

Sustainable Infrastructure Delivery for Expo, Hospitality, and Entertainment Districts in Saudi Arabia: Energy, Compliance, and Legacy Value under Vision 2030

SAQUIB SYED

ORCID: 0009-0006-4891-9077

Abstract- Saudi Arabia's expansion of expo, hospitality, and entertainment districts creates an opportunity to treat infrastructure as a long-term regional asset rather than a temporary response to visitor demand. This review examines how energy strategy, regulatory compliance, construction delivery, and post-event adaptation can be integrated across the lifecycle of such districts under Vision 2030. Thirty publications and institutional sources issued between 2020 and 2025 were synthesised through a structured thematic review. The evidence indicates that the strongest delivery model begins with district-scale load planning, passive climatic response, high-efficiency cooling, renewable electricity, water reuse, and digital measurement, while simultaneously embedding statutory approvals, sustainability certification, commissioning, supply-chain controls, and legacy conversion requirements. Event-led developments frequently underperform when permanent and temporary assets are planned separately, operational data remain fragmented, or legacy uses are defined after construction. Conversely, adaptable buildings, shared utilities, transit integration, modular components, and transparent performance indicators reduce stranded capacity and improve regional value. The paper proposes an integrated delivery framework linking energy, compliance, and legacy decisions through staged assurance gates from briefing to operation. It concludes that Saudi districts can create durable economic, environmental, and social outcomes when peak-event performance is treated as one operating mode within a broader, measurable, and adaptable urban system.

Keywords: Sustainable Infrastructure, Expo 2030 Riyadh, Hospitality Districts, Entertainment Districts, Energy Efficiency, Compliance, Commissioning, Legacy Planning, Vision 2030

I. INTRODUCTION

Saudi Arabia is developing large visitor districts that combine exhibition halls, hotels, cultural attractions, arenas, retail, public space, transport interfaces, and

supporting utilities. These programmes support economic diversification, tourism growth, cultural participation, and urban quality under Vision 2030 [1]. Expo 2030 Riyadh adds a specific deadline and a globally visible test of the Kingdom's ability to deliver an event precinct that remains useful after the six-month exposition. Host documents describe a permanent post-event destination, renewable energy, efficient cooling, environmental regeneration, and adaptable structures rather than a disposable site [2,3]. Similar questions arise across hospitality and entertainment destinations, where the opening date is commercially important but the operating life extends for decades.

The sustainability problem is not limited to construction impacts [8,9,11]. It concerns whether energy, water, mobility, building systems, public realm, and governance can support normal regional use, extreme event demand, and future conversion. A district may be efficient during a controlled event yet become expensive afterwards if plant capacity, space planning, security layers, or access systems are unsuitable for ordinary use. Conversely, a design optimised only for steady hotel or retail demand may fail during ceremonies, festivals, conferences, seasonal tourism peaks, or emergencies. Sustainable delivery requires infrastructure that can move between these states without excessive redundancy or loss of service quality.

Global evidence shows that megaproject sustainability is shaped by purpose, people, and process, not isolated environmental technologies [12]. Reviews repeatedly identify weak front-end definition, fragmented accountability, unstable requirements, and insufficient lifecycle evaluation as causes of poor outcomes [13]. Event legacy research

reaches a similar conclusion: venue and precinct value depends on early decisions about ownership, transport, land use, adaptability, community access, and operating finance [14,15]. World Expo sites are especially relevant because pavilions and service networks must accommodate intense short-term activity while creating a viable post-event district.

Saudi conditions strengthen the need for integration. Hot-arid weather creates high cooling loads and demands control of solar gain, humidity, outdoor comfort, water use, and equipment reliability. Hospitality operates continuously, contains diverse thermal zones, and must protect guest experience as occupancy changes [26,29]. Entertainment venues create peaks associated with schedules, crowd movement, kitchens, lighting, audiovisual systems, and security. Exhibition precincts add temporary fit-outs, international participant requirements, logistics, and large public flows. The Saudi Building Code, energy provisions, green-building requirements, and national sustainability rating system establish obligations that must become coordinated design evidence and verified performance [5-7].

This review addresses the gap between sustainability ambitions and practical infrastructure decisions. It treats an expo, hospitality, or entertainment district as a regional operating system rather than separate buildings. The analysis asks how demand should be forecast; which energy and utility strategies are robust; how compliance should be managed across packages; how construction and commissioning can preserve intent; and how legacy value can be protected through adaptable physical, commercial, and governance arrangements. The framework is intended for owners, developers, designers, programme managers, contractors, operators, regulators, and investors.

1.1 Aim and objectives

The aim is to develop an evidence-based framework for sustainable infrastructure delivery in Saudi expo, hospitality, and entertainment districts. The objectives are to synthesise recent evidence on district energy, event delivery, hotel performance, transport, circular construction, and legacy planning; identify recurring technical and governance risks;

define lifecycle controls linking design intent with measured operation; and propose practical indicators for assessing energy, compliance, resilience, and post-event value.

The review also distinguishes event-time success from regional success. Event-time success concerns safe capacity, visitor comfort, reliable utilities, and schedule certainty. Regional success concerns affordable operation, adaptable land and buildings, continuing demand, local enterprise participation, and measurable environmental improvement. This distinction prevents short-term operational excellence from being mistaken for durable sustainability.

II. REVIEW METHODOLOGY

A structured integrative review was undertaken to combine peer-reviewed research with current institutional requirements. The review window was restricted to 2020-2025 so that the synthesis reflected contemporary energy systems, event standards, Saudi codes, digital delivery practices, and the current Vision 2030 implementation context. Searches were organised around six themes: sustainable megaproject management; World Expo and event legacy; hospitality and venue energy performance; district cooling and grid interaction; green-building compliance; and adaptive reuse or circular construction.

Sources were screened for direct relevance to large visitor destinations, the built environment, or Saudi delivery conditions. Purely promotional material without identifiable mechanisms was excluded from the analytical evidence, although official programme documents were retained when they defined regulatory requirements, host commitments, or master-planning intentions. Thirty sources were selected. These comprised Saudi strategic and regulatory documents, international standards and sector reports, and academic studies addressing infrastructure, buildings, tourism, events, governance, transport, and heritage-led reuse.

The analysis used thematic coding rather than statistical meta-analysis because the evidence included reviews, case studies, standards, simulation

studies, policy reports, and conceptual frameworks with different outcome measures. Each source was coded against four questions: the intervention proposed; the delivery stage at which it operates; the evidence or verification method; and its potential contribution to energy, compliance, resilience, or legacy. Findings were then grouped into six themes: demand and capacity planning, climate-responsive energy systems, compliance assurance, construction and commissioning, operational readiness, and legacy conversion.

A second synthesis examined dependencies between themes. For example, district cooling cannot be evaluated only through plant efficiency because its legacy performance depends on network phasing, customer diversity, tariff design, redundancy, and post-event loads. Likewise, a reusable pavilion is not circular if dismantling information, storage, ownership, or future sites are undefined. The review

therefore favoured mechanism-to-outcome reasoning and explicit performance indicators. The attached Saudi heritage study informed the treatment of adaptive reuse, local identity, stakeholder participation, and long-term cultural value, particularly its emphasis on combining contemporary function with material authenticity and community benefit [30].

Quality was judged through source authority, methodological transparency, direct relevance, and clarity of evidence. Official sources were used for obligations and programme commitments, while peer-reviewed studies were used to interpret mechanisms and risks. Claims were not treated as equivalent merely because they used the term sustainable. Greater weight was given to measured outcomes, clearly defined baselines, lifecycle analysis, and comparative case evidence.

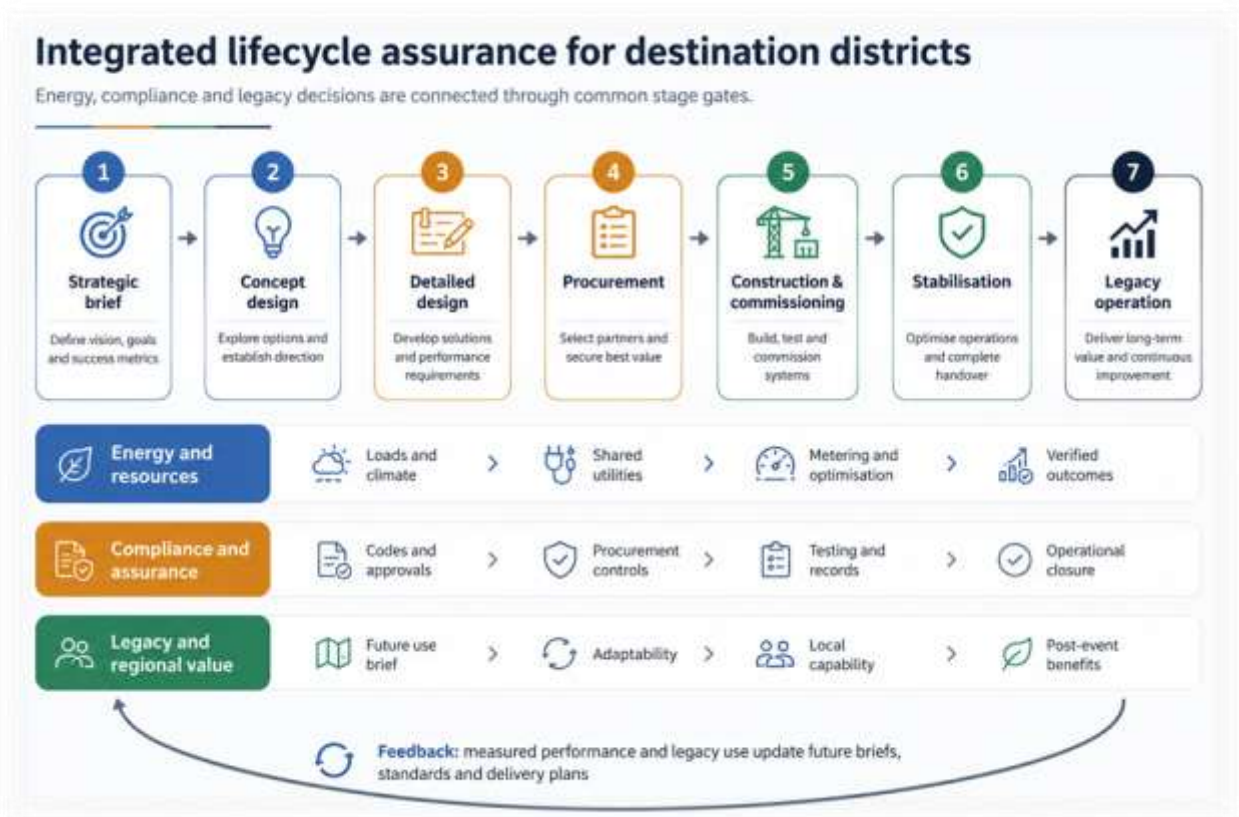


Figure 1. Integrated lifecycle assurance model for sustainable destination-district delivery.

Table 1. Evidence themes and implications for Saudi destination districts.

Theme	Core evidence	Delivery implication	Example indicators
Demand and capacity planning	Event peaks differ from normal tourism and community demand.	Model multiple operating modes; avoid permanent oversizing.	Peak kW; load factor; occupancy profile
Climate-responsive energy	Cooling, solar gain and water stress dominate hot-arid performance.	Prioritise passive response, efficient cooling and district integration.	EUI; cooling COP; thermal-storage utilisation
Compliance assurance	Codes, sustainability systems and event requirements overlap.	Create a single requirements register with evidence owners and stage gates.	Approval closure; non-conformance ageing
Construction and commissioning	Design intent is frequently lost at interfaces and handover.	Protect functional testing, seasonal verification and data quality.	Test completion; unresolved defects; meter completeness
Operational readiness	Visitor experience depends on trained teams, controls and service continuity.	Use scenario drills, operator training and performance dashboards.	Recovery time; comfort hours; alarm burden
Legacy and adaptive reuse	Long-term value depends on future use, accessibility and local participation.	Define conversion scenarios, reversible assets and community value before procurement.	Reuse rate; post-event occupancy; local spend

III. DISTRICT CONTEXT AND PLANNING BOUNDARIES

The planning boundary is the first determinant of infrastructure performance. Building-by-building design can meet individual code requirements while producing inefficient district outcomes through duplicated standby plant, oversized electrical connections, inconsistent controls, and uncoordinated maintenance access. A district boundary allows designers to combine loads, exploit diversity, share utilities, stage investment, and assess transport, public realm, landscape, water, waste, and energy as connected systems. This approach is especially valuable where hotels, arenas, exhibition halls, offices, retail, and cultural uses operate at different times.

Demand modelling should distinguish base, variable, peak, emergency, and legacy loads. Base demand includes year-round hotels, operations centres, public spaces, and essential services. Variable demand follows occupancy, weather, event schedules, and

seasonal tourism. Peak demand is associated with simultaneous venue operation, arrival surges, temporary kitchens, media systems, and outdoor cooling. Emergency demand covers life safety, communications, crowd management, and critical cooling. Legacy demand represents the post-event mixture of permanent activities. Treating a single maximum load as the design case encourages overcapacity; ignoring short peaks creates service risk. Probabilistic profiles, diversity factors, and scenario testing provide a more defensible basis for plant selection and phasing.

Spatial planning must also preserve utility corridors, plant expansion zones, logistics routes, service yards, and interfaces between permanent and temporary assets. Expo research demonstrates that transport and land-use decisions can create either durable connectivity or an ambiguous legacy when infrastructure is detached from future density and mixed-use development [16,17]. The same principle applies inside destination districts. Stations, pedestrian routes, shaded links, parking, and service

access should support everyday regional use after event overlays are removed. Permanent infrastructure should therefore follow the future city plan, while temporary elements should connect through standardised, reversible interfaces.

Visitor districts are also social and cultural places. The heritage-conservation evidence from Ushaiger shows that long-term value is strengthened when reuse protects identity, supports local enterprises, and gives communities a continuing role rather than treating authenticity as a visual theme [30]. For new districts, this implies using local climate knowledge, landscape systems, materials, craft, programming, and public access to create a place that remains meaningful beyond the opening campaign. Legacy planning should start with a defined future user population, service model, operating budget, and governance entity. Without these, “legacy” remains an aspiration rather than a deliverable.

The boundary should also include the wider electricity, water, wastewater, transport, and emergency-service networks affected by the project. Exporting congestion, peak demand, or maintenance burden outside the plot does not create a sustainable district. Regional capacity studies should identify upstream reinforcement, cumulative development loads, and shared investment opportunities before plot connections are committed.

IV. ENERGY AND UTILITY STRATEGIES

Energy planning should begin by avoiding unnecessary demand. In the Saudi climate, massing, orientation, external shading, envelope performance, glazing ratios, roof reflectance, air tightness, and shaded movement networks directly affect cooling capacity and outdoor comfort. These decisions are most valuable before architectural form and commercial schedules become fixed. The Saudi energy code for non-residential buildings establishes minimum requirements for envelopes, heating, ventilation, air-conditioning, service water heating, indoor air quality, lighting, and equipment [5]. Minimum compliance is insufficient for districts exposed to high occupancy and long hours. Project targets should use simulated energy-use intensity,

peak electrical demand, cooling energy, and carbon intensity, with separate benchmarks for hotels, halls, arenas, retail, kitchens, offices, and public realm systems [28].

District cooling can aggregate diverse loads and enable efficient central plant, thermal storage, staged redundancy, and professional operation. Research highlights storage, renewable integration, and waste-heat recovery as important improvements [21]. Yet district cooling is not automatically efficient. Low temperature differential, excessive pumping, poor balancing, oversized branches, uncontrolled tenant systems, and weak metering can erode benefits. Networks should be designed around realistic return temperatures, pressure zones, plant sequencing, part-load efficiency, and building-side commissioning. Connection agreements must define data access, maximum demand, water quality, controls, and responsibility for poor return temperatures.

Thermal storage is useful where event peaks are short and predictable. Chilled-water or ice storage can shift compressor operation, reduce chiller capacity, and support resilience. Its value depends on tariffs, losses, controls, and post-event loads, so storage should be sized through hourly simulation. Batteries can support critical loads, photovoltaic self-consumption, demand response, and power quality, but should not substitute for efficient buildings or appropriate emergency generation.

On-site renewable electricity should be planned across roofs, parking canopies, and service areas without compromising public space or maintenance. Grid-interactive research emphasises combining efficiency, digital control, generation, storage, and flexible loads [10]. Controllable loads include chilled-water production, water heating, kitchens, laundry, irrigation pumping, vehicle charging, and selected ventilation or pre-cooling schedules. A district energy platform can forecast weather and attendance, optimise plant dispatch, coordinate flexible loads, and preserve comfort limits.

Hospitality needs specific treatment because hotels operate continuously and contain guest rooms, restaurants, kitchens, laundries, pools, meeting

spaces, and back-of-house functions. Post-evaluation studies show that hotel retrofits require calibrated baselines and measurement after implementation [22]. Energy rating research also supports separating hotel zones because occupancy and intensity differ across functions [23]. Hotels should therefore be submetered by major use, with room controls, efficient hot-water generation, heat recovery where feasible, kitchen ventilation optimisation, laundry-water management, and plant sequences linked to occupancy.

Entertainment and exhibition venues create another problem: very large spaces may be occupied briefly. Zoning, localised ventilation, demand-controlled outside air, efficient fans, variable pumping, and rapid mode changes can reduce idle consumption. Controls should include event, rehearsal, cleaning, setup, standby, and unoccupied modes, each with an approved sequence and acceptance criteria. Temporary systems should use metered distribution boards and standard connection points so participant loads remain visible.

Water and energy decisions must be integrated. Potable water production, pumping, cooling towers, hot water, irrigation, and wastewater treatment all carry energy impacts. The green-building code and national rating system address water efficiency, resource conservation, indoor quality, and carbon alongside energy [6,7]. District strategies should combine low-flow fixtures, condensate recovery, treated wastewater, leak detection, pressure management, drought-tolerant planting, and cooling-water optimisation. Water balances should cover ordinary operation and event peaks.

Digital measurement closes the gap between design and operation. Major plant, buildings, tenants, temporary connections, and utility processes need meters matched to operational questions. Data architecture must define naming, intervals, synchronisation, retention, ownership, cybersecurity, and platform interfaces. Human-building research warns that energy use is strongly influenced by occupants and practices, while datasets often lack consistent protocols [25]. The solution is governed

data linked to decisions, alarms, work orders, and performance review.

V. COMPLIANCE AND ASSURANCE

Compliance should be managed as an integrated evidence system rather than late approvals. Large districts involve planning authorities, civil defence, utility providers, environmental bodies, transport agencies, event organisers, hotel operators, international participants, insurers, and certification assessors. Requirements become duplicated when packages maintain separate registers. A programme compliance matrix should identify every obligation, responsible party, submission, approval date, design dependency, construction record, test, and handover item.

Saudi codes provide the statutory baseline, including mechanical, electrical, fire, plumbing, accessibility, energy-conservation, existing-building, historical-building, and green-building provisions [5,6]. The national sustainability system adds assessment at design, construction, and operation stages, covering energy, water, quality of life, environmental impact, and performance [7,24]. ISO 20121:2024 provides an event management-system approach addressing environmental, social, and economic impacts, stakeholders, supply chains, continual improvement, and legacy [4]. These frameworks should be aligned at briefing stage so evidence can serve several purposes without weakening accountability.

The owner's project requirements should convert ambition into measurable outcomes. Statements such as "world-class sustainable venue" are not testable. Requirements should specify energy-use targets, peak demand, renewable contribution, water intensity, indoor conditions, resilience duration, public-transport share, waste diversion, modular recovery, commissioning scope, and conversion dates. Each target needs a baseline, calculation rule, boundary, data source, approver, and change process.

Design assurance should operate through stage gates. Concept review verifies master-plan loads, utility capacity, passive design, future use, and compliance pathways. Schematic review covers system options,

resilience, space, metering, maintainability, and authority interfaces. Detailed design demonstrates calculations, coordinated models, sequences, access, testing, and evidence schedules. Procurement preserves performance through specifications, approved-equal rules, supplier data, mock-ups, factory tests, and whole-life evaluation. Construction gates confirm concealed work, traceability, installation quality, and closure of non-conformities.

Independent review is important where delivery partners divide the district into plots and infrastructure packages. Interface failures occur at chilled-water conditions, electrical protection, drainage levels, communications, fire strategy, public realm levels, or control protocols. A common data environment helps only when information requirements, ownership, and acceptance rules are clear. Governance research shows that multi-sector partnerships require balanced participation and explicit agreement mechanisms [19]. The programme therefore needs an interface authority able to resolve cross-package issues before they become site changes.

Compliance continues after opening. Operational certification, permit conditions, environmental monitoring, event obligations, and energy targets require periodic evidence. Linking compliance data with asset information, maintenance systems, meters, incidents, and management review converts the handover archive into a controlled operating process.

VI. DELIVERY, COMMISSIONING, AND OPERATIONAL READINESS

Sustainable intent is vulnerable during procurement and construction because cost, schedule, and package boundaries can favour short-term substitutions. Whole-life value should be embedded in evaluation. Bidders should disclose energy performance, maintainability, embodied impacts, spare-parts strategy, local capability, commissioning resources, and recovery plans for temporary assets. Circular-construction research emphasises design for disassembly, standardisation, material passports, reuse pathways, and retained ownership [20]. These principles apply to exhibition fit-outs, temporary

facades, seating, kitchens, barriers, media systems, and overlay structures.

Construction logistics should be treated as a district system. Delivery booking, worker transport, laydown areas, waste segregation, dust control, temporary power and cooling, water, and commissioning access all influence performance and risk. Permanent utilities should not be energised informally without metering and responsibility. Temporary systems need efficiency requirements and shutdown controls. Material traceability should connect approved submittals to locations and tests. Where local materials or craft reinforce identity, quality criteria must protect durability and integration with contemporary systems.

Commissioning is the main mechanism for proving that infrastructure works as one system. It should begin during design with review of requirements, maintainability, controls, and testability. The plan must cover district utilities, buildings, public realm, transport interfaces, temporary systems, life safety, cybersecurity, and operational scenarios. Functional testing should verify normal, part-load, peak-event, emergency, recovery, and legacy modes. Performance tests require stable boundaries, calibrated instruments, known occupancy, and acceptance thresholds.

Seasonal and deferred testing is essential because not every condition occurs before opening. Cooling plant may finish during mild weather; venues may not reach full attendance until a major event; hotel occupancy may ramp gradually. Unverified conditions should enter a controlled plan with dates, parties, data, and commercial retention. The record should include unresolved observations and operational risks rather than presenting handover as binary completion.

Operational readiness must run beside physical completion. Operators need trained staff, procedures, emergency plans, spares, warranties, vendor support, cleaning strategies, security coordination, transport plans, tenant manuals, and accurate asset data. Rehearsals should test the visitor journey and backstage system: arrival, screening, ticketing,

circulation, comfort, toilets, concessions, waste, incident response, evacuation, transport recovery, and overnight reset. Event schedules should create energy and staffing forecasts. Rehearsal data should adjust plant sequences, signage, queues, and maintenance coverage.

After opening, stabilisation should compare measured performance with approved baselines. Energy, water, comfort, reliability, complaints, faults, waste, and transport indicators should be reviewed daily during initial events and then less frequently. The process should distinguish design defects from occupancy, tenant behaviour, or exceptional weather. Corrective actions must be documented and retested, preserving performance after project teams demobilise.

VII. LEGACY VALUE AND REGIONAL DEVELOPMENT

Legacy value is the capacity of infrastructure, land, institutions, skills, and cultural assets to continue producing benefits after the event or initial development phase. Research warns that legacy is a process shaped by stakeholder interests, governance, and changing conditions rather than an automatic consequence of investment [18]. A successful opening can coexist with weak legacy if operating costs are excessive, venues lack demand, transport does not serve future communities, or temporary assets have no recovery route.

The first principle is adaptability. Permanent buildings should use grids, floor heights, cores, loading, service zones, acoustic separation, and facades that permit subdivision or change of use. Exhibition halls can become convention, logistics, education, production, or mixed commercial spaces when access, daylight, and servicing are considered early. Pavilions may be retained, relocated, dismantled, or reassembled, but each pathway needs an owner, method, budget, schedule, and receiving use. Expo research shows that post-event land-use patterns vary widely and equitable outcomes require deliberate planning [15].

The second principle is right-sizing. Peak-event capacity should not become permanent burden. Shared plant, modular utilities, rentable equipment, demountable seating, and temporary overlay can cover exceptional demand while keeping enduring assets proportionate. Temporary does not mean low quality: components require safe connections, documented loads, fire performance, maintainability, and circular recovery. Contracts should favour leasing, take-back, resale, relocation, and standard components where credible.

The third principle is mixed demand. A district containing hotels, offices, residences, culture, retail, education, public services, and open space is more likely to sustain transport, utilities, and public life than a single-purpose event park. Diversity improves cooling load factors and supports activity at different times. Transport investments should connect metropolitan destinations and future development rather than only event gates. The Dubai Route 2020 case illustrates continuity beyond the event and alignment with transit-oriented development [16].

The fourth principle is cultural and community value. New districts should not imitate heritage while excluding local narratives and enterprises. The Ushaiger study shows stronger outcomes when traditional materials, contemporary use, tourism, local businesses, and community participation reinforce one another [30]. New Saudi destinations should involve local institutions, artists, operators, educators, and small businesses in programming and procurement. Public spaces should remain accessible outside ticketed events. Cultural assets need operating plans and curatorial continuity, not merely opening content.

The fifth principle is institutional continuity. Legacy requires an accountable entity with authority over land, utilities, public realm, data, programming, maintenance, and tenant standards. It needs revenue, technical capability, and published indicators. During delivery, a temporary programme organisation may decide rapidly, but post-event management needs stable governance. Asset ownership, utility tariffs, lifecycle replacement, event overlays, and public access should be resolved before handover.

The sixth principle is measurable regional impact. Attendance and construction spending do not show whether the district strengthens productivity, employment, supply chains, skills, tourism dispersal, or environmental quality. Indicators should include permanent jobs, local procurement, business survival, public-space use, transit ridership, hotel occupancy outside events, venue utilisation, energy and water intensity, renewable generation, operational carbon, asset reuse, waste diversion, and community satisfaction. Environmental regulation can improve tourism eco-efficiency when it changes investment and behaviour rather than remaining formal compliance [27].

Legacy planning should acknowledge uncertainty. Visitor preferences, climate, technology, energy prices, and commercial models cannot be predicted precisely. Adaptability, data transparency, staged investment, and periodic review are therefore more valuable than rigid forecasts. A district capable of learning is more resilient than one designed around a single promised scenario.

VIII. INTEGRATED FRAMEWORK AND DISCUSSION

The evidence supports an integrated framework with three concurrent value streams: energy and resources, compliance and assurance, and legacy and regional value. These streams should pass through the same lifecycle gates rather than separate teams. Figure 1 illustrates the process. Strategic briefing defines future land use, normal and event demand, outcomes, authority requirements, and legacy ownership. Concept design compares district utilities, transport,

passive measures, adaptability, and resilience through whole-life scenarios. Detailed design converts strategies into coordinated requirements, sequences, meters, tests, and evidence. Procurement protects outcomes through performance specifications and supplier obligations. Construction and commissioning verify installation and integrated operation. Stabilisation uses measured data to correct performance. Legacy management updates the district plan as demand evolves.

Table 1 summarises the themes and implications. The literature rejects technology-only interpretations of sustainability. Efficient chillers, photovoltaics, or digital twins cannot compensate for oversized capacity, weak interfaces, unsuitable future use, or absent operational responsibility. Legacy rhetoric cannot compensate for unverified energy performance or inadequate compliance. Governance and technical systems must therefore be managed together.

Figure 2 presents a conceptual prioritisation matrix. Measures with high lifecycle value and manageable complexity, including passive load reduction, metering, controls, commissioning, and standard utility interfaces, should be implemented first. Measures with high potential but greater complexity, such as thermal storage, large-scale water reuse, advanced demand response, or relocatable structures, should proceed through modelling, pilots, and contractual controls. Low-value additions that increase maintenance or create uncertain demand should be redesigned or omitted.



Figure 2. Lifecycle-value prioritisation matrix for infrastructure measures.

Table 2 proposes a performance dashboard that separates design predictions from measured results and requires every indicator to state its boundary, period, baseline, and owner. Event periods can distort annual averages, so reporting should distinguish ordinary operation, setup, peak attendance, recovery, and post-event use. Weather, occupancy, floor area, and operating hours should be used for normalisation where relevant.

The framework also affects delivery culture. Teams often treat compliance as the regulator's concern, operations as the future operator's concern, and legacy as the master planner's concern. In reality, responsibilities overlap. An inaccessible valve affects commissioning, energy, safety, and maintenance. A transport alignment affects capacity, emissions, land

value, and social access. A pavilion connection affects fire safety, utilities, dismantling, and reuse. Cross-functional decisions need an owner authorised to resolve trade-offs using lifecycle criteria.

Limitations remain. Public post-occupancy datasets for major Saudi destinations are limited, and international cases operate under different climates and institutions. The framework is analytical rather than predictive. Future research should test it using measured Saudi data, compare delivery packages, quantify district-cooling and storage performance,

examine visitor mobility, and track legacy indicators over several years. Transparent cases would allow rapid development to produce transferable knowledge as well as projects.

Table 2. Suggested district performance dashboard across delivery and legacy stages.

Value stream	Indicator	Boundary or normalisation	Primary review stage
Energy	Annual and peak energy-use intensity	Weather, area, occupancy and event mode	Design; stabilisation; operation
Cooling	Plant and distribution efficiency	Load-weighted seasonal performance	Commissioning; operation
Renewables	On-site and contracted renewable contribution	Matched to district electricity boundary	Procurement; operation

Value stream	Indicator	Boundary or normalisation	Primary review stage
Water	Potable use and reuse ratio	Visitor-days, floor area and landscape demand	Design; operation
Compliance	Approval and certification closure	Requirement owner, evidence date and residual risk	Every stage gate
Commissioning	Functional and seasonal test closure	System, interface and operating scenario	Handover; stabilisation
Reliability	Critical-service availability and recovery time	Normal, peak-event and emergency conditions	Readiness; operation
Adaptability	Assets reusable without major reconstruction	Permanent, convertible, relocatable or recoverable	Brief; design; legacy
Legacy use	Post-event occupancy and programmed activity	Venue, precinct and seasonal profile	Legacy operation
Regional value	Local employment, supplier participation and visitor spend	Defined geography and reporting period	Procurement; operation; legacy

IX. CONCLUSION

Sustainable infrastructure delivery for Saudi expo, hospitality, and entertainment districts requires a shift from project completion to lifecycle value. The central task is to create a district that performs under ordinary demand, exceptional event peaks, emergencies, and future reuse without carrying unnecessary capacity or losing service quality. The review shows that this outcome depends on early boundary definition, diversified load modelling, passive climate response, efficient district utilities, flexible controls, integrated water planning, measurable requirements, coordinated approvals, rigorous commissioning, and stable post-event governance.

Energy, compliance, and legacy should not be managed as separate workstreams. They are different expressions of the same delivery decisions. Plant sizing affects capital cost, grid demand, resilience, and future tariffs. Transport alignment affects event access, emissions, regional development, and social inclusion. Adaptable structures affect construction waste, commercial flexibility, cultural programming, and asset value. When these relationships are recognised at briefing stage, sustainability becomes a

practical basis for design and procurement rather than a certification exercise.

For Vision 2030 programmes, the strongest legacy will be an operational district that remains useful, affordable, connected, culturally grounded, and capable of adaptation. Success should be demonstrated through measured energy and water performance, reliable services, verified compliance, asset reuse, continuing public activity, local economic participation, and transparent long-term reporting. Expo 2030 Riyadh and related destination programmes can establish an international benchmark if temporary spectacle is delivered through permanent institutional learning and durable regional infrastructure.

This approach also improves investment discipline. Capital is directed towards assets that reduce recurring demand, protect service continuity, and remain useful across changing programmes, while unnecessary prestige features and poorly justified redundancy can be challenged early. The result is not a less ambitious destination, but a destination whose ambition is supported by evidence, operational capability, and credible future use.

Consistent public reporting matters because transparent baselines and post-occupancy evidence allow regulators, investors, operators, and communities to distinguish genuine performance from aspiration and systematically improve subsequent districts through documented lessons.

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