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# The formation of invisible architecture according to environmental tendencies techniques

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## ABSTRACT

Increasing awareness of the need to take care of the planet and reduce the negative effects of human impact on the environment at the level of all aspects of life, including architecture has become essential. The invisible architecture and in accordance with the environmental tendencies appeared as one of the contemporary trends to be that formation that achieves a blend with the environment surrounding and based on techniques that reduce its appearance to emphasize the importance of the external environment and trying to return to nature and increase green spaces in a manner that reduces pollution to the minimum level. Therefore, this architecture is part of the site and not just an added part to it, as well as its quest to increase operational efficiency and to reduce its negative impact on the environment in addition to improving the built environment that enhances health and well-being of the user. Many previous international studies highlighted various aspects of invisible architecture and the techniques and technologies for achieving them, noticing the limitation of Arabic and local studies that dealt with this topic. This research aims to provide clear and comprehensive knowledge of the techniques of achieving invisible architecture in its environmental perspective with its multiple formations, which can be adopted effectively by the designer in general, and in a manner, that serves the reality of the Arab and local experience. And in line with the local natural and urban environment to keep pace with contemporary global trends.

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## 1. Introduction

The signs of invisible architecture appeared in the various eras of history and since ancient times, despite not referring to them conceptually. Where man adopted the first structural patterns, such as the cave, which was masked by mountains or hills and even within the ground, aiming to achieve shelter [1], and the Holy Qur'an mentioned the wonderful models of the buildings of the ancient nations and the various geometric shapes, such as the houses of Thamud and the palace of the prophet Suleiman. In the text of the noble verse: (you take for yourselves palaces from its plains and carve from the mountains, homes) (Surat Al-A'raf, verse 74), it was also stated in the text of the verse: (It was said to her: Enter the palace, but when she saw it she deemed it to be a great expanse of water and bared her legs. He said: Surely it is a palace made smooth with glass. She said: My Lord! surely, I have been unjust to myself, and I submit with Sulaiman to

Allah, the Lord of the worlds) (Surat An-Naml, verse 44). The edifice was made of transparent and reflective glass that freshwater was running under. In other words, it did not rely on the visual aspect only; but the sense of touch to perceive it, [2]. The interest also appeared during the ancient and medieval historical times using optical illusion to manipulate the dimensions of spaces, to pay attention to light and sound design, and influence the perception of the recipient by finding the boundaries of space without the need for architectural elements such as walls, ceilings, and doors, as in Roman temples, [3]. In addition to the use of mosaics and drawings, the spaces seem different from their true identities, and the art of decoration (arabesque) gives the impression of movement to a fixed body [4], [5].

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For the time being, invisible architecture is emerging as one of the contemporary global trends towards harmony with the surrounding environment, whether natural or artificial and achieving environmental sustainability in particular, in terms of the fact that architecture is much more than its physical construction, as it has another invisible aspect that is more vital and makes it associated with its surroundings as a part of it and not added to it, [8] so was the protected underground architecture that excavated the components of the earth from soil, rocks or caves to be part of the building elements and merge with it, to achieve protection and maintain energy efficiency Increasing the green spaces [9] and controlling the relationship with the ground levels, which may be in direct contact with the outside or indirect contact, to mask the building and achieve security and safety and arousing the feelings of the recipient. [10].

On the other hand, the invisible architecture was found by adopting the method of camouflage and with the intention of disguise through the use of elements similar to the elements of the surroundings and the use of transparent materials, to achieve communication between the interior and the exterior, and blending with the surroundings [11] besides the use of each of the elements of the environment such as air and sound to create non-physical boundaries that separate the interior from the exterior and characterized by being unstable, ephemeral, dependent on the senses of the recipient to perceive it [12], the adoption of media facades and Atmosphere facades to mask architectural solidity transforming architecture from stability to movement, interactive dynamism with a view to the interaction between the recipient, interface and the environment, making it characterized by vitality and ambiguity [13], [14].

Accordingly, it is clear that there is a multiplicity and diversity in terms of invisible architecture formations, techniques and technologies adopted in general, according to the environmental trend in particular in terms of striving to reduce the negative environmental impact and achieve both harmony and sustainability to create an architecture with distinctive aesthetic values and economic benefits that meets multiple functional needs, which formed an incentive for this research in order to clarify the techniques adopted in the formations of invisible architecture from the environmental perspective, which can be effectively adopted by the designer, and in order to serve the Arab and local experience to catch up with contemporary global trends, so the research relied on the descriptive approach in analyzing Prior knowledge and applied experience, by a sequential steps that begins with building a conceptual framework for each of the concepts of the invisible in general and in architecture in particular, in a way that determines its most important forms, and then forming a cognitive framework for the techniques adopted in the formation of the invisible architecture according to the environmental trend, secondly, to apply that framework on Selected models from Arab projects, third, to determine a set of conclusions and recommendations regarding the reality of the Arab experience, and fourth, the possibility of adopting the knowledge presented in future local projects.

## 2. Architecture and Invisibility concept

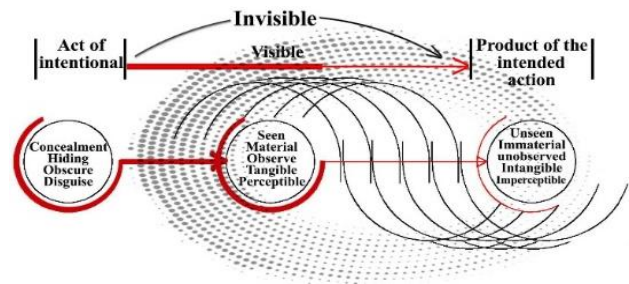
### 2.1. Define the concept of the invisible in general

The invisible concept can be defined in the Arabic language, by what contradicts it from the visible concept. Considering that (In) is received

linguistically as being a noun meaning neither nor not, as in not clear, and the Almighty's saying: (But whoever is forced, neither desiring nor transgressing), meaning he who is forced is hungry, neither oppressive nor normal [15]. Thus, the invisible refers to what is not under consideration, for it is what is neither observed, nor material, nor tangible, nor seen, nor perceptible [16].

In the English language, the concept is given as (invisible), and it indicates, according to Merriam-Webster's dictionary, that it is by nature incapable of seeing, difficult to perceive by sight [17]. While the Oxford Dictionary defines it through a set of synonymous meanings, it includes all of the following: (Unseen, Conceal, Hidden, out of sight, Undetectable and Unnoticeable or Unobserved) [18].

Thus, it is clear that the concept is associated linguistically with two main aspects: the first, the act of intentional concealment, mask, disguise, or hiding, and the second, the product of the intended action, which is incapable of detected as shown in (Fig. 1).



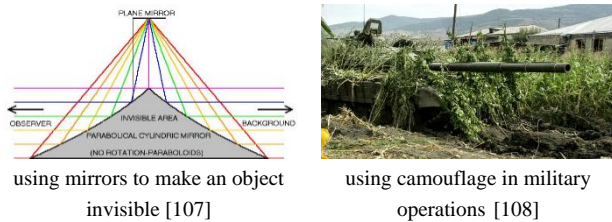
**Figure 1.** A model showing the visible and the invisible linguistically [1]

Idiomatically, the definitions of the invisible have varied with the multiplicity of opinions and trends of researchers in various fields of knowledge, as it refers in philosophy to everyone who is essentially hidden (what is essential) and it did not have an intentional act of concealment, except that it is felt internally or perceived and felt, or what is covered, masked, concealed, or hidden by an intentional act to be invisible, which is difficult to distinguish and perceive, but it can be perceived later after scrutiny [19], [20].

In physics, the invisible refers to the intangible elements that are not considered concealed, because they can be perceptually perceptible and are known as the elements of the atmosphere (light, air, sound, and temperature), and they can be controlled and manipulated to affect the recipient's sense [21] by adopting advanced technology, it is possible to find intangible components that cannot be perceived or detected, by an intentional act of perceptual concealment, for each of the visual and sensory terms, for example, what has been focused on in strategic aviation techniques and increasingly within defense networks, to penetrate the enemy airspace by stealth aircraft [22].

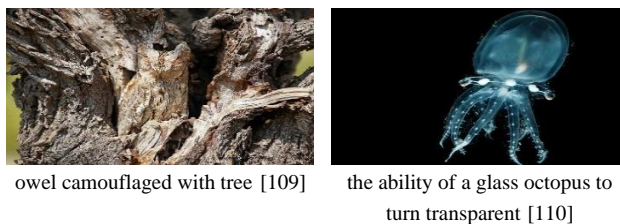
On the contrary, the invisible in physics also refers to the unseen and unobserved bodies that are difficult to distinguish and perceive, but they are realized later after scrutiny and are achieved by an intentional act of masking, hiding, or disguise, and this is by relying on other bodies (such as forts and shelters) so the bodies are unseen, or through camouflage, so the bodies are unobserved for the purpose of shelter, depending on the shape of

the body and its background, so they are blended with the surrounding environment, which was invented militarily for the first time in the mid-nineteenth century, such as coloring clothes, or using river mud to dye themselves, so they become unnoticed or unobserved [23], or masking based on the physical properties of objects that allow light to pass through them and become transparent objects, or by manipulating the light path through the use of reflective mirrors [24], [25]. (Fig. 2).



**Figure 2.** Invisibility in physics

The invisible in biology refers to the organisms that are difficult to distinguish and perceive, but are realized later after scrutiny, and are achieved by an intentional act of mask or hide. This is done by relying on objects and elements found in nature (such as plant leaves, rocks, etc.), so that the organisms are unseen for shelter and hunting, or the adoption of camouflage so that the bodies are unobserved in blend with the surrounding environment for protection by relying on the shape of the body and its background, and coloring and reincarnation, such as what merges the owl with the background and takes on the shape of the tree trunk, as well as for the frog and the caterpillar with the leaf [26]. Octopus species can become translucent or manipulate the light path through the reflective outer layer into unobserved bodies as in a sea worm that produces a dazzling display of light in a process known as bioluminescence, confusing predators and those who think they are looking at sunlight The spotted striking the surface of the water [27]. (Fig. 3).



**Figure 3.** Invisibility in biology

The invisible in the arts refers to the objects that are difficult to distinguish and perceive, but they are realized later after scrutiny, relying on optical illusion, which is one of the techniques of creativity, as it deliberately manipulates the awareness and mind of the recipient, so the objects appear in a way other than what they appear as in visual art (Op-Optical Art) [28]. As the invisible concept appeared in the performing arts and the cinematic field, visual effects had a significant impact on the development of the concept, which refers to techniques used by filmmakers to show what is not real, as something real and existing [29]. In the past, these effects relied on simple and traditional techniques, including masking the features of the actor's character by disguise, especially in the field of fashion and make-up. Sometimes the character needs to blend with the design of the scenes or the directing choices, so attention is given to highlighting the elements that

make the character in its unseen form [30]. Then there were many devices and programs in this field, and among the visual effects that make the body look unobserved by disguise is the Motion Capture, which allows the actor to be unobserved by disguising any character, and this is by wearing special clothes, linked to a group of devices wired when the actor moves, these devices capture the movement and convert it into keyframes on the graphics programs [31]. As for the visual effects that make the body in its intangible form, it is the green or blue screen, or what is known as chroma, which is It is the construction and design of the surrounding environment on the graphics programs and then merging it with the scene depicted on a green or blue background [29].

It is clear from all linguistic and idiomatic definitions that the invisible has many forms that depend on several techniques to achieve it. Including the concealed forms associated with the human feeling, which are essentially concealed, meaning that no intentional act of concealment, mask, disguise, or hide occurred on them, and the unseen form of the body that depends on other bodies to masked it without any changes to it. As for the unobserved form, it depends on a change in the characteristics of the body or external influences that lead to a change in the body itself. As for the intangible form, it is real and existing, but it does not have a physical presence, but it can be perceived.

## 2.2. Invisible architecture Definition

Studies have put forward several definitions of invisible architecture, as they defined it as the architecture of the cover, which depends on the use of the nature of the land to build a shelter for the human being, to protect against climatic conditions [10]. It is also known as the architecture that intends to mask the building by relying on other structural elements [5], [12]. While other studies defined invisible architecture as those whose buildings try to be hidden from the view of everyone and reduce the appearance of what is being built, through the development of a series of operations such as camouflage and the use of optical illusion so that it is difficult to distinguish them despite their physical presence, or blending the edges of the building With the elements of the external spaces, making the shape of the building difficult to distinguish, when the architect wants to highlight the features of something else, such as the surrounding natural features and blend with them [6] [32]. It can also resort to mimicry along with optical illusion, and uses various technologies such as screens, mirrors (including water mirrors and reflective surfaces in general), video cameras, etc., to make its buildings difficult to distinguish, even if they are huge. Which tends to be in blend with its surroundings in which it is located. [33], an architecture that can depend on the nature and characteristics of materials and the interaction of possible boundaries between man and technology, such as floating or cloud architecture, which is transparent, light, and melting with the site, to adapt to the environment [34]. The Inclusive Intelligence Research Institute (CIRI) defined invisible architecture as those that can be perceptually perceptible with the help of technology, and take light, color, sound, and smell as elements to define space and create sensory spaces, like its tectonic counterpart represented by walls, ceilings, and doors. Where the location, shape, and boundaries to create, whether they are public buildings or homes, or even at the level of designing outdoor spaces. It operates in a way that the biological senses are not directly aware of and affects the minds and behaviors of the viewer more than visual buildings [35], [3]. Where its definition is related to the so-called immaterial materiality, which is the possibility of building material things so that solid bodies are formed in a stationary state. However, it gives the impression of a state of movement, and thus generates

many perceptions throughout the duration of its movement and defines media buildings [36]. Thus, the immaterial form of architecture depends on sensory influences to be perceptible, using elements of the atmosphere such as air, light, and sound to complement the material experience of architecture, to create walls, ceilings, and furniture instead of traditional building materials, and the requirements to achieve them include the use of techniques and technology of materials and tools [37], [38]. It is considered one of the contemporary trends towards the future of sustainable design, to design buildings that reduce energy use and greenhouse gas emissions, to improve the sustainability of the built environment while supporting the architectural aesthetic of efficient, beautiful, and integrated buildings [39]. It is clear from the foregoing that the invisible architecture is the architecture of sensory perception based on the intentional action of the designer in terms of hiding, mask, and disguise, and it included the following forms, see (Fig. 5).

- Unseen form: It is the form of invisible architecture that relies on other elements to mask it, which may be structural elements or those elements from the environmental surrounding for the purpose of protection, and it cannot be perceptually perceptible only after scrutiny and focus later.
- Unobserved form: It is the form of invisible architecture that depends on the physical properties of its components and according to camouflage and optical illusion to blend with the environmental surrounding, and it is difficult to perceptible it only after scrutiny and focus later.
- Immaterial form: It is the intangible form in invisible architecture that depends on the material and kinetic energy to create the boundaries of the building like its tectonic counterpart, to transform architecture from fixed and stable material existence to a moving immaterial existence that requires sensory perception.

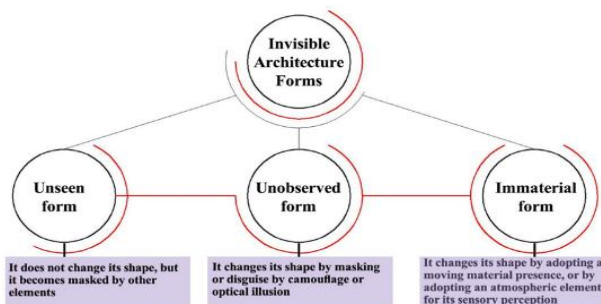


Figure 5. A model showing the forms of the invisible in architecture [35]

### 3. The invisible architecture in its environmental perspective

The invisible architecture in its environmental perspective is based mainly on trying to blend with its environmental surroundings, which includes:

- The ecological environment: It is all the living and non-living elements in which man has not had any interference. It is known as pure nature, which affects the lives of living organisms directly or indirectly, such as (seas, deserts, terrain, climate, plants, and animals).
- Built environment: It is the physical and urban structure built by man and includes all facilities, whether residential, industrial, or service, and even the natural man-made ones, which work to organize societies

and serve human needs, through systems Integrated social, political, economic, cultural, educational, moral, technological, and urban [40] [41].

Accordingly, it's defined as it is the architecture that compositionally depends on the unseen, unobserved, and immaterial architecture in order to reduce its appearance to a minimum, which is difficult to perceive and aims to blend with its environmental surroundings by relying on several techniques and what it contains technology and materials included within it with contemporary trends of sustainability, conservation of energies and resources, as well as enhancing aesthetic, functional and sensory qualities.

This research has invested many previous studies and international and Arab applied projects, for determining the techniques adopted in the formation of invisible architecture in its environmental perspective, in a manner that is consistent with the goal of the research, and these techniques were classified according to each of the following:

#### 3.1. Techniques of the unseen formation of invisible architecture in the environmental perspective

They are those techniques that are adopted to reduce the appearance of the building with the intention of mask and hiding and by relying on other elements, which may be natural or artificial (structural or non-structural), while preserving the original formal characteristics of the building unchanged to achieve protection from environmental conditions in the main, so that it is difficult to perceptible except After scrutiny and focus later, to include all the following:

##### 3.1.1. Merging with Landscape technique

This technique refers to the merging of elements of the building with the elements of its surroundings so that the building appears as part of or as an extension of the landscape or the surrounding outdoor spaces, and the effect of this method is very strong for architects who want their buildings to appear as a result of their surroundings [42], integration with the site is also associated with criteria such as biophilic design, green architecture or eco-design to achieve sustainable design, as well as the integration of historic urban sites with contemporary built areas [43]. This technique relies on a set of technologies as follows:

**Landscape Intersection Technology:** This is based on the melting and fading of the building lines with the site topographic lines [44], as in the Sancaklar Mosque in Istanbul.

**Underground Architecture Technology:** This technology depends on the containment and mask of the building through burial and the construction of the entire building under the surface of the ground, or the Pit by constructing the building close to the surface of the ground or sculpting in the mountains in a similar way to caves [45] [46] [47], as in the cave-like house in Greece.



Figure 6. A model showing merging with landscape technique

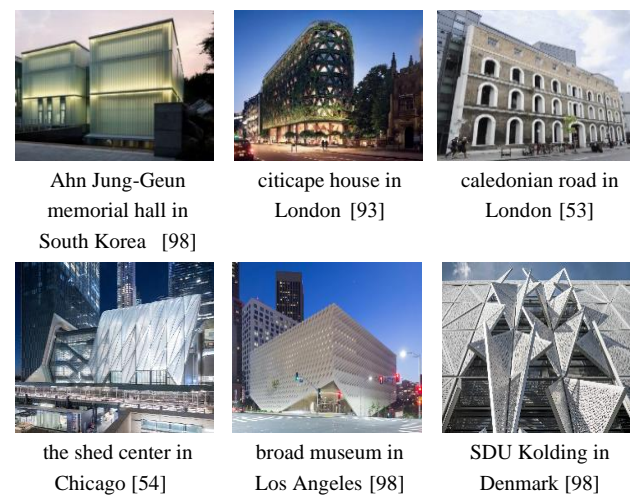
Submerged under Water Architecture Technology: where the whole or part of the building is submerged below the water level with the intention of masking [48], as in the underwater discovery center in Australia (Fig. 6).

**3.1.2. Wrapping Technique**

The technique of wrapping in buildings depends on what is known as the language of Layering, where the building consists of the main layer represented by the original building mass that is intended to be made invisible, and the secondary layer, which is a material layer that works to wrap the building either by coating it or surrounding it, which makes the building mass invisible without affecting the shape of the original mass of the building, and helps to protect from the surrounding environmental conditions in addition to enriching the building and creativity [5]. This technique relies on a set of technologies as follows:

**Coating Technology:** It is based on coating the surfaces of building units either with membrane components coating such as cloth or plastic or coating with green walls one of the patterns of biophilic design, which are basically vertical walls covered with plants and natural elements as well as some water delivery systems, or By adopting screen coating, which uses a curtain layer that is wrapped on the building envelope, this technology works to control solar energy by reducing glare and heat gain, and is also used to achieve privacy, insulation and visual comfort. [12] [49], [50] [51], as in the Ahn Jung-Geun Memorial Hall in South Korea and Citicape House in London.

**Façadism Technology:** It is considered one of the controversial technology to preserve the context of the urban environment, which means demolishing the old building historically and creating a new building for new purposes or function, while keeping the old facade around it to mask the modern building [52] and benefiting from the facade by controlling shade and light And providing natural ventilation due to the distance between the facade and the modern building, which reduces heat gain and achieves visual and thermal comfort [53], as in the National Provincial bank in London.



**Figure 7.** A model showing wrapping technique

**Surrounding Technology:** It is based on surrounding the original building with a secondary mass, where this construction technology is simulated to Russian dolls, by designing one building inside the other, for environmental, privacy, security, or service reasons [12] and this technology can be achieved through the building in the building. In this

technology, the original building is inside a secondary building or structure, where the original building maintains its characteristics, while the secondary building works to control solar energy and keep the building cool as well as providing the new shape and additional space [54], as in the shed center in Chicago, or the adoption of an exterior structure that allows shading and self-ventilation of the building [55], as in the Broad museum in Los Angeles, and kinetic facades can be adopted with the intention of completely or partially masking the building to be adapted to the environmental surroundings. It aims to respond to changing environmental conditions and enhance the aesthetic qualities [56][57], whether those facades are sliding, folding or tracking, as in the SDU Kolding in Denmark (Fig. 7). From all above, it is possible to summarize the unseen formation techniques for the invisible architecture in the environmental perspective and the technologies included in (Table 1).

**Table 1.** The unseen formation techniques and technologies for the invisible architecture from the environmental perspective (source: researchers).

Formation techniques	Formation technologies	
Merging with Landscape	Landscape Intersection Technology	melting and fading the building lines with the site topographic lines
	Underground Architecture Technology	Burial, Pit, Sculpting
	Submerged Architecture Under Water Technology	whole or part of the building submerged below the water level
Wrapping	Coating Technology	coating with membrane components such as cloth or plastic, green walls, screen coating
	Façadism Technology	Architectural preservation of old facades in buildings with new buildings built behind them
	Surrounding Technology	Building in building, Exterior structure, Kinetic Facades

**3.2. Techniques of the unobserved formation of invisible architecture in the environmental perspective**

Techniques that are adopted to reduce or delay the process of detecting the building with the intention of mask and disguise by relying on the physical characteristics of the components of the architectural form essentially to achieve blending with its environmental surroundings in the basic degree, so that it is difficult to realize it only after scrutiny and focus later, to include all the following:

**3.2.1. Camouflage Technique**

Camouflage is defined as a tactical concept as one of the techniques of formal adaptation of the body to reduce visual detection or recognition of the object by the observer and to play with its perceptions [58]. By studying the technologies of the camouflage technique, the architects were able to

take advantage of the concept of interdependence between the shape of the building and its surroundings, which works to reduce what appears from the building and which delays detection or recognition of the shape of the building, making it blend with its surroundings, focusing on the importance of the environmental surroundings, whether natural or an urban landscape [59]. This technique relies on a set of techniques as follows:

**Dazzling Camouflage Technology:** This technology depends on the factors of dazzling and dispersion with the intent of masking, where complex patterns of geometric shapes or others are used in contrasting colors, and intersecting with each other, thus giving greater confusion and difficult to distinguish the shape of the building, and this technology can be achieved through drawing directly on the surface of the building envelope, either by coloring the building in a color similar to its surroundings or by drawing shapes similar to its surroundings, so it is difficult to distinguish the shape of the building in order to focus on the importance of that surroundings [60], as in drawing the sky on the building by the artist Benjamin Lozninger, or by adopting digital camouflage patterns in pixels in a way similar to the speckled textures and rough borders found in nature that are used in military equipment and clothing, in order to distort the shape of the building [61], as in Digital Camouflage Pattern (CADPAT).

**Mimicry Technology:** The camouflaged building in this technology looks like something else, and it depends on the nature of the surrounding site, and this is called what is known as Stealth, and this is not intended to escape from the area, place and site, but to involve a relational mechanism with the environment that surrounds the architecture at different levels [11], and this technology can be achieved through either disguise, where the building uses the properties of the surroundings such as shape and material [58] to influence the perception of the recipient [62], as in the Stone house in Portugal, or the building copying the shape of the surroundings, which leads to a change in the shape of the building according to the change of the surroundings around it, and based on each of the photographic prints [63], as in the public toilet in Amsterdam And the reflective surface [3], as in Cira Center tower in Philadelphia and the Mirror Garden in China, and the transparent surface as in Apple store in New York as well as the Light Reflecting (LED) technology[64], as in the Infinity tower in South Korea (Fig. 8).

### 3.2.2. Optical illusion Technique

It is a technique used for deception and entertainment to manipulate the recipient's perception of reality, and impressions of space and structure can be controlled by changing the proportions and appearance of building elements [65]. It is also considered one of the dynamic arts, as it transmits kinetic energy in the form, through the participatory relationship between the eye and the mind, which modifies the image of the figure in a way that is different from its real form [66] and this helped improve the quality of the internal environment by controlling access to Sunlight and reduce heat gain, and this technique depends on a group of technologies as follows:

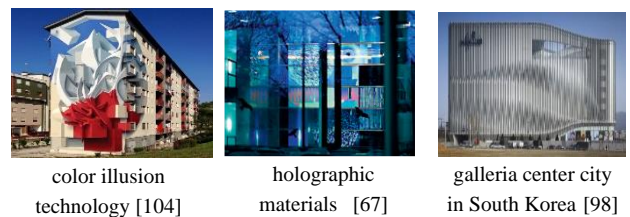
**Color Illusion Technology:** It depends on the factors of optical tricks and confusion, and both color and light are among the main effects and technologies on which the optical illusion technique depends to disguise itself in another form to improve the shape or image of old buildings or those that contain some defects so as not to affect the scene of the environmental surroundings [3], this technology also uses dichroitic and holographic materials can change color when viewed from different angles [67] [68].

**Kinetic Illusion Technology:** It relies on visual tricks that suggest a sense of movement, and this is produced using wavy and intersecting lines and overlapping circles [4], which makes it difficult to perceive the true shape

of the building. It aims to control the penetration of daylight into the interior spaces as well as to achieve pleasure with the intention of disguising itself in a changing form [69], as in Galleria Center city in South Korea (Fig. 9).



**Figure 8.** A model showing the camouflage technique



**Figure 9.** A model showing optical illusion technique

From all above, it is possible to summarize the unobserved formation techniques for the invisible architecture in the environmental perspective and the technologies included in (Table 2).

### 3.3. Techniques of the immaterial formation of invisible architecture in the environmental perspective

Techniques that transform architecture from its material existence to immaterial moving existence by relying on intangible (atmospheric and kinetic) elements to create the boundaries of the building essentially to achieve both interaction with the environmental surroundings and sensory comfort, which thus requires a sensual perception of it, to include as follow:

**3.3.1. Inversion of Atmosphere Technique**

It is a technique based on decreasing the solidity and stability of the architectural form, as it creates boundaries for the architectural building that are like its tectonic counterpart, and it also shows the vital relationship between the interior and the exterior, through what it contains of elements such as air, water, light, heat, and sound [70]. This technique relies on a set of technologies as follows:

Light Architecture Technology: Light is invested as a building material in architecture by framing the surface that defines the shape of the building or finding boundaries that are immaterial nature and separate the interior from the exterior while providing a sense of openness to the outside [3], as in the memorial tribute light in New York.

**Table 2.** The unobserved formation techniques and technologies for the invisible architecture in the environmental perspective

Formation techniques	Formation technologies	
Camouflage	Dazzling Camouflage	Based on the melting and fading of the building lines with the site topographic lines
	Mimicry	Disguise by Adoption of the properties of the perimeter (shape and material)
		Copy by Photographic prints, reflective surface, translucent surface, Light Reflecting (LED)
Optical illusion	Color Illusion, kinetic Illusion	



**Figure 10.** A model showing the inversion of the atmosphere technique

**3.3.2. Media Architecture Technique**

Media architecture is defined as-built structures in which materials with dynamic properties are mixed, that allow dynamic or interactive behavior to facilitate communication with the audience. and in media architecture, in media architecture, the relationship between architecture, media, external spaces, and the idea of visual interaction and audience involvement is emphasized, as it is sometimes accompanied by environmental, artistic, or social content through which visual, audio, and dynamic messages are conveyed to the viewer and creating interaction between the building and

its surroundings [72]. This technique relies on a set of technologies as follows:

Media Facades Technology: In it, layers of individually controlled lights are adopted, and woven with the building structure to act as a dynamic panel for texts, graphics, video animations and large screens associated with production and computer technologies [73], so the virtual representation of the architecture, by removing its material property, so dynamic images replace static structures and create the interaction between architecture, and its surroundings and the viewer [74], and the various forms of technologies used in contemporary media facades that are concerned with the environment and energy conservation depend on the way in which they are these technologies are integrated with the facade, either as a subsequent addition to it, or to be integrated with the components of the facade, which achieves visual comfort, as it allows penetration of daylight and visual openness from the inside to the outside, to include display facades that communicate with the environment [75], as in the DEXIA Climate tower in Brussels, sustainable media facades whether integrated with LED technology and photovoltaics, ETFE-enabled, responsive, or transparent displays e. [76] [77] [78] [79].

Media Interiors Technology: Mainly based on Interiors that rely on the effectiveness of the cinematic experience, with the ability to expand themselves beyond their surface appearance. Where a material structure confronts an immaterial structure using media such as video, film, display screens and LED technologies to create forms aimed at solving the concept of a world of static materials that expands the user's perception of reality, transcends, and presents an entirely new dimension of creative architectural expression [65], this technology can be achieved using interactive surfaces, digital interior and virtual reality [80] [81] [82]. (Fig. 11).From all above, it is possible to summarize the immaterial formation techniques for the invisible architecture in the environmental perspective and the technologies included in (Table 3).



**Figure 11.** A model showing the media architecture technique

**Table 3.** The immaterial formation techniques and technologies for the invisible architecture from the environmental perspective (source: researchers).

Formation techniques	Formation technologies
Inversion of Atmosphere	light Architecture, Blur or Cloud Architecture, Water Walls or Curtains, Ambient Sound
Media Architecture	Media Facades display facades that communicate with the

	environment, sustainable media facades, transparent displays
Media Interiors	interactive surfaces, digital interior, virtual reality

**3.4. Techniques of the Invisible Sustainability Architecture Formation**

Techniques that are based on achieving sustainability through their integration with the techniques of architecture formations that are not visible in their environmental perspective (unseen, unobserved, immaterial), one or more, to achieve environmental goals in the first place, as well as goals related to creating healthier urban environments, luxury and comfort for its occupants in both internal and external configurations, so that the architecture is characterized by invisible sustainability, as energy-efficient buildings [83]. These techniques and the technologies they include can be identified in the following:

**3.4.1. Passive Design Technique**

The concept of passive design revolves around taking advantage of natural energy flows to maintain thermal comfort, and the choice of passive design techniques depends mainly on the local climate where the project is located, as the integration of these techniques contributes to transforming the building envelopes into a barrier between the natural climate and the virtual climate to meet the required level of comfort Humanity [84]. This technique relies on a set of design considerations, such as building orientation [85]. Building Shape and Mass [86] and choosing materials (Choice of Materials) [84]. In addition to considering, the design of outdoor spaces (Landscaping) [87].

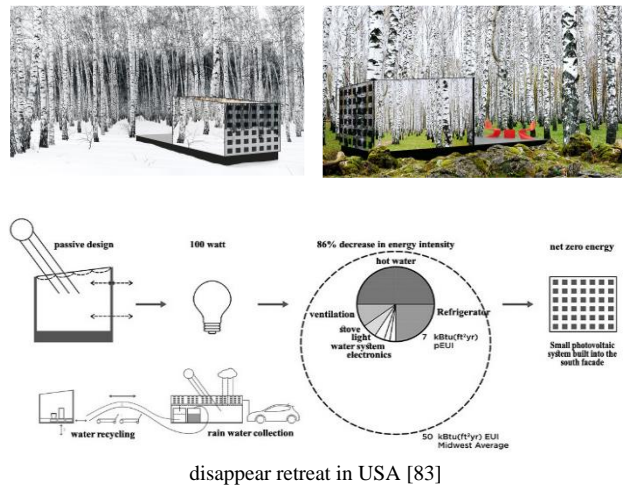
**3.4.2. Off-Grid Design Technique**

An off-grid technique has emerged as one of the solutions that allow living to be self-sufficient in terms of energy and water as well as - for many people - in terms of food, where off-grid traditionally refers to not being connected to the electrical grid and the building being able to produce electricity and/or heating itself in order to meet its own needs, but can also include other utilities such as water, gas and sewage systems, and can range from residential homes to small communities [88] [89], and Off-grid technique include main components: Generation of electricity, Energy Storage, Back up units, Devices in a house that consume electricity, and a connection to an electric grid line when present, and simulation package (DEMkit) [90]. This technique relies on a set of technologies by which invisible sustainability can be achieved, including:

**Renewable Energies:** A natural sources of energy that are constantly renewed, represented by the sun, wind, geothermal heat, water, biomass, and oceans [91], and this can be achieved through either a single off-grid system, where it involves the use of a single source of renewable energy, or multiple off-grid systems, in which more than one source of renewable energy is combined.

**Intelligent Building Management System Technology:** Where the entire building structure is managed through an intelligent building management system using modern techniques and technology to balance the work of the building at all times and thanks to the external and internal sensors, the

system responds automatically to external conditions, and will ensure safety, energy efficiency and maximum comfort while managing resources such as water in a smart way, as well as On the possibility of producing vegetables and herbs at a time when the concept of vertical and horizontal farms is increasing outside and inside [92], as in Disappear Retreat in USA (Fig. 12)



**Figure 12.** A model showing off grid design technique

From all the above, the techniques of the invisible sustainability architecture formation and the technologies included in it can be summarized in Table 4.

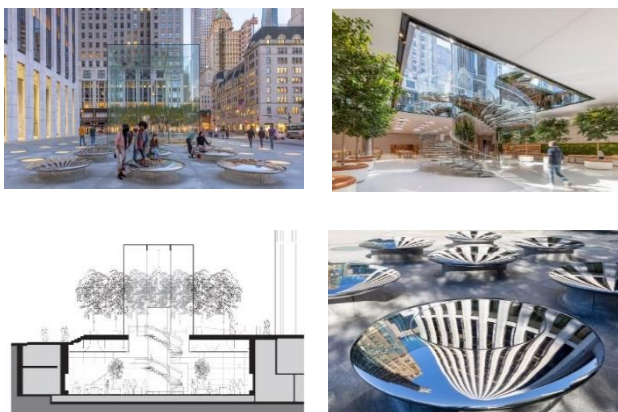
**Table 4.** The invisible sustainability formation techniques and technologies for invisible architecture from the environmental perspective

Formation techniques	Formation technologies	
Passive design	Building orientation	Orientation of the building appropriate to solar radiation and wind movement
	Building shape and mass	Minimizing outdoor surfaces exposed to climatic conditions Fixed or moving shading tools
	Choosing materials that are resistant to different climatic conditions	
Off grid design	Landscaping	
	Adopted Renewable Energy	Singular Off grid System Multiple Off grid System
	Intelligent Building Management System	Water efficiency Provide food



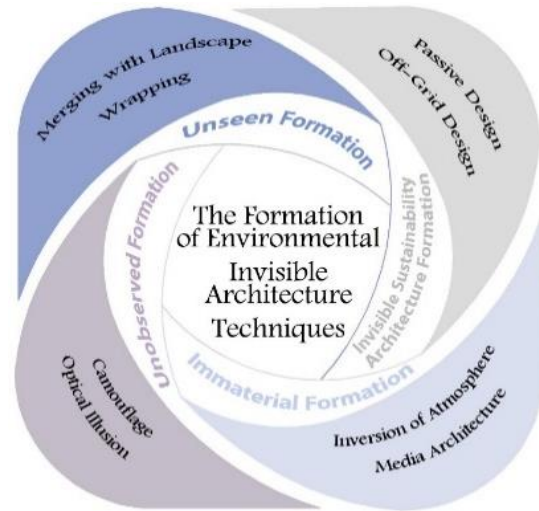
#### 4. The superimposed formation for environmental invisible architecture

In the previous paragraphs, the multiple techniques that are adopted in the formations of environmentally invisible architecture, which are achieved at internal and external levels in architecture and with various materials, and according to the objectives to be achieved in each of them, were identified. The presence of these formations in their multiple techniques separately does not necessarily negate the possibility of adopting more than one formation in a single architectural project, which contributes to creating an invisible architecture on the environmental level, as it is possible to combine more than one formation within an integrated unit, and perhaps the project to expand the Louvre Museum in Paris is a good example. The part of the museum under the surface of the earth refers to the unseen formation, while the transparent pyramid part refers to the unobserved formation of the environmentally invisible architecture. The same method was adopted in the Apple Fifth Avenue building in New York (Fig. 13), which combines several formations of environmentally invisible architecture, as the building was designed underground, which indicates the unseen formation of environmentally invisible architecture, while the above-ground part of the building is designed in the form of a transparent glass cube, and the floor surrounding the cube includes circular elements that transmit natural light to an underground level and are coated with a reflective material to reflect the perimeter of the building, and glass walls were used inside to give more space to space The interior, which achieves the unobserved formation of environmental invisible architecture. The interior ceiling is designed to change to match the color temperature outside as thousands of LEDs and sensors make the store glow, from bluish-white in the morning to golden later in the day, and fruit trees are planted inside to achieve harmony with nature, which indicates the use of the intelligent supervision system for the building, thus achieving the formation of the invisible sustainability architecture [93]. This superposition can be represented in (Fig. 14).



apple fifth avenue in New York [93]

**Figure 13.** A model showing the superimposed formation for environmental invisible architecture



**Figure 14.** Representation of the theoretical framework for the formations of environmentally invisible architecture, source.

#### 5. Practical study

The presentation of the previous propositions emerged from the global interest in designing the invisible architecture according to the environmental perspective as one of the contemporary trends, and in line with the increasing interest in trying to blend with the environmental surrounding (natural and urban), but Arab knowledge and experiences in general and local experiences in particular, did not pay attention to that aspect as it should be parallel to the global interest, so it will be possible to determine the level of application with Arab models, as there are no local models so far, with a focus on models from the Arab Gulf countries, due to the interest of these countries in adopting the latest trends as well as taking into account the advanced environmental solutions, in a way that enables investment These experiences are to create distinctive local experiences, in addition to clarifying the multiple ranges within which it is possible to develop the Arab experience and in line with the advanced global experiences in this regard.

The research supposes the adoption of the Arab experience in the context of its realization of the environmentally invisible architecture, and multiple techniques in its formations, with a focus on the techniques of the unseen formation and invisible sustainability architecture formation. Various sources with photos and illustrations.

##### 5.1. Project selection

After representing the level of application by contemporary Arab projects (in the Gulf countries in particular) was determined, and to achieve the purpose of the research is investigating the specificity of Arab architecture’s dealing with the environmentally invisible architecture, projects will be selected to direct the application process, as this choice was based on each of the following:

- The diversity of structural patterns in the projects, as the previous propositions showed the interest in designing the environmentally invisible architecture without being restricted to a specific structural pattern and to serve multiple goals.

- These projects are distinguished by their great interest in the adoption of invisible architecture formations, and their consideration of the important attempts in dealing with the environment.
- Availability of sufficient information and plans for the selected projects.

## 5.2. Project description and analysis

According to the above paragraph, five Arab projects were selected, represented by:

### 5.2.1. O-14 Tower in Dubai - United Arab Emirates

The project is a commercial tower designed by (Reiser + Umemoto, USA) and completed in 2010, consisting of (22) floors, characterized by (1326) slots distributed randomly and varying in size throughout the entire external structure, and the tower includes more than (27,900) square meters of office space is located along the Dubai Creek in the Business Bay district of Dubai, occupying a prominent waterfront location. (O-14) was named after the plot, and it is considered one of the first towers to appear on the skyline of Business Bay. The project generated exceptional international interest in the architectural press, as it is among the first innovative designs to be built among a sea of public office towers that have become the standard in Dubai's current building boom [94]. The tower was designed using Exoskeleton technology, which is based on surrounding the main glass part of the building with an external structure, perforated from the abstraction of the shape of the Arabic Lattice to work as a contemporary Mashrabiya, so that the passive design is essential in it, through the adoption of elements The perforated shell in shading the building, as well as achieving natural ventilation according to the chimney effect as a result of the space between the external structure and the main part [95], (Fig. 15).



Figure 15. O-14 tower in Dubai - United Arab Emirates [95]

Thus, the wrapping technique was adopted to find the unseen formation of the environmentally invisible architecture, by using the technology of surrounding the main mass of the tower with an external structure. The passive design technique was also adopted as one of the Techniques of the invisible sustainability architecture formation by considering the external structure as fixed shading tools, the chimney improves the quality of the internal environment and takes advantage of the longitudinal mass shape of the building to reduce the surfaces exposed to the sun as well as to face the movement of the wind.

### 5.2.2. The Doha Tower in Qatar

Doha Tower is the fifth largest tower in Doha with an area of (110,000) square meters. It was awarded the Best Tall Building in the Middle East and Africa by the Council of Tall Buildings and Urban Accommodation in 2012. It was designed by architect Jean Nouvel and completed in 2012, as it reflected the language of Islamic architecture design through the Mashrabiya, given that Qatar has a hot desert climate and in summer the

average temperature can exceed (38) degrees, and there is almost no rainfall, the kinetic façade of Doha Tower, with its complex geometric pattern of four layers, was designed to function as the Mashrabiya [96]. The plan of the tower is circular in diameter (45 meters) with a perimeter structural system that allows better controlling the lighting of the interior spaces, it is crowned with a dome that ends with a light tower at a height of (231.50) meters, and a huge lobby rises from the ground floor with a height of (112) meters to level (27) [97], (Fig. 16).



Figure 16. Doha Tower in Qatar [97]

Concluding, the adoption of wrapping technique to find the unseen formation of the environmentally invisible architecture, through the use of both the surrounding technology and the responsive sliding kinetic facades that follow the path of the sun, and the passive design technique was adopted as one of the techniques of the invisible sustainability architecture formation by considering the facade Kinetic as mobile shading tools with a smart system (technological Mashrabiya), and taking advantage of the longitudinal mass shape of the building to reduce the surfaces exposed to the sun as well as facing the movement of the wind.

### 5.2.3. Wasit Wetland Center in Sharjah, United Arab Emirates

The Environment and Protected Areas Authority in Sharjah, in the United Arab Emirates, referred the project to the architectural studio (X-Architects) in Dubai, where Wasit Reserve was originally a sewage and waste dump, and the rehabilitation process for the damaged ecosystem began in 2005, where 40,000 square meters of rubbish were removed, 35,000 trees replanted, land healing from toxic chemicals, unique salt flats and coastal sand dunes preserved, home to 350 bird species, a landing area for 33,000 migratory birds and a breathing lung for the city of Sharjah. The site center was set up to continue protecting the natural environment, educating people about the richness of the wetland ecosystem, and providing information about birds that frequent the area and other wetland areas in the emirate [98]. The architecture of the center merges with its surroundings and uses the existing topography to reduce the visual impact on the landscape. When visitors arrive, an underground path leads them to a linear gallery, and a fully transparent wall allows visitors to experience and become a part of the natural environment of the birds. Rainwater that collects on the ceiling has also been tapped into spigots that have been carefully integrated to blend in with the surrounding elements [99] (Fig. 17).

Thus, the merging with the landscape technique was adopted to find the unseen formation of the environmentally invisible architecture, through the use of underground architecture technology based on pit the construction at a level close to the surface of the earth and in closer contact with external spaces and focusing on them, and passive design was also adopted as one of the techniques of the invisible sustainability architecture formation

through the form of mass and the reduction of surfaces exposed to the external environment.



**Figure 17.** 5.2.3. Wasit Wetland Center in Sharjah, United Arab Emirates [98]

#### 5.2.4. Maraya Center in AlUla, Saudi Arabia Kingdom

The Maraya building is in the northwestern desert of the Kingdom of Saudi Arabia, designed by (Giò Forma Studio Associato S.r.l.), setting a record for the largest reflective building on earth, and a record for construction time, which was completed in just two and a half months (2019). It is a multi-purpose hall for concerts and entertainment and is a destination of global importance with (200,000) years of human history and culture at the crossroads of ancient civilizations. The project was designed based on the translation of the Arabic word “Maraya” in the form of a mirror or reflection, where the past and the future meet together at the same moment to add another level of awareness, pointing to the presence of amazing ancient tombs only 22 km from the new building, and the mirror is a way to create a dialogue between nature, history and the future, where visitors are truly amazed by the mirrored effect and the way it perfectly blends and reflects its surroundings. The building consists of a giant cube of mirrors adapted to withstand harsh environmental conditions, with a subtle curvature of the facade so that from a distance the building appears as a shimmering mirage of the surrounding panorama as it aims to focus on it, but as visitors approach, they see a perfect reflection of themselves [100] [101] (Fig. 18).



**Figure 18 .** Maraya Center in AlUla, Saudi Arabia [100]

Thus, the camouflage technique was adopted as one of the unobserved formations of the environmentally invisible architecture techniques, using copy technology with the reflective surface to focus on the importance of the surrounding environment, and passive design was adopted as one of the techniques of the invisible sustainability architecture formation using materials resistant to harsh climatic conditions.

#### 5.2.5. To DA in Dubai, United Arab Emirates

It is considered the first unique theater for digital art in the United Arab Emirates designed by (European Digital House), which opened in 2020, which offers its visitors to experience art differently when visiting the exhibition, and its uniqueness lies in the modern and immersive way to discover the masterpieces of the most famous artists world as well as contemporary digital artists by strolling through an art space, where unforgettable photos can be taken during the show. Stunning digital shows combine cutting-edge technology and art, accompanied by stunning music, visual effects, and surround sound. Covering more than 1,000 square meters, viewers can also explore inspiring and entertaining activities such as live concerts, master painting classes, virtual reality technology, and immersive shows. The project relied on media architecture, which included the use of virtual reality displays and the use of large high-definition screens with (LED) technology on the walls, ceiling, and floors with high-quality surround sound. Projecting 360-degree images on all surfaces creates a unique viewing space that makes viewers feel like they are part of an immersive artwork [102] (Fig. 19).



**Figure 19.** ToDA in Dubai, United Arab Emirates [102]

Thus, the media architecture technique has been adopted to find the immaterial formation of the environmentally invisible architecture, through the use of virtual reality technology in designing virtual environments for the environmental surroundings such as forests and living organisms, and digital interiors technology based on the integration of digital technology with (LED) screens in the roof's interior display spaces.

## 6. Results

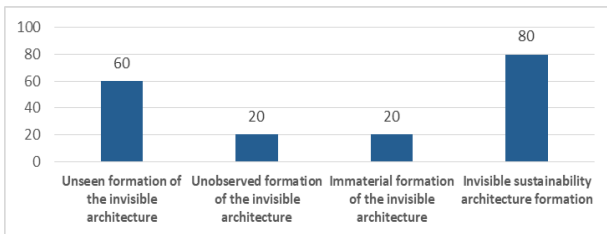
The results of the application revealed in general according to (Table 5), the adoption of the unseen formation of the invisible architecture from the environmental perspective by (60%), and the unobserved formation of the invisible architecture from the environmental perspective by (20%). And the immaterial formation of the invisible architecture from the environmental perspective by (20%), while the formation of the invisible sustainability architecture was approved by (80%). as in (Fig. 20).

The results of the application also revealed a discrepancy in the adoption of the techniques of each of the unseen, unobserved, immaterial, and invisible sustainability architecture formations of invisible architecture in the environmental perspective. Where the results of the application showed the adoption of the elected Arab projects by the unseen formation of the environmentally invisible architecture techniques represented by merging with the landscape by (33.33%) and the wrapping by (66.66%), while the unobserved formation of the environmentally invisible architecture techniques represented by camouflage at a percentage of (100%), and on the adoption, the immaterial formation of the environmentally invisible architecture techniques represented by media architecture at a percentage

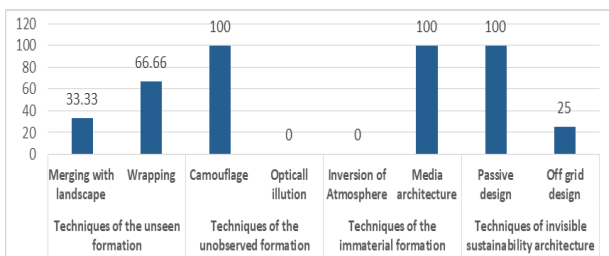
of (100%), and the results showed the adoption of the invisible sustainability architecture formation techniques represented by passive design (100%) and off-grid design (25%), as shown in (Fig. 21).

**Table 5.** Application of the invisible architecture formations techniques from its environmental perspective in the selected projects

Formations	Techniques	Projects Elected for Application				
		A	B	C	D	E
Unseen formation of environmentally invisible architecture	Merging with landscape	0	0	1	0	0
	Wrapping	1	1	0	0	0
Unobserved formation of environmentally invisible architecture	Camouflage	0	0	0	1	0
	Optical illusion	0	0	0	0	0
Immaterial formation of environmentally invisible architecture	Inversion of atmosphere	0	0	0	0	0
	Media architecture	0	0	0	0	1
Architecture of invisible sustainability formation	Passive design	1	1	1	1	0
	Off grid design	0	0	1	0	0



**Figure 20.** Application of the approved formations of the invisible architecture in the environmental perspective, (source: the researcher).



**Figure 21.** Application of invisible architecture techniques in the environmental perspective, (source: the researcher).

Thus, the results are consistent with what the research assumed about the specificity of the Arab experience in its application of environmentally invisible architecture.

**7. Conclusions**

- Diversity has emerged regarding techniques that can be adopted in finding invisible architecture formations for their environmental perspective, in terms of the techniques of each unseen, unobserved, immaterial, and even invisible sustainability architecture formation.
- It is possible to adopt more than one technique and for more than one formation of environmentally invisible architecture within the same project within an integration that serves several environmental goals and according to functional and contextual requirements.
- The practical study, in general, showed the adoption of the Arab experience, an integration between the techniques of each of the formations (unseen, unobserved, immaterial, and invisible sustainability architecture) of environmentally invisible architecture.
- The Arab experience focused on adopting the techniques of the unseen formation of invisible architecture in the environmental perspective, especially wrapping and merging with the landscape through the pit technology under the surface of the earth, and in accordance with the local specificity of the building techniques adopted in its traditional architecture, which was based on the adoption of Mashrabiya and even Underground construction.
- The Arab experience relied on the technique of passive design to achieve the invisible sustainability architecture formation through the adoption of fixed and mobile shading tools with a smart system, choosing the shape of the building mass and reducing surfaces exposed to different environmental conditions, with the limited adoption of the off-grid design technique, which was limited to the intelligent management system of the building represented in managing and collecting rainwater, given the interest of these countries in adopting the latest trends, as well as taking into account advanced environmental solutions.
- The limited adoption of the Arab experience for both the unobserved and immaterial formation techniques of environmentally invisible architecture, so it was limited to the adoption of the camouflage technique through the technology of copying the surroundings with the reflective surface and the media architecture technique through digital and virtual technologies.
- The knowledge provided in this research can be invested by both the Arab and the local designer in enhancing their professional practices and taking advantage of the multiple techniques and technologies to find various formations of invisible architecture from its environmental perspective and in line with the local natural and urban environment and with the presence of contemporary architecture that keeps pace with global trends.

**Authors’ contribution**

All authors contributed equally to the preparation of this article.

**Declaration of competing interest**

The authors declare no conflicts of interest.

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