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Climate Adaptation Methods and Their Role in Sustaining Heritage Houses in Mosul

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Abstract

The research topic entitled “Climate Adaptation Methods and Their Role in Sustaining Heritage Houses in Mosul” examines heritage houses by addressing their definition and their linguistic, archaeological, and architectural terminology, and then explores their heritage and architectural importance in the city of Mosul. It also examines methods for preserving and protecting these houses from climatic and weather conditions, as well as methods of maintenance and restoration intended to ensure their sustainability for a longer period. This is achieved by identifying the climate-adaptation methods that affect heritage houses in the city of Mosul. Sustainability, in its simplest sense, refers to practical measures aimed at adapting to the negative effects of climate change, such as water scarcity, rising temperatures, and floods. The research therefore considers the most prominent methods that should be followed to preserve heritage buildings from dete-

rioration, erosion, and destruction resulting from the passage of time, variations in temperature, humidity, cold, and other accompanying environmental factors. Humidity, rainfall, and winds directly affect many of the architectural elements of heritage houses in the city of Mosul. This situation necessitates identifying preventive and sustainable methods for these heritage buildings, protecting and maintaining them, and continuing to restore and prepare them so that they remain suitable for living and residence. Such work should adopt raw materials that are capable of resisting climatic factors throughout the seasons of the year and under varying weather conditions, thereby helping to sustain the buildings and preserve their architectural and cultural value for future generations.

Keywords: heritage houses, climate adaptation, Mosul, sustainability, maintenance and restoration

1. INTRODUCTION

THE LINGUISTIC AND TERMINOLOGICAL MEANING OF “DŪR” (HOUSES)

The word *dūr* (plural) comes from the singular *dār*, which is synonymous with *bayt* (house) and *maskan* (dwelling). In heritage contexts, it refers to the traditional residential structures that embody both the physical shelter and the cultural identity of their inhabitants. ⁽¹⁾ It denotes the place where a person or a family resides, but there are subtle differences in usage. *Al-dār* may refer to the entire building and its land, focusing on the designated space for a single family. *Al-maskan* includes any place of residence, even if not built, or belonging to a group such as workers or students. *Al-dār* refers to both land and building together; it may contain one or more houses, or it may be a service building without a dwelling, such as *Dār al-Qaḍā'* (House of Justice) or *Dār al-Ṭibā'a* (Printing House). *Al-dār* is the specific place in which a person or a family resides, and it may be a room within the house: it is the *dār*, it is the *maskan*, and it is the real place where a human feels privacy and can reveal their true personality. ⁽²⁾

The function of traditional houses in Mosul lies in their role as a link between the individual and society. At present, it can be observed that the family, through its individual members, seeks to create closeness, balance, and satisfactory relationships between its basic needs and its values. The function of the dwelling goes beyond its traditional limits of providing shelter for humans to extend further, encompassing the improvement of the health, cultural, social, and economic level of the family and society by providing a suitable residential environment that accommodates the family's activities and requirements, enabling it to develop, strengthen its social relations, and raise the productivity level of the individual.

Household needs include multiple aspects within the dwelling: human needs related to providing protection from extreme weather, psychological needs tied to the need for security, and needs connected to the cultural standards of the family and society, which may extend beyond basic human needs. One example is the number of bedrooms required for each family, as this depends primarily on its cultural standards. Every society has specific behavioral rules that function as cultural standards for its members, including those related to available and desirable housing. Housing standards indicate the quality of construction, type of ownership (owned or rented), space, cost, and neighborhood. Each of these standards varies according to the ages of family members and their composition. ⁽³⁾

The house or *dār* may refer to the entire building and its land, while *bayt* focuses on the specific lodging place for a single family. *Maskan* includes any place of residence, even if not built, or belonging to a group such as workers or students. The word *bayt* refers to both land and building together; it may contain one or more houses, or it may be a service building without a dwelling, such as *Dār al-Qaḍā'* (House of Justice) or *Dār al-Ṭibā'a* (Printing House). The *bayt* is the specific place where a person or a family lodges, and it may be a room within the house: it is the *bayt*, it is the *maskan*, and it is the real place where a human feels privacy and can reveal their true personality. It is the link between the individual and society. At present, it can be observed that the family, through its individual members, seeks to create closeness, balance, and satisfactory relationships between its basic needs and values, on the one hand, and its dwelling, on the other, to provide housing through which human behavior can be influenced. There must be a balance between the available alternatives of different dwellings and the desires of individuals themselves. Specialists describe the dwelling as an institution or system, not merely a building, created for complex and multiple purposes.

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¹[1] In the cited lexical discussion, the house is described as the place in which a person stays and as a dwelling that provides shelter, particularly at night. The term also encompasses the idea of settling or residing in a place. A domestic dwelling may include roofed rooms, an internal courtyard, and a kitchen used by a person and family. The broader term *dār* is associated with a place in which people live and move and may include one or more rooms, houses, and an unroofed courtyard. For further discussion, see Ibn Manẓur, *Lisan al-Arab*, vol. 1, p. 123.

²[2–5] Ibn Sidah, Ali ibn Ismail, *Kitāb al-Mukhassas*, vol. 5, al-Matba'ah al-Kubra al-Amiriyya, 1318 A.H., p. 125; Al-Bustani, Butrus, *Muḥit al-Muḥit: Qamus Mutawwal li-al-Lughah al-Arabiyyah*, 1977, p. 16; Al-Razi, Muhammad ibn Abi Bakr Abd al-Qadir, *Mukhtar al-Sihah*, 1983, p. 655; Ibrahim, Muhammad Ismail, *Mu'jam al-Alfaz wa-al-A'lam al-Qur'aniyyah*, vol. 1, 1968, p. 84.

³[6–8] Al-Diwaji, Sa'id: The House of Mosul, *Al-Turath Al-Shaabi Magazine*, vol. 2, no. 6, Baghdad, 1975, p. 24, Jirjis, Abd al-Jabbar Muhammad: The Mosul House and Service Buildings until 1980, Al-Intisar Press, Mosul, 2014, pp. 209–211, Thannoun, Youssef: Residential Buildings, University of Mosul, Engineering Construction Office, vol. 1, 1983, pp. 7–11.

⁴[9–12] Saeed, Salwa Ahmad Muhammad, 1986, pp. 17–24; Al-Sinjari, Hassan Abd al-Razzaq Hassan, 1990, p. 11; Mahdi, Rana Waad Allah: Corbels in

2. THE IMPORTANCE OF THE SUSTAINABILITY OF TRADITIONAL HOUSES IN MOSUL

The importance of the houses of Mosul lies in the local heritage and inherited traditional legacy they contain, which, with its architectural and civilizational aspects, has overshadowed other building and architectural units in the city of Mosul. This is due to the Arab-Islamic heritage preserved by the city of Mosul through long ages. The word heritage carries lofty meanings, as it includes everything that fathers and grandfathers leave to their children and relatives, whether material or immaterial, and it is inherited one after another. Its origin revolves around “what a person leaves for those after him.” In language, heritage is inheritance, and it indicates that the individual has left a legacy that is inherited generation after generation. It is considered an identity of the fathers and grandfathers, which the children must preserve and safeguard because of the moral, material, and civilizational value it contains, such as architecture, literature, art, customs and traditions, sciences, and good values. ⁽⁵⁾ The meaning of heritage appears in many details associated with its significance, as it represents everything produced by the human mind in various aspects of intellectual, material, and moral life, through intellectual and social interaction and movement. It became an inheritance for sons from fathers, whether architectural and material inheritance, or language, thought, customs and traditions, experiences, or social relations, etc.

Researchers and specialists in the fields of urban and architectural planning have increasingly paid wide attention to the planning of houses and their architecture, and to the artistry of their design, since the establishment of the first Islamic city. Among them is the city of Mosul, with its unique architectural and artistic model. It was distinguished by an engineering style that gave great attention to the construction of the facades of its heritage buildings, which were highly characterized by their decorations, carvings, and traditional Arab-Islamic ornamentation.

This style dominated its construction with entrances framed by geometric outlines, horizontal lintels, arches, vaults, and integrated or composite columns, all interwoven with great diversity in building materials. Most prominently, limestone, marble, gypsum, and brick were used. Entrances in Arab-Islamic houses in general, and in Mosul in particular, occupied the most prominent and essential elements of the Mosuli dwelling. ⁽⁶⁾

3. METHODS FOR SUSTAINING TRADITIONAL HOUSES IN MOSUL

Sustainability is defined as support that extends life and enables survival, as well as the process of providing sustenance. It is also a quality describing something that receives support, comfort, and nourishment so that it can continue to exist. It is the ability to meet the needs of the present without harming the ability of future generations to meet their needs.

It includes natural resources, the environment, the economy, and society to ensure the continuation of life in a permanent and healthy way. The concept of sustainability is no longer merely an academic term or an environmental slogan, but has turned into an urgent necessity and inevitability imposed by the increasing challenges facing our planet. From climate change and environmental degradation to resource scarcity and social inequality, it has become clear that the traditional development model is no longer sustainable in the long term.

Sustainability, simply, is the ability to meet the needs of the present without compromising the ability of future generations to meet their own needs. This concept involves three main, interrelated, and overlapping dimensions:

- Environmental sustainability: preserving the natural environment and its resources, reducing pollution, protecting biodiversity, and mitigating the effects of climate change.
- Economic sustainability: ensuring balanced economic growth without depleting natural resources.
- Social sustainability: promoting social justice, equality, and community well-being.

⁽⁷⁾ Sustainability is a comprehensive concept linked to the development required by society. Advanced methods and innovative approaches for dealing responsibly with natural resources require coordinated efforts by specialists, including architects, planners, and researchers, working in cooperation with decision makers and focusing on environmentally friendly technologies, particularly in construction and planning. Social sustainability encompasses distributive justice, the condition and security of society, and the opportunities that should be available to all members of the community. Together, these ideas require a sustainable balance among the three principal dimensions of sustainability: the environmental dimension,

the Houses of the City of Mosul during the Ottoman Era, *Adab Al-Rafidayn*, no. 64, 2012, p. 387; Mohammed: Mosul's Urban Heritage: Research and Studies, pp. 77–81, 142–143.

⁵[13, 14] Hassan, Nazim Ezz al-Din: Poetic Texts in the Standing Buildings of the City of Mosul from the Jalili Era (1139–1249 A.H.), Master's thesis, College of Archaeology, University of Mosul, 2025, p. 70; Saleh, Ahmed Ali: Qur'anic Texts on the Architecture of the City of Mosul during the Jalili Era (1139–1249 A.H.), Master's thesis, College of Archaeology, University of Mosul, 2023, p. 22.

⁶[6–8] Al-Diwaji, Sa'id: The House of Mosul, *Al-Turath Al-Shaabi Magazine*, vol. 2, no. 6, Baghdad, 1975, p. 24, Jirjis, Abd al-Jabbar Muhammad: The Mosul House and Service Buildings until 1980, *Al-Intisar Press*, Mosul, 2014, pp. 209–211, Thannoun, Youssef: Residential Buildings, University of Mosul, Engineering Construction Office, vol. 1, 1983, pp. 7–11.

⁷[15, 16] Mohsen, Riyad Malik: Sustainability: The Necessity of the Age and the Responsibility of the Future, Al-Mustaqbal University, 2025, Johar, Mohammad Amin (Yassin Ashur, Hayman Nasreddine) Climate Change and its Impact on Achieving Sustainable Development in Iraq, Faculty of Education, Karmian University, 2023, p. 382,

the economic dimension, and the social dimension. The purpose of this balance is to meet the requirements of society, maintain harmony with the environment, and obtain the greatest reasonable benefit from available natural potentials without undermining their continuity. Human beings remain the principal focus of sustainability because people constitute the real wealth of every society. Social sustainability therefore seeks to empower people, build their capacities, expand their opportunities in economic, political, and social life, promote justice between generations, and respect traditions, customs, and social particularities as sources of enrichment for society. The social dimension is reflected directly in the improvement of the quality of life of local communities, the promotion of health and safety, and the benefits provided to disadvantaged groups. The environmental dimension, in turn, is reflected in reducing waste, mitigating adverse effects on human health, and reducing the use of toxic substances ⁽⁸⁾. Achieving sustainable design additionally requires full integration among architecture, environmental design, and urban planning, together with coordinated contributions from electrical, mechanical, and structural engineering disciplines. Alongside the traditional architectural concerns of size, proportion, scale, texture, shadow, and light, sustainable design also requires complementary consideration of future costs and related long-term aspects ⁽⁹⁾. This approach emphasizes that the three dimensions should not be treated as isolated categories. Environmental protection, economic continuity, and social well-being must operate together in the same planning and design process. In practical terms, this means that decisions concerning construction, conservation, resource use, and urban development should be evaluated not only for their immediate technical effectiveness but also for their longer-term effects on people, available resources, and the surrounding environment. The same integrated approach applies to heritage buildings, where conservation choices should respect architectural identity while also considering material durability, future maintenance needs, environmental performance, and the social value of continued use.

Sustainable architecture is regarded as one of the modern trends in architectural thought. It focuses on the relationship between buildings and the environment while seeking to satisfy human architectural needs in terms of beauty, function, and durability. In the context of heritage, the importance of sustainability is reflected in preserving planning patterns, design characteristics, decorations, inscriptions, written elements, engineering features, human and animal representations, and other archaeological and heritage components of the urban environment. The concept of sustainability also refers to the optimal and balanced use of available resources, whether natural, material, human, or heritage-related, in an environmentally and urbanistically responsible manner. Its purpose is to ensure continuity without sacrificing ancient art, architecture, or heritage. Accordingly, the idea of sustainability is based on leaving land, urban fabric, sculptures, and old heritage buildings in a sound condition for future generations, while maintaining human activity through reliance, where appropriate, on original natural materials ⁽¹⁰⁾. Within this framework, preservation does not mean freezing the building in a single historical condition. Rather, it means maintaining the significant planning, architectural, artistic, and material characteristics that give the heritage structure its identity while allowing appropriate maintenance and restoration to continue. The use of natural and original materials is therefore connected to continuity, compatibility, and the ability of the building to remain serviceable under changing seasonal conditions. This relationship between architectural heritage, resource use, and environmental response is central to the discussion of sustainability in the traditional houses of Mosul.

The concept of sustainable development has become a comprehensive model of development, a guiding theme for international support agencies, a central subject of conferences and academic research, and a widely used concept among activists working in development and environmental fields at both domestic and international levels. The concept emerged through successive developments in the understanding of development itself. A number of theories in the political, economic, and development literature attempted to explain development, including modernization and commercialization theories, world-system approaches, and, later, globalization. The large number of theoretical and practical proposals produced by these approaches, together with the policies adopted by many developing countries, demonstrated the inadequacy of reducing development to rapid economic growth alone. Some countries achieved national-income growth rates close to desired targets while the living standards of large parts of their populations remained unimproved and many people continued to experience poverty, limited education, disease, and unemployment. These concerns, proposals, and experiences were increasingly incorporated into the broader idea of sustainable development, which consequently came to include economic advancement together with environmental protection, social well-being, and long-term continuity. The discussion therefore moves beyond a development model measured only by the speed of economic growth. It recognizes that an increase in national income does not automatically produce equivalent improvements in living conditions for all sectors of society. The persistence of poverty, illness, unemployment, limited educational opportunities, and unequal

⁸[17–20] Al-Ahbab, Shaimaa Hamid Hussein: Sustainable Urban Conservation in Heritage Areas, *Journal of the Faculty of Engineering, Al-Nahrain University*, vol. 17, no. 2, 2014, pp. 14–25, Hammouda, Rawya Ezz El-Din: Sustainable Development as an Approach to Urban Preservation and Development, Eighth International Scientific Conference, Cairo, 2001, p. 25, Al-Maliki, Qabila Faris: Arab Urban and Architectural Innovations, Preservation, Maintenance and Rehabilitation, Amman, Jordan, 2004, p. 100, Barakat, Waleed Mohammed Alghamry, Basant Abdelbary Mahdi Amara, and Nesreen Youssef Abu Muslim: A Comparative Study between LEED Standards and Principles of Sustainability in Islamic Architecture, no. 10, Cairo, 2018, pp. 786–802.

⁹[15–17] Mohsen: Sustainability: The Necessity of the Age and the Responsibility of the Future, 2025, Johar, Muhammad Amin: Climate Change and its Impact on Achieving Sustainable Development in Iraq, p. 382, Al-Ahbab: Sustainable Urban Conservation in Heritage Areas, pp. 14–25.

¹⁰[18–20] Hammouda: Sustainable Development as an Approach to Conservation and Urban Development, p. 25, Al-Maliki: Urban and Architectural Heritage in the Arab World, p. 100, Barakat et al.: A Comparative Study, pp. 786–802.

access to resources demonstrates why development must also be assessed through social and environmental outcomes. Sustainable development consequently brings together economic progress, social conditions, environmental protection, and the capacity of future generations to continue meeting their own needs.

3.1. CHARACTERISTICS OF APPLYING THE CONCEPT OF SUSTAINABILITY TO HERITAGE HOUSES IN MOSUL

Throughout history, people have sought shelter that protects them from harsh climatic conditions, including excessive cold and heat. Over time, human communities gradually developed a closer relationship with the surrounding environment and continuously attempted to adapt buildings and settlements to different environmental settings. The Industrial Revolution, however, together with the widespread availability of relatively low-cost energy sources, particularly hydrocarbons, introduced new architectural trends in which environmental considerations often declined in importance. These modern trends consequently affected traditional architecture. In many local environments, modern architecture also continued to imitate Western models without sufficiently considering differences in climate, urban identity, environmental conditions, or cultural context. In the effort to develop architecture that is better suited to local environmental conditions, it is therefore necessary to return to traditional local architecture, examine the urban and architectural heritage already present in the local environment, and understand its technical and architectural experience in responding to local environmental data, particularly in residential architecture ⁽¹¹⁾. This return to traditional architecture is not intended as a rejection of modern construction. Instead, it provides a basis for understanding how earlier builders responded to heat, cold, orientation, privacy, local materials, and the organization of residential space before mechanical systems became dominant. Studying these responses can help identify design principles that remain relevant under present environmental conditions. The local heritage thus becomes a source of practical architectural knowledge as well as a cultural resource, particularly when contemporary buildings must respond simultaneously to climatic pressures, changing lifestyles, and the need to maintain the urban identity of Mosul.

From this perspective, traditional architecture can be seen as having interacted intelligently with the local environment through a predominantly horizontal building form that opens inward, thereby supporting both privacy and environmental harmony. The window is one of the most prominent architectural elements demonstrating this interaction. Its function was not limited to ventilation; it also provided access to sunlight, outward or internal views, natural lighting, and architectural beauty. In some forms of contemporary architecture, by contrast, the role of the window has declined, and windows may become closed, opaque, poorly oriented, or without a meaningful view when the design does not sufficiently consider the surrounding context. The increasing use of mechanical ventilation has also reduced practical dependence on windows. Limited setbacks, increased building heights, and inadequate access to sunlight can further reduce attention to windows and views, so that openings may become small, semi-closed, opaque, or lacking clear architectural value. Contemporary architectural design should therefore reconsider methods for avoiding direct and exposed views while preserving light, air, and visual quality. Traditional architecture addressed direct overlooking through devices such as mashrabiya, trees, and inward-oriented openings, reflecting a broader understanding of the role of windows in environmental and aesthetic comfort. Social relationships in the modern city have also changed in parallel with building systems. The development of communication technologies and the acceleration of daily life have made spatial proximity less necessary for maintaining family ties. Telephones, mobile phones, the Internet, and other communication technologies allow continuous contact among relatives and friends without requiring frequent face-to-face meetings, thereby changing the nature and patterns of daily social communication ⁽¹²⁾. The traditional treatment of openings demonstrates that ventilation, light, privacy, and visual connection were considered together rather than as separate design problems. Inward-looking houses could admit daylight and air while limiting direct exposure to the street and neighboring properties. Trees and mashrabiya also mediated views rather than eliminating them completely. These approaches illustrate how architectural elements were expected to perform several environmental and social functions at the same time. Contemporary design can benefit from the same integrated logic even when modern materials, mechanical systems, and communication technologies have changed the way residents use and experience domestic space.

4. CLIMATE CHANGE AND ITS IMPACT ON THE SUSTAINABLE DEVELOPMENT OF RESIDENTIAL HOUSES

Climate change has substantially affected human activities and countries in general, particularly countries characterized by low annual rainfall and high temperatures. Achieving sustainable development is closely related to the condition of the

¹¹[6–8, 21] Al-Diwaji: The Mosul House, p. 24, Jirjis: The Mosul House and Service Buildings until 1980, pp. 209–211, Thannoun: Residential Buildings, pp. 7–11, Karkaja, Fawaz Ayed Jassim: The Urban Deterioration and Formal Urban Deterioration of the Old City of Mosul, Unpublished Ph.D. Thesis, Faculty of Education, University of Mosul, 2000, pp. 20, 42.

¹²[6–8] Al-Diwaji: Al-Bayt al-Musli, p. 24, Jirjis: The Mosul House and Service Buildings until 1980, pp. 209–211, Thannoun: Residential buildings, pp. 7–11.

natural environment; nevertheless, public policy, appropriate measures, effective administration, and careful planning can help reduce the negative consequences associated with climate change. Iraq is among the countries in which these effects have become visible through declining water levels, changes in the amount and type of precipitation, rising temperatures, prolonged drought, increasing desertification, shrinking areas of cultivable land, and population movement from rural regions toward urban centers. The city of Mosul has experienced these problems in varying proportions. Because of its geographical location, long history, urban plans, neighborhoods, and residential quarters, the city displays many effects associated with environmental and climatic change. These effects are also visible in residential architecture and in related architectural components such as mosques, schools, and other structures. This condition makes reconstruction, sustainability, maintenance, repair, and renovation of traditional residential houses increasingly important. Sustainable development in this region is therefore a complex matter that requires coordinated local administration and long-term planning to address continuing environmental and climatic problems while protecting the residential heritage of Mosul. Achieving sustainable development cannot be reduced to climate change alone; administrative, political, economic, and social dimensions also play important roles in sustaining, restoring, and preserving residential houses. For this reason, the relationship between climate change and sustainable development in the buildings of Mosul must be studied as a combined environmental, architectural, social, and administrative problem⁽¹³⁾. The architectural consequences are particularly important because heritage houses do not exist independently of their urban surroundings. Streets, adjoining buildings, mosques, schools, service structures, water conditions, land use, and patterns of population movement all influence the long-term condition of residential heritage. For this reason, maintenance of an individual house cannot be separated completely from planning at the neighborhood and city scales. Administrative decisions, available financial resources, community participation, and the social use of the buildings all affect whether restoration measures can be maintained after they are completed.

4.1. THE CONCEPT OF CLIMATE CHANGE AND SUSTAINABLE DEVELOPMENT

4.1.1 The Concept of Climate Change

Climate change is a major challenge facing humanity, and scientific interest in the phenomenon developed strongly toward the end of the nineteenth century as researchers in climatology and earth sciences increasingly recognized that the Earth's climate changes over time. Since then, several definitions have been proposed. The United Nations Framework Convention on Climate Change defines climate change, in its first article, as a change in climate attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is observed in addition to natural climate variability over comparable periods of time.

The Intergovernmental Panel on Climate Change defines climate change in terms of changes in the state of the climate that can be identified, for example by statistical tests, through changes in the mean and/or variability of its properties and that persist for an extended period, typically decades or longer. This formulation recognizes changes arising from natural variability as well as changes associated with human influences⁽¹⁴⁾.

4.1.2 Natural Causes

The climate is controlled by various processes and cycles, including geological and chemical processes that affect the interactions between the various environmental components, and the following natural causes can be identified:

1. Volcanic eruptions, which can emit greenhouse gases and aerosols in large quantities.
2. Dust storms in arid and semi-arid regions affected by deterioration of vegetation, limited agriculture, and low rainfall.
3. The phenomenon of sunspots, which occurs in an approximately 11-year cycle and is associated with variations in solar magnetic activity and in the energy emitted by the Sun.
4. Cosmic rays associated with energetic events in space, which interact with the Earth's upper atmosphere and contribute to the formation of radioactive carbon.
5. Tectonic processes, including continental displacement, which operate over long geological timescales.

¹³[21–23] Karkaja: The Formal Urban Deterioration and Deterioration of the Old City of Mosul, pp. 20, 42, Odeh Rashid Al-Jayousi, Islam and Sustainable Development: New Cosmic Visions, translated by Jumana Walid, et al., Jordan-Iraq Office: Friedrich Ebert Foundation, 2013, p. 22., Harbiyah, Shirza Azizou Yousef Ali Mohammed, Climate Change Indicators of Climate Elements in Diyala Governorate, Diyala Journal for Humanitarian Research, Part Two, Issue 88, 2021, p. 1.

¹⁴[24–26] Mahmoud Khalil Jaafar, The Extent of Armed Conflicts Linked to Climate Change, Journal of the Faculty of Law, Al-Nahrain University, Vol. (24), Issue (1), 2022, pp. 201–202, Nadia Bensalam, Climate Change as the Source and Incubator of Natural Disasters, Future Horizons Magazine, Emirates Center for Studies and Research, Issue (25), 2015, p. 5. Al-Ghamdi, Abdulaziz Bin Saqr: Human Resources Development and the Requirements of Sustainable Development Arab Security, Naif University for Security Sciences as a Model, Working Paper Presented to the Third Arab Forum, Beirut, Education and Sustainable Education in the Arab World, 2006, pp. 491–513.

6. Astronomical changes, including changes in the shape of the Earth's orbit, the angle of axial tilt, and the direction of axial tilt. ⁽¹⁵⁾

4.2. MAIN OBJECTIVES OF SUSTAINABLE ARCHITECTURE

The main objectives of sustainable architecture include the following:

- Reducing environmental impact: reducing the consumption of natural resources and limiting harmful emissions.
- Energy efficiency: designing buildings that consume less energy and use renewable energy sources where appropriate.
- Water management: optimizing water use and developing systems that reduce unnecessary waste.
- Sustainable materials: using recycled, renewable, durable, or otherwise sustainable building materials.
- Health and comfort: improving indoor air quality and providing comfortable, safe, and healthy environments.
- Climate adaptation: designing buildings that are resilient to climate change and its present and anticipated impacts.
- Social sustainability: strengthening local communities and supporting positive forms of social interaction.

These goals aim to strike an appropriate balance among environmental, economic, and social needs.

4.3. THE MOST IMPORTANT PRINCIPLES OF SUSTAINABLE ARCHITECTURE

1. Reducing energy consumption Designing buildings to benefit from natural lighting and good ventilation, which reduces the need for energy use. The construction site should be chosen so that it is close to public transportation and basic services to reduce the need for the use of cars. Using technologies such as thermal insulation, double windows, and natural ventilation technologies to reduce the need for industrial heating and cooling and incorporating renewable energy systems such as solar or wind energy to provide the necessary energy for the building.
2. Use of sustainable materials: Choosing renewable or recycled materials such as sustainable wood and local materials to reduce the carbon footprint associated with transportation, and resources must be used efficiently, which in turn leads to reducing the consumption of materials by designing buildings in a way that makes the most of available resources.
3. Water Management: Designing rainwater harvesting systems, using technologies such as vertical gardens to reduce water consumption, reusing greywater to reduce water consumption, and designing efficient drainage systems.

4.4. SUSTAINABILITY IN URBAN CONSERVATION PROCESSES

Sustainability may be defined as a process with economic, environmental, social, and technical dimensions that is connected to different areas of life through an integrated set of applications implemented over a planned period of time. Settlements with a strong civilizational and historical dimension are particularly suitable for applying this concept because they embody continuity between the past and the present. The historical evidence found in ancient cities constitutes cultural symbols that require continuous maintenance and careful treatment, together with the preservation of environmental resources. The general objective of sustainability is to establish a balance among its urban, environmental, social, and economic dimensions and to strengthen the continuity of each dimension. In contemporary academic and professional usage, sustainability is not limited to the relationship between development and the natural environment; it also concerns urban, economic, and social dimensions. In other words, sustainability has a broad and comprehensive meaning that seeks balance in development decisions among the principal components of the urban environment, economic activity, and social life. Sustainable development should meet the needs of present society without weakening the ability of future generations to meet their own needs. In urban-conservation practice, this process includes several basic stages: monitoring and establishing databases and baseline information; carrying out analysis and evaluation; identifying design alternatives and project programs; organizing work into appropriate time stages; developing implementation mechanisms; and, finally, undertaking continued evaluation and follow-up ⁽¹⁶⁾. The sequence of monitoring, analysis, design, implementation,

¹⁵[22, 23] Odeh Rashid Al-Jayousi, *Islam and Sustainable Development: New Cosmic Visions*, translated by Jumana Walid et al., Friedrich Ebert Foundation, Jordan–Iraq Office, 2013, p. 22; Harbiyah, Shirza Aziz, and Yusuf Mohammed Ali Hatem Al-Hadhal, "Indicators of Climate Change for Climatic Elements in Diyala Governorate," *Diyala Journal for Human Research*, no. 88, pt. 2, 2021, p. 1.

¹⁶[15–20] Mohsen: Sustainability: The Necessity of the Age and the Responsibility of the Future, 2025, Johar, Muhammad Amin: Climate Change and Its Impact on achieving sustainable development in Iraq, p. 382, Al-Ahbab: Sustainable Urban Preservation in Heritage Areas, pp. 14–25, Hamouda: Sustainable Development as an Approach to Preservation and Urban Development, p. 25, Al-Maliki: Urban and Architectural Heritage in the Arab World, p. 100, Barakat et al.: A Comparative Study, pp. 786–802.

and follow-up is especially important in heritage areas because conservation decisions have cumulative effects over time. Reliable baseline information makes it possible to distinguish existing conditions from later deterioration, while periodic evaluation allows conservation programs to be adjusted when environmental, social, or economic circumstances change. Dividing implementation into realistic stages also helps connect long-term conservation objectives with available institutional and financial capacities. In this way, sustainability in urban conservation becomes a continuing management process rather than a single restoration intervention carried out once and then left without follow-up.

4.5. THE PRINCIPLES OF URBANISM ON WHICH TRADITIONAL ARCHITECTURE IS BASED

The most important architectural principles on which traditional architecture is based can be summarized as follows:

1. **Simplicity:** Simplicity expresses cohesion, equanimity, and humility. It is manifested in the movement and composition of volumes, internally and externally, in the treatment of expressive façades, and in the selection and use of building materials.
2. **Privacy:** Privacy is achieved through a hierarchy of spaces extending from the public level to the semi-public level and then to private space. This principle had a clear impact on the development of a distinctive architectural style. In many houses, openings on the ground floor were minimal or nearly absent, while openings on upper floors took the form of mashrabiyas and windows. Openings facing the exterior were commonly positioned above normal eye level. Privacy was also achieved internally; some houses contained more than one courtyard, with spaces allocated to the owner and family, the reception or living suite, and other activities. Spatial relationships between men and women were also organized to achieve an appropriate degree of privacy.
3. **Respect for the human scale:** Traditional architecture sought a balanced relationship among built composition, spatial voids, and the human beings who occupied them. This relationship was reflected in social interaction, behavior, movement, and psychological comfort.
4. **Respect for the surrounding environment:** Interaction with the environment was achieved through internal courtyards, attention to orientation, and respect for appropriate views and visual relationships.
5. **Expression:** Architectural elements were expected to express function clearly, so that the form and components of a mosque, a khan, a school, or a house could reflect the purpose of the building.
6. **Contradiction and contrast:** Traditional architecture frequently displayed deliberate contrasts between solid and open surfaces, interior and exterior façades, and irregular exterior boundaries and more regular internal courtyards. Openings in house façades were often arranged according to the requirements of interior spaces rather than according to strict exterior symmetry. The designer also reconciled irregular site boundaries with comparatively regular courtyards, halls, and surrounding iwans, producing a distinctive relationship between external irregularity and internal order.
7. **Compatibility of form and content:** Traditional architecture was characterized by harmony between architectural form and functional content. The architecture of a mosque therefore differs from that of a school or a house, and the value of a building is closely related to its suitability for its intended function. A dwelling is more successful when it provides refuge, beauty, tranquility, security, and a spatial organization appropriate to everyday life. This principle reinforces the idea that architectural form should not be separated from use, environmental conditions, or the needs of the inhabitants⁽¹⁷⁾.
8. **Functional and environmental integration:** Traditional architecture further demonstrates harmony between form and functional content through design from the inside outward, ease of movement, and strong connections among architectural elements. The dwelling separates movement arriving from outside from movement within the private residential space, while natural ventilation is supported through openness toward the courtyard. Additional ventilation may be provided through simple roof-level openings and horizontal apertures that help capture and direct air⁽¹⁸⁾.
9. **Relationship between the dwelling, inhabitants, and climate:** The architect sought to create a dwelling closely related to its inhabitants by establishing an organic relationship with human needs and with climatic and social conditions

¹⁷[22–24] Al-Jayousi: *Islam and Sustainable Development*, p. 22, Mohammed: *Climate Change Indicators of Climate Elements*, p. 3, Jaafar: *The Extent of Armed Conflicts Linked to Climate Change*, pp. 201–202.

¹⁸[27, 28] Al-Saad, Ahmed Majd: *Towards an Accessible Housing Entitled Sustainability Open to the Inside*, Saudi Council of Engineers, Riyadh, 2016, p. 30, Pitts, Adrian: *Planning and Design Strategies for Sustainability and Profit*, Arabic translation by Ziad Ahmed Mohammed Alameddine, King Saud University Press, Riyadh, 2010, pp. 11, 41.

(¹⁹). Differences in floor levels within rooms were also taken into account, with the room floor commonly raised above the courtyard level. This arrangement reflects the behavior of cooler air, which tends to settle at lower levels in the courtyard, while raised thresholds at the bottoms of doors help limit the movement of that cooler air into the rooms when such movement is undesirable.

Traditional residences in the Old City of Mosul are distinctive stone-built structures, many of which date to the Ottoman period, although portions of some ground floors may belong to earlier periods. Rooms formed a principal architectural and structural element. A common or dominant configuration was approximately square, with a side length of about 5 to 6 meters, and its roof was supported by structural ribs. In some older buildings, the four corners rested on large square columns or on the supporting edges of the surrounding construction (²⁰).

There are four types of houses (doors) in the city of Mosul:

1. Simple two-room houses arranged one above the other.
2. Iwan houses, which consist of two parts arranged around a central space, namely the iwan.
3. Houses built around a courtyard with a pool of water in the middle and vaulted arcades distributed along its sides.
4. An intermediate type between the preceding styles consists of U-shaped houses that are similar to iwan houses, but extend on either side of them with rooms overlooking one courtyard.

5. ENVIRONMENTAL CONSIDERATIONS IN THE DESIGN OF TRADITIONAL HOUSING

The traditional house (dwelling) used to interact with the surrounding environment and adapt to it in its design, taking into account the most important conditions necessary for this, and the most important of these conditions are discussed below:

1. Environmental and climatic conditions: Climate is influenced by several natural factors, including astronomical and geographical location. Mosul lies within the broader climatic context of northern Iraq and is characterized by long, hot summers and cold winters, with seasonal variations in temperature and humidity. A climate that tends toward heat requires architectural methods capable of adapting to local conditions. In summer, residents need effective air movement and ventilation; in winter, the building should retain useful solar heat gains while minimizing unnecessary heat loss. Traditional architecture therefore sought to provide thermal moderation, natural lighting, and ventilation through several measures. First, an appropriate site was selected with consideration for environmental conditions, access to natural advantages, and security. Second, compact urban form was used, with buildings positioned close to one another so that exposed façade areas were reduced. Variations in building height further moderated the effects of sun and wind. As a consequence of this compact form, streets often developed as narrow lanes or paths primarily accommodating pedestrian movement and only rarely vehicles, because historical settlement patterns preceded the modern demand for large numbers of vehicles and wide streets (²¹). The compact urban pattern also reduced the amount of building surface directly exposed to intense solar radiation and prevailing winds. Narrow streets, closely spaced houses, and differences in height created shaded areas and moderated the immediate microclimate around residential buildings. These characteristics were closely connected with the historical scale of pedestrian movement. Because the old urban fabric developed before contemporary levels of motorized traffic, its streets and lanes were proportioned primarily for people and local access rather than for large vehicles. This historical relationship between urban form, movement, and climate is an important part of understanding the environmental performance of traditional Mosuli neighborhoods.
2. Narrow and winding roads: The narrow and winding roads of the old city performed an environmental role comparable in some respects to that of the internal courtyard. Their proportions, enclosure, and irregular alignment helped protect urban spaces from excessive summer heat and from cold winds in winter, thereby providing substantial protection from harsh weather conditions (²²).

¹⁹[24, 25] Jaafar, The Extent to which Armed Conflict is Linked to Climate Change, pp. 201–202, Bensalam: Climate Change as the Source and Incubator of Natural Disasters, pp. 44–45.

²⁰[27–29] Mustafa, Mozahim Mohammed, Daizhizhong, and Yuan Hong: The Characteristics of Architecture Style of the Traditional Houses in the Mosul City—Analytical Study, pp. 380–389; Al-Saad: Towards an Accessible Housing Entitled Sustainability Open to the Inside, p. 30; Pitts: Planning and Design Strategies for Sustainability and Profit, pp. 11, 41.

²¹[22–24] Al-Jayousi: Islam and Sustainable Development, p. 25, Mohammed: Climate Change Indicators of Climate Elements, p. 3, Jaafar: The Extent of Armed Conflicts Linked to Climate Change, p. 49.

²²[26, 27] Al-Ghamdi, Abdulaziz Bin Saqr: Human Resources Development and the Requirements of Sustainable Development Arab Security, Naif University for Security Sciences as a Model, Working Paper Presented to the Third Arab Forum, Beirut, Education and Sustainable Education in the Arab World, 2006, pp. 491–513, Ahmed Majd, Al-Saad: Towards an Accessible Housing Entitled Sustainability Open to the Inside, Saudi Council of Engineers, Riyadh, 2016, p. 30.

3. **Building materials:** Building materials constitute one of the most important elements of traditional architecture. The principal structural and finishing materials included marble, local stone, limestone, wood, iron, and, in later interventions, cement and additional iron components. Marble and limestone appeared in varied forms and colors, including white, green, blue, and darker varieties. Limestone wall cladding helped protect houses from thermal fluctuations. The compact arrangement of traditional buildings, in which adjacent structures commonly shared walls and reduced the number of externally exposed façades, also simplified construction and reduced the area requiring exterior treatment. At the same time, interior courtyards could receive decorative stone cladding in accordance with the financial means of individual households.
4. **Natural conditioning through the courtyard:** The process of natural environmental conditioning begins with the internal courtyard, which functions as the principal natural ventilation space of the dwelling. Although open to the sky, the courtyard provides a degree of protection and separation from the external climate and helps moderate thermal effects, air movement, wind, sound, noise, and pollution. The open iwan allows residents to benefit directly from the courtyard environment. Ornamental plants, including trees and flowers, together with pools supplied by taps or fountains, contribute shade and moisture and can help humidify dry air. Social and economic conditions, as well as the introduction of new materials and construction methods, have subsequently influenced the form and environmental performance of contemporary housing ⁽²³⁾.

5.1. FACTORS THAT LED TO CHANGES IN THE DESIGN OF HERITAGE HOUSES

Several interconnected factors have contributed to movement away from traditional architecture. Population growth, changes in family structure from extended to smaller household units, and the desire of each family to obtain a separate and multifunctional dwelling have increased pressure on housing provision. Social changes have occurred alongside climatic changes during recent decades, while traditional products and construction practices have often been replaced by quick, ready-made, and prefabricated modern solutions. Horizontal expansion has also been replaced in many locations by insufficiently planned vertical expansion as available land has become scarcer and population has increased. Rapid construction undertaken without integrated planning has frequently attempted to respond to housing shortages, while residents have simultaneously demanded separate housing units. These pressures encouraged modern and rapid building solutions. A number of factors therefore hinder the application of sustainability principles in contemporary residential architectural design and contribute to the neglect of traditional design knowledge. The principal factors considered here include building laws, social change, economic conditions, cultural change, and technological development. These factors do not operate independently. Population pressure can influence land prices and building density; building regulations can shape setbacks, heights, and the orientation of openings; technological change can introduce materials and systems that differ from traditional construction; and social change can alter expectations concerning privacy, family structure, and the arrangement of domestic spaces. The combined effect can gradually weaken the connection between the dwelling and the environmental, cultural, and social principles that shaped the traditional house. A sustainable response therefore requires attention to the interaction among these factors rather than treating each one as an isolated cause.

1. **Building laws:** Building codes have been among the principal factors contributing to the transformation of both the appearance and function of traditional dwellings into contemporary forms. Regulations requiring prescribed setbacks and separations between buildings have changed the relationship among neighboring structures, increased exposure to the exterior, and in some cases reduced privacy. Standardized plot dimensions, setback ratios, and height limits have also encouraged similarities among designs. As dwellings became oriented more strongly toward the exterior, houses increasingly overlooked one another or opened directly onto busy streets, reducing acoustic privacy and replacing the protected views formerly provided by internal courtyards. In many cases, building codes focused on measurable dimensions, spaces, heights, and setbacks without giving equivalent attention to the organization of openings needed to preserve privacy. These conditions can make contemporary housing less responsive to some of the social and environmental needs traditionally addressed by the Mosuli house ⁽²⁴⁾.
2. **Social changes:** Changes in customs and traditions have altered older patterns of dialogue, participation, neighborhood familiarity, and social interaction. Some religiously and culturally informed spatial concepts have also been replaced by newer urban ideas and design theories. Individual owners may increasingly seek to emphasize the appearance and distinction of their own buildings without sufficient regard for neighboring buildings or the collective character of the street. At the same time, the need to provide housing for lower-income groups has encouraged the

²³[25, 27] Al-Saad: Towards an Accessible Housing Entitled Sustainability Open to the Inside, p. 30, Bensalam: Climate Change as the Source and Incubator of Natural Disasters, pp. 44–45.

²⁴[22–25, 27] Al-Jayousi: Islam and Sustainable Development, p. 22, Mohammed: Climate Change Indicators of Climate Elements, p. 3, Jaafar: The Extent of Armed Conflicts to Climate Change, pp. 201–202, Bensalam: Climate Change as the Source and Incubator of Natural Disasters, pp. 44–45. Towards an Accessible Housing Entitled Sustainability Open to the Inside, p. 30, Bensalam: Climate Change as the Source and Incubator of Natural Disasters, pp. 44–45.

construction of a greater number of housing units within limited areas. The resulting parallel and repetitive housing units may lack several design values associated with traditional housing, particularly the internal and external privacy of residents.

3. Technological factors: Scientific and industrial development has introduced new construction methods, structural systems, materials, and techniques. These developments have enabled high-rise construction and a wider variety of building forms, but they can also create imbalances among architectural masses and alter the visual image of the city when they are applied without sufficient contextual control. They have also encouraged residential buildings with larger and wider openings, thereby affecting the form, façade composition, environmental behavior, and overall architectural character of residential units ⁽²⁵⁾.

6. MODERN CONCEPTS AND THEIR RELATIONSHIP TO THE DWELLING

Architecture has experienced substantial development in the concepts and theories guiding residential design in response to accelerating environmental, social, and technological change. These concepts have reshaped the relationship between the dwelling and its surrounding environment and can be examined in relation to both traditional and contemporary housing. The traditional dwelling provides an early model of several ideas now associated with environmental design, while selected principles derived from that model can inform a contemporary housing approach that seeks to maintain environmental and social sustainability without losing contextual architectural coherence. Bioclimatic architecture is one such approach. It is based on the local climate, which forms a relatively stable component of the geographical structure of a place, and it seeks to achieve energy efficiency and environmental comfort through climate-responsive design. Bioclimatic architecture therefore represents a considered response to nature by using resources such as solar radiation and wind to reduce unnecessary energy consumption and improve users' quality of life. Traditional dwellings already demonstrated several comparable strategies: they responded to seasonal differences, benefited from solar radiation during winter, promoted cooling during summer through the shade created by narrow streets and courtyards, used local and natural building materials, relied on natural lighting and ventilation, and attempted to control humidity according to seasonal and environmental needs ⁽²⁶⁾. The value of the traditional dwelling in this discussion lies in the way several responses were combined within one architectural system. Courtyards, shaded circulation spaces, local materials, narrow streets, controlled openings, and seasonal patterns of use worked together to moderate environmental conditions. The objective was not simply to reduce energy consumption in the modern technical sense, but to create habitable spaces suited to the local climate and social life. Contemporary bioclimatic design can reinterpret these principles rather than copy historical forms literally, maintaining the underlying relationship among climate, material choice, spatial organization, ventilation, lighting, and user comfort.

6.1. THE MOST IMPORTANT FACTORS INCREASING NATURAL HAZARDS TO HISTORIC BUILDINGS

1. Vulnerability and fragility of local communities.
2. Unsustainable development and its intersection with natural-hazard areas.
3. The principal natural factors affecting historic buildings are atmospheric and climatic conditions, including solar radiation, rainfall, atmospheric pollution, humidity, and repeated heating-cooling processes. These processes can cause expansion, contraction, material fatigue, and cracking in architectural and structural elements. Among the most important hazards arising from climatic influences and contributing to deterioration of historic architectural heritage are the following ⁽²⁷⁾:

- Slow-changing and fast-changing effects

Slow changes include natural factors and variables that affect historic buildings continuously and permanently, leading to their weakness, deterioration and then collapse in a slow and continuous manner, and with the neglect of these effects and the delay of dealing with and treating them for a long time, it may eventually lead to a serious deterioration and damage to the architectural and structural elements of the heritage building, which leads to their loss. These effects include changes in temperature, rainfall, wind, sea level rise, drought, desertification, atmospheric pollution gases, and other variables.

²⁵[15–18] Mohsen: Sustainability: The Necessity of the Age and the Responsibility of the Future, 2025, Johar, Muhammad Amin: Climate Change and Its Impact on achieving sustainable development in Iraq, p. 382, Al-Ahbab: Sustainable Urban Conservation in Heritage Areas, pp. 14–25, Hamouda: Sustainable Development as an Approach to Conservation and Urban Development, p. 25.

²⁶[16, 17, 19, 20] Johar: Climate Change and its Impact on Achieving Sustainable Development in Iraq, p. 382, Al-Ahbab: Sustainable Urban Conservation in Heritage Areas, pp. 14–25, Al-Maliki: Urban and Architectural Heritage in the Arab World, p. 100, Barakat et al.: A Comparative Study, pp. 786–802.

²⁷[25–27] Al-Ghamdi: Human Resources Development and the Requirements of Sustainable Development, pp. 491–513, Al-Saad: Towards an Accessible Housing Entitled Sustainability Open to the Inside, p. 30, Bensalam: Climate Change as the Source and Incubator of Natural Disasters, pp. 44–45.

6.1.1 Temperature

Temperature is one of the most important elements of climate and is a major driver of many other climatic processes. Temperatures vary considerably across the world, from one region to another, and from one season or period to another within the same country. Temperature affects humans, animals, and plants and also influences other climatic elements, including atmospheric pressure, evaporation, humidity relationships, and the behavior of building materials.

High temperatures are among the important factors that can damage the materials of architectural and structural elements in heritage and historically valuable buildings. Elevated temperature can increase the rates of chemical reactions and biological growth, particularly when moisture is present, and repeated or prolonged heating can contribute to deterioration in many building materials, especially stone. High temperature can also accelerate evaporation of salt-bearing liquids. As moisture evaporates, dissolved salts may crystallize either on the surface or immediately below the surface, creating pressures that contribute to scaling, powdering, detachment, and other forms of material deterioration ⁽²⁸⁾.

6.1.2 Wind Speed

In open locations above or adjacent to water bodies, wind speed may reach high values at elevations of approximately 274 meters, while the corresponding height may increase to about 366 meters over land characterized by dense trees and low buildings. Wind is an important weather factor affecting historic buildings, and the degree of damage depends on wind speed, direction, exposure, and the materials carried by the airflow. Winds passing through neighboring areas may transport large quantities of dust and sand. When such winds are strong, wind-driven particles strike the surfaces of heritage buildings and can contribute to abrasion, surface loss, cracks, and openings. Hot and cold winds may also alter surface temperatures and intensify thermal fluctuations in exposed historic buildings. In addition, wind can transport pollutants, airborne salts or vapors, and other contaminants to horizontal and vertical surfaces, where deposition may contribute to further deterioration.

The effect of wind is particularly evident on the external walls of heritage buildings because these surfaces are directly exposed to air currents, especially when buildings stand in open areas and lack trees or other forms of afforestation that can function as windbreaks ⁽²⁹⁾.

6.1.3 Humidity

High humidity can produce harmful effects in historic buildings, including deterioration of constituent materials, deformation or surface alteration of marble, damage to ceilings, and deterioration of stucco decoration. Humidity may be understood as a pathological condition of a building in the sense that, like a symptom in medicine, it should first be diagnosed before treatment is selected. Moisture is usually the result of a particular physical source or transport mechanism, and that source must be identified in order to understand the nature of the deterioration. The effects of moisture on buildings are numerous. Excess moisture can create unhealthy conditions for occupants and can weaken the coherence of the building fabric by contributing to fragmentation and deterioration of walls, floors, and ceilings. It can damage timber, promote corrosion of metal components, degrade paint and electrical systems, and create conditions favorable to fungi and bacteria. Water may be present as atmospheric humidity, rainwater, groundwater, leakage, or condensation, and each form can damage old building materials physically, chemically, or biologically. Moisture also plays a major role in the transport, redistribution, and crystallization of soluble salts. It can facilitate the transformation of atmospheric pollutants into damaging acids and can create a suitable microclimate for the growth of biological organisms on or within building materials. The location and pattern of moisture are therefore as important as the visible symptoms. Dampness may rise from the ground, penetrate through walls or roofs, condense on cold surfaces, or be introduced by internal activities and defective services. Each pathway can produce a different distribution of damage, and treatment that addresses only the visible stain or damaged finish may fail if the source remains active. For heritage structures, diagnosis should therefore precede repair so that interventions do not trap moisture, accelerate salt movement, or introduce materials that are incompatible with the existing fabric.

Moisture in heritage buildings may originate from the external atmosphere or from human activities and services within the building. Atmospheric humidity can affect historic buildings when relative humidity becomes either excessively high or excessively low, particularly when repeated fluctuations occur. Because moisture has several possible sources and pathways, diagnosis should distinguish among the most important forms discussed below ⁽³⁰⁾.

²⁸[22–24, 27] Al-Jayousi: Islam and Sustainable Development, p. 22, Mohammed: Climate Change Indicators for Climate Elements, p. 3, Jaafar: The Extent of Armed Conflicts to Climate Change, pp. 201–202, Al-Saad: Towards an Accessible Housing Entitled Sustainability Open to the Inside, p. 30.

²⁹[30, 31] Al-Ammari: The Problem of Sustainable Development and Its Dimensions, p. 4, Robert W. Kates, Thomas M. Parris, and Anthony A. Leiserowitz, What Is Sustainable Development? Goals, Indicators, Values, and Practice. Environment: Science and Policy for Sustainable Development, vol. 47, no. 3, 2005, pp. 8–21.

³⁰[32–34] Al-Issawi: Development in a Changing World: pp. 17–20, Mensah Justice, Sustainable Development: Meaning, history, principles, pillars, and implications for human action: Literature review, Cogent Social Sciences, 5 (1), 2019, pp. 4–5. , United Nations, 3-14 June 1992. Report of the United Nations

Rainfall Historic buildings may be exposed to frequent rainfall, particularly when preventive measures are insufficient to keep rainwater away from vulnerable surfaces and structural elements. In Iraq, rain can be an important climatic source of moisture-related deterioration, although its effects vary according to the location of the building, construction materials, roof and drainage conditions, and maintenance history. Rainwater can penetrate roofs, walls, cracks, joints, and porous building materials. This penetration may contribute to disintegration of materials, loss of inscriptions and colors, movement or weakening of foundations, and dissolution and redistribution of salts. Effective protection therefore requires appropriate maintenance of roof surfaces, wall joints, drainage routes, cracks, and other water-entry points using materials compatible with the historic fabric. Rain may also encourage growth of unwanted plants after the rainy season when wind-borne seeds reach damp walls, roofs, or adjoining soil. Buildings founded on certain clay-rich soils may experience additional problems because repeated wetting and drying causes soil expansion and contraction, potentially affecting foundation stability. In general, heritage buildings in dry environments with limited precipitation may experience different moisture risks from those in humid and rainy environments, where water can accumulate near foundations or remain on upper wall and roof surfaces for longer periods⁽³¹⁾. Rain-related deterioration should also be considered together with roof geometry, drainage, wall exposure, surface condition, and the permeability of repair materials. Water that enters through a small defect can migrate through porous masonry and appear at a location distant from the original entry point. Repeated wetting and drying can then intensify salt transport, surface loss, and biological growth. Preventive maintenance is therefore important because repairing gutters, joints, roof surfaces, and localized cracks before extensive water penetration occurs can reduce the scale of later deterioration and help preserve both structural and decorative elements.

Condensation Cold air can hold less water vapor than warm air. When warm, moisture-laden air cools near colder wall surfaces, its capacity to retain vapor decreases and condensation may occur. Water vapor then changes from a gaseous state to liquid droplets, which may appear as scattered damp spots, films, or droplets on wall surfaces and within colder cracks or corners. Repeated condensation can keep materials damp and may contribute to staining, salt activity, biological growth, and gradual material deterioration⁽³²⁾.

Salts Salts commonly appear on brick and other porous masonry surfaces, and their treatment requires careful diagnosis of both the salt source and the moisture mechanism that transports the salts. Salt-related deterioration may not always be visible to the naked eye at an early stage. The building should therefore be studied in detail with attention to the materials used in construction, moisture pathways, previous repairs, and the distribution of visible damage. Because soluble salts within building materials can present a serious conservation problem, representative samples may be taken from affected walls and examined through appropriate laboratory or field tests, including tests related to material strength, abrasion, moisture, and salt content. Treatment should also include control of moisture sources, improvement of the surrounding environmental conditions where possible, and periodic monitoring. These combined measures can reduce recurrent salt crystallization and help limit continuing deterioration⁽³³⁾. Salt treatment should consequently avoid being reduced to simple surface cleaning. Removing visible deposits without controlling the moisture source may provide only a temporary improvement because dissolved salts can migrate back toward the surface during later wetting and drying cycles. Periodic observation is necessary to determine whether treatment has reduced the rate of recurrence. The selected conservation method should also remain compatible with the original masonry and mortar so that the intervention does not create a denser or less permeable layer that redirects moisture and salt crystallization into adjacent historic material.

6.1.4 Air Pollution

Atmospheric air pollutants arise from both natural and anthropogenic sources. Natural sources include volcanic activity, dust storms, and forest fires, whereas anthropogenic sources include transport, combustion, industry, and other human activities. The danger to heritage materials increases when deposited pollutants react with atmospheric moisture and are transformed into acidic compounds or other chemically active substances capable of attacking stone, mortar, metals, and decorative surfaces⁽³⁴⁾.

Conference on Environment and Development. New York: United Nations, p. 3.

³¹[33, 34]. Mensah Justice, Sustainable Development: Meaning, History, Principles, Pillars, and Implications for Human Action: Literature Review, Cogent Social Sciences, 5 (1), 2019, pp. 4–5. , United Nations, 3-14 June 1992. Report of the United Nations Conference on Environment and Development. New York: United Nations, p. 3.

³²[30, 32] Al-Issawi: Development in a Changing World, p. 17, Al-Ammari: The Problem of Sustainable Development and Its Dimensions, p. 4.

³³[22, 25–27] Al-Jayousi: Islam and Sustainable Development, p. 22, Bensalam: Climate Change as the Source and Incubator of Natural Disasters, pp. 44–45, Al-Ghamdi: Human Resources Development and the Requirements of Sustainable Development, pp. 491–513, Al-Saad: Towards an Accessible Housing Entitled Sustainability Open to the Inside, p. 33.

³⁴[24, 26, 27] Jaafar: The Extent of Armed Conflicts Linked to Climate Change, pp. 201–202, Al-Ghamdi: Human Resources Development and the Requirements of Sustainable Development, pp. 517, 534, Al-Saad: Towards an Accessible Housing Entitled Sustainability Open to the Inside, p. 34.

7. CONCLUSION

Archaeological and historical cities function as mirrors of the past in which present societies can recognize their cultural and architectural history. If these cities and their buildings are preserved without disturbing the environmental, demographic, social, and economic balance of their communities, their historical image can be maintained and the deterioration or loss of heritage buildings can be delayed for many years. Conservation should therefore be understood as a continuing process that combines physical protection with appropriate management, community awareness, compatible use, and sustained maintenance. The recommendations that follow are therefore directed toward both the physical fabric of heritage areas and the institutional and social conditions required for their continuity. Protecting individual buildings, documenting their condition, strengthening legal protection, involving residents, allocating financial resources, and encouraging appropriate reuse are complementary actions. Their combined purpose is to keep heritage buildings active within the contemporary city while reducing avoidable deterioration and maintaining the architectural and cultural qualities that give the old urban fabric its significance.

1. Developing plans for the neighborhoods of heritage and archaeological cities
2. Preventing buildings from being left to neglect, abandonment, or tampering by vandals.
3. Conducting an archaeological and heritage survey of the area to be protected.
4. Preparing lists of buildings to be protected and placing them under an appropriate framework of legal protection.
5. Raising awareness by explaining to citizens the historical, economic, and cultural importance of these buildings and by clarifying their shared responsibility for protecting them.
6. Involving citizens in the responsibility of protecting national and archaeological heritage by including them in the competent government committees.
7. Developing institutions that help raise citizens' awareness and explain the dimensions of the heritage issue and its benefits to citizens.
8. Calling on the relevant authorities to allocate funds to protect those buildings.
9. Rationalizing the use of these physical envelopes and issuing legislation to regulate such use.

Sustainable conservation processes must extend to improve the built environment in the area itself and in the surrounding environment.

The process of improving the built environment involves preserving the existing urban mass as a wealth of social and economic value that is required to be better exploited and reused.

8. RECOMMENDATIONS

- Working to make urban heritage an integral part of the cultural, economic and urban structure of Islamic countries.
- Identifying and defining the essential elements of urban heritage in the Islamic world, taking into account the common local environmental and cultural elements that constitute the urban character.
- Employing heritage in an integrated manner in all its natural, cultural and urban aspects as an economic resource within sustainable development plans.
- Raising private-sector awareness of the importance of participating in the preservation and reuse of urban heritage and making this one of its priorities in the field of social responsibility, including supporting local associations to contribute to development, and supporting educational institutions in the field of preserving and repurposing heritage buildings.
- Activating the use of local building materials in the restoration of heritage buildings and urban projects, and working to develop them in line with the requirements of the times, through research centers specialized in the development of traditional building materials using modern technologies.
- Using computer programs and documentation techniques for archaeological buildings and their development.

AUTHOR CONTRIBUTIONS

All authors contributed to the development of the study, critically reviewed the manuscript, approved the final version, and agreed to be accountable for all aspects of the work.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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DATA AVAILABILITY

Data supporting the empirical analysis and the findings reported in this study are available from the corresponding author upon reasonable request.

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