



Priorities of Architectural Programming for Sustainability: Designs of Norman Foster as a Case Study

Asma H. Al-Dabbagh ^a, Mohammed M. Taha ^b

^a Department of Architectural Engineering, College of Engineering, University of Mosul, Mosul, 41001, Iraq
<https://orcid.org/my-orcid?orcid=0000-0003-1503-1961>

^b Department of Architectural Engineering, College of Engineering, University of Mosul, Mosul, 41001, Iraq
<https://orcid.org/0009-0005-6786-1651>

*Corresponding author E-mail: asma.dabbagh@uomosul.edu.iq

Abstract

Architectural programming is defined as a systematic method that leads to a statement of the architectural problem, which defines the Goals to produce the most appropriate solution. Goals are defined as a statement that expresses aims and purposes and are considered a means for decision-making. The Sustainable Development Goals (SDGs) were identified in 17 goals, of which Goals 11 and 7 were linked to architectural design. By delineating three Aspects for goals: the categories and main values of the goals, and the physical positions for their application, this research seeks to uncover the goals of architectural programming (Independent variables) regarding sustainability and their physical positions (Dependent variables). By analyzing texts in which the architect Norman Foster specified aspects of applying sustainability, and classifying its mechanisms, aiming to determine priorities of goals during the programming phase and mechanisms during the application phase. The results demonstrated that Foster focuses mainly on environmental goals, followed by economic and social goals. These goals are applied mainly in external building masses, internal spaces, and techniques used to recycle materials and reduce energy consumption. The conclusions were linked to SDG 11 in terms of its focus on environmental aspects, as well as SDG 7 through its focus on energy issues. The recommendations included the importance of discussing environmental and social goals in the initial stages of architectural programming, and that it is also possible to analyze, measure, and evaluate solutions within the mechanisms of the external mass using traditional methods or modern software during these stages. Furthermore, the importance of targeting economic objectives in new and old designs was highlighted to improve the sustainable performance of existing buildings.

Keywords: Architectural programming, Goals delineation, Sustainability, Sustainable architecture, Norman Foster

1. Introduction

Architectural Programming is a distinct and independent part of the pre-design stage; the planning and analyzing at the initial stage of the project are of great economic benefits [1]. because it may cost 1.5% of the total cost of building life, but it affects the performance and running costs, which may be 80% of the total cost of building life, that means it is an important to relate between the design goals and its characteristics [2].

Programming represents early preparation for design, the most efficient use of resources, reducing errors, correct use of human and environmental forces. Programming is a method to improve the level and the quality of design, because it makes the designer familiar with the various topics of the project, then qualifies him to set his goals in order to produce the most appropriate solution [3]. Moreover, programming gives knowledge that enhances the decision-making stage, with



This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited. © 2025 The Authors

<https://www.muthuni-ojs.org/index.php/mjet/index>

greater efficient and sustainable design. Finally, programming has a role in improving the organized professional behavior [1].

The development of programming curricula came due to the development in several areas, including the development of specialized criteria that embody the client's goals, the development of research methods and means of measurement and evaluation that enable access to quantitative and qualitative information, the development of laws and policies, the development of methods of analyzing and modeling information through artificial intelligence [4], and the development of environmental, social, psychological and construction criteria, which allowed their application in wider areas than they were [5]

As for sustainability, Lago et al. organized a digital workshop aiming to understand how sustainability can be incorporated into system design, concluding that concrete goals, more leadership, more examples, and application methods would help in activating it [6].

Peña and Parshall defined architectural programming as a searching for sufficient information to clarify, understand and define the problem, which is a systematic method of research, a five-stage process (within five considerations) [7]. Cherry and Petronis defined architectural programming as a method to search and decision-making, to state the more important problem and its requirements [8]. Hershberger also defined programming as the preliminary stage of design, the stage of discovering the nature of the design problem or its essence, more than discovering the nature of design solution [9], and defines it as a comprehensive and systematic evaluation for all issues, goals, facts, and needs, related to the client's organization, requirements, users, and surrounding community [10]. Hershberger also defined programming as a process that facilitates design, implementation, and operation process, and extends along these stages [9].

UN and RIBA collaborate on the development of guidelines on the implementation of the SDGs in architectural practice and the construction industry, and balancing environmental, economic and social aspects that sometimes conflict with other requirements is an essential role for architecture. In 2015, 17 principles were developed, which fall within 4 issues, including the environmental issue, which includes sustainable cities and communities, and here the architect's responsibility lies in developing sustainability strategies and applying their considerations at all stages of the project, discovering sustainable solutions for buildings, assigning a participatory approach to environmental challenges, adopting initiatives to raise environmental responsibility, and developing and disseminating environmentally friendly technologies. [11].

Bertone et al. developed and applied quantitative SDG contribution classification system to a Bachelor of Architectural Design program of an Australian university, the results showed that the largest contribution was towards Goal 11, which includes building a sustainable society, building resilience, air quality ideas, waste management and providing green spaces, while Goal 7 ensures energy efficiency, renewable energy and design based on negative solutions [12]. Similar findings were achieved by Hendawy et al. SDG 11 was the most adopted, focusing on improving slum areas, providing safe housing, and promoting sustainable urban settlements while preserving cultural heritage [13].

Mendler et al. added that discussion of sustainable issues and opportunities, including time and cost, then set a sustainable goal with team members to hold wide goals and measurable outcomes, then establish sustainable design goals clearly, which must be distinct from other project goals, specific and quantified [14].

Goals can be defined as a sentence that expresses intent, direction of searching and analysing, including decision-making methods, to meet the important and necessary needs, this sentence determines the level and quality of the ideal solution; therefore, it must be clear, without limiting the creative capabilities of the designer [2].

Hershberger mentioned that the goals could be delineate when defining the initial design topics along with their order of priorities, these clarified goals, important topics and ordered priorities can direct the design process to achieve specific outputs, to ensure the success of the project [9].

So, the operational definition for architectural programming considered it as a systemic method that leads to the statement of architectural problem, which sets goals to produce the most appropriate solution. The previous literature has expanded on the study of programming goals and their priority and deference in various cases, as well as their relationship to the mechanisms adopted and the physical positions to apply these goals in architectural designs. Regarding sustainability, the literature has not specified the priority of its goals and the mechanisms for achieving them in the physical positions. Meanwhile the analysis of design from programming point of view can be helpful to solve sustainable issues.

Duerk indicated that the priorities of each project differ according to its nature, its designer and culture, as well as other issues. These priorities can be determined with a set of goals that are achieved by specific mechanisms to make an impact upon the design outputs, accordingly Duerk classified goals, and their values; the most important are the **project's goals**, which are directed to the required outputs [2]. Faatz also classified these goals; as **organizational, economic, environmental and social** [1], these goals are all related to sustainability. While Hershberger mentioned other types of goals some are related to sustainability, such as **environmental, economic, cultural goals**, as well as technical, historical, aesthetic, human and security goals, Hershberger believes that the **values** of these goals affect the **physical position** of their application in the design [9]. Cherry & Petronis also demonstrated the correlation of goals values with different aspects of design that can be applied in different positions in the design, and the **economic goals** are related to issues of **energy conservation** and sustainability, moreover they made a connection between Architectural programming and contemporary practice, which contain **social facts** and deals with **economic criteria** such as implementation and running **cost** [8].

While Pena & Parshall implicitly touched on some aspects of sustainability through defining **programming goals** with four topics: function, form, economy and time [7]. Payman pointed the emergence of **environmental** awareness as another dimension of the **decision-making process**, which requires a review for the **programming process**, to devote this awareness within some of its approaches. Such as Knowledge-based approach, this knowledge deriving from the interrelated sciences, such as **environmental, social sciences**, environmental psychology and human ecology. While Value-based approach investigating the effect of client's capabilities and physical factors (such as project's location and climate) upon the goals topics, ideas, and needs [5]. Yatt declared that precise goals have an obvious impact on the formulation of design, by using **mechanisms** to achieve these goals [15].

According to Hershberger, the client's goals are linked to eight contemporary values, which are translated into issues and then embodied in design ideas, and the eight contemporary values are related to **environmental, economic**, safety, technological, human, contemporary, cultural and aesthetic standards, which means touching aspects of sustainability in its broad sense. However, the study did not address **the physical positions** that can embody these values related to sustainability [9].

Féria considered that Preliminary design phase as the most important one in determining the key strategies for Sustainability, such as the design of **opening elements** to assure proper ventilation. Also, the **orientation, form, internal layout, opening elements and shading systems** strategies for **energy efficiency**. the **internal layout and geometry of spaces** are defined and **materials**, including soundproof insulation as strategies for acoustic comfort. Finally, **the structural and internal layout** - and thus flexibility and adaptability of spaces as strategies for the durability of the building [16].

The previous evidences indicate the deferent categories, the main values of sustainability goals, and the physical positions to apply these goals, as shown in Table 1, where (The main values of goals) considered as (Independent variables), and (The physical positions to apply goals) considered as (Dependent variables).

Table 1: Defining Aspects for Goals Stage within the Architectural Programming for Sustainability (Researcher)

Defined Aspects	Possible Values	Possible Sub-Values	Codes
Categories of Goals	Goals of the programming process and their resources	Organizational goals	GP/O
		Practical facilitative goals	GP/F
	Educational goals		GE/
	Design-based goals	Personal goals for the designer or team	GD/Pe
		Project goals	GD/Pr
The main values of goals (Independent variables)	Environmental		EN-
	Economic		EC-
	Social		SO-
The physical positions to apply goals (Dependent variables)	External	Global	E/G
		Local	E/L
	Internal	Global	I/G
		Local	I/L
	Technology	Related to material recycling	T/M
		Linked to reducing energy using structures and devices	T/E

This paper seeks to classify the "Defining aspects for goals delineation stage" within the process of architectural programming, Table 1. Those aspects related to sustainable architecture precisely (the current paper objective). The defined aspects are related to each other in the same sequence as the architectural programming process, by defining the classification of goals, then the value of the goals in terms of its relationship to sustainability, and then its physical positions in the product.

Sustainability application or the pursuit of achieving it become a necessity required by the current state, because of the increased pollution expected by environmental, economic and social scientists, as well as depletion of resources and exacerbation of social problems, which are supposed to be reduced, by the endeavors of sustainability architects.

Therefor this paper investigates the main designer's goals and the sub-goals within, and the physical positions and mechanisms to achieve those goals, within a practical study carried out for the British Architect Norman Foster.

2. The Concept of sustainability

Sustainability (Linguistic) refers to the duration of things carefully, it also means the continuation of survival and communication, and (Environmentally) it means the preservation of resources that a person needs [17]. The American Institute of Architects (AIA) defined sustainability as "the ability of a society to continue in the future without forces affecting its existence by consuming or exceeding the limits of systems-dependent resources" [14]. Sustainability is often understood to be the resultant of the balanced intersection between the social, economic, and environmental dimensions [18] fulfilling the needs of the society at present without affecting the future generations in fulfilling their future needs [19]

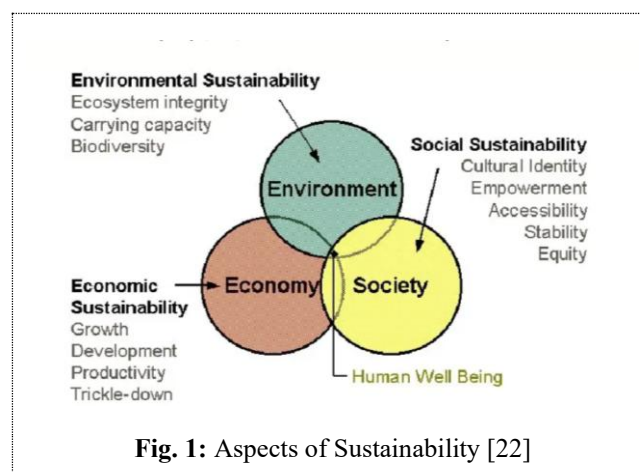
The concept of sustainability (according to the holistic view) represents the ability of natural and cultural systems to survive over the time [20]. Hence Brian Edward explained that sustainability emerged in the Middle Ages in Europe through producing works that embodied this concept, by using local materials, recycled water and developed renewable energy such as water/windmills, these organized communities took into account cultivated land that needs care in accordance with environmental principles [21].

Lago et al. stated that definition of sustainability, makes the impact of sustainability measures explicit, and concluded the importance of evaluation techniques to achieve sustainability goals, and the importance of developing new architectural models for sustainable architecture that embody architectural decisions related to various aspects of sustainability, and to achieve them requires commitment and cooperation at all levels and stage explicit [6].

Sustainability in buildings revealed an ongoing tension between functionalist approaches which aim to establish sustainability in the built environment as a pragmatic field guided by quantitative standards and humanist approaches which aim to establish sustainability in the built environment as a non-regulatory field able to generate radical change and innovation [18].

While Al.shamari stated that The goals of the sustainable architecture are to enhance the effectiveness of Resources, Energy efficiency and nature compatibility, the steps of the designing process depend on three basic levels, coming subsequently from top to bottom like this: Principles, Strategies and Means [19].

The concept of sustainability in architecture includes three aspects (Environmental/ Economic/ Social) and reflected through tangible characteristics in the design [14]. Environmental aspect means preserving nature in a sound way, within environmental system that structurally and functionally accomplished, that will guarantee the protection of nature, and provides the main incomes for sustainability from resources and raw materials that meet human needs and preserve nature from being waste. While economic aspect looking for advantages achievement, and manufacturing. Social aspect includes preserving society and human, through identity and heritage incarnation, satisfying equality, diversity, pluralism, social cohesion, originality, and system [22].



Féria thinks that design methodologies and theories must be capable to apply and integrate with principals of sustainability; by selecting strategies that enable the designer to predict the performance of the building in terms of energy, water, sustainability, spatial needs and comfort, this allows sustainable design strategies to be integrated with the initial design concept, and these strategies must meet goals of sustainability [16].

Sustainable design means achieving optimistic state through the least means, by using "passive architectural methods" to store energy instead of relying on mechanical means, by using renewable fuels equipment, with less pollution. The main feature of sustainable design is the high-performance concerning energy-efficient, which should be 80% or more. Sustainable architecture needs to have its own shape; airflow and natural ventilation have a major impact on building shape [21].

Sustainable design is an integrated product between architecture and other engineering branches, and it is the ideal method for bringing people closer to the environment, preserving environmental systems, reducing manifestations of environmental stress. Architecture can be means to save the environment, and to reach energy-saving buildings, that can be more valuable to owners and occupants, by reducing construction, operating, and maintenance costs [22]

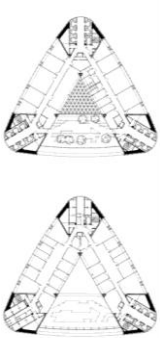
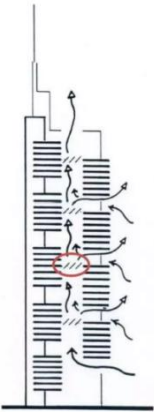
3. Methods

The literature of "Architectural Programming" presented different methods of programming theoretically, without exploring them in any of the architectural trends practically, also the literature of "Sustainable Architecture" were descriptive analytical nature for many of the implemented projects, while "Architectural literature" was deficient in analysing sustainable architecture from architectural programming point of view.

This paper aims to investigate the physical positions of goals application in the products of Sustainable Architecture, and the nature of applied mechanisms to achieve these goals (Research Objective), by analysing the works carried out by the British Architect Norman Foster (Research Problem). The analysis was conducted by considering the values of the goals as independent variables and their physical positions as dependent variables. And therefore, aims to determine the type of physical locations related to the values of the objectives. Excluding the aspect of (categories of goals) for methodological reasons because it needs data about client and organization goals.

Through the selection of five implemented projects (Fig. 2), depending on the descriptions provided by the official website of his office, <http://www.fosterandpartners.com> [23] to ensure the reliability of the data related to designer's goals, and avoiding the subjectivity in defining these goals on the researcher's side. The selection of these projects is based on the descriptive texts confirming their application of sustainability-related mechanisms. Some of them have won global awards in this regard, and they are also office building projects. The Foster's website expanded on providing their details, which enabled the research to measure them.

Adopting the hypothesis, "There is a focus on specific sustainability goals based on priority, which is reflected in the application of specific mechanisms at physical positions to achieve those goals, especially the environmental goal, which is achieved primarily at the holistic level". The application included direct analysis of the descriptive texts of five projects, which Foster himself considered them among Sustainable Architecture, Tables 3, 4, 5, 6, and 7 (Appendix).

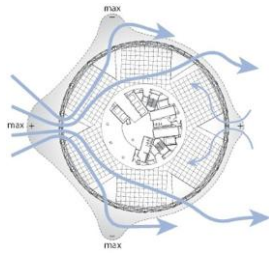
Projects No.	Plan	View	Detail
Title, address, date, Function and height			
1-			
Commerzbank Head- quarters / Frankfurt, Germany / 1991-1997			
Office building			
35 Floors			

2-

Swiss Re Headquarters / London, UK / 1997-2004

Office building

41 Floors

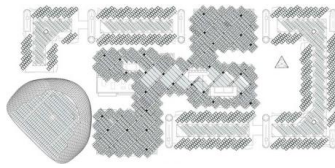


3-

Masdar Institute / Abu Dhabi, United Arab Emirates / 2007-2010

Office building

5 Floors

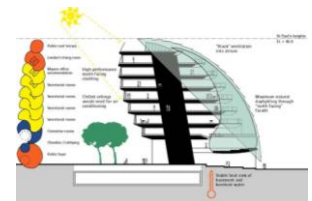
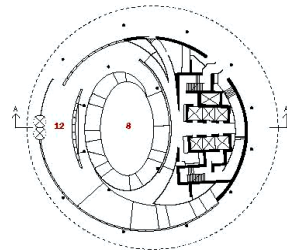


4-

City Hall / London, UK / 1998-2002

Office building

10 Floors



5-

Reichstag, New German Parliament / Berlin, Germany / 1992-1999

Office building

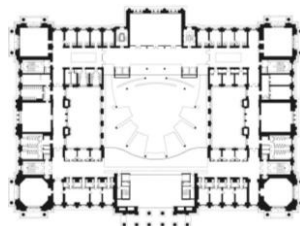


Fig. 2: The case studies for the application

The results obtained by calculating the mathematical summation of the "physical positions" of applied sub-goals within the main goals, Table 2.

4. Results discussion

The results, Table 2. Indicate that Foster is focusing on environmental goals in the first place, then economic and social while specifically, Foster applies environmental goals through global mechanisms for external mass, then local mechanisms for external mass. While he applies economic goals through technical mechanisms by recycling materials and reducing energy consumption using healthy structures and devices. Finally, he applies social goals through global mechanisms for external mass, then local mechanisms for internal spaces.

As a conclusion, the environmental goals of sustainable architecture achieved through external mass mechanisms, whether these mechanisms were global or local, which includes orienting the building mass towards preferred directions, overall formulation to suit good orientation and direction of the wind, reducing surface area, carving through staggering, subtraction, division and furrowing, or complete encapsulation with another layer such as glass or shading, as well as the use of beverages and wind towers. These mechanisms related completely to the external mass, which means that the designer decisions at the programming stage for sustainable architecture must be directed firstly to the external mass and be processed according to environmental data of all kinds. These mechanisms can be applied with accurate measurements objectively, through using special computer software, particularly designer decisions regarding mass processors are often in the early stages of developing a design idea after the stage of programming ideas, which is notable in the initial analytical studies held by Foster himself.

Table 2: Results/ Physical positions (mechanisms) of applied sustainable aspects (sub-goals)

Sustainable Aspects (Sub-goals)	Codes of Measured Values (Mechanisms)	Project 1	Project 2	Project 3	Project 4	Project 5	Total
Environmental Aspect	EN-G/E	5	5	2	5	4	21
	EN-G/I	1	1	-	-	-	2
	EN-L/E	2	-	4	2	1	9
	EN-L/I	2	1	2	-	-	5
	EN-T/E	-	2	2	1	2	7
	EN-T/M	-	-	-	-	1	1
Economic Aspect	EC-G/E	-	1	-	2	1	4
	EC-G/I	-	-	-	-	-	-
	EC-L/E	1	-	-	-	-	1
	EC-L/I	2	-	-	-	-	2
	EC-T/E	-	2	3	3	1	9
	EC-T/M	1	1	4	1	2	9
Social Aspect	SO-G/E	2	2	3	2	-	9
	SO-G/I	2	2	-	-	-	4
	SO-L/E	-	-	1	1	3	5
	SO-L/I	1	1	-	1	1	4
Total		19	18	21	18	16	92

These findings are related to what was previously mentioned firstly by Bertone et al. about Goal 11 of the Sustainable Development Goals, with a primary focus here on environmental issues, because the study projects are located in newly designed areas. Where building a sustainable community and resilient buildings, and maintaining sustainable indoor environmental conditions, is a priority in contemporary designs.

Economic goals of sustainable architecture were achieved through technical mechanisms by recycling building's materials in backfilling and floors, and pre-fabrication of some elements, as well as water recycling used for irrigation, fountains and hygiene purposes. While other technical mechanisms were used to reducing energy consumption by using solar devices, such as heating, lighting and underground heat devices. These mechanisms do not completely consider within the stage of architectural programming, instead they can be used to improve the implemented or old buildings in terms of their sustainable performance. Bertone et al. mentioned secondly Goal 7 which focus on energy issues.

The social goals of sustainable architecture were achieved through global mechanisms for external mass, including the distinctive shape such as the organic form, or by exaggeration in size through height increasing. These mechanisms are com-

pletely of a luxurious nature, which means that they are more applicable in the buildings of a cultural, social and recreational nature more than others. In addition, some of these mechanisms can be applied at the advanced stages of programming due to their local nature.

5. Conclusion and recommendations

The difference in focusing upon the main goals of sustainable architecture was obvious in Foster's work, that consider his priorities for programming sustainable architecture, as it is clear that environmental and social goals fall within architectural programming specifically, needed for more focusing by programmers especially in the early stages of programming, and in other stages as well. Some mechanisms can be applied at constructing stages, or for the implemented and old buildings as well.

The focus on external mass mechanisms allows for design formulation in their initial stages using traditional methods and assistive software for generation and evaluation, which ensures the achievement of environmental and social sustainability goals. Such mechanisms can also facilitate directly the application of economic sustainability mechanisms, as mentioned in previous literature, and indirectly by ensuring that studying, analyzing, and evaluating the comprehensive external design in the initial stages guarantees overcoming unforeseen complex problems that may exacerbate the negative impact of architecture in the future.

So, recommendations listed forward, the necessity of discussing the sustainability aspects related to the environmental and social aspect in the early stages of architectural programming, especially in the academic context. And improving methodologies to analyse, evaluate, and test sustainable designs. In addition, applying mechanisms concerning economic goals to improve the new designs and implemented buildings, in terms of their sustainable performance.

Availability of data and material

Data can be available by contacting the corresponding authors upon reasonable request.

Acknowledgement

All authors contributed equally to the preparation of this paper, The authors appreciate the scientific and logistic supports from the College of Engineering/ University of Mosul.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Funding source

This paper didn't receive any specific funds.

References

- [1] Faatz, S., "Architectural programming: providing essential knowledge of project participants needs in the pre-design phase", *Organization, Technology and Management in Construction: An International Journal*, 1(2), (2009) 80–85. <http://hdl.handle.net/20.500.12708/166855>
- [2] Duerk, P. D. *Architectural Programming: Information Management for Design*, New York: John Wiley & Sons, Inc. (1993) 7-45.
- [3] Mahmoodi, Seyed, A. S. "Architectural Programming, A Necessity for Design" Journal: *Honar- Ha- Ye- Ziba: Memary Va ShahrSazi*: University of Tehran Electronic Journals Database, (Volume: 2, Issue: 44) feb. (2012) 5-85.
- [3] Mahmoodi, S. A. S. Architectural Programming, A Necessity for Design. *Journal of Fine Arts: Architecture & Urban Planning*, (2010); 2(44): 77-85.
- [4] Cherry, E. (FAIA), *Programming for design from theory to practice*, 10th. Edition, Edited by J. Wiley, United States of America, (2006).
- [5] Shalche, F.F.A., Dabbagh, A.H.A. "Roles of Variation in Architectural Programming Approaches in Architectural Designs" *International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies*, 13(5), 13A5E, 1-12. (2022) <http://TUENGR.COM/V13/13A5E.pdf> DOI: 10.14456/ITJEMAST.2022.89
- [6] Lago, P. Danny Greefhorst, D. and Woods, E., "Architecting for Sustainability", *Volker Wohlgemuth et al. (Hrsg.): EnviroInfo 2022, Lecture Notes in Informatics (LNI), Gesellschaft für Informatik, Bonn (2022) 200-210*

- <https://www.archixl.nl/assets/files/architecting-for-sustainability.pdf>
- [7] Pena, W., & Parshall, S. *Problem Seeking*, (5th ed.). Wiley. Retrieved from <https://www.perlego.com/book/1011001/problem-seeking-an-architectural-programming-primer-pdf> (Original work published (2012) 12-16. ISBN 9781118152935)
- [8] Cherry, E. & Petronis, J. *AIA, AICP, Architectural Programming: Whole Building Design Guide*, FAIA (<http://www.faia.com>) Last updated: 11-2-(2016), <https://www.wbdg.org/design-disciplines/architectural-programming>
- [9] Hershberger, R. "Behavioral-Based Architectural Programming" This article is adapted from Chapters 1, 5, and 6 of the author book: *Architectural Programming and Predesign Manager*, New York, McGraw-Hill, (1999) 292-297. <https://www.scribd.com/document/357865060/Hershberger-Behavioral-Based-Architectural-Programming-pdf>
- [10] Al-Dabbagh, A. H. "Goals Delineation in Architectural Programming within Iraqi Academic Context", *Proceeding of the Second Scientific Engineering Conference*, (2013)19th – 21st November.
- [11] -UN Sustainable Development Goals in Practice (2020), <https://www.architecture.com/knowledge-and-resources/resources-landing-page/un-sustainable-development-goals-in-practice>
- [12] Bertone, E., Bischeri, C., & Boddy, J., "Integration of the sustainable development Goals (SDGs) in architecture curriculum – quantifying the extent of SDG contributions". *Environmental Education Research*, (2024) 1–20. <https://doi.org/10.1080/13504622.2024.2365403>
- [13] Hendawy, M. Junaid, M. Amin, A. "Integrating Sustainable Development Goals into the Architecture Curriculum: Experiences and Perspectives", January 2024, *City and Environment Interactions*, January 2024, [City and Environment Interactions](https://www.researchgate.net/publication/377492595_Integrating_Sustainable_Development_Goals_into_the_Architecture_Curriculum_Experiences_and_Perspectives) 21(3):100138, DOI: [10.1016/j.cacint.2023.100138](https://doi.org/10.1016/j.cacint.2023.100138), 21(3):100138, DOI:10.1016/j.cacint.2023.100138, https://www.researchgate.net/publication/377492595_Integrating_Sustainable_Development_Goals_into_the_Architecture_Curriculum_Experiences_and_Perspectives
- [14] Mendler, S., Odell, W., Lazarus, m., *The Hok Guidebook to Sustainable Design*, John Wiley & Sons Inc, (2000). <https://cushman.host.dartmouth.edu/courses/engs44-old/HOK-Guidebook.pdf>
- [15] Yatt, B. D., *Critical Thinking for Architecture Students: Developing a Project Premise and Concept*, AIA, CSI, <https://www.scribd.com/document/326837243/Critical-Thinking-for-Architects>
- [16] Féria, M. D. C., *Sustainability in Architectural Design Guidelines for a Sustainable Project*, Thesis to obtain the Master of Science Degree in Architecture, TECNICO LISBOA, 2018.
- [17] Karrufa, O. H., *Energy in Sustainable local Architecture*, PhD thesis, Dept. of Architecture, University of Baghdad, 2006.
- [18] Goubran, S., Carmela, C. Integrating the Sustainable Development Goals in Building Projects, *journal of Sustainability research* (hapres.com), (2019). <https://doi.org/10.20900/jsr20190010>
- [19] Al.shamari, S. Green Architecture & sustainability, *Multi-Knowledge Electronic Comprehensive Journal For Education And Science Publications* (MECSJ) ISSUE (6), Mar. (2018) ISSN : 2616-9185 Multi-Knowledge Electronic Comprehensive Journal For Education & Science Publications (MECSJ).
- [20] Jones, A., R. *Sustainable Architecture in Japan – The Green Buildings of Nikken Sekkei*, Kabushiki Kaisha, 牧, 英二, and Anna Ray-Jones, (2000), Chichester, West Sussex: Wiley-Academy.
- [21] Edwards, B. *Green Architecture Pay*, Edwards, B., E & FN SPON An Imprint of Routledge London and New York, (1998). ISBN: 0-203-18037-2 (Adobe e-Reader Format) <https://ebookgate.com/download/green-buildings-pay-2nd-edition-brian-edwards/>
- [22] Hui, S., C., M. *Sustainable Architecture and Building Design (SABD)*, (2002), <https://www.scribd.com/document/251926082/Sustainable-Architecture-and-Building-Design-SABD-pdf>
- [23] <http://www.fosterandpartners.com> / website of Norman Foster Office
- [24] Mossin, N. Stilling, S. et.al *AN ARCHITECTURE GUIDE to the UN 17 Sustainable Development Goals*, 1st edition, Copenhagen publishing, (2018), [sdg_commission_un17_guidebook.pdf](https://www.scribd.com/document/357865060/Hershberger-Behavioral-Based-Architectural-Programming-pdf)

(Appendix)

Table 3: The Analysis of Commerzbank Headquarters/ Germany/ 1991-1997 (Project 1)

Sustainable Aspects	Measured Values	Description	Mechanisms	Codes
The Environmental Aspect	Thermal comfort and interior environment quality	Adopt optimal guidance to provide a comfortable	Building block Treatment	EN-G/E
		Providing solar spaces for the building's evacuated mass	Hollow building block from different sides	EN-G/E
		Building cool naturally cooled ceilings	Cooling Roofs	EN-L/E
		Self-shading split building block	Divide the building block	EN-G/E
	Natural lighting	Investment in daylight	Central atrium	EN-G/I
		The light penetrates all the spaces of the building	Moving holes in the façade	EN-L/I
	Natural ventilation	Brings natural air	Building's evacuated mass from different sides	EN-G/E
		Office spaces naturally ventilate up to 60%	Chimney	EN-L/I
	Passive Design	Use of natural systems and environment control	Sculpting within the building and cavities within the mass	EN-G/E
		Renewable energy	Green heavenly gardens within the building block	EN-L/E
The economic aspect	Reducing energy costs (energy conservation)	50% energy consumption compared to a similar traditional building	Heavenly gardens within the building block	EC-L/E
	Reducing water costs associated	Reducing water consumption	Water condensers	EC-T/M
		Water recycling and reuse	Fittings	EC-L/I
	Reducing costs associated with materials and waste recycling	Re-use of some materials such as wood and waste separation From the site	Inside the building and in some parts of it	EC-L/I
The social aspect	Social interaction and creating positive spaces	Provide opportunities for dating and provide a relaxing atmosphere and being a social and visual center	Internal space Zoning	SO-L/I
	Green spaces	Winter gardens, natural environment, and plant utilization within the building's voids	Interior design, atrium, and heavenly courtyards	SO-G/I
	Communication and movement between the blocks	The linkage of administrative groups with a distinct movement system interspersed with places of rest	The movement system Connecting the building	SO-G/I
		The linkage of building with transportation system	Building site (Location)	SO-G/E
	Symbolism and culture	Hegemony over the skyline and forms a distinctive icon	Height and shape of the building	SO-G/E

Table 4: The Analysis of Swiss Re Headquarters/ London, UK/ 1997-2004 (Project 2)

Sustainable Aspects	Measured Values	Description	Mechanisms	Codes
The environmental aspect	Thermal comfort and interior environment quality	Reducing gain and heat loss	Double skin of facades	EN-G/E
		Reducing wind force	Plan of circle shape	EN-L/I
	Natural lighting	The building opens to natural light and exterior views	Grooves within the façade	EN-G/E
		Achieve the largest natural lighting	Glass envelope of rhombic shape	EN-G/E
		Reducing vision problems associated with lighting	The open intermediate core between the floors in the form of fingers adapts to enter the lighting	EN-G/I
	Natural ventilation	Unique system for natural ventilation	Openable panels at the front	EN-T/E
		Fresh air in Office windows	Open window automatically	EN-T/E
	Passive Design	Responding to the local environmental conditions surrounding	The streamline building shape	EN-G/E
		Renewable Energy - Reducing Fossil Fuel Consumption	Evaporative Cooling Towers	EN-G/E
The economic aspect	Reducing energy costs (energy conservation)	Reducing the use of mechanical conditioners and consuming 50% of the energy of a building of similar size	Water-cooled freezing machines as well as water-cooled jellies	EC-T/E
		Lamps operate economically	Lighting elements	EC-T/E
		Computer analysis of building design - technology	Building structure and reference points	EC-G/E
			The shape and details of the public building	
	Reducing costs associated with materials and waste recycling	Reducing emissions of carbon dioxide gases	Treated materials	EC-T/M
The social aspect	Social interaction and creating positive spaces	Providing public spaces inside the building	Vertical spiral interior decoration and the presence of atrium	SO-G/I
	Green spaces	Celestial gardens and natural plants	Interior courtyards within the building floors	SO-G/I
	Communication and movement		Circulation	SO-L/I
	Symbolism and culture	The shape of the building	The shape of the building unique	SO-G/E
		The building stands erect in the low sky of London	Building height	SO-G/E

Table 5: The Analysis of Masdar Institute / Abu Dhabi, U. A. E. / 2007-2010 (Project 3)

Sustainable Aspects	Measured Values	Description	Mechanisms	Codes
The environmental aspect	Thermal comfort and interior environment quality	Create a microclimate by reducing solar thermal gain	Shaded surfaces	EN-G/E
		Providing cool air and self-shade	Barrier intermediate spaces and traditional wind towers	EN-L/I
		Sun protection	Shading balconies and screening	EN-L/E
		The city is designed in a way that respects the sunlight and provides self-shading	Facades orientation and Mashrabiah	EN-L/E
	Natural lighting	Provide natural light	Holes protected by screening	EN-L/E
	Natural ventilation	Apply strategies to natural ventilation	Pedestrian streets	EN-L/E
		Night cooling wind-sensitive	Intermediate spaces, wind towers, patios, fountains	EN-L/I
	Passive Design	Effective and natural environmental strategies	Shaded open spaces	EN-G/E
		Innovatively air sensitive and natural cooling	Isolate the interface	EN-T/E
		Renewable Energy - Solar cell surface coating for clean energy processing.	Solar cells on the roof of the building	EN-T/E
The economic aspect	Reducing energy costs (energy conservation)	Reduce energy demand by 51%, save electricity and hot water	Solar roof panels	EC-T/E
		Save 30% of energy and supply 50 MW	Solar collectors	EC-T/E
	Reducing water costs associated	Provide water for evaporative cooling purposes	Water pools and fountains	EC-T/E
		Reduce water consumption by 54% by reusing	Efficient bathroom equipment and watering gardens	EC-T/M
	Reducing costs associated with materials and waste recycling	Waste separation and its recycling	Full works and floors	EC-T/M
		Pre-fabrication of elements	Balconies and Mashrabiah	EC-T/M
		Concrete with little co2 content, cement and wood.	Library space is wood structure	EC-T/M
The social aspect	Social interaction and creating positive spaces	Encouraging events through flexibility of spaces and creating an interactive atmosphere	Simulating the spaces of traditional Arab cities and linking housing with laboratories	SO-G/E
	Green spaces	Outside views of open spaces depend on open interfaces	Open interfaces as intermediate gardens	SO-G/E
	Communication and movement	Providing a walk-dependent communication and encouraging healthy life walking	Lifts position encourage the use of stairs and the provision of a transportation system	SO-L/E
	Symbolism and culture	The simulation of the traditional old tissue	Formation of organic mass	SO-G/E

Table 6: The Analysis of City Hall / London, UK / 1998-2002 (Project 4)

Sustainable Aspects	Measured Values	Description	Mechanisms	Codes
The environmental aspect	Thermal comfort and interior environment quality	Achieve a comfortable environment by increasing the shading	Efficient glass facade, wrapped with high performance materials	EN-G/E
		Office cooling and reduced heat loss	Reduce the surface area of the shape	EN-G/E
		Self-shading for the sun's most exposed facade	Graded from top to bottom and floors are shaded on each other	EN-G/E
	Natural lighting	Achieve direct illumination of the northern façade	The transparent envelope of the facade	EN-G/E
	Natural ventilation	Naturally ventilated, fresh air enters	Holes in the building and floor, and a hole above the building	EN-L/E
	Passive Design	Reducing the surface area by 25% compared to the size of a similar building	The shape of the spherical building compared to the cube	EN-G/E
		Clean energy generation -	Renewable photovoltaic cells	EN-T/E
		Computer modeling investment	Innovative design of detail and unique shape	EN-L/E
The economic aspect	Reducing energy costs (energy conservation)	Increased shading and energy conservation	The streamlined shape of the building reduces the surface area	EC-G/E
		Consumption energy 25% of a similar building,	High performance glass cover	EC-T/E
		Reducing heating and energy savings	Investing groundwater	EC-T/E
	Reducing water costs associated	Reducing the consumption of good water and recycling	Efficient health equipment and use the water in the toilets	EC-T/M
		Investing groundwater for cooling	Geothermal heat	EC-T/E
	Reducing costs associated with materials and waste recycling	Insulated and composite panels with high performance glass,	The roof of the building and its structure, and the external envelope	EC-G/E
The social aspect	Social interaction and creating positive spaces	Use of spaces as a gallery	The monitoring room	SO-L/E
	Green spaces	Providing parks	Integrated space with mass	SO-G/E
	Communication and movement	Adopt walking circulation in building	Spiral sloping	SO-L/I
	Symbolism and culture	Express the spirit of openness, transparency, and democratic process	Enlarge the building's glass mass	SO-G/E

Table 7: The Analysis of The New German Parliament/ Germany/ 1992-1999 (Project 5)

Sustainable Aspects	Measured Values	Description	Mechanisms	Codes
The environmental aspect	Thermal comfort and interior environment quality	Reduce CO2 by 94%		EN-L/E
	Natural lighting	Employ natural light	Transparent surfaces	EN-G/E
		Bring natural light to the heart of the building,	The huge glass dome	EN-G/E
	Natural ventilation	Recycle fresh air	Heat exchanger	EN-T/M
	Passive Design	Green and natural building, environmental protection, sun movement around the building,	The basement roof and the solar complex	EN-G/E
		Renewable energy - biofuels about 80%	Biomass plant fuel	EN-T/E
		Geothermal heat	Pump within the site ground	EN-T/E
		The use of plants	in all parts of the building	EN-G/E
		Energy conservation by reducing electricity in the council Hall during the day	Slots that move in response to the sun and solar panels on the ceiling	EC-T/E
		Reducing water costs associated	Devices that consume the least clean water and the invalid water circulating to irrigate the gardens	EC-T/M
The economic aspect	Reducing energy costs (energy conservation)	Investment of stone building crust.	Building structure and cladding	EC-G/E
		Protecting the building by constructing it with stone materials from the remains of the previous building. Reducing debris	Recycling building materials with walls	EC-T/M
	Reducing costs associated with materials and waste recycling	Seeing members of Parliament, providing a democratic atmosphere, comfortable spaces	A unified entrance for all, a glass wall, and supervision of the podium	SO-L/E
		Green gardens	Green gardens	SO-L/E
	Communication and movement	Feeling a sense of belonging, communicating easily with people	The existence of the glass dome movement's passages, and the possibility of walking around it provides endless degrees.	SO-L/I
	Symbolism and culture	The history of the building is preserved as a living museum and the symbolism of the memorial wall	Memorial walls and features of ancient architecture	SO-L/E