architectural heritage considerations	Max	Points	Architectural heritage considerations focus on prevention of negative impact of project development on any kind of cultural heritage. Qualitative indicator assessed in 10-point scale by experts: 1 = no solutions for architectural heritage preservation, 10 = advanced architectural heritage preservation solutions.
	q_{ed5}	Architectural functionality, flexibility and adaptability	Max	Points	Comfort of apartment to residents, expressed in terms of functionality, flexibility and adaptability. Functionality is the potential of the apartment to serve its functions; flexibility – the potential for spaces to be used in a variety of ways; adaptability is the potential for the apartment to be modified with relative ease to accommodate change. Qualitative indicator assessed in 10-point scale by experts: 1 = the lowest level of functionality, flexibility and adaptability, 10 = the highest level of functionality, flexibility and adaptability.
Social sustainability dimension					
Accessibilities	q_{sa1}	Distance to the city center	Min	km	The distance to the geographical city center, expressed in kilometers.
	q_{sa2}	Access to public transportation	Min	m	The distance to the nearest public transport station, expressed in meters.
	q_{sa3}	Access to employment opportunities	Max	Number per 1000 residents	Number of jobs per 1000 residents in the district. Assessed from national statistical bureaus' data.
	q_{sa4}	Access to educational institutions	Min	m	The distance to the nearest school, expressed in meters.
	q_{sa5}	Access to shops	Min	m	The distance to the nearest supermarket, expressed in meters.
	q_{sa6}	Access to health care services	Min	m	The distance to the nearest clinic, expressed in meters.
	q_{sa7}	Access to child care	Min	m	The distance to the nearest kinder garden, expressed in meters.
	q_{sa8}	Access to leisure facilities	Min	m	The distance to the nearest leisure facilities, expressed in meters.
	q_{sa9}	Access to open green public space	Min	m	The distance to the nearest open green public space, expressed in meters.
	q_{sa10}	Car parking capacity	Max	Number	Number of car places at external parking
Neighborhood /community considerations	q_{sn1}	Safety (crime rate)	Min	Crime rate per 1000 residents	Annual crime rate per 1000 residents in the district.
	q_{sn2}	Neighborhood reputation	Max	Points	Qualitative criterion assessed in 10-point scale by experts: 1 = very low neighborhood reputation, 10 = the highest neighborhood reputation (prestigious district)
	q_{sn3}	Population density	Min	Residents number/	Number of residents per km^2 in the district.

Category	No	Indicators	Max/ Min	Unit of Measuring	Description
				km^2	
	q_{sn4}	Community cohesion	Max	Points	Community cohesion describes the ability of all communities to function and grow in harmony together rather than in conflict. It aims at building communities where people feel confident that they belong and are comfortable mixing and interacting with others, particularly with people from different ethnic backgrounds or people of a different faith. Building cohesion within and between communities is an essential step towards improving people's quality of life. Qualitative indicator assessed in 10-point scale by experts: 1 = very week community cohesion, 10 = very strong community cohesion in the district.
	q_{sn5}	Privacy	Max	Points	Qualitative indicator assessed in 10-point scale by experts: 1 = internal and external privacy is not ensured, 10 = the highest internal and external privacy insured (i.e. private leisure zones, terraces, balconies).
Economic sustainability dimension					
	q_{e1}	Price of the apartment	Min	EUR/m^2	Average price of 1 m2 of the apartment.
	q_{e2}	Housing affordability	Min	Number	Number of average net wages needed to purchase 1 m^2 of the apartment.
	q_{e3}	Mortgage interest rates	Min	Percentage	Average interest rates paid for housing mortgage.
	q_{e4}	Value stability	Max	Percentage	Probability that the value of the apartment will not change in the future. Assessed by experts.
	q_{e5}	Added value	Max	Points	Added value to local economy. Qualitative indicator assessed in 10-point scale by experts: 1 = the lowest added value, 10 = the highest added value.
	q_{e6}	Satisfaction of demand	Max	Percentage	Percentage of sold apartments.

Table S2. Normalized, weighted decision-making matrix and efficiency indexes (all categories).

Category	Indicators	LITHUANIA			LATVIA			ESTONIA		
		A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**
Environmental sustainability dimension										
Land use considerations	Appropriate site selection	0.203	0.152	0.203	0.152	0.177	0.203	0.228	0.228	0.203
	Developing damaged areas	0.153	0.076	0.076	0.076	0.115	0.115	0.191	0.076	0.076
	Landscape design	0.022	0.031	0.040	0.022	0.031	0.031	0.044	0.031	0.040
	Ecosystem preservation	0.064	0.096	0.255	0.096	0.159	0.191	0.255	0.159	0.287
	Quality of outdoor environment	0.044	0.061	0.070	0.044	0.061	0.061	0.087	0.070	0.078
	Housing density	0.015	0.011	0.019	0.033	0.018	0.015	0.015	0.013	0.018
	Infrastructure efficiency	0.129	0.103	0.116	0.090	0.090	0.103	0.129	0.103	0.116
S_j		**0.629**	**0.530**	**0.779**	**0.361**	**0.474**	**0.516**	**0.721**	**0.452**	**0.615**
Water efficiency considerations	Quality of potable water	0.633	0.562	0.703	0.633	0.633	0.703	0.633	0.703	0.703
	Implementation of alternative water resources	0.098	0.098	0.098	0.195	0.195	0.195	0.098	0.098	0.098
	Water conservation	0.020	0.020	0.020	0.061	0.102	0.102	0.020	0.020	0.020
S_j		**0.751**	**0.680**	**0.821**	**0.889**	**0.930**	**1.000**	**0.751**	**0.821**	**0.821**
Energy and atmosphere considerations	Energy efficiency of housing	0.457	0.343	0.343	0.229	0.229	0.343	0.343	0.343	0.343
	Lighting efficiency	0.031	0.055	0.043	0.031	0.031	0.055	0.049	0.049	0.055
	Renewable energy use	0.236	0.030	0.030	0.030	0.059	0.030	0.030	0.030	0.295
	Greenhouse gas emission	0.193	0.129	0.166	0.105	0.105	0.130	0.127	0.166	0.152
S_j		**0.917**	**0.556**	**0.581**	**0.394**	**0.423**	**0.557**	**0.548**	**0.587**	**0.845**
Materials and waste management	Use of materials with low environmental impact	0.421	0.361	0.541	0.361	0.421	0.481	0.481	0.481	0.541
	Use of regional/local materials	0.119	0.155	0.143	0.119	0.108	0.172	0.119	0.143	0.167
	Materials and products reused	0.089	0.089	0.134	0.089	0.089	0.178	0.116	0.178	0.178
	Availability of waste management facilities	0.098	0.098	0.098	0.076	0.087	0.098	0.098	0.109	0.098
S_j		**0.727**	**0.703**	**0.916**	**0.645**	**0.704**	**0.929**	**0.814**	**0.911**	**0.984**
Indoor environmental quality	Thermal comfort and control	0.464	0.515	0.412	0.412	0.412	0.464	0.412	0.412	0.464
	Indoor air quality (IAQ) solutions	0.251	0.195	0.223	0.223	0.195	0.195	0.223	0.223	0.251
	Lighting comfort	0.029	0.037	0.033	0.037	0.033	0.033	0.037	0.037	0.041
	Visual comfort	0.039	0.054	0.062	0.062	0.062	0.069	0.077	0.054	0.077
	Aural comfort	0.116	0.093	0.093	0.081	0.093	0.093	0.104	0.104	0.116
S_j		**0.898**	**0.894**	**0.822**	**0.815**	**0.794**	**0.854**	**0.853**	**0.830**	**0.949**

Category	Indicators	LITHUANIA			LATVIA			ESTONIA		
		A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**
External pollution	Pollution by NO2	0.054	0.073	0.056	0.038	0.022	0.022	0.064	0.073	0.094
	Pollution by CO	0.095	0.124	0.107	0.111	0.107	0.107	0.072	0.090	0.050
	Noise pollution	0.101	0.067	0.085	0.068	0.056	0.063	0.072	0.130	0.095
	Pollution reduction considerations	0.290	0.435	0.507	0.435	0.435	0.435	0.580	0.507	0.652
S_j		**0.539**	**0.698**	**0.756**	**0.652**	**0.621**	**0.627**	**0.787**	**0.800**	**0.891**
Innovation and design process considerations	Innovation in design	0.109	0.155	0.124	0.093	0.109	0.124	0.140	0.140	0.140
	Environmentally friendly design	0.197	0.230	0.263	0.230	0.263	0.296	0.296	0.263	0.329
	Quality of facilities /equipment	0.088	0.088	0.088	0.077	0.099	0.099	0.099	0.088	0.110
	Architectural heritage considerations	0.073	0.088	0.102	0.117	0.117	0.117	0.146	0.117	0.117
	Architectural functionality, flexibility and adaptability	0.208	0.208	0.234	0.182	0.234	0.208	0.234	0.208	0.260
S_j		**0.675**	**0.769**	**0.811**	**0.699**	**0.822**	**0.844**	**0.915**	**0.816**	**0.955**
Social sustainability dimension										
Accessibilities	Distance to the city center	0.034	0.013	0.057	0.009	0.023	0.021	0.026	0.006	0.011
	Access to public transportation	0.082	0.056	0.131	0.049	0.010	0.049	0.098	0.163	0.196
	Access to employment opportunities	0.238	0.103	0.115	0.051	0.051	0.053	0.090	0.102	0.110
	Access to educational institutions	0.105	0.115	0.041	0.019	0.017	0.038	0.043	0.058	0.062
	Access to shops	0.011	0.015	0.012	0.035	0.008	0.015	0.018	0.026	0.016
	Access to health care services	0.012	0.004	0.005	0.002	0.111	0.002	0.013	0.010	0.021
	Access to child care	0.001	0.001	0.001	0.002	0.001	0.105	0.001	0.001	0.002
	Access to leisure facilities	0.003	0.008	0.014	0.014	0.014	0.014	0.023	0.056	0.020
	Access to open green public space	0.002	0.062	0.062	0.004	0.003	0.003	0.016	0.031	0.012
	Car parking capacity	0.010	0.007	0.002	0.012	0.010	0.012	0.012	0.014	0.025
S_j		**0.497**	**0.385**	**0.439**	**0.197**	**0.247**	**0.314**	**0.340**	**0.468**	**0.475**
Neighborhood /community considerations	Safety (crime rate)	0.146	0.326	0.283	0.170	0.136	0.227	0.486	0.352	0.200
	Neighborhood reputation	0.081	0.054	0.090	0.045	0.063	0.063	0.090	0.072	0.072
	Population density	0.025	0.013	0.030	0.059	0.059	0.059	0.033	0.027	0.032
	Community cohesion	0.127	0.190	0.169	0.084	0.084	0.148	0.169	0.169	0.148
	Privacy	0.156	0.117	0.117	0.117	0.175	0.136	0.156	0.136	0.156
S_j		**0.535**	**0.700**	**0.689**	**0.475**	**0.518**	**0.633**	**0.933**	**0.756**	**0.608**

Category	Indicators	LITHUANIA			LATVIA			ESTONIA		
		A1	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**
Economic sustainability dimension										
	Price of the apartment	0.037	0.041	0.034	0.055	0.035	0.033	0.021	0.025	0.019
	Housing affordability	0.219	0.241	0.200	0.243	0.177	0.133	0.230	0.271	0.208
	Mortgage interest rates	0.155	0.174	0.155	0.161	0.161	0.161	0.136	0.155	0.174
	Value stability	0.055	0.032	0.052	0.055	0.055	0.055	0.058	0.058	0.055
	Added value	0.204	0.159	0.182	0.182	0.136	0.159	0.227	0.182	0.204
	Satisfaction of demand	0.214	0.199	0.175	0.201	0.088	0.107	0.214	0.193	0.161
S_j		**0.885**	**0.846**	**0.798**	**0.897**	**0.653**	**0.648**	**0.886**	**0.883**	**0.820**

Table S3. Normalized, weighted decision-making matrix and efficiency indexes (environmental sustainability dimension).

Category	LITHUANIA			LATVIA			ESTONIA		
	A1	A2	A3	A4	A5	A6	A7	A8	A9
Environmental sustainability dimension									
Land use considerations	0.065	0.055	0.081	0.038	0.049	0.054	0.075	0.047	0.064
Water efficiency considerations	0.025	0.022	0.027	0.029	0.031	0.033	0.025	0.027	0.027
Energy and atmosphere considerations	0.327	0.199	0.207	0.140	0.151	0.199	0.195	0.209	0.301
Materials and waste management	0.181	0.175	0.228	0.161	0.175	0.231	0.203	0.227	0.245
Indoor environmental quality	0.130	0.129	0.119	0.118	0.115	0.123	0.123	0.120	0.137
External pollution	0.076	0.098	0.106	0.092	0.087	0.088	0.111	0.112	0.125
Innovation and design process considerations	0.037	0.043	0.045	0.039	0.046	0.047	0.051	0.045	0.053
S_j	**0.841**	**0.721**	**0.813**	**0.616**	**0.654**	**0.775**	**0.782**	**0.788**	**0.953**

Table S4. Normalized, weighted decision-making matrix and efficiency indexes (social sustainability dimension).

Category	LITHUANIA			LATVIA			ESTONIA		
	A1	A2	A3	A4	A5	A6	A7	A8	A9
Social sustainability dimension									
Accesibilities	0.697	0.540	0.616	0.276	0.346	0.440	0.477	0.656	0.666
Neighborhood/ community considerations	0.174	0.227	0.224	0.154	0.168	0.205	0.303	0.246	0.197
S_j	**0.871**	**0.767**	**0.839**	**0.431**	**0.514**	**0.646**	**0.780**	**0.902**	**0.863**

Table S5. Normalized, weighted decision-making matrix and efficiency indexes (overall ranking).

Dimension	LITHUANIA			LATVIA			ESTONIA		
	A1	A2	A3	A4	A5	A6	A7	A8	A9
Environmental sustainability	0.429	0.368	0.415	0.314	0.334	0.395	0.399	0.402	0.486
Social sustainability	0.238	0.209	0.229	0.117	0.140	0.176	0.213	0.246	0.236
Economic sustainability	0.264	0.253	0.238	0.268	0.195	0.194	0.265	0.264	0.245
S_j	**0.931**	**0.830**	**0.882**	**0.700**	**0.669**	**0.765**	**0.877**	**0.912**	**0.967**