Supplementary Materials

Table S1. Spatial characteristics of selected public spaces in Beirut

Site	Description
Horsh Beirut	A large peri-central urban park (~300,000 m²) designed as a forested green lung, offering ecological value and biodiversity. However, perimeter fencing and controlled access points limit spatial and social accessibility. While the internal paths enhance functionality, the absence of full-time access, visual permeability, along with the presence of wide roads surrounding the park, reduces connectivity and inclusivity.
Saanayeh Park	A human-scaled neighborhood park integrated within a dense urban fabric. Surrounded by mixed uses and accessible from all sides, it promotes walkability, comfort, and informal social interaction. Shaded paths, active edges, and diverse seating support inclusive usability, while its compact size enhances spatial legibility and safety through natural surveillance.
Gebran Khalil Gebran Park	A memorial park with limited greenery and fragmented spatial programming. The park lacks clear transitions between active and passive zones, with minimal edge permeability and weak pedestrian connectivity. Bounded by vehicular traffic and institutional buildings, it offers low levels of comfort, environmental quality, and social engagement.
Zeitouna Bay	A waterfront development centered around a marina, featuring formal hardscaping, luxury retail, and cafes. It includes a public promenade that offers open sightlines, quality paving, and opportunities for passive recreation. While the space is legally accessible and well-maintained, its design emphasizes consumption and leisure, with adjacent private developments and commercial uses contributing to a perceived exclusivity. This can subtly affect the sense of inclusivity and belonging in the space.
Ain El-Mreisse	A linear, accessible seafront promenade providing high visual and physical connectivity along the coast. The uninterrupted pedestrian pathway, presence of vendors, benches, and occasional palm trees contribute to comfort and active use across demographics, though shade is minimal due to the sparse canopy of palms. It remains one of Beirut's few truly open spaces that promotes walkability and social cohesion.
Raouché	A naturally contoured coastal headland with informal trails and open toward an important landmark "Pigeon rocks". Though lacking formal infrastructure, its topography and openness provide spontaneous public use. The site suffers from absence of management and an approaching threat of privatization raising concerns over long-term accessibility, safety, and ecological preservation.
Samir Kassir Square	A small, well-articulated civic space featuring shaded seating, softscape elements, and water features. Embedded in the city core, it supports rest, reflection, and symbolic memory, with strong spatial definition and visual access.
Martyr's Square	A historically significant but underutilized urban void, characterized by a large expanse of hardscape with minimal program or human-scale design. Its low legibility, lack of shade, and poor interface with surrounding uses hinder everyday functionality. The space performs primarily symbolic or political roles, but fails to meet criteria for everyday comfort, safety, or sociability.
Nejmeh Square	A formal civic plaza with radial symmetry centered on a clock tower and surrounded by restored Ottoman-style buildings. Despite high material quality, its

	controlled access and military presence severely limit spontaneous use, inclusiveness, and civic ownership. Visually elegant, but functionally passive.

Table S2. Descriptive statistics of public open space quality factors.

Descriptive Statistics			
	Mean	**Std. Deviation**	**N**
Intensity	2.9259	.72683	297
Accessibility	2.6890	.36227	297
Activity	3.3367	1.15713	297
Management	3.3374	.45717	297
Facility	3.6132	.69534	297
Natural Elements	3.7340	1.12404	297
Valid N (listwise)	.	.	297

Table S3. Factor analysis for the public open space's factors.

Public open spaces quality factors	
Factor Name	**Factor Loadings**
Intensity	.521
Accessibility	.603
Activity	.374
Management	.717
Facility	.736
Natural Elements	.582
Extraction Method: Principal Component Analysis.	

Survey

Section 1: Demographic Information

1. What is your age?

- ☐ <18
- ☐ 18-24
- ☐ 25-34
- ☐ 35-49
- ☐ 50-63
- ☐ 64+

2. What is your gender?

- ☐ Male
- ☐ Female

Section 2: Quality of Public Open Space

3. How often do you visit public spaces in Beirut city?

- ☐ Everyday
- ☐ 2-3 days a week
- ☐ About once a week
- ☐ 2-3 days a month
- ☐ Once a month

4. How would you rate the level of people crowdedness in this open space when you visit it?

	Not crowded	crowded	Very crowded
People crowdedness	☐	☐	☐

5. How safe do you feel when you are in this public place?

	Very unsafe	Unsafe	Safe	Very safe
During the Day	☐	☐	☐	☐
During the Night	☐	☐	☐	☐

6. Do you face any limitation or restriction in accessing this or any other public space during:

	Yes	No
Timing (Day/Night)	☐	☐
Holidays	☐	☐
Weekends	☐	☐
Special occasions (ex. Parliamentary sessions)	☐	☐

7. Do you visit this public space to socialize with friends, engage in physical activities, or exercise?

Strongly agree	Agree	Disagree	Strongly disagree
☐	☐	☐	☐

8. How clean is this public space?

Very unclean	Unclean	clean	Very clean
☐	☐	☐	☐

9. How would you rate the aesthetic appeal of the landscape space?

Very unsatisfactory	Unsatisfactory	Satisfactory	Very satisfactory
☐	☐	☐	☐

10. How comfortable are you using this site in:

	Very uncomfortable	Comfortable	Very Comfortable
Sunny days	☐	☐	☐
Cloudy days	☐	☐	☐
Rainy days	☐	☐	☐
Stormy days	☐	☐	☐
Day	☐	☐	☐
Night	☐	☐	☐

11. Rate the functionalities of this space

	Very unsatisfactory	Satisfactory	Very satisfactory
Walking path availability	☐	☐	☐
Walking path width	☐	☐	☐
Walking path condition	☐	☐	☐
Walking path safety	☐	☐	☐
Vegetation area	☐	☐	☐
Facilities (kids' playground, restrooms, seating, etc.) availability	☐	☐	☐
Facilities (kids' playground, restrooms, seating, etc.) Condition	☐	☐	☐
Lighting Availability	☐	☐	☐

Lighting Condition	☐	☐	☐

12. Are any of these economic challenges or barriers are faced when accessing or utilizing the public space?

	Strongly agree	**Agree**	**Disagree**	**Strongly disagree**
Limited transportation options	☐	☐	☐	☐
High parking fees	☐	☐	☐	☐
Presence of nearby Cafes/shops	☐	☐	☐	☐

13. Are the nearby cafes/shops near the public space significantly more expensive than the average market prices?

Strongly agree	**Agree**	**Disagree**	**Strongly disagree**
☐	☐	☐	☐

14. How would you rate the suitability of the public space for:

	Very unsatisfactory	**Unsatisfactory**	**Satisfactory**	**Very satisfactory**
Young children	☐	☐	☐	☐
Teenagers	☐	☐	☐	☐
Seniors	☐	☐	☐	☐
People with special needs	☐	☐	☐	☐

15. How much are you satisfied with the number of accessible open spaces in Beirut?

Very unsatisfactory	**Unsatisfactory**	**Satisfactory**	**Very satisfactory**
☐	☐	☐	☐

Section 3: Psychological Questionnaires

16. Positive and negative affect schedule (PANAS)

Indicate the extent you have felt this way when visiting this public space.		Very slightly or not at all	A little	Moderately	Quite a bit	Extremely
PANAS 1	Interested	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 2	Distressed	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 3	Excited	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 4	Upset	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 5	Scared	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 6	Enthusiastic	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 7	Proud	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 8	Alert	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 9	Ashamed	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 10	Inspired	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 11	Nervous	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 12	Attentive	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 13	Jittery	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 14	Active	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5
PANAS 15	Afraid	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5

17. Subjective Vitality Scale (SVS)

Please respond to each of the following statements by indicating the degree to which the statement is true for you regarding your experience in this public space?

1	2	3	4	5	6	7
Not at all True	Slightly True	Moderately True	Quite True	Very True	Extremely True	Absolutely True

I feel alive and vital.	1	2	3	4	5	6	7
Sometimes I feel so alive I just want to burst.	1	2	3	4	5	6	7
I have energy and spirit.	1	2	3	4	5	6	7
I look forward to each new day.	1	2	3	4	5	6	7
I nearly always feel alert and awake.	1	2	3	4	5	6	7
.I feel energized	1	2	3	4	5	6	7

Thank you for taking the time to complete this survey!

Final Designs for Selected Beirut Public Spaces (RTD Methodology)

The intervention in Gebran Khalil Gebran Garden in Beirut reimagines this public space as an inclusive, accessible, and ecologically resilient urban park, while preserving its symbolic identity dedicated to the Lebanese author. Guided by the UN-Habitat 2018 Global Public Space Toolkit, the project integrates core principles of accessibility, safety, inclusivity, and sustainability, and is framed within a dual methodological structure combining Research for Design (RfD) and Research Through Design (RTD).

The design process builds on empirical studies on public space and mental well-being [1,30,37,38,91], a site-specific spatial and ecological assessment, and benchmarks such as Gravesend Park in Brooklyn. This RfD phase led to a strategic plan to introduce a dedicated children's playground inspired by Gebran's themes of nature and wisdom, employing organic, nature-based forms that stimulate physical and cognitive development. The playground was located in the center of the park to repurpose deteriorated lawn, supporting both efficient land use and equitable distribution of active space.

Accessibility improvements targeted the park's entrance, previously a barrier to people with reduced mobility. The redesign applied universal design principles—step-free access, tactile paving, and widened entryways—to ensure continuous and inclusive circulation. Lighting enhancements improved safety and extended evening use, using energy-efficient solar-powered systems aligned with UN-Habitat's guidance on natural surveillance and safe design. Seating elements were replaced with durable, shaded benches distributed in socially interactive areas to encourage intergenerational use and comfort.

The intervention also revitalizes the park's existing water feature, preserving its calming and cooling function through improved maintenance and circulation. The landscape strategy emphasized planting native and endemic vegetation, enhancing both biodiversity and user experience. Species such as *Quercus ilex*, *Lavandula stoechas*, and Rosa phoenicia were selected for resilience, seasonal variety, and sensory richness. Scented shrubs were introduced at a density of 5 to 20 per 100 m^2, offering a therapeutic olfactory environment proven to reduce stress and anxiety. All species were chosen for their ecological compatibility and ability to contribute to a restorative, multisensory experience.

Through RTD, the park serves as a living laboratory where spatial configurations and planting choices are evaluated in situ. Real-time observations, user feedback, and ecological monitoring allow iterative design refinements and adaptive management. This approach supports long-term sustainability and community ownership, turning the site into a replicable model for post-crisis urban landscape recovery.

By integrating cultural memory, inclusive spatial design, and environmental restoration, the Gebran Khalil Gebran Garden intervention meets both local urban needs and international planning standards. It demonstrates how public spaces in crisis-affected cities can be transformed into resilient, equitable, and health-promoting environments through design-based research and strategic alignment with global frameworks.



Figure S1. Proposed design plan for Gebran Khalil Gebran Park.



Figure S2. Vegetation concept plan for Gebran Khalil Gebran Park.

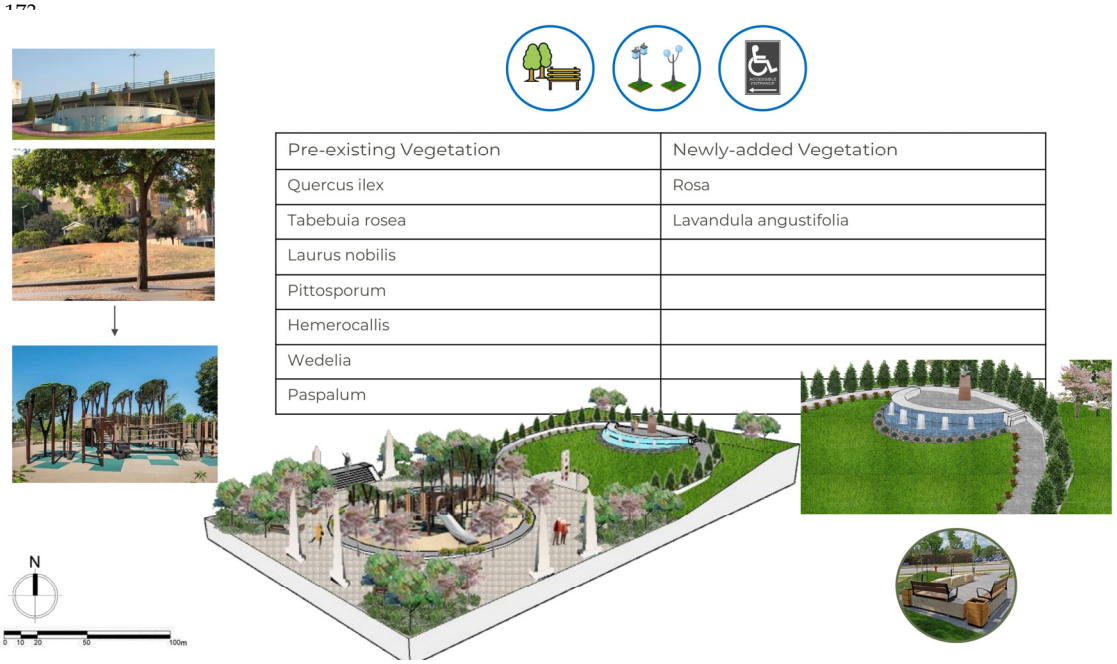

Figure S3. Pre-existing and newly-added vegetation in Gebran Khalil Gebran.

The intervention at Ain El-Mreisse promenade, classified as a "promenade-type" public open space, followed research findings that identified it as the lowest-ranking site in design quality, functionality, and user experience among the three studied locations. Despite its strategic coastal setting and frequent use for rest and physical activity, the space lacked cohesion, inclusive infrastructure, and essential amenities that contribute to

well-being. In response, a comprehensive design (Figure S4) aligned with UN-Habitat's 2018 Global Public Space Toolkit, to enhance accessibility was developed safety, inclusivity, and resilience.

Framed within a Research for Design (RfD) and Research Through Design (RTD) methodology, the intervention began with the identification of key elements essential for positive spatial experience: green cover, shaded seating, lighting, and accessible circulation. The RfD phase, informed by literature on mental well-being and public space quality [1,37,38], shaped the spatial framework, while the RTD phase allowed site-responsive adjustments based on user behavior and environmental feedback.

The design vision prioritizes mental restoration and inclusive mobility, integrating shaded seating areas, contemplative zones with sea views, and clearly defined paths for both pedestrians and cyclists. These elements promote physical activity while offering quiet spaces for reflection, key to psychological well-being. The promenade's direct exposure to harsh winter conditions required the construction of sea walls for coastal protection, ensuring long-term resilience and public safety.

To strengthen environmental quality and sensory engagement, the planting strategy introduced native and non-invasive species, with a focus on shade, scent, and seasonal color. *Quercus ilex* was selected as the dominant shade tree for its climate adaptability, while Lavandula angustifolia, Gardenia *jasminoides*, Lemongrass, and Rosa spp. were introduced to stimulate olfactory perception and reduce stress. Complementary shrubs such as Dahlias, *Osteospermum ecklonis*, and *Hemerocallis* spp. were added for their aesthetic contribution and flowering cycles. Scented vegetation was distributed at a density of 5 to 20 shrubs per 100 m^2, varying by species size and spatial configuration, to support a multisensory, immersive landscape experience.

The spatial layout integrated natural surveillance principles to improve perceived and real safety. Seating and vegetation were arranged to maintain open sightlines, and lighting enhancements increased nighttime visibility. Universal design guided the development of continuous, step-free paths, ensuring accessibility for individuals with reduced mobility and accommodating diverse users. The promenade thus became a site that supports equity, movement, and relaxation.

By treating the promenade as a design-research site, RTD enabled feedback-based adaptation and knowledge generation. Iterative evaluation of user movement, environmental performance, and sensory impact allows for ongoing improvements and informs broader coastal urban space strategies.

This holistic intervention transforms Ain El-Mreisse into a resilient, inclusive, and restorative public space, contributing to mental well-being and urban quality. It provides a replicable model for upgrading underperforming public coastal landscapes in Mediterranean cities through participatory, evidence-based, and ecologically grounded design.

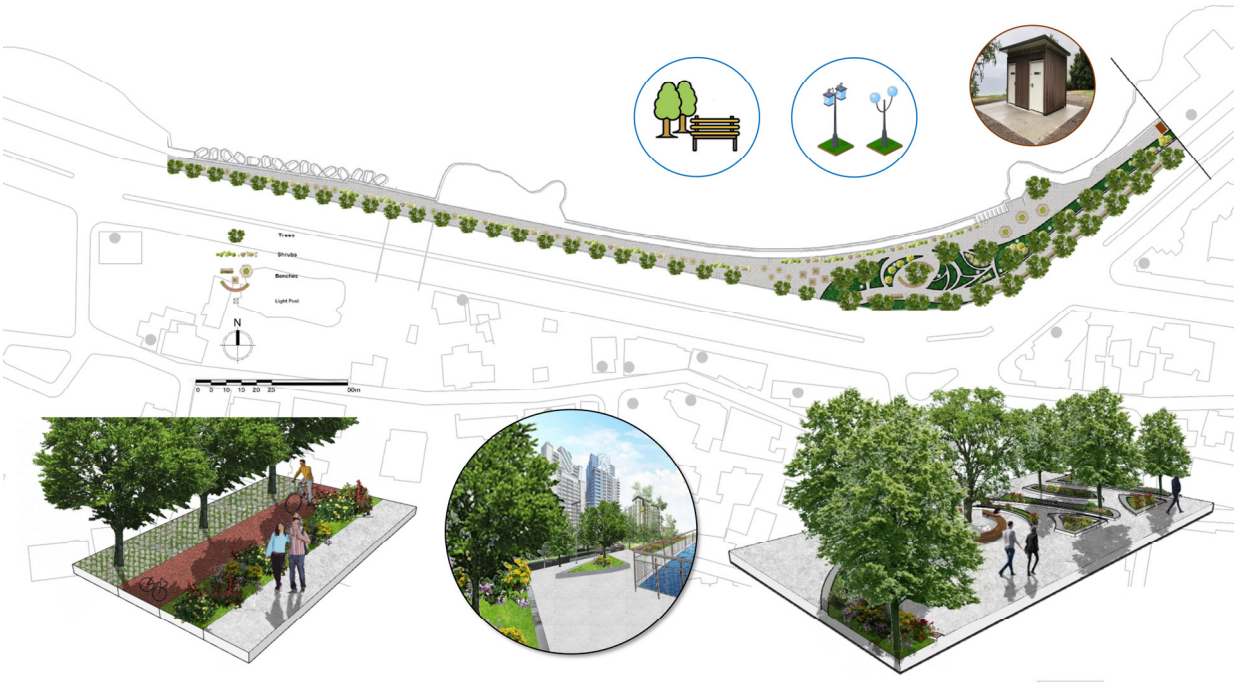

Figure S4. Proposed design plan for Ain El-Mreisse Promenade.



Figure S5. Vegetation concept plan for Ain El-Mreisse Promenade.

Martyr's Square, the third and final site studied, ranked lowest across all spatial quality indicators, revealing significant deficiencies in design, usability, and functionality. Despite its symbolic importance and strategic location in downtown Beirut, the square lacked essential characteristics of a vibrant public space. In response, the intervention aimed to align with emerging trends in resilient landscape design, guided by the UN-Habitat 2018 Global Public Space Toolkit and structured through a Research for Design (RfD) and Research Through Design (RTD)methodology.

RfD findings emphasized the need to prioritize livability, safety, health, sustainability, and accessibility, particularly for workers and passersby who frequent the space as a daily escape. Informed by evidence [1], the intervention addressed the concrete-dominated context by reintroducing natural elements and opportunities for physical and sensory activity, known to enhance urban mental well-being. The site design (Figure S6) integrates clearly defined areas for relaxation, recreation, and community engagement, fulfilling multiple spatial functions in a holistic manner.

Green infrastructure was introduced to soften the hardscape, with shade-providing trees such as Quercus ilex and Fraxinus angustifolia strategically planted to improve thermal comfort and visual quality. A land-water fountain was added to enhance mood and reduce stress, acting as a focal point of calm in an otherwise dense environment. The inclusion of permeable pavement supports resilience by facilitating natural drainage and reducing runoff, in line with climate-adaptive urban design.

Recognizing the high value of pedestrian-oriented space and in response to potential pressure to convert the square into a parking area. The researchers designed the entire site as car-free to enhance safety, accessibility, and environmental quality. This move reinforces pedestrian comfort while encouraging inclusive, equitable use of the square. Dedicated recreational zones, including a shaded picnic area, respond to the local economic crisis by offering a free alternative to commercial cafés, ensuring that families, workers, and visitors can engage with the space.

Introduction of scented shrubs and flowering plants—such as *Gardenia jasminoides*, *Rosa* spp., Cymbopogon (Lemongrass), and Chrysanthemum— enriched the sensory experience, distributed at a density of 5 to 20 plants per 100 m^2, depending on size and placement. These selections contribute to a calming and immersive environment, reinforcing the role of natural stimuli in stress reduction and social comfort. The green layout and pathways were designed to maintain natural surveillance, ensuring visibility and user safety. Lighting infrastructure was also upgraded to allow safe nighttime use and extend visitation hours.

Through RTD, the project becomes an iterative, site-specific research model. Monitored user behavior, movement patterns, and plant performance provide data to assess the design's long-term impact, enabling continuous feedback and improvement. This transforms Martyr's Square into a resilient, people-centered landscape that supports mental well-being, social interaction, and ecological recovery.

By combining historical symbolism with forward-looking, inclusive design, the intervention reclaims Martyr's Square as a civic anchor in Beirut's urban core—balancing function, memory, and resilience through research-based, participatory, and sustainable landscape practice.



Figure S6. Proposed design plan for Martyr's Square.

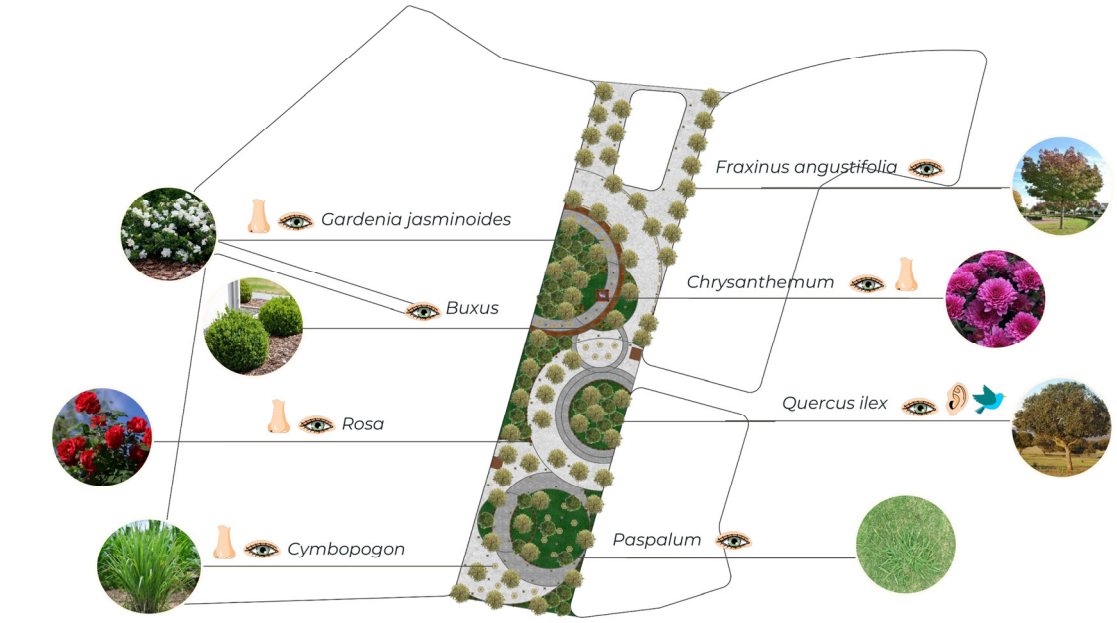

Figure S7. Vegetation concept plan for Martyr's Square.

Table S4 provides a comparative overview of the three urban landscape interventions implemented in Beirut's public spaces: Gebran Khalil Gebran Garden, Ain El-Mreisse Promenade, and Martyr's Square. This synthesis highlights the spatial context, design objectives, key interventions, and ecological strategies for each site. It further details how

each intervention aligns with the UN-Habitat Global Public Space Toolkit (2018) principles, including accessibility, safety, inclusivity, and sustainability, and reflects the dual methodological framework of Research for Design (RfD) and Research Through Design (RTD). This comparative analysis serves to contextualize the site-specific strategies aimed at enhancing urban mental well-being, resilience, and social equity across diverse urban typologies.

Table S4. Comparative Summary of the three urban interventions implemented in Gebran Khalil Gebran Garden, Ain El-Mreisse Promenade, and Martyr's Square, based on site characteristics, design strategy, and alignment with UN-Habitat (2018) guidelines and RfD/RTD research frameworks.

Criteria	Gebran Khalil Gebran Garden	Ain El-Mreisse Promenade	Martyr's Square
Site Typology	Memorial garden within a residential urban fabric	Linear coastal public space	Central symbolic square in the historic downtown
Spatial Deficiencies Identified[1]	Poor grass condition; lack of child-oriented features; underutilized space	Weak spatial definition; poor design quality; insufficient sensory experience	Absence of vegetation, shade, and infrastructure; hardscaped, car-dominated
Primary User Groups[2]	Local families, children, elderly	Walkers, joggers, elderly, nearby residents	Office workers, tourists, occasional civic groups
Design Objective	Create a sensory, inclusive, memorial-aligned play space	Introduce green infrastructure and safe movement paths along coastline	Reclaim symbolic civic space for daily use and community gathering
Key Spatial Interventions[3]	- Nature-based playground - Restored fountain - Inclusive access - Shaded seating - Scented planting	- Sea wall for wave protection - Shaded paths - Seating nodes - Cycling/walking lanes - Coastal planting	- Tree planting and permeable paving - Water fountain - Picnic area - Full pedestrianization - Aromatic planting scheme
Vegetation Strategy[4]	Quercus ilex, lavender, Rosa spp., Wedelia, Hemerocallis	Quercus ilex, lavender, Gardenia, Lemongrass, dahlias	Quercus ilex, Fraxinus angustifolia, Rosa spp., Cymbopogon, Chrysanthemum
Sensory Design Focus[5]	Olfactory and visual stimulation	Olfactory enhancement with coastal ambiance	Full multisensory landscape with scent, shade, and water
RfD Inputs[6]	Site diagnostics; literature on children's well-being and play in green spaces	Use-pattern analysis; environmental psychology studies	Data on workers' needs, spatial inequity, and access to open space
RTD Implementation[7]	User observation of play zones and vegetation adaptation	Adjustment of circulation paths and vegetation layout	Continuous spatial testing of shading, flow, and user engagement
UN-Habitat 2018 Goals Addressed[8]	Accessibility, Inclusivity, Safety, Sustainability	Walkability, Green design, Coastal resilience, Equity	Car-free design, Livability, Climate

			adaptation, Symbolic value
Water Management Strategy[9]	Restored passive water element	Sea wall and improved water infiltration	Fountain + permeable surface to reduce runoff
Accessibility Enhancements[10]	Step-free entrance; inclusive circulation paths	Tactile, wide, and continuous walkways	Fully pedestrianized; universally accessible layout
Targeted Well-being Outcomes[11]	Child development, family interaction, psychological restoration	Physical activity, relaxation, visual connection to nature	Worker comfort, social cohesion, climate comfort
Urban Function & Symbolism[12]	Memorial expression blended with ecological healing	Coastal connector that invites continuous movement and scenic interaction	Iconic national site reimagined as inclusive, everyday civic space

319

[1] 320

[1] Spatial Deficiencies Identified: Based on user surveys, spatial audits, and cross-sectional quality assessments conducted at each site.

[2] Primary User Groups: Identified through observational mapping and semi-structured interviews.

[3] Key Spatial Interventions: Physical design elements implemented on-site to address both functional and experiential needs.

[4] Vegetation Strategy: Selection based on native and climate-adapted species, with attention to ecological services and sensory engagement.

[5] Sensory Design Focus: Indicates how the intervention fosters olfactory, visual, and tactile experiences to promote psychological well-being.

[6] Research for Design (RfD): Pre-intervention planning informed by literature, empirical data, and stakeholder consultation.

[7] Research Through Design (RTD): Design as a method of inquiry, using real-time observation and iteration to refine spatial and ecological solutions.