

Data Collection on Sustainable Building Criteria

Category	Criteria	Description	References
Sustainable Project Orientation	Introduction of sustainability principles	The introduction of sustainability principles to the team members could provide a better work outcome by improving the cooperative work in all the building systems in order to meet the sustainable missions.	[1], [2], [3]
	Understanding green project requirement	Pre-introduction, before the project starts, will support the effort reduction and effectiveness of the design of sustainable building goals achievement (SDGs), as well as cost-effectiveness.	[1], [2], [3]
	The setting of sustainability goal and priorities	This is the early setting up criteria of the planning stage to meet the utmost outcome after the construction is completed. Moreover, a proper set of sustainability goals and project priorities would set a clear framework that would help in the later decision makings in the project.	[1], [4]
	Sustainability engagement in the project baseline	During the definition of project scope, project charter, design drawing, contract, and project management plan, it is crucial to include the sustainability requirement and concern in order to select the best option to achieve the target of sustainability.	[1], [5]
	Code of behaviors	This can be used as a regulatory tool with the early set criteria to achieve the goal of sustainability for the associated stakeholders.	[1]
	Political and regulation factors	Stakeholders with appropriate skill and competency are driven or get approved by the strong governing or effective monitoring rules in terms of sustainable technology to environmental advantages.	[6]
	The key dimensions of the project	Society, economics, and the environment are integrated factors during sustainable building development.	[2]
	Awareness and demand of stakeholders	Involving peoples in the sector are encouraged to experience the sustainable benefits considered enough in terms of materials, and energy usages.	[6]
	Cost intimation	The project director needs to prepare an actualized expense to the clients corresponding to the stakeholders' effort in terms of sustainable design and construction intention.	[6]

	Reasonable incentive support	Incentives can be provided in terms of money, or other to the stakeholders to improve the working performance including the sustainability concept.	[1]
	Materials resources study	The comprehension of material sourcing, characterizing, certificating, selecting is encouraged essentially to stakeholders in terms of sustainability in the construction industry.	[6]
Sustainable Project Planning	Early stakeholders gathering	By bringing all the stakeholders to collaborate and share their ideas as early as possible during the planning stage, the sustainable project could be achieved at a lower cost; moreover, the well-functioned team in the early stage tends to show better quality in the following preparation.	[5]
	Diverse stakeholders in planning	When various groups of stakeholders work together in the early process using effective communication (which includes engineering, operation and maintenance, and outsider), the sustainable building project could provide a better result.	[1]
	Effective communication and charrettes	The ineffective communication among various professionals makes it difficult for dealing with issues such as managing changes, risk-reduction, and limiting the cost. The addition of charrettes (an intense period of designed activities) to the regular progress meeting since the beginning in the planning stage could improve the effectiveness in communication and the exchanges of ideas.	[5]
	Documenting requirements for sustainability and integrated design process	The incorporation of sustainability and integrated design requirements into the comprehensive project documents and project plans are crucial for delivering a successful project.	[1], [5]
	Planning-stage commissioning process	The adding of the commissioning process in the planning stage could ensure that the system performs as designed, and the issue in the system could be solved in the pre-design stage, which could reduce the cost spent, as the commissioning agent has the role to ensure that the works meet expectations.	[5]

	Whole building design	Whole building design refers to the design that incorporates the knowledge from all relevant stakeholders from the whole project life cycle to look at the project objectives and other design elements from different perspectives. A cost-effective and efficient building can be achieved through the use of a whole-building design approach to maximize multiple benefits resulting from the independencies in the systems.	[1], [5], [7]
	All project stakeholder's reflection	Sustainable development considers all the stakeholders' perspectives in decision making as the planning process could determine the future performance of the building.	[5]
	End user community reflection	The designs that fulfill the requirement of the community and perform its purpose well tend to be given more care and maintenance, which is likely to be more sustainable; therefore, the involvement from the users or representative of end-users is important in the planning as well as the design stage.	[5]
Sustainable Team Formation	Partner with "sustainability quality"	The selection of project managers, designers, contractors, consultants should consider the quality and capacity in the focus of sustainability as well as the familiarity of product type, market and experience with the projects which could contribute to the success of the project.	[1], [5], [6]
	Participation's competence qualification	The professionals of the team who will work throughout the whole process are required to be certified in terms of engineering ethics, and sustainability concept awareness since the concept has recently popped up and is being developed.	[1], [2]
	Team members with the sustainability concept	The comprehensive understanding of the knowledge base concept sustainability of each member can achieve the desired future result.	[1], [2],[5]
	Sustainability goals information	The design and stakeholders will be pre-informed of the sustainability missions needed to be achieved at the end of the completion.	[1],[2]
	The cross-functional integrated project team	The core integrated project team with a cross-functional system allows different parties to work closely and understand each other's concerns and problems, which could allow all the stakeholders to be actively engaged in the planning process to achieve a sustainable building project.	[1], [5]

	Office of sustainability coordination	The office should be established with a group of sustainability specialists to coordinate the sustainability concept with the design team.	[1], [5], [8]
	Design charrettes	Design Charrettes are the planning process of a multi-day collaborative session that produces consensus among stakeholders through the design phases.	[9]
	Progress meetings	They are the important occurrences of concluding the involving candidates' idea and availability to meet the possible peak of the project goals and mission before the construction starts.	[10]
Sustainable Project Stakeholders	Lenders & Investors	The lenders can be educated in sustainable project knowledge; so, they can take the chance to spread the greenery and understand the investors to feel the encouragement and advantages from the concept.	[10]
	Construction Manager	The knowledge of selecting the structural material and construction strategies is another important factor to achieve the sustainable building design	[11]
	Sustainability coordinators	Sustainability coordinators provide advice or solutions to the project stakeholders in the company or organization to obtain the sustainability goals, as well as provide the recommendation on reducing the environmental impact and carbon footprint using the procedures that effectively utilizes the use of resources and technologies.	[5]
	Facility managers or owners	Facility managers (who may or may not be owners) have a role in the operation stage of the building as they monitor, take care and maintain the whole operation as the building is completed.	[12]
	Community stakeholders	The involvement from the local communities or local government could ensure that the building's planning followed and satisfied the region's regulations and needs as well as the achievement of sustainable concepts.	[5],[10]
	Constructors, sub-constructors, suppliers	These people are always along after architects and engineers finish the drawing and planning; so, a good communication with them will avoid the extra cost and ensure the process of green materials supply, confidentially.	[10]

	Civil engineers	Civil engineer's role in green building can include the addressing of the site problems and potential hazards such as environmentally polluted sites, and also the water related issues such as water resource management and stormwater management.	[10], [13]
	MEP engineers	<p>Mechanical engineers have the role in distributing and supplying energy such as in heating and cooling systems. The reduction of energy consumption and its environmental impacts could be an important role for this profession.</p> <p>Electrical engineers responsible for circuit, wiring and telecommunication design and in some cases the electrical lighting, which could consume a large amount of energy especially in commercial buildings.</p> <p>Plumbing engineers have a role in the use of water fixtures and the connection of the water systems. As the water becomes scarcer, this sustainability in this specialist becomes more important in improving the use of water.</p>	[13]
	Architects and design professionals	The people's competence is certified or qualified in terms of architectural planning and drawing with the understanding of sustainable development principles.	[10], [13]
	Interior designers	Interior designers play an important role in providing the good indoor air quality and the sustainability of the materials and furniture such as the resources used for manufacturing, life duration as well as its potential for recycling as the designers have the choice in designing the whole space (lighting, finishing material, furniture, decoration...).	[13]
	Landscape architects	Landscape Architects normally cover the landscape design; so, the additional design in terms of greenery and sustainable concepts should be included to make the construction more alive.	[10], [13]
	In-house staff	The project personnel and vendors, in supporting the sustainable projects, have the roles in making sure that the sustainability focus is included in their works and the adherence to the company's sustainability development methodology is realized.	[4], [5], [10]

	Market representatives	Market representatives such as brokers, lenders, appraisers have the role in the determination of the asset's value and viability, which is crucial to be educated in the sustainability and project delivery process.	[5]
Sustainable Site Selection	Environmental performance target Initiation	At the start of the project, the building owner establishes specific performance goals. These should be ideal for the location and program.	[14]
	Retrofitting existing structures	Reuse as much of an existing structure as possible by renovating or redeveloping it.	[14]
	Locating in brownfield or grey-field	Brownfields are the sites that were previously developed which may or may not be environmentally contaminated, which require the site cleanup before reuse. Grey-fields are those that were previously developed but not contaminated. By locating the site on the brownfield and grey-field, the quality of the used land can be improved and further destruction of the natural land is reduced.	[15], [16], [17]
	Building orientation	The proper orientation of the building according to the direction of sun path and wind direction could take the advantage of the sun's energy and reduce energy consumption, and provide good ventilation.	[10], [16]
	Walkable neighborhoods	The walkable sidewalks, and bike friendly roadways is a way to encourage the culture of walking and biking, and it can simply use the time-tested block, or alley system in grid configuration to have efficient ways. This can reduce the carbon impact by excessive vehicle uses.	[10], [17]
	Environmental suitability	Environmental suitability must be taken into consideration before the construction to minimize the negative environmental impact on the soil, land, and the whole ecosystem.	[35]
	Existing surrounding infrastructures	The presence of existing infrastructure is also an important factor for inhabitants to access the available services surrounding the site which can promote the livability.	[18]
	Connection with community	The potential positive contribution to the development of the surrounding community must be taken into consideration before proposing the particular project.	[22]

	Land function analysis	Landscape Function Analysis (LFA) is a surveillance procedure used to measure the functional status of field areas. The program consists of various modules: a theoretical framework, a practice area and an interpretive framework. The framework is based on the economies and the processes governing the space movement and usage of water, topsoil and organic compounds in the ecosystem.	[19]
	Salvaged materials observation	Look for suitable salvageable materials from demolition contractors, specialist suppliers, salvaged construction material suppliers, or deconstructed buildings early on. All consultants should be prepared to specify salvaged materials if the situation arises. When a source has been found, the availability, content quality, timing, and storage should all be checked.	[14]
	Proximity to basic services	Choosing the site surrounded by basic services such as public transit, pedestrian path, bicycle routes, etc. It will improve the quality of living in terms of transportation cost, especially, reducing pollution from vehicle usages.	[1], [10],[14],[15]
	Urbanized area	Selecting the site that is located in the developed urban area will provide many good services for daily living such as better quality of roads, better public transport, etc.	[14]
	Mixed-use development	It's a form of urban development or zoning that combines residential, commercial, cultural, institutional, or entertainment uses into a single space.	[14],[20]
	Amenity	Amenity is something that makes life easier or more pleasant, a convenience that is a welcome part of daily life. It is a good decision to choose a place that has a desirable or practical amenity for sustainable development.	[14]
Sustainable Site Design	Preservation and enhancement of site	It is a strategy to preserve and improve the site's ecological integrity and biodiversity by providing shelter to wildlife, plant native species, etc.	[14],[15]
	Eliminating light pollution	Artificial outdoor light could have many impacts to the environment such as disrupting the natural pattern of light and dark which could affect the animal's sleep cycle and plant growth, glare and temporary blindness, waste energy.	[16], [17]

	Clustering home	The design of clustering homes (dense communities with open spaces that can be used as a recreational or environmental park [much like Borey]) could increase the site value and promote the sense of community while preserving the landscape as well.	[15], [16]
	Passive solar design	Passive solar design is the design using the building's site's natural energy as resources such as wind, sunlight, vegetation... for ventilation, heating, cooling purposes.	[10]
	Surface water management	Surface water management is the design of the site features to minimize the erosion and rainwater runoff, organic rainwater management usage, and install water separators.	[14], [15], [17],[18]
	Prevention or minimization of potable water usage for irrigation	Few strategies should be conducted such as harvesting rainwater or wastewater for irrigation, using water-efficient plants, and using water-efficient irrigation.	[14]
	Urban heat islands minimization	Maximize green space, maximize previous surfaces, provide shading, are effective strategies to practice.	[14]
	Start early to source salvaged materials	We look for the appropriate salvageable materials from demolition contractors, suppliers, and buildings that are being deconstructed.	[14]
	Research funding opportunities	Funding and other resources, find out the building that met all requirements.	[14]
	Reuse existing building for worker	Reuse existing buildings as much as possible for workers living during the construction work.	[14]
	Supportive infrastructure for alternative transportation	Its strategies are to locate buildings to be accessible to public services, encourage walking and bicycling, maximize bicycle-parking, etc.	[14]
	Site protection	Minimizing site disturbance decreases the impact of new building construction on the site and the regional ecosystem by minimizing the part of the site impacted by development, limiting grading, limiting soil erosion, and safeguarding existing plants and other natural resources.	[21]
	Carbon offset	There are multiple ways of reducing carbon emission such as: capturing and eliminating the greenhouse gas, producing clean and renewable sources of energy, collecting the stored gases to prevent it from affecting the atmosphere.	[36]

	Landscape design	Design the landscape and effective irrigation system to reduce the overall irrigation water usage and also reduce the heat island effect	[15],[18]
	Density/compact design	Compact design development will lead to more efficient land use, and reduce pollution and cost of vehicle usage, and improve social interaction as well.	[10], [15], [18]
Building Cost Reduction Plan	Material cost	Local manufactured products are cheaper and more convenient than the imported material. Research in China shows a 10.9% increase compared to the average cost of a normal building. Whereas, LEED rating standards estimate the cost on the local material usage or eliminate some features to save overall costs.	[23]
	Energy consumption cost	The energy consumption cost has been discovered to be higher than normal equipment. A study in China has shown that the total energy cost has covered more than the excessive cost of constructing the building. However, in the long run, the building is able to generate its useful features for power consumption and save the electricity cost by a great amount.	[24]
	Anticipate productive gain	We are able to show the worthiness of our green building design toward the productivity of the user. All the features such as heating, lighting, and energy efficient equipment are said to be very costly compared to normal building design but at the same time, they provide the most comfortable condition for workers.	[25]
	Design estimate cost	the varieties of value estimates encountered run parallel with the making plans and design	[26]
	Initial cost planning and reduction	The initial cost, or the entire cost including cost of material, cost of consultant, cost of land, and cost of construction, etc. is a large amount. Should also consider some reduction because economic evaluation of the initial cost is the primary concern for the client. The initial cost reduction plan should be taken into consideration at the design phase to make the project feasible.	[27], [28]
	Operation cost planning	The operation cost will exist during the building getting ready to serve, or after the construction is finished. Should be estimated in the design phase and develop the strategic method to minimize both the maintenance cost and operation cost which results in total cost over a long-term period.	[27]

	Maintenance cost	The maintenance cost happens in another stage of demolition. It includes recycling building materials or components, reusing the existing structure, and the environment.	[27]
	Recovery cost planning	The cost of demolition and material recovery can be considered as the rare case. The recycling potential of demolition building and reuse building material should be planned.	[27]
Design for Indoor Environmental Quality	Indoor light control	The building with good quality of light allows the natural sunlight or uses the lighting system that works as similar to the natural light as possible. With the right amount of light, it helps users to concentrate more and be productive.	[16],[25]
	Thermal control	With good control, we can benefit from the energy consumption that is supposed to be used by the heater or air conditioner to moderate the comfort level of temperature which boosts productivity and concentration.	[12], [16],[25]
	Ventilation control	With suitable natural ventilation, the process can help promote user well-being, productivity as well as saving the electricity bill. The process begins with the site selection where there is an adequate amount of free space of air flow in the specific region	[29]
	Humidity control	With the right amount of moisture content of the air, people can avoid dehydration due to dryness of the air that can pose many problems to our skin and respiratory system. Furthermore, with excess humidity up to 16% can lead to molding in wood which causes unhealthy air quality as well.	[30]
	Indoor carbon control	Carbon can be produced as a form of Carbon dioxide (CO ₂) from any combustion machine and metabolism of the organism body. High amounts of CO ₂ level in the building commonly occur in grounded areas such as office space, conference hall and also in tidy space, lack of ventilation	[31]
	Noise pollution control	Noise from appliances such as lighting, ventilation systems, motors... and other sources could bring some discomfort and sometimes affect the health of the residents. Some subtle background noise could also cause irritation and loss of productivity.	[16]
	Odor control	The disturbing smell can be controlled by removing and isolating the contaminants that cause odor as well as the selection of less odorous products.	[16]

	Value aesthetic decisions	The provision of good view and connection between people and nature contribute to improving the indoor environmental quality including the color of the building, the shape, the arrangement of the plant, the view on the walk path, the design of fountain, aquarium	[16],[27]
	Physical resources protection	The risk mitigation plan to prevent any hazardous event like earthquake, fire incident, flooding and terrorism should be implemented to eliminate the loss of human's life and physical property.	[27]
	Low pollutant material	Some materials emit pollutants such as VOCs (Volatile Organic Compounds) which could affect the health of the occupants and the environment; therefore, are not accepted in the high-performance green building.	[16]
Resource Conservation Plan	Energy conservation planning	Large amounts of energy and resources are consumed throughout the entire process of construction. Therefore, strategic planning should be considered beforehand.	[16],[27]
	Material conservation planning	Most raw materials are extracted from natural resources. Therefore, the selection of materials and waste management should be taken into consideration at the planning and design phases.	[27], [32]
	Land conservation planning	Urban expansion is one of the concerns in both developed and developing countries. Therefore, the use of land should be optimized by effective planning.	[27]
	Water conservation planning	Huge amount of water has been consumed to operate throughout the life cycle of the building which can lead to water crisis. Hence, water conservation planning should be developed to mitigate the utmost concern for environmental issues.	[27], [33]
Water-Saving System Design	Water-efficient plumbing utilization	A sustainable construction can be improved by utilizing the efficient system in flow of handheld or sensor toilets, urinals, showerheads, washing machines, sink, etc.	[3], [27]
	Dual plumbing design	It is used to recycle water for toilet flushing, or to have a grey water system recovering rainwater, or not-potable water for site irrigation.	[27]
	Rainwater and grey water storage design	The storage will be used for reducing treated water consumption by using rainwater as drinking water (traditionally), or for irrigation.	[27], [37]

	Pipe network and pipeline design	The design can lower the pressure of the water that can correspond to the related parameter, the water flow rate, hydraulically. This is also an effective way to control the water saving system.	[27], [38]
	Efficient hot water recirculating system design	This design could enhance the distribution to conserve water which is commonly wasted by the warming duration the users are waiting for.	[27], [39]
Sustainable Building Space Design	Building shape	Some building shapes use resources more efficiently than others. For example, a square shaped building uses less resources than the rectangular one for the same floor area.	[10]
	Smaller building footprint	As the size of the household decreases and the cost of building increases, the smaller unit of home becomes more demanded. Smaller buildings use less resources to construct as well as require less operating energy.	[10]
	Space utilization strategies	The effective design with the full use of space for small and compact units could provide a fully functional home that uses fewer resources and energy.	[10], [40]
	Smart sizing	The structural dimension of the building can efficiently maximize the use of the resources by following the standard uses of construction material. For example, as the materials commonly come in even dimensions, the use of odd dimensions requires more cutting and generates more waste.	[10]
	Eliminating hallways or corridors	The elimination of the hallway through organizing the floor plan around the living room could efficiently transform the free space into the living space and save some spaces.	[10]
	Multi-function flex spaces	The flexibility of function in the space could create effective use of the space; for instance, in a smaller unit of the home, some spaces can serve multiple functions.	[10]
	Build-ins and other storages	Build-ins such as bookshelf, laundry machine, storage drawers, and children's bed recessed in the wall could elevate up the degree of functionality of the space, and it can save the expense on furnishing.	[10]

Building Design for Energy Efficiency	Maximizing the use of renewable energy	Renewable energy such as solar and wind energy is perceived to be a clean source of energy and contributes to the low energy and low carbon footprint.	[3], [16]
	Daylighting design	The effective use of daylighting while preventing heat gain could reduce building energy consumption. The strategies for providing daylighting include placing the windows according to the orientation of the building as well as equipping automatic lighting controls.	[3], [17]
	Natural ventilation design	The design to maximize the use of natural ventilation provides fresh air for occupants. Moreover, the use of natural ventilation through an operable window could reduce the need for the cooling system; therefore, save the cost and energy.	[3], [16]
	Adoption of BIM to optimize energy usage	The Building Information Modeling tool can be used to optimize the design of mechanical systems and the building shell in the design stage to optimize energy usage.	[16]
	Building envelope insulation	It is the design of a proper energy conservation system to reduce the amount of heat loss and recover some of the loss to conserve the energy in the building	[3], [27]
	Choices of material	A wise choice of material selection is important to reduce the energy consumption in the building.	[27]
Sustainable Material Selection	Pollution prevention	Pollution reduction to environmental sustainability is caused by the effort of the design during manufacturing, construction progress, and transportation.	[27]
	Hazardous chemicals reduction	Hazardous chemicals can be natural chemicals (such as lead) or synthetic (such as dioxin) which could affect health.	[27], [16],[38]
	Maximizing local material consumption	Using locally produced and locally manufactured products can minimize the environmental impacts through less distance transportation.	[27], [16],[38]
	Maximizing energy efficiency	Materials that improve energy efficiency use less energy which means less pollution created. An example could be the materials of the building envelope that control the solar heat gain.	[38]

	Minimizing embodied energy	Embodied energy refers to the total invested energy required to produce the materials or product. Therefore, the best use of materials has to be promoted in order to avoid the embodied energy being wasted. For example, the use of 500-years old trees to make papers is not an efficient use of embodied energy.	[16],[38]
	Maximizing material durability	The material with great durability can delay the frequency of material replacement, which can save resources and energy.	[27], [17],[38],[41]
	Maximizing maintainability	Maintainability refers to the ability of a facility that after the maintenance, the specific condition can be retained or restored.	[38], [42]
	Maximizing recycled content	The use of recyclable material could contribute to either less waste generation or energy consumption during recycling.	[38], [16]
	Adopting material waste management	A proper waste management plan to minimize the usage of environmental resources by construction waste reduction and recovery, reusing and recycling the materials to the utmost possibility, and managing the waste storage appropriately included non-preventable waste and toxic material.	[27],[38],[43]

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