

Futuristic Library Architecture in the Context of Sustainable Development Goal (SDGs)

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ABSTRACT

In the era of recent advancements in technology and growing concerns about the environment, libraries are also playing a significant role in promoting sustainability and becoming a multifunctional knowledge hub. This paper focuses on how different architectures of various globally recognized libraries promote sustainability and Green Initiatives. By analyzing case studies from International Libraries like The Deichman Library, Oslo, Norway, The National Library of Qatar, The Tianjin Binhai Library, China, The Seattle Central Library, USA, Springdale Library, Toronto - the paper identifies key architecture features including green infrastructure, green technology, green initiatives, and sustainable development.

KEYWORDS: Futuristic Libraries, Green Architecture, Sustainable Development, Sustainable Library Design, Smart Technology.

1. INTRODUCTION

Libraries have always been significant places where people read, learn, and access new information. Libraries have evolved, and they are now more advanced and are contemporary places that use advance technology to fulfill users' needs. At the same time, they are also focusing on environmental aspect like climate change, pollution, and energy scarcity. To contribute to saving Mother Earth, libraries are promoting the concept of sustainable development and green initiatives. Thus, libraries are not just buildings with books; they have significantly expanded through innovative architecture, smart green technology, and different sustainable innovations. The concept of futuristic libraries is beyond that of traditional libraries. The libraries of the 21st century are designed to fulfill multiple needs of the user and the environment. They are more technically advanced, dynamic, and sustainable. Innovative architecture is inculcated with smart technology, sustainable gadgets, and green initiatives. According to Report of the World Commission on Environment and Development: Our Common Future, "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (*Sustainable Development*, n.d.).

2. OBJECTIVES

- To define the concept of sustainable and futuristic library architecture.
- To identify essential features of green library design.
- To explore selected case studies of libraries that exemplifies sustainable practices.

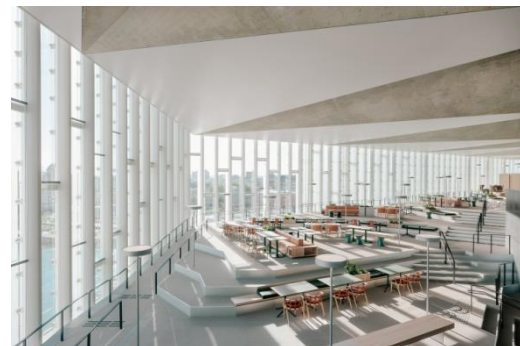
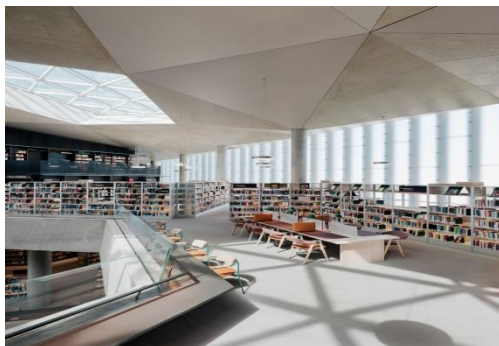
3. RESEARCH METHODOLOGY

This study adopts a qualitative multiple case study approach to examine selected library buildings with a focus on sustainable design, architectural innovation, and user-oriented services. The case study method enables an in-depth understanding of real-life examples within their specific contexts, allowing for a comparative analysis of design practices and functional outcomes. The libraries have been selected based on criteria such as global recognition, innovative architecture, incorporation of sustainable practices, and availability of reliable data, including examples like the Deichman Bjørvika Library, Tianjin Binhai Library, and Seattle Central Library. The study relies on secondary data sources such as research articles, official library websites, reports from organizations like the International Federation of Library Associations, and architectural platforms. The collected data is analyzed using thematic analysis to identify key aspects such as sustainability features, spatial design, and technological integration. Although the study is limited by its reliance on secondary data and selected cases, it provides valuable insights into best practices in contemporary library architecture.

4. CASE STUDIES OF FUTURISTIC INTERNATIONAL LIBRARIES

4.1. The Deichman Library, Oslo, Norway

The Deichman Bjørvika Library is the central public library of Oslo, Norway, and one of the most significant cultural infrastructure projects in the city's recent urban transformation. Officially opened in 2020, it replaced the former main library and was designed to serve as a 21st-century public knowledge and community hub in the rapidly developing Bjørvika district—situated between Oslo's Central Station and the Opera House. Oslo Fjord Guide +1 The library covers approximately 18,000 m² of floor space spread across multiple levels, housing a diverse array of cultural and educational functions beyond traditional book lending, including workshops, creative labs, digital media studios, performance spaces, and community areas. The library is the blend of traditional as well as modern amenities focused on sustainable development for the service delivery.



(Deichman Library / Atelier Oslo + Lund Hagem, 2021)

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4.1.1 Sustainable Design Features

- **Energy Efficiency:** The library incorporates energy-saving technologies, including smart climate control systems that adjust lighting and temperature based on occupancy, reducing energy consumption. (*FutureBuilt*, n.d.)
- **Natural Lighting:** Large windows and strategically placed light shafts allow ample natural light to penetrate the building, minimizing the need for artificial lighting during the day (*Deichman Library / Atelier Oslo + Lund Hagem | ArchDaily*, n.d.)
- **Eco-Friendly Materials:** Construction utilizes low-carbon materials, such as recycled concrete and sustainably sourced wood, to reduce the building's environmental footprint.
- **Water Conservation:** water-saving fixtures, systems to minimize water usage.

4.1.2. Architectural Highlights

- **Modern Iconic Design:** Designed by Atelier Oslo and Lund Hagem, the library represents contemporary Nordic architecture with a strong urban identity (*ArchDaily*, n.d.).
- **Cantilevered Upper Floors:** Features a distinctive cantilevered structure that extends over the entrance plaza, creating shade and a striking visual form (*ArchDaily*, n.d.).
- **Open and Transparent Structure:** Extensive use of glass façades enhances transparency, natural light, and visual connection with the surrounding cityscape (*FutureBuilt*, n.d.).
- **Multi-Level Spatial Design:** Six floors organized with flexible, open-plan layouts that support diverse user activities and efficient space utilization (*IFLA*, n.d.).

4.2. The National Library of Qatar

The Qatar National Library (QNL) is a major cultural, educational, and community institution located in Education City, Doha, Qatar. It is designed by world-renowned architect Rem Koolhaas of OMA.

The 45,000-square-meter facility opened to the public in 2018 and integrates three key roles:

- National library preserving Qatar's cultural and documentary heritage,
- Research-level university library, and
- Public metropolitan library serving the reading and learning needs of the wider community.

Situated in a major academic and innovation hub, QNL aims to support Qatar's knowledge-based economy and lifelong learning goals, aligning with national strategic visions such as Qatar National Vision 2030.

4.2.1. Sustainable Design Features

The Qatar National Library (QNL) exemplifies a commitment to environmental sustainability through its architectural and operational strategies:

- **Energy Efficiency:** The library has an innovative Building Management System that controls energy. The Lighting system is preprogrammed in such a way that it dims the light automatically when not in use or after library hours. This helps in saving electricity (*Qatar National Library's Efforts in Promoting Environmental Awareness and Sustainability | Qatar National Library*, n.d.)
- **Water Conservation:** QNL has water taps with a sensor that helps in water conservation (*Qatar National Library's Efforts in Promoting Environmental Awareness and Sustainability | Qatar National Library*, n.d.)

- **Waste Reduction:** The library has incorporated a comprehensive waste management program with various bins for recycling cans, glass, used paper, and food waste. It has also collaborated with Qatar Foundation's General Services Department to recycle electronic waste and to treat chemical waste generated by its Conservation and Preservation Lab(*Qatar National Library's Efforts in Promoting Environmental Awareness and Sustainability | Qatar National Library, n.d.*)

4.2.2. Architectural Highlights

QNL's architectural design reflects innovation and functionality:

- **Open-Plan Design:** big and expansive room where there are no walls and no obstruction of view. A user can move freely and enjoy the sense of openness (*Qatar National Library - Danish Architecture Center - DAC, n.d.*).
- **Natural Lighting:** The designed to allow an ample amount of sunlight. The building's glass façade filters the sunlight and creates a natural light environment for the reader (*Qatar National Library - Danish Architecture Center - DAC, n.d.*)

4.3. The Tianjin Binhai Library, China

The Tianjin Binhai Library, located in Tianjin, is a prominent public library developed as part of the Binhai Cultural Center to enhance cultural and educational engagement. Designed by MVRDV in collaboration with Tianjin Urban Planning and Design Institute, the library was opened in 2017 and spans approximately 33,700 square meters, with a capacity of around 1.2 million books (ArchDaily, n.d). It is widely recognized for its unique architectural design, particularly the large spherical auditorium at its center, which gives it the nickname "The Eye." The interior is characterized by terraced, floor-to-ceiling bookshelves that create a visually striking and futuristic environment while also serving functional purposes. The library acts as a major cultural hub, providing spaces for reading, learning, and community activities, thereby contributing significantly to public knowledge dissemination and urban cultural development (ArchDaily, n.d.).

4.3.1.Sustainable Design Features

Although the Tianjin Binhai Library is primarily celebrated for its visual innovation, it also incorporates sustainable principles through intelligent design choices:

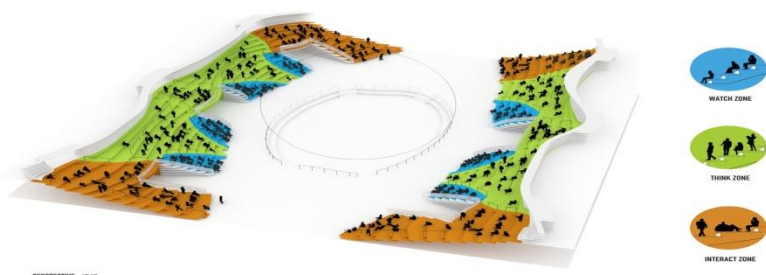
- **Natural Ventilation and Lighting:** The building has a central spherical auditorium, surrounded by bookshelves that double as louvered steps and walls. Natural light is allowed to penetrate deep into the building through this design, minimizing the use of artificial lighting during the day (*Tianjin Binhai Library / MVRDV + Tianjin Urban Planning and Design Institute, 2017*)
- **Energy Efficiency:** The curvature and white interior facilitate better light reflection and heat dispersion, which helps regulate the energy within the building more effectively. Thermal insulation is provided by the materials adopted in the building, and HVAC loads are minimized(*MVRDV - Tianjin Binhai Library, n.d.*)

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4.3.2. Architectural Highlights

The library's design is futuristic and symbolic, earning it the nickname "The Eye of Binhai."

- **Central Auditorium "The Eye":** The building has a large spherical auditorium in the center. Bookshelves surround the sphere, and these stairs act as seats, stairs, and also extend across the ceiling like a glowing landscape (*Tianjin Binhai Library / MVRDV + Tianjin Urban Planning and Design Institute, 2017*)
- **Terraced Bookshelves:** the most attractive feature is terraced bookshelves, which are stairs, seats, and they are also divided into 3 types of zones- Watch Zone, Think Zone, and Interact Zone



(*Tianjin Binhai Library / MVRDV + Tianjin Urban*

Planning and Design Institute, 2017)

Glass Façade: The front side of the building allows natural light as source of light in library.

4.4. The Seattle Central Library, USA

The Seattle Central Library, located in Seattle, is a landmark public library known for its innovative and contemporary design. It was designed by OMA (Office for Metropolitan Architecture) in collaboration with LMN Architects and officially opened in 2004 (ArchDaily, n.d.). The building spans approximately 34,000 square meters and is structured with a unique geometric glass-and-steel façade that enhances transparency and natural lighting. One of its key features is the "Books Spiral," a continuous ramp system that allows the entire nonfiction collection to be arranged in a seamless sequence, improving accessibility and user navigation. The library is designed to support multiple functions, including reading areas, digital access zones, and community spaces, making it a dynamic knowledge hub. It plays a significant role in urban development and public engagement by integrating technology, flexible spaces, and user-centered services (ArchDaily, n.d.; OMA, n.d.).



(*Gallery of Seattle Central Library / OMA + LMN - 1, n.d.*)

4.4.1. Sustainable Design Features

- **Energy Efficiency:** The library utilizes a triple-glazed curtain wall that maximizes daylight while minimizing solar heat gain. This reduces reliance on artificial lighting and air conditioning. The building is 10% more energy-efficient than Seattle's strict energy codes ("Seattle Central Library, US," n.d.). "The building received Leadership in Energy and Environmental Design (LEED) Silver Certification from the

U.S. Green Building Council (USGBC) in 2005, becoming one of the first 50 buildings in the nation to receive a Silver rating”.

- **Natural Ventilation and Lighting:** The library is designed with open spaces, glass facades, and large skylights, which allow natural light to penetrate deep into the interior. This not only saves energy but also creates a pleasant reading environment (*Central Library Architecture*, n.d.)
- **Material Sustainability:** The construction made extensive use of recycled materials and low-VOC (volatile organic compound) products. The structural steel includes recycled content, and locally sourced materials were prioritized (*Library Revolution - Seattle Public Library*, n.d.-a). “Its flooring uses a recycled product known as Worthwood, made by Oregon Lumber”(Central Library, 2002-Present, *The Seattle Public Library*, n.d.-a).
- **Water Conservation:** Low-flow fixtures and drought-resistant landscaping reduce water use. Additionally, the building’s irrigation system uses captured rainwater(Central Library, 2002-Present, *The Seattle Public Library*, n.d.-a)

4.4.2.Architectural Highlights

The architectural design of the Seattle Central Library emphasizes futuristic aesthetics, functionality, and user engagement:

- **Unique Structural Form:** Designed by Rem Koolhaas and LMN Architects, the building’s distinctive diamond-shaped glass and steel façade gives it a futuristic identity. Its geometric, transparent structure symbolizes openness and access to information (*Central Library Architecture*, n.d.)
- **Books Spiral:** A revolutionary feature, the "Books Spiral" is a four-story continuous ramp that displays the non-fiction collection in a seamless, Dewey Decimal System-aligned order, improving accessibility and navigation(*Central Library, 2002-Present, The Seattle Public Library*, n.d.-b)
- **Multi-Zone Design:** The building features distinct functional zones—Reading Room, Mixing Chamber (information help desk), Living Room, and technology-rich zones for youth—each designed for specific user needs, creating a holistic library experience (*Library Revolution - Seattle Public Library*, n.d.-b)

4.5. Springdale Library, Toronto

The Springdale Branch Library, located in Toronto, is a modern community-focused public library designed to serve the diverse population of the Springdale neighborhood. It was developed as part of the Toronto Public Library system and officially opened in 2016 (Toronto Public Library, n.d.). The building is known for its contemporary architectural design, featuring a transparent glass façade that enhances natural lighting and creates a welcoming and open environment. The library offers flexible interior spaces, including reading areas, study zones, and community meeting rooms, designed to support learning, collaboration, and cultural activities. Emphasizing accessibility and user comfort, the library integrates modern technologies and efficient spatial planning to improve service delivery. As a community hub, it plays an important role in promoting literacy, digital inclusion, and social engagement within the local population (Toronto Public Library, n.d.).



(Springdale Library & Komagata Maru Park / RDHA, 2023)

4.5.1. Sustainable Design Features

Natural Day lighting: The facade of the building is mostly glass (70%) with ceramic frit patterns creating the facade, designed to avoid unnecessary solar heat gain. Another intention of this white to grey color frits design is to depict the pages of the book. The vertical composition of the glazed facade goes hand in hand with the thin steel columns supporting the canopy roof (Patil, 2021a).

LEED Gold Certification: The library is constructed and designed in such a way to attain LEED Gold Certification. This includes –

- Grey water system
- Geothermal heating and cooling
- Solar-responsive windows. The space between the white and grey shaded striated patterns expands and contracts as per the orientation of the sun, thus reducing the solar heat gain.
- Use of natural lighting in the library. The Oculus skylights, big windows, and white-colored roofscape help to keep all the areas of the library well lit.
- Electric car charging stations at the parking area.
- A green roof that morphs with the landscape around the structure (Patil, 2021a)

4.5.2. Architectural Highlights

- **Integration with Komagata Maru Park:** The library is in a Triangular shape, a single-storey Building, and it is built around Komagata Maru Park. It is built in memory of the Komagata incident of 1914. It is a symbol of multiculturalism and immigration to Canada (Patil, 2021a)
- **Oculi-shaped structures:** The oculi-shaped structure in the Children's area is not only a showpiece but also creates a half-enclosed space. The sky is visible, and the floor is covered with green carpets, creating a positive environment for children. This structure also helps in minimizing the sound and natural light ventilation (Patil, 2021b).
- **Drywall Ceiling:** The perforated drywall ceiling is made to absorb sound. All the necessary mechanical articles are concealed in the ceiling. The white textured paint of the ceiling helps to reflect and spread the light in the library, illuminating the large area with natural light. Floors are in grey polished concrete in some areas (Patil, 2021b)

5. DISCUSSION

The global case studies of futuristic library design indicate that libraries are focused on sustainability, technological innovation, and community participation. The libraries included in this study are all adopting renewable energy technologies such as solar panels and geothermal heating, as well as passive strategies such as natural day Lighting and ventilation, which limit the libraries' dependence on other energy sources. The presence of smart technology is also highly consistent across several sites: technologies such as automated check-in and check-out processes, climate controls, and RFID-enabled services that enable users to self-check-out books and materials make library services more efficient and improve sustainability. Architects have also created layouts in futuristic libraries that emphasize flexibility and multi-purpose spaces so that libraries can provide services for a variety of user needs, allowing for collaborative learning, innovation, and inclusivity. Most futuristic libraries operationalize historical and cultural references that illustrate their local identity and societal responsibility, which encourages users to consider their own societal responsibility. Overall, libraries in the contemporary world are transitioning from static, traditional spaces to multifunctional, sustainable institutions, which are strongly aligned with the United Nations Sustainable Development Goals (SDGs).

6. APPLICABILITY OF SUSTAINABLE LIBRARY ARCHITECTURE IN THE INDIAN CONTEXT

The examples of the world, used in this study prove the idea that the sustainable library architecture is not connected with the highly developed countries; on the contrary, it offers a model which can be transmitted to the countries of developing world like India. Green or sustainable library is described as a library in which the environmental issues are taken into consideration, and the library can encourage the social consciousness and interest towards the community (Kumar and Kaur, 2023). These institutions inform the world on environmental matters by using environmentally friendly facilities, collections, and programs thus going beyond being mere repositories of knowledge.

Sustainable construction practices are already developing rapidly in India. Green buildings in the country conserve about 199.3 billion liters of water per year and 53.1 million tonnes of carbon which shows the amount of environmental benefits of large scale that can be realized by use of environment friendly infrastructure (Times of India, 2025). These figures show that the implementation of sustainable architectural concepts into Indian libraries is viable and has a significant effect on the environment.

Moreover, it has been reported that green buildings normally consume a lot less energy as compared to other traditional buildings (25-30%), which indicates evident benefits in terms of operation (Kats et al., 2003). Research also documents that retrofits can save up to 25 percent of the total energy usage and 40 percent of the water usage when made energy-efficient through the use of renewable sources of energy like solar power and rainwater harvesting. These strategies are very applicable to the Indian public and academic libraries, most of which work on a limited budget and would enjoy the savings in the long-run.

International Federation of Library Associations (IFLA) stresses that a sustainable library incorporates environmental, economic, and social aspects in its activities (IFLA, n.d.). Using this framework in India might

include developing climate sensitive structures where natural lighting and cooling are as much as possible - a strategy that would fit well in the various climatic regions in India. Also, the inclusion of solar panels, water recycles, and a locally sourced material would support the national sustainability efforts as well as lowering the cost of operations.

This transition is also encouraged by policy-level. India, as an example, has municipal programs, which provide incentives to buildings that install environmentally friendly measures such as rainwater harvesting, solar energy installation, and recycling of wastewater. These steps are indicative of the fact that government structures are more conducive to the use of green infrastructure, and sustainable library architecture is becoming more feasible.

Thus, with passive design concepts, renewable technology, and policy facilitation, Indian libraries can be realistic in its ability to adapt the best practices worldwide. Not only would this increase the responsibility of the environment but the libraries would also become community-focused institutions that encourage sustainability consciousness and life-long learning.

CONCLUSION

Futuristic library architecture represents a fundamental shift in how knowledge spaces are designed and used. Case studies of international libraries, such the Deichman Library in Oslo, the Qatar National Library, and the Seattle Central Library, demonstrate how sustainable infrastructure may be efficiently coupled with digital innovation and user-centered services. These libraries not only save energy and resources by using eco-friendly architectural principles, but they also create accessible and adaptable spaces that function as cultural, educational, and community centers. Futuristic libraries embody the concepts of sustainability, accessibility, and innovation through the use of green technologies, adaptable layouts, and smart systems. These global models serve as a road map for India's present and future libraries to become more ecologically responsible and socially meaningful.

REFERENCES

- [1] *Arts & Culture*. (n.d.). Retrieved May 14, 2025, from <https://www.spl.org/programs-and-services/arts-and-culture>
- [2] *Central Library, 2002-present, The Seattle Public Library*. (n.d.-a). Retrieved May 14, 2025, from <https://www.historylink.org/File/4303>
- [3] *Central Library, 2002-present, The Seattle Public Library*. (n.d.-b). Retrieved May 14, 2025, from <https://www.historylink.org/File/4303>
- [4] *Central Library, 2002-present, The Seattle Public Library*. (n.d.-c). Retrieved May 14, 2025, from <https://www.historylink.org/File/4303>
- [5] *Central Library Architecture*. (n.d.). Retrieved May 14, 2025, from <https://www.spl.org/hours-and-locations/central-library/central-library-highlights/central-library-architecture>
- [6] *Deichman Bjørvika Library • Helvar*. (n.d.). Retrieved May 8, 2025, from https://helvar.com/case-studies/culture/deichman/?utm_source=chatgpt.com
- [7] *Deichman Library / Atelier Oslo + Lund Hagem*. (2021, July 7). ArchDaily. <https://www.archdaily.com/942813/deichman-library-atelier-oslo-plus-lund-hagem>
- [8] *Deichman Library / Atelier Oslo + Lund Hagem | ArchDaily*. (n.d.). Retrieved May 8, 2025, from

https://www.archdaily.com/942813/deichman-library-atelier-oslo-plus-lund-hagem?utm_source=chatgpt.com

[9] *FutureBuilt*. (n.d.). Retrieved May 8, 2025, from https://www.futurebuilt.no/English/Pilot-projects?utm_source=chatgpt.com

[10] *Gallery of Seattle Central Library / OMA + LMN - I*. (n.d.). ArchDaily. Retrieved May 14, 2025, from <https://www.archdaily.com/11651/seattle-central-library-oma-lmn/572196fce58ecea06b000007-seattle-central-library-oma-lmn-photo>

[11] Lam, E. (2020, February 6). Landing Site: Springdale Library & Komagata Maru Park, Brampton, Ontario. *Canadian Architect*. <https://www.canadianarchitect.com/landing-site/>

[12] *Learning*. (n.d.). Retrieved May 14, 2025, from <https://www.spl.org/programs-and-services/learning>

Library Revolution—Seattle Public Library. (n.d.-a). Retrieved May 14, 2025, from <https://www.spacesaver.com/case-study/library-revolution-seattle-public-library>

[13] *Library Revolution—Seattle Public Library*. (n.d.-b). Spacesaver Corporation. Retrieved May 14, 2025, from <https://www.spacesaver.com/case-study/library-revolution-seattle-public-library#>

[14] *MVRDV - Tianjin Binhai Library*. (n.d.). Retrieved May 13, 2025, from <https://mvrdiv.com/projects/246/tianjin-binhai-library>

[15] Patil, G. (2021a, September 28). Springdale Library & Komagata Maru Park by RDH Architects A Point of Pride. *RTF | Rethinking The Future*. <https://www.re-thinkingthefuture.com/case-studies/a5335-springdale-library-komagata-maru-park-by-rdh-architects-a-point-of-pride/>

[16] Patil, G. (2021b, September 28). Springdale Library & Komagata Maru Park by RDH Architects A Point of Pride. *RTF | Rethinking The Future*. <https://www.re-thinkingthefuture.com/case-studies/a5335-springdale-library-komagata-maru-park-by-rdh-architects-a-point-of-pride/>

[17] *Qatar National Library*. (n.d.). Danish Architecture Center - DAC. Retrieved May 9, 2025, from <https://dac.dk/en/knowledgebase/architecture/qatar-national-library/>

[18] *Qatar National Library—Danish Architecture Center—DAC*. (n.d.). Retrieved May 9, 2025, from https://dac.dk/en/knowledgebase/architecture/qatar-national-library/?utm_source=chatgpt.com

[19] *Qatar National Library's Efforts in Promoting Environmental Awareness and Sustainability | Qatar National Library*. (n.d.). Retrieved May 9, 2025, from https://www.qnl.qa/en/blogs/13294?utm_source=chatgpt.com

[20] Seattle Central Library, US. (n.d.). *World Construction Network*. Retrieved May 14, 2025, from <https://www.worldconstructionnetwork.com/projects/seattle-central-library-us/>

[21] *Springdale Library & Komagata Maru Park / RDHA*. (2023, January 9). ArchDaily. <https://www.archdaily.com/938665/springdale-library-and-komagata-maru-park-rdh-architects>

[22] *Sustainable Development*. (n.d.). International Institute for Sustainable Development. Retrieved April 4, 2025, from <https://www.iisd.org/mission-and-goals/sustainable-development>

[23] *Tianjin Binhai Library / MVRDV + Tianjin Urban Planning and Design Institute*. (2017, November 2). ArchDaily. <https://www.archdaily.com/882819/tianjin-binhai-library-mvrdiv-plus-tianjin-urban-planning-and-design-institute>