

Received 15 March 2022: accepted 26 March 2023.

Available online 29 March 2023

## Exploring Biophilic Walkable Bridges as A Paradigm for Sustainable Cities

Nora Mohammed Rehan, Associate Professor, Head of Architectural Engineering Department, Faculty of Engineering, Ahrum Canadian University (First Author)  
nora.rehan@yahoo.com

Nisreen Samy Abdeen, Associate Professor in Architecture Department, BUE University, Faculty of Arts and Design  
nisreen.abdeen@bue.edu.eg (Second Author)

### ABSTRACT

The Egyptian cities' urban renewal movement has succeeded in enhancing the planning of road and vehicle bridge networks. Bridges are frequently recognized as a symbol of a city's economic potential and prosperity, but the disappearance of green features is considered one of the negatives, particularly after the construction of many bridges and the consequent difficulties faced by pedestrians. Because the visual quality of bridge experiences might influence on urban sustainability, biophilic urbanism that has arisen to incorporate nature more purposefully into cities. Adding visual value (using bridge sidewalks) and creating more enjoyable spaces can solve many urban space informality issues while preserving the city's visual and aesthetic elements. As a result, the research aims to develop a green approach for building walkable green bridges over these car bridges to connect the vertical and horizontal green elements together, revitalizing the city's green image. From this point of view, this paper focuses on two main issues: first, the theoretical approach, which will focus on the biophilic urban design and the benefits of integration with the urban design of streets based on environmental, social, and economic functions. Secondly: the evaluation and analysis of the area in Egypt (Nasr City) to reduce the impact of climate change by applying a balance between green and built spaces to upgrade urban streets. Based on the theoretical and applied approaches, the research proposes a green framework for the design of green biophilic pedestrian bridges to be a link between vertical and horizontal green elements to achieve sustainability.

**KEYWORDS:** Biophilic – Sustainable Cities -Walkability - Green Architecture.

### ابتكار جسور المشاه البيوفيليقية الخضراء الحيوية كنموذج لتحقيق مدن مستدامة

#### ملخص البحث

نجحت حركة التطور العمراني التي تشهدها المدن المصرية في تطوير تخطيط شبكات الطرق وجسور المركبات وتعتبر هذه الجسور رمزا للإمكانيات الاقتصادية في المدينة وازدهارها. لكن اختفاء العناصر الخضراء يعتبر أحد السلبيات خاصة بعد بناء العديد من الجسور وما يترتب على ذلك من صعوبات يواجهها المشاة. ونظراً لأن جودة الصورة البصرية المرئية للجسور تؤثر على الاستدامة الحضرية، فهذا يستدعي انتهاج مبدأ العمران البيوفيليكى لدمج الطبيعة بشكل هادف مع المدن، ويتضمن ذلك إدخالها في المدن وإليها، وكذلك داخل المباني والبنية التحتية وفيما بينها، لتعزيز الاتصال بين الناس والبيئة مع الاستفادة أيضاً من الخدمات والوظائف الطبيعية. إن إضافة قيمة بصرية (باستخدام أرصفة وجوانب الجسور) وإيجاد المزيد من الفراغات والأنشطة الممتعة تؤدي إلى حل العديد من المشكلات والقضايا في المناطق العمرانية مع الحفاظ على الصورة المرئية للمدينة والعناصر الجمالية. ونتيجة لذلك فإن الهدف من البحث هو إيجاد منهجية خضراء لإنشاء جسور خضراء قابلة للمشاة فوق جسور السيارات هذه لربط العناصر الخضراء الرأسية والأفقية معاً، وتنشيط الصورة الخضراء للمدينة والتغلب على الصعوبات التي يواجهها المشاة. من هذا المنطلق تركز هذه الورقة على مدخلين رئيسيين: أولاً المدخل

النظري الذي سيركز على التصميم الحضري الحيوي البيوفيليك، وفوائد التكامل مع التصميم الحضري للشوارع على أساس الوظائف البيئية والاجتماعية والاقتصادية. ثانيًا: المدخل التطبيقي ويتناول تقييم وتحليل منطقة من أهم المناطق العمرانية في مصر (مدينة نصر) للحد من تأثير التغير المناخي من خلال تطبيق التوازن بين المساحات الخضراء والمساحات المبنية لتطوير الطرق والفراغات العمرانية. واستنادا على المنهجين النظري والتطبيقي، يقترح البحث إطارًا أخضر لتصميم جسور المشاة الخضراء الحيوية لتكون رابطاً بين العناصر الخضراء الرأسية والأفقية لدمج الطبيعة في التصميم الحضري للمدن وربط الإنسان بالطبيعة لتحقيق الاستدامة.

**الكلمات الدالة:** مبدأ البيوفيليك – المدن المستدامة - قابلية المشي – العمارة الخضراء.

## INTRODUCTION

The global shift towards ecofriendly design continues to grow. There are initiatives in many nations that emphasis on the importance of nature as a fundamental component of daily urban life, despite the nomenclature utilized varying. (Almusaed, A., & Almssad, A. 2006). Biophilic urbanism has brought nature more in streets as a link between buildings and suspended nodes for communal activity. Streets are the main city image, not just for mobility, as per Jane Jacobs, and Jan Gehl, to enhance environmental aspects in the infrastructure of cities (Croeser, T., Ordóñez, C., Threlfall, C., Kendal, D., van der Ree, R., Callow, D., & Livesley, S. J. 2020), to increase sustainable connectivity (Asim, F., & Shree, V. 2019). The research addresses this theme in a practical way to be applied along bridges, to adjust walkability trails as walkable bridges to be parallel to the vehicle bridges in order to avoid crossing or crisis.

## 1. RESEARCH PROBLEM

1.1- The Research Problem: is that greenery is vanishing in urban context. There is a great shortage of miss connection between green nodes and walkability.

1.2-The Paucity Between Social Interactions and Green Spaces in Specific Case Studies: regarding air pollution, mental health, and carbon dioxide emissions. So, the paper is based on biophilic elements related to human scale and overcoming the negativity facing nature decline in streets as transformative urban development in our urban design, as a future global emergency for Covid-19, and coping with climate change to have a holistic framework linked with human dimensions and environment.

1.3- The Limitations Facing the Research: were the lack of a pedestrian-connected network to cross the extended roads and bridges, and even the sidewalks are small and unconnected.

## 2. RESEARCH OBJECTIVES

2.1-The Main Objective is Creating an Analytic Application: “A green agenda” for the design of green biophilic pedestrian bridges to be a link between vertical and horizontal green elements, integrating nature into the urban design of cities, and linking man with nature. This main objective is achieved by completing the following set of secondary objectives.

2.2- Creating a Continuous Walkway Trail in Streets: Applying it above the constructed bridges to strengthen the pedestrian network with nature in daily activity. By using the given policy of the site typology and applying biophilic design coping with its climate, scale of the street, building scale and resembling to the district scale to apply equity and balance, to link our accessibility with biodiversity in an effective way. The paper highlights on key design paradigm, classifying major streets, then minor streets in way

of solving infrastructure and walkability in the urban built environment in a functional context, represented in analytic application to be a policy in applying walkable bridges afterwards in city at different scales (Wijesooriya, N., & Brambilla, A. 2021). So The paper applied comparative analysis between different cases to verify the effectiveness of biophilic design as a solution in walkability, as a real evolution way to fact by simulation and S.W.O.T analysis to link between theoretical and practical regeneration in its interrelations, represented in three major sectors, social cohesion, air quality, and physical activity. All these indicators reflect afterwards on the aesthetical value per each zone to distinguish between them as most of the constructed bridges are prototype in the same form and shape where it blocks the view of the street image (Taylor, R. P., Juliani, A. W., Bies, A. J., Boydston, C., Spehar, B., & Sereno, M. E. (2018).

2.3-Applying Art in Streets is An Aesthetic Quality: by integration with the environment; that was a main assessment tool to evaluate the different applications, relevant to the varieties in building scale, and different pedestrian attitude. So, the research focused on the identifying characteristics of each site, location, and assessing the influence of the suggested design.

2.4-Sustainability Implementation in Infrastructure Design, and Urban Construction: is a crucial core that will practice directly on health conditions according to traditional nature, historicity, and sense of place by applying maintenance of its green spaces as a sustainable landmark in streets, and vertically on walkways and bridges (Croeser, T., Ordóñez, C., Threlfall, C., Kendal, D., van der Ree, R., Callow, D., & Livesley, S. J. 2020).

2.5- Demonstrating How Biophilic Walkable Bridges Can Serve as a Gateway to Biophilic Urbanism: Studying benefit a variety of economic, environmental, and social functions, with its main aspects to incorporate biophilic elements into the design of new streets and the rehabilitation of traditional papers (Taylor, R. P., Juliani, A. W., Bies, A. J., Boydston, C., Spehar, B., & Sereno, M. E. 2018).

### **3. RESEARCH METHODOLOGY**

The research deals with two basic framework approaches, the first is the theoretical one, which includes biophilic principles (Dias, B. D. 2015) and documentary study of the two case studies “Vancouver Pedestrian Land Bridge, and “Friedrich Bayer Bridge, Sao Paulo, Brazil” that concludes eight features of Walkable bridges as a green agenda to achieve biophilic walkable bridges. The second framework is the national case studies, upon a field visit to one of the most vital local district areas in Nasr City after studying the current situation of the region, deducing the weaknesses, and strengths of the area (SWOT analysis) in order to identify the most important needs to provide the eight features aligned with the proposed agenda. And to improve the environment of new bridges for healthy efficient space for users, to upgrade the sustainable environment for the existing urban design, for having sustainable healthy future environment (Soderlund, J., & Newman, P. 2015). Based on the theoretical and applied study, the research comes up with a proposal for “A green agenda” for the design to achieve A Biophilic Walkable Bridge and sustainability, as shown in (Figure1).

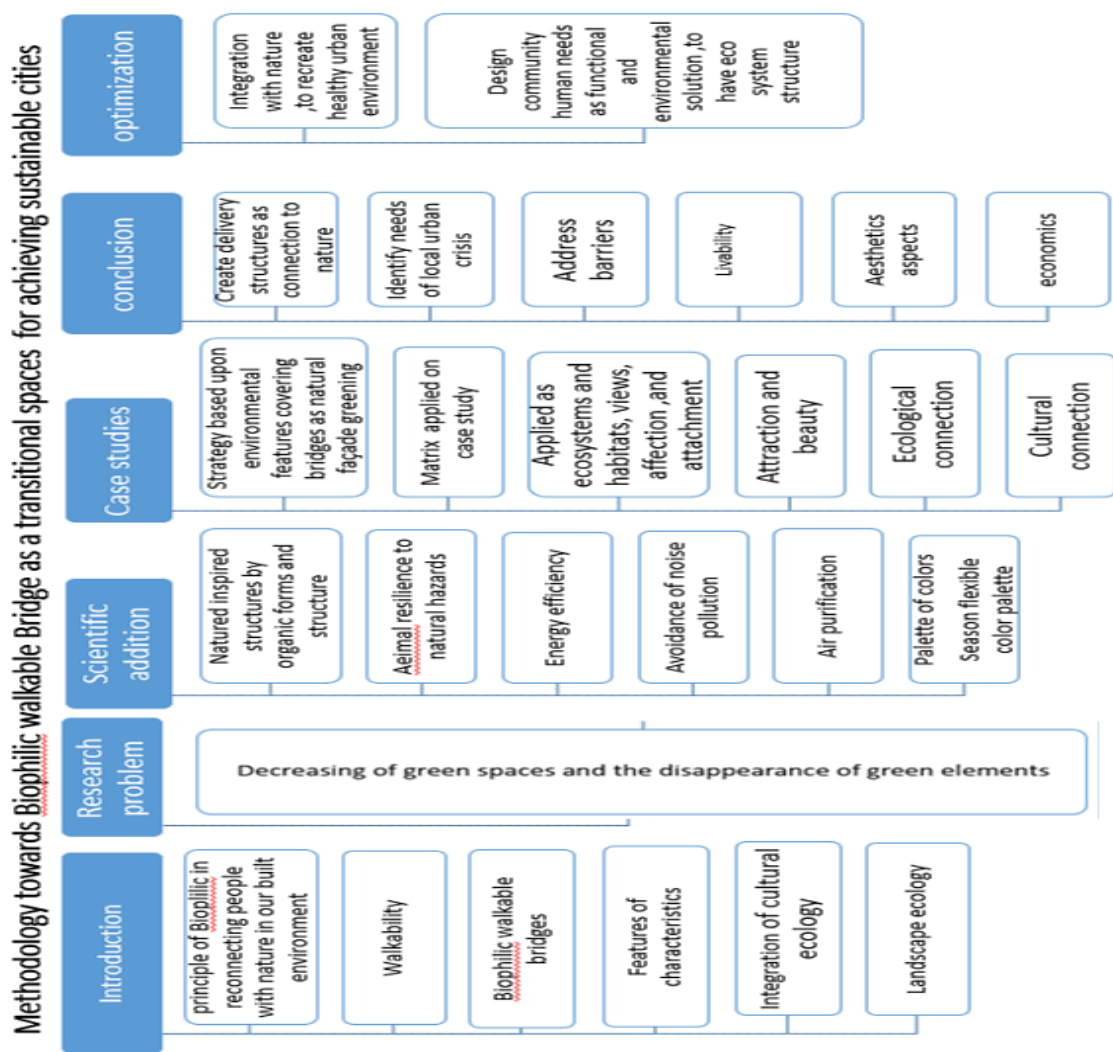


Figure (1) Methodology towards a biophilic walkable bridges.  
Source: Authors.

Suggest a biophilic local agenda for walkable bridges to achieve sustainability. It includes urban, environmental, economic solutions to solve problems that face walkable bridges planning and disappearance of green elements (Khoja, A., & Waheeb, S. 2020).

## 5. BIOPHILIC

Erich Forman was a German psychoanalyst who defined Biophilic as” love of life”, Salingraro defined the structure of nature in the built environment to uplift the urban space in a vertical way that will encourage human activity, to use natural system in designing our networks for practical application (Beatley, T. 2016), Kerlett and Clalbrese defined biophilic design elements as a sustainable development to the place. As urban population increases, the vegetated spaces decrease, so we want to revive the theories of history in maintains parks as a focal point and landmarks, to lessen the stress of circulation in outdoor as daily life routine]. From this point of view the research shed light on fields of biophilic in urban design especially pedestrian bridges and aims to implement biophilic based upon ecological systems, (Boakye-Dankwa, E., Nathan, 2019) to nourish the green effect on daily basis as essential element in urban living, to increase productivity, improve outdoor environment that affects our health, provide safe walkability as a lighted trail, decrease carbon confiscation, reduce energy consumption,

and save air quality (Browning, W., Kallianpurkar, N., Ryan, C., & Labruto, L. 2012). Biophilic design in urban planning as a reply to the citizen needs in the built environment (Soderlund, J., & Newman, P. (2015). The patterns are used as a biological linking into application form that affectively improves connection with nature, to overcome of lack in greenery (Cabaneck, A., Zingoni de Baro, M.E., & Newman, P. 2020).

## **6. SPACE PATTERNS OF BIOPHILIC IN URBAN DESIGN**

Connecting natural systems (visual and non-visual temperature and air flow, dynamic and diffuse sunshine, non-regular sensory inputs, and presence of water) with Building, street, Block, neighborhood, region, and community. (Croeser, T., Ordóñez, C. 2020) It is not simply just green presence, but it needs design and modification to the current situation as way of solving the pollution problem, and to identify urban context (Kellert, S., & Calabrese, E. 2015).

## **7. BIOPHILIC PRINCIPLE TO ACHIEVE SUSTAINABLE CITIES**

The link of biophilic urban development as sustainable interaction is based on how to identify the national urban context, showing the interaction relation between environment and human in space and green foundations, to apply balance in urban scale in future to return safety and resilient cities (Croeser, T., Ordóñez, C., Threlfall, C., Kendal, D., van der Ree, R., Callow, D., & Livesley, S. J. 2020), to revive the social interaction among landscape with heathy future environment. Biophilic cities is an extension of the biophilic design paradigm. The potential aspects are to transform the desolate urban areas into places that are supportive of life by the biophilic urbanism movement, which was presented as an emergent planning and urban design strategy. The basic objective of biophilic urbanism is to foster the daily experiences of nature as an essential component of urban living, and to strengthen the relationship between urban people and urban nature. (Salman, M., Siddiquee, T. A. R., Nasir, M., & Kunwar, R. 2021). In this way, biophilic design and urbanism consciously create possibilities for city dwellers to experience nature on a regular basis, to connect the communities as a successful biophilic in urban (Matai, J., & Zimunya, W. 2020).

## **8. BIOPHILIC WALKABLE BRIDGE PRINCIPLES**

8.1. Benefits of human-nature interaction in being incorporated into contemporary constructed environments (Dias, B. D. 2015) by incorporating nature both inside and outside into buildings, (Green, T. L. 2021). and apply it as constructed infrastructure in urban environment (Hopkins, K. S. 2014).

8.2. Implementing urban bridges as public places rather than just transportation corridors: Given that people spend eight to ten times as much time on streets as in parks, healthier street design should be prioritized over healthier park design. Many different experiences, especially those connected to nature, are available to street users. (Kellert, S. R., Heerwagen, J., & Mador, M. 2011). The best design strategies would need to take a range of local conditions and needs into account in order to be appropriate for each street. This could include the history of the street, the current social and environmental conditions, the architectural and structural features, the infrastructure already in place, the policies and regulations, the size of the project, the zoning and land use, and the street's potential future as a destination. ( Kellert, S., & Calabrese, E. 2015)

8.3. Assess its positive impact on the environmental, economic, and social aspects.

### 9- BIOPHILIC WALKABLE BRIDGE OBJECTIVES

The objectives of Biophilic Walkable Bridge are to achieve comfort, protection, and delight, as shown in (Figure 2).

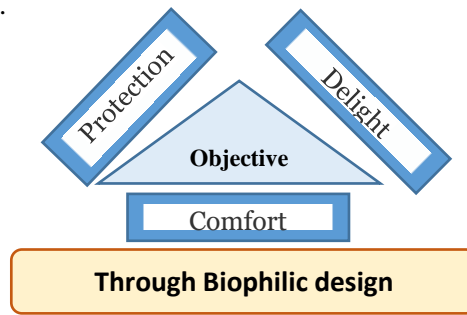


Figure (2) Biophilic Walkable Bridge Objectives

Source: Authors

#### 9.1. Comfort: It can be applied by:

- Creating interesting views with greeneries, Tree canopies / Vegetated paths.
- Vertical gardens (creepers or green walls).
- Naturalistic forms and materials, naturalistic products (facades and pavements).
- Urban furniture with built-in water features, vertical gardens, and plant beds.
- Using planted hedges to create intimate spaces, workout and playing zones.
- Biophilic architecture like green bus stop shelters, City Trees, and parklets (Khoja, A., & Waheeb, S. 2020).

#### 9.2. Protection

It is the basic rule for continuation of biophilic a longtime by:

- Hedges with vegetation for road safety.
- A tree canopy to shield from the weather and muffle sounds
- Plant palette that collects and holds airborne debris particles
- Diffuse and dynamic lighting is produced by the placement of trees, shrubs, and water features.
- Portable structures like the "City Tree" and "Mobile Forest," as Pop-up Parks (Croeser, Ordóñez, Threlfall, Kendal, van der Ree, Callow & Livesley, 2020)

#### 9.3. Delight

- Pubic green areas must be well-designed to meet a variety of requirements. - Plant choice consistent with climate, seasons, soil to maximize sensual and aesthetic experiences. (Matai, J., & Zimunya, W. (2020).
- Portable and transient structures like parklets, pop-up gardens, the "City Tree," green bus shelters, and the Mobile Forest that mimic human scale with greenery as shown in Table No. (1).

Table. (1) Economic, environmental and social benefits

<b>Economic, environmental and social benefits</b>	Employee attraction and increased workplace productivity
	Increased retail potential, improved health and healing
	Employee attraction, reduced crime and violence
	Enhanced property values and livability in densely populated areas
	Carbon confiscation
	Reduced energy use and impact of the urban heat island
	Water management, air quality, and quality
	Biodiversity conservation

Source: Authors

### 10. WALKABILITY

It is essential for effective ground transportation in metropolitan areas. The most economical form of transportation is walking. Thus, the development of a walkable city offers the most affordable and egalitarian form of transportation that each community can plan, design, build, and manage. In a walkable city, the urban environment may model, scale, combine, and integrate its resources as natural and economic resources (Salman, M., Siddiquee, T. A. R., Nasir, M., & Kunwar, R. 2021). through social connection, physical fitness, less crime, and increased wellness they help to solve many social and economic problems. We can live in constructed surroundings that lead to whole happy and healthy lives for citizens in walkable cities. This strengthens their sense of connection to their communities as shown in Table No. (1) Cities in nations such as Denmark and the Netherlands have focused more on designing bike-friendly sidewalks and bridges. However, some cities have chosen to go car-free entirely. The phrase "walkability" is new as it describes the way pedestrian-friendly in the city planning. The Walkable and Livable Communities Institute defines walkable communities as those where "people, not their cars, are considered to be at the center of the design scale. (Soderlund, J., & Newman, P. 2015). "Communities that are built with the human foot in mind are vibrant in terms of the environment, society, and economy as shown in (Table No. 1)

### 11. CASE STUDY 1: VANCOUVER PEDESTRIAN LAND BRIDGE

The Vancouver Land Bridge links historic Fort Vancouver to the city's Columbia River shoreline and aids in the restoration of the natural landscape continuum from upland prairie to river edge. This serpentine bridge mixes perfectly with its surrounding, meandering across marshes, showcasing historical objects, and providing visual and educational experiences that shed insight on the region's history. To minimize archaeological relics and effects to Fort Vancouver, the bridge design had to comply with FAA height regulations for the neighboring Pearson Airport; cross over WSDOT SR-14; cross under the BNSF Railroad; and not jeopardize the future off-ramp from Columbia River Crossing. Despite the significant dead loads from landscaping soils, the structure maintains a slim profile. To offset these soil stresses efficiently, innovative structural solutions were used, including upturned, bent longitudinal girders to keep the landscape soils on the bridge and avoiding cast-in-place concrete deck to save weight. Storm water storage, reuse for irrigation, storm water planters, rain garden, native landscaping, explanatory signage, and other architectural components all contribute to the project's sustainability as shown in Figure (3)





Figure (3) Landscape architecture + urban design in Vancouver pedestrian land bridge  
Source: (DesignRulz, 2012)

### 11.1. Site Features

The Hudson's Bay Company was the first European trade station in the Pacific Northwest, and European and Native American cultures met at this Columbia River location, where the Hudson's Bay Company was the first European trading post in the Pacific Northwest. The site now includes a 40-foot-wide earth-covered pedestrian bridge that spans State Route 14 and connects ancient Fort Vancouver to the Columbia River, allowing the fort's influence to reach from Mexico to Alaska and across the Pacific Ocean. Along the Land Bridge, which climbs up to an excellent view of the river and the surrounding mountains, the Land Bridge was created with the site's indigenous vegetation in mind. (Taylor, R. P., Juliani, A. W., Bies 2018) there is a comfortable gate on the south pedestrian path under the bridges. As a historic tribal crossroads and a place of contact between European and Native people, cedar canoe panels were embellished with a cast-glass sculpture of a Chinook woman's face. Visitors are greeted at the Welcome Gate, which represents how Chinook people would greet someone arriving by canoe. Two wood logs are topped with crossed canoe paddles and a Chinook woman's cast-glass visage as shown in Figure (4)



Figure No (4) shows:

-  Green elements
-  Path /pedestrian in between green nodes

Source: (Sipes, J. L., & Sipes, M. L. 2013).

### 11.2. Ethnobotanical Walkway

Up to the 17th century, this landscape was a mosaic of prairie, forest, and monuments. Explanatory panels mark the Land Bridge route, which is now home to native plant species from these many environments, as shown in Figure (5).



Gate, lighting elements, shading and pedestrian Landscape architecture + urban design



Figure (5) Landmark, (World War 1 wall) waves path Landscape architecture + urban design

Source: (Confluence, 2023)

### 11.3. Overlooks

Three vistas on the bridge each designate the River, Prairie, and Village. The characters in Lillian Pitt's Spirit Baskets are based on petroglyphs that are discovered near the



Columbia River. From the previous lines we can conclude achieving sustainability is essential in the first case study, as shown in (Table 2).

**12. CASE STUDY2, FRIEDRICH BAYER BRIDGE**

In Sao Paulo, Brazil, the Friedrich Bayer Bridge is positioned in front of the headquarters of the German global pharmaceutical corporation Bayer. The Bayer-commissioned the pedestrian and bicycle bridge spans to be near the reservoir of Guarapiranga Canal, to be close to its junction with the Pinheiros River. The bridges connect both sides of the river, allowing commuters to access the metro station through a cycling route that runs parallel to the river. The bridge is made up of two spherical platforms or islands, each measuring 5.4 meters in diameter, supported by concrete pillars, and surrounded by miniature gardens. That decreases the Carbon dioxide emissions into the environment, to be reduced by roughly 300 tons per year as a result of the vegetation. The middle span, which connects the two islands, can be swept open, as shown in Figure (6), and Table (3).

Table No. (2) Achieving sustainability in the first case study

Feature	1- Coherence	2- Continuity	3Equilibrium	4- Safety	5- Comfort	6Accessi-bility	7- Efficiency	8Attractiveness
Achieving sustain-ability	✓	✓	✓	✓	✓	✓	✓	✓

Source: Authors



Figure (6) Friedrich Bayer Bridge  
Source: Authors

The design, two metal islands that are covered in lush foliage, creates a comfortable waiting space for pedestrians while the boats sail by. Table No. (3)

Table No. (3) Achieving sustainability in the second case study

Feature	1- Coherence	2- Continuity	3- Equilibrium	4- Safety	5- Comfort	6- Accessibility	7- Efficiency	8- Attractiveness
Achieving sustain-ability	✓	✓	✓	✓	✓	✓	✓	✓

Source: Authors

From the previous case studies, we can conclude 8 features of Walkable bridges as a green agenda to achieve biophilic walkable bridges as shown in Table(4)

1- Coherence	5- Comfort
2- Continuity	6- Accessibility
3- Equilibrium	7- Efficiency
4- Safety	8- Attractiveness

Source: Authors

### 13. A GREEN AGENDA TO ACHIEVE BIOPHILIC WALKABLE BRIDGES

These 8 features of Walkable bridges are needed to be applied on local district in Nasr City after studying the current situation of the region, deducing the weaknesses, and strengths of the area (SWOT analysis) through the site visit, in order to achieve Biophilic Walkable Bridge as shown in Figure (7)

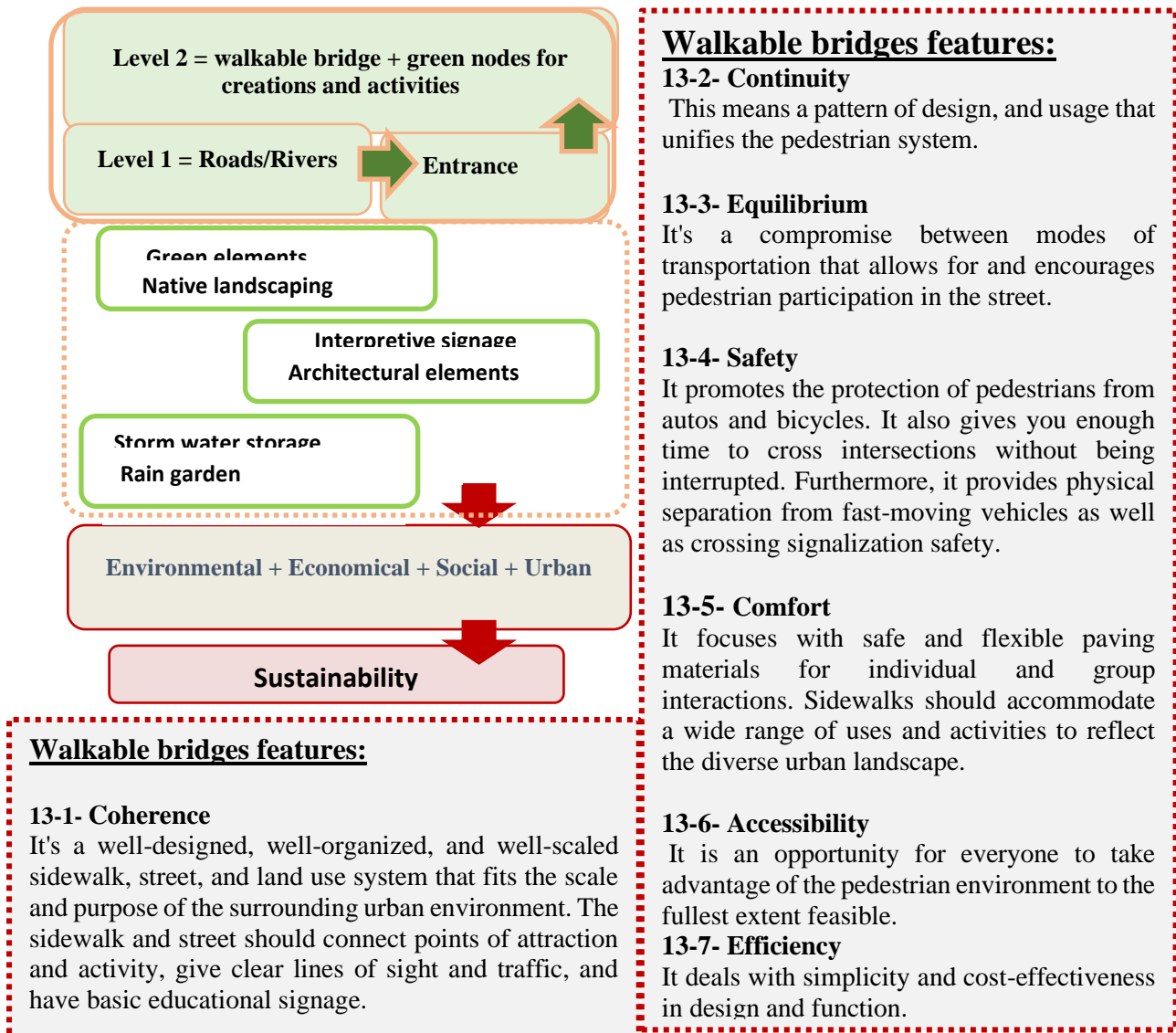


Figure (7) A green agenda to achieve biophilic walkable bridges  
Source: Authors

Follows Figure (7) A green agenda to achieve biophilic walkable bridges  
Source: Authors

### 14. LOCAL REGION IN NASR CITY

There aren't any street furniture existing in the specific case study or walkable paths for pedestrians. As shown in Figures No. (8), (9). The national case studies are chosen in the places that are condensed by population such as Youssef Abbas Street, Ali Amin Street, and Taryn Street.

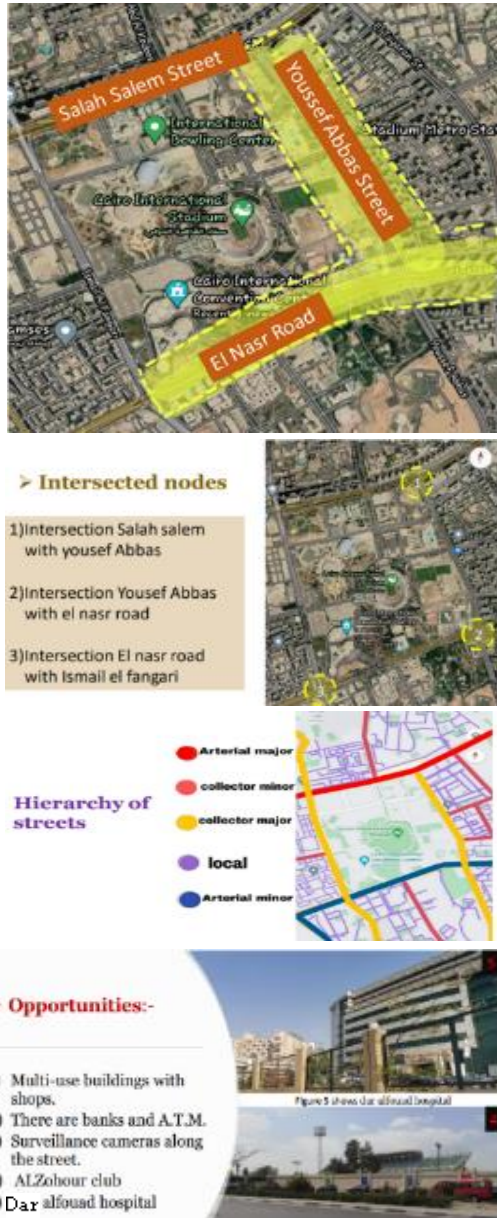


Figure (8). Shows the current situation analysis in our region  
 Source: Authors by Site Visit



There are no green spaces along the streets



There are neither seats nor street furniture to rest while walking



There are not any walkable paths for pedestrians

Figure (9) Shows a great shortage between social interactions and green spaces (current situation analysis in our region)  
 Source: Authors by Site Visit

## 15. CURRENT SITUATION ANALYSIS IN OUR REGION

The current situation analysis in the region through a site visit. Figures (10, 11)

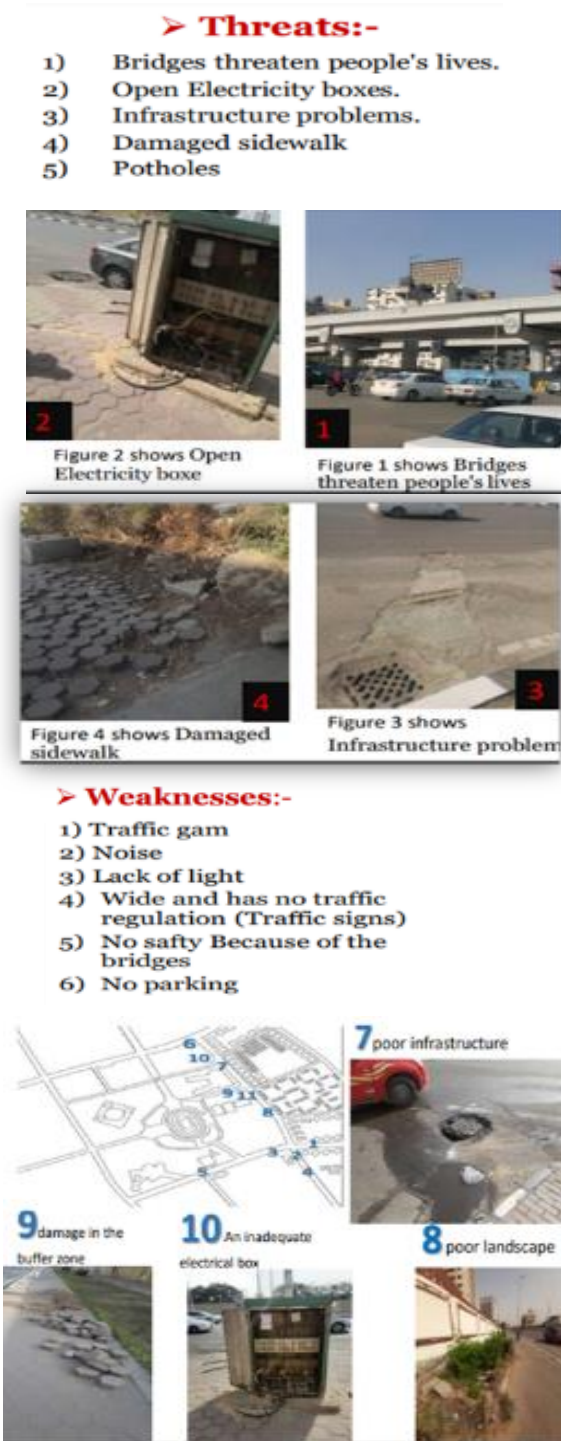


Figure (10) shows the current situation analysis in the region  
Source: Authors by Site Visit



Figure (11) shows problems in the region  
Source: Authors by Site Visit

## 16. CONCLUSIONS OF THE SITE VISIT

**16.1. Lack of Walkability in Nation Districts:** There is a great shortage in provided public transportation near walking routes to facilitate their transportation. The walkable bridges have to be shaded as a shelter from the high temperature in outdoor. Some of the users felt that walking is tiring, dislike being among crowded places and the majority fear crossing the roads; they prefer to use their own vehicle.

**16.2. Sustainable Streets:** Sustainability is an essential principle in applying comfort, and balance in social, environmental, and economic impact. It should be applied as a strategy in all new cities as an energy conservation strategy, walkable bridges to decrease carbon dioxide. Purify air for citizens in outdoor, as the indoor atmosphere is affected by outdoor atmosphere. Nasr City needs treatment to enhance walkable bridges in continuous routes by providing shading; and creating recreational activities with maintenance. Most of the newly constructed bridges face a great lack in having green buffer along them.

**16.3. Accessibility:** The recent changes in the urban configuration on a larger scale have produced new boundaries within the district in crossing the streets. They replaced the medians with bridges to facilitate vehicle flexibility, interrupting the pedestrian motion. The change is not only precise on visual aspects, as well analyzing the social behavior of its inhabitants.

**16.4. Hierarchy of Pedestrian Movement:** The narrow pathway that is interrupted by vehicular and causes a great obstacle in accessibility for an emergency, or ambulance, besides having a great shortage in having urban public spaces as an essential activity, that is needed alongside streets, to fulfill a healthy interaction, to encourage walkability.

**16.5. Societal Benefit of Walkability:** Walkability enhances the free healthy transitional transportation that builds a healthy social interaction. So, to implement walking routes there should be public spaces with all the facilities needed, aligned with a green space to enhance an effective community center. As these public spaces have the function, it reflects positively on its community to raise the quality of life for its citizens, where it needs continuous restoration and maintenance to preserve its efficiency and security.

**16.6. Safety of Walking Routes:** Providing a safe environment crucial to be effective, create activity in public spaces, and (security support the walkable bridges, that needs attached services to be provided such as security centers along the walking routes.

**16.7. Diversity of Walkable Bridges:** Safe community is the main goal for new urbanism avoiding congestion, and pollution by creating a green hub within an effective recreational activity in suspended nodes linked to green nodes. There is no safe crossing, no places to walk. We should coordinate with utility providers regarding the location of utility elements as cabinets, grates, and manholes.

**16.8. Planning Walkability by A Walkable Bridge in Nation Street Networks as Main Process:** There should be compatibility of urban mobility with the current land use function properly. As recently the districts suffer from a great shortage regarding urban mobility, out of concentrating all activities in one area.

=Accordingly, the research reached a set of suggestions through a framework (Agenda) for biophilic walkable bridge design as follows as shown in Table (5).

**Table (5) Shows Framework (Agenda) for biophilic walkable bridge design**

17. A FRAMEWORK (AGENDA) FOR BIOPHILIC WALKABLE BRIDGE DESIGN			DESIGN FUNCTIONS	OBJECTIVES	BRIDGES FAÇADES
1-Sidewalk	Design attractive walkways, invitingness (to encourage people for walking, having a good aesthetic view, not be trapped between fences). Provide Transparency for visual Connections in networks and	Using adequate sidewalk width, hindrance, accessibility, urban furniture, stations, impediments, vegetation, public transportation, and physical indices to create comfort in the sidewalk	4- Landscape	Purification and recycling water. Wijesooriya, N., & Brambilla, A. (2021).	-Rain-filtering green walls and roofs -Rain gardens, linear gardens, street trees
			5-Biodiversity management	Urban ecosystem restoration and biodiversity enhancement	Planting shrubs and trees, green walls, and water features.
			6-Bridge furniture	Providing seats, signs, bicycle shelters, and street art.	Apply vertical gardens.
2-Traffic planning	Redesigning bridge lanes to make spaces for biophilic designs. Croeser, T., Ordóñez, C., (2020)	Integrating vertical greenery into and onto buildings, as green walls, green balconies, planter boxes, and green	7-Street scape	Enabling leisure activities to be merged with nature to meet social, and cultural needs to increase street value.	Integrated bridge furniture with green features and water features
3-Energy management	Cooling bridges for walking, saves energy through insulating bridges. Kellert, S. R., Heerwagen, J., & Mador, M. (2011)	-Green walls, roofs, Combination of green roofs and solar panels -Tree canopies that shade pedestrians	8- Cycling	The cycling zone was linked with the vegetated area to establish a safe zone for cycling.	Green borders should be placed along the streets as a flower box.

**Source: Authors**

**16.9. Human Scale of Walking Routes:** Mainly it is important to plant aligned the walkable bridge routes, to provide shading. Design outdoor sustainable corridors as an environmental schemes along routes are used for trips between the greatest numbers of destinations (Croeser, T., Ordóñez, C., Threlfall, C., Kendal, D., van der Ree, R., Callow, D., & Livesley, S. J. 2020).

The following figures Figure (12), (13) show the percentage of design recreational activity before and after applying the suggestion Framework (Agenda) for biophilic walkable paths (Dias, B. D. (2015).

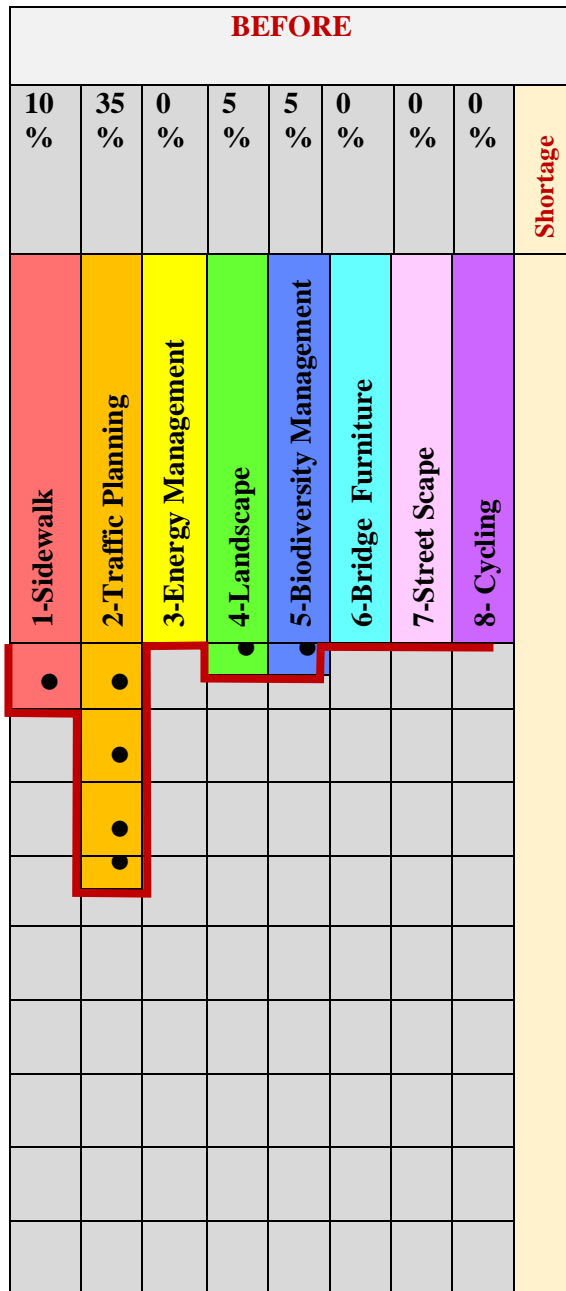


Figure (12) Design recreational activity percentage before applying the suggestion Framework (Agenda) for biophilic walkable paths  
Source: Authors

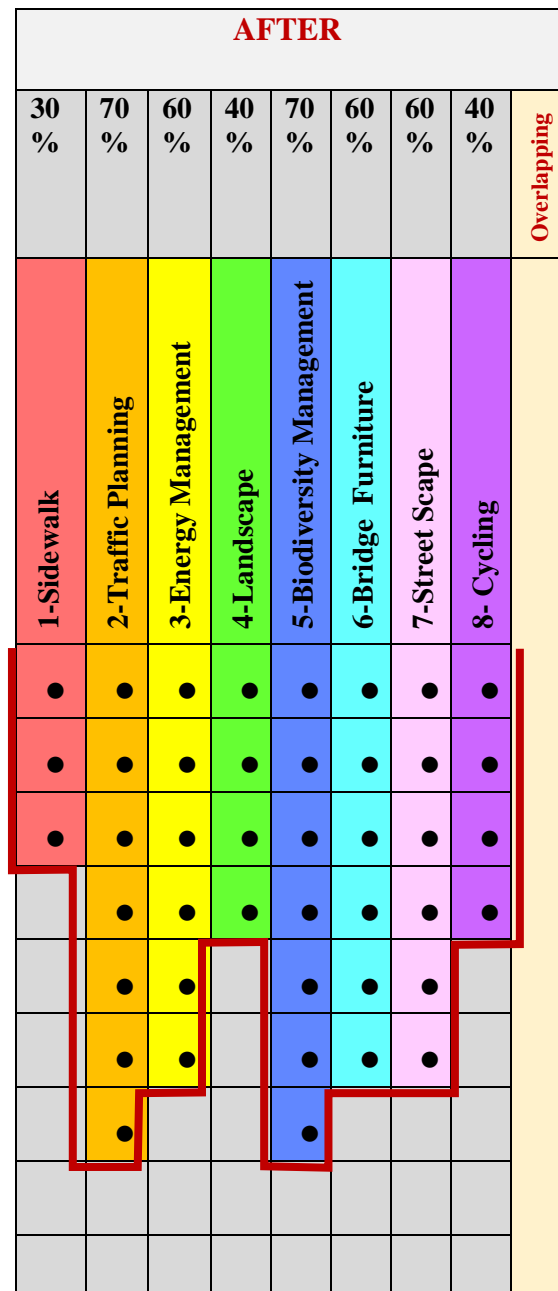


Figure (13) Design recreational activity percentage after applying the suggestion Framework (Agenda) for biophilic walkable paths  
Source: Authors

The following figures Figure No (14), (15), (16), (17) show the percentage of designed recreational activity before and after applying the suggestion Framework (Agenda) for biophilic walkable paths.

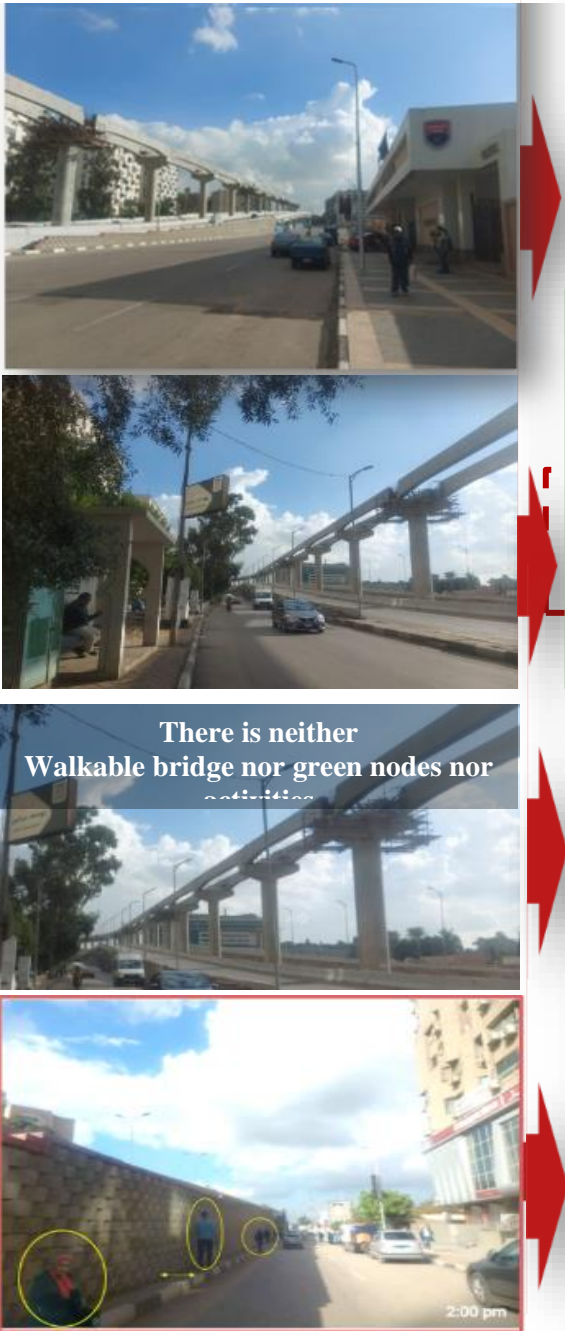


Figure (14) Design recreational activity percentage before applying Framework (Agenda) for biophilic walkable paths  
Source: Authors

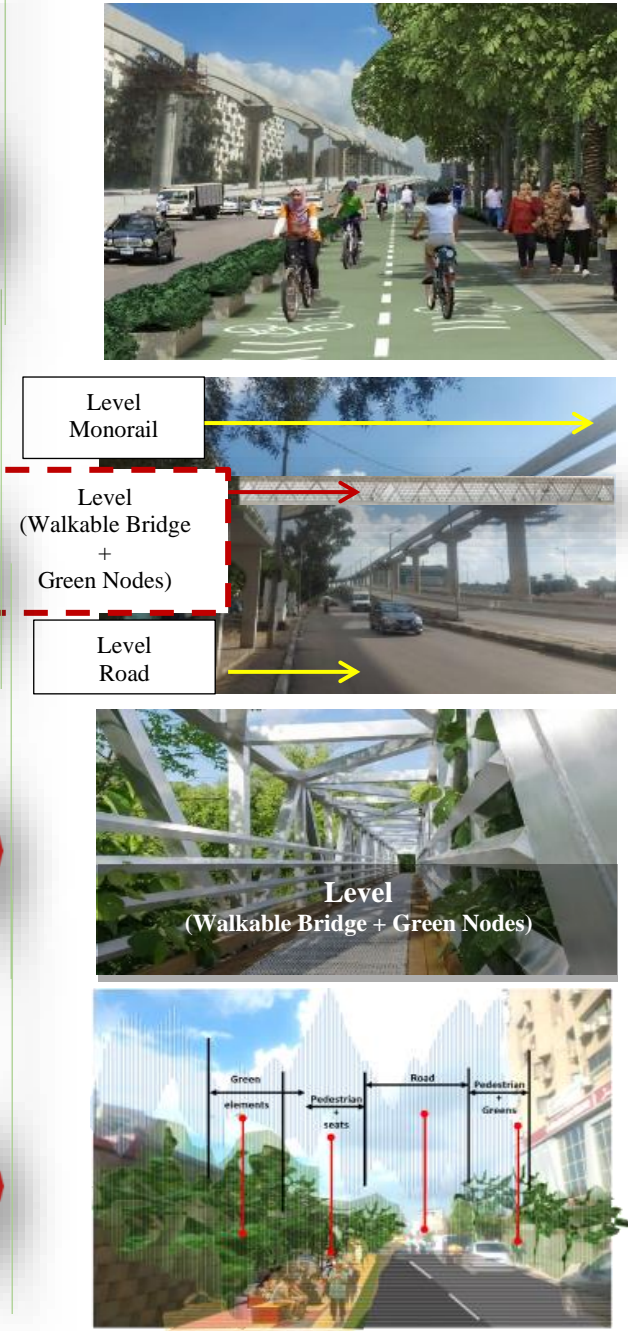


Figure (15) Design recreational activity percentage after applying Framework (Agenda) for biophilic walkable paths  
Source: Authors





Figure (16) shows a suggestion for applying biophilic in public spaces

Source: Authors

### ❖ Crosswalks

A marked part of a road where pedestrians have right of way to cross; a pedestrian crossing.



Figure (17) Suggestion for crosswalks

Source: Authors

However, after investigation of the current situation to the national case studies in Nasr city ,there is a great shortage in the landscape ,and quality of environment, because of the increase of Co2 emissions of vehicles, so after applying the suggested agenda for integration of biophilic walkable bridges, it will improve the quality of health envelopment ,as the landscape will be 50 % in whole roads aligned with transportation and minimize the speed of vehicles to increase the visibility of streets for safety as an initiative ecological friendly technique, as well as a regional and social solution insignificant portion of 55% street furniture, 55% Landscape, 80% experience of natural sense of outdoor space, and 90% increase visual aspects for national streets for providing shelter space for natural elements , by Implementing multifaceted composite landscape. Accordingly, after designing biophilic walkable bridges. The research goal can be achieved regarding safety, comfort, accessibility, efficiency, and continuity of green nature element in national streets, by increasing 90% of the recreational activities to enhance human- nature link.

## 17. CONCLUSION

Biophilic design is used in our research as a solution to purify the air quality, decrease noise pollution, and overcome the lack of greenery outdoor as a physical solution to the existed damage, due to the expansion of bridges, and building of new bridges above the

boulevards. So, the research goals focus on ecological and human needs to reduce stress outdoor for pedestrians. Hence, the researchers suggest linking vertical green nodes with land nodes to have extension vertically for green belt aligned with walkable bridges as a landmark for green sustainable walkability, based on the standardized terminology of the built environment, and thermal comfort outdoor, by connecting it to a natural environmental system. The paper highlights on the weakness of the current situation in the new bridges as a way of effective opportunity in resolving the urban development, as an urban theme to be applied to all constructed bridges, especially since they are all prototypes in shape and way of construction. These common characteristics' helps us to unify a new green methodology for pedestrian crossing by having these walkable bridges above these existed bridges in a qualitative way, based upon analytical case studies approach and site analysis. The research simulation confirmed the hypothesis as a source of connectivity in walkable trails as a lack of longitudinal connectivity with minor streets for its significant location on the set of biophilic indicators with city fabric, biophilia ratio, and performance, as an effective connectivity walkable link connecting human with nature. On-site, each indicator reflects a value that reflects its effectiveness (Salman, M., Siddiquee, T. A. R., Nasir, M., & Kunwar, R. (2021).

The recommendations are to activate the national regulations to preserve the nature of green spaces horizontally and vertically in continuous trails along bridges and walkways as a role of cultural perception, as a main urban development for future generations.

## REFERENCES

- Almusaed, A. (2010). Biophilic and bioclimatic architecture: analytical therapy for the next generation of passive sustainable architecture. Springer Science & Business Media. <https://doi.org/10.1007/978-1-84996-534-7>
- Almusaed, A., & Almssad, A. (2006). Biophilic architecture: The concept of healthy sustainable architecture. In PLEA2006-The 23rd Conference on Passive and Low Energy Architecture, Geneva, Switzerland, 6-8 September 2006 (pp. 383-387). Universite de Geneve.
- Asim, F., & Shree, V. (2019). Biophilic Architecture for Restoration and Therapy within the Built Environment: A Review. Preprint <https://doi.org/10.20944/preprints201907.0323.v1>.
- Beatley, T. (2016). Handbook of biophilic city planning & design. Island Press, Washington, DC. <https://doi.org/10.5822/978-1-61091-621-9>
- Boakye-Dankwa, E., Nathan, A., Barnett, A., Busija, L., Lee, R. S., Pachana, N., Turrell, G., & Cerin, E. (2019) Walking behaviour and patterns of perceived access to neighbourhood destinations in older adults from a low-density (Brisbane, Australia) and an ultra-dense city (Hong Kong, China). *Cities*, 84, 23-33, <https://doi.org/10.1016/j.cities.2018.07.002>
- Browning, W., Kallianpurkar, N., Ryan, C., & Labruto, L. (2012). *The Economics of Biophilia: Why Designing with Nature in Mind Makes Financial Sense*. New York: Terrapin Bright Green, LLC, 2015. Print.
- Cabanek, A., Zingoni de Baro, M.E., & Newman, P. (2020). Biophilic streets: a design framework for creating multiple urban benefits. *Sustainable Earth*, 3(1), 1-17. <https://doi.org/10.1186/s42055-020-00027-0>
- Confluence. (2023, February 10). Vancouver Land Bridge - Confluence Project. Confluence Project. <https://www.confluenceproject.org/river-site/vancouver-land-bridge/>
- Croeser, T., Ordóñez, C., Threlfall, C., Kendal, D., van der Ree, R., Callow, D., & Livesley, S. J. (2020). Patterns of tree removal and canopy change on public and private land in the City

- of Melbourne. *Sustainable Cities and Society*, 56, 102096.  
<https://doi.org/10.1016/j.scs.2020.102096>
- DesignRulz. (2012, May 29). Amazing and Elegant Vancouver Land Bridge. <https://www.designrulz.com/outdoor-design/public-spaces-outdoor-design/2012/05/vancouver-land-bridge-vancouver-washington/>
- Dias, B. D. (2015). Beyond sustainability—biophilic and regenerative design in architecture. *European Scientific Journal*, 11(9), 147-158, <https://doi.org/10.19044/esj.2015.v11n9p%25p>.
- Green, T. L. (2021). Healthy by Design: Development of a Biophilia Design Decision Support Framework. Doctoral dissertation, Virginia Tech. <http://hdl.handle.net/10919/103279>
- Hopkins, K. S. (2014). A Biophilic Landscape Design in Shanghai, China. Master's Thesis, Department of Landscape Architecture, University of Colorado at Denver. <https://digital.auraria.edu/work/ns/16ff1b28-d184-4279-bda0-c0a24d15d8b8>
- Kellert, S. R., Heerwagen, J., & Mador, M. (2011). *Biophilic design: the theory, science and practice of bringing buildings to life*. John Wiley & Sons
- Kellert, S., & Calabrese, E. (2015). *The practice of biophilic design*. London: Terrapin Bright LLC, 3, 21, <https://www.biophilic-design.com/>.
- Khoja, A., & Waheeb, S. (2020). Vernomimicry: Bridging the Gap between Nature and Sustainable Architecture. *Journal of Sustainable Development*, 13(1), 33. <https://doi.org/10.5539/jsd.v13n1p33>
- Matai, J., & Zimunya, W. (2020). Connecting Biophilic Design to Neighbourhood Energy Use Optimization in Rural Towns: The Case of Birchenough Bridge. *Journal of Urban Systems and Innovations for Resilience in Zimbabwe-JUSIRZ*, 2(1), 40-60.
- Salman, M., Siddiquee, T. A. R., Nasir, M., & Kunwar, R. (2021). Paradigm for Livable & Sustainable City: Biophilic Design as a tool to bridge the gap in between the nature and human interaction. *PalArch's Journal of Archaeology of Egypt/Egyptology*, 18(4), 6291-6298.
- Sipes, J. L., & Sipes, M. L. (2013). *Creating green roadways integrating cultural, natural, and visual resources into transportation*. Island Press.
- Soderlund, J., & Newman, P. (2015). Biophilic architecture: a review of the rationale and outcomes. *AIMS environmental science*, 2(4), 950-969. <https://doi.org/10.3934/environsci.2015.4.950>
- Taylor, R. P., Juliani, A. W., Bies, A. J., Boydston, C., Spehar, B., & Sereno, M. E. (2018). The implications of fractal fluency for biophilic architecture. *Journal of bio urbanism*, 6, 23-40.
- Wijesooriya, N., & Brambilla, A. (2021). Bridging biophilic design and environmentally sustainable design: A critical review. *Journal of Cleaner Production*, 283, 124591. <https://doi.org/10.1016/j.jclepro.2020.124591>.