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The Role of Animal-Aided Design in Sustainable Architecture

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ABSTRACT

Environmentally insensitive practices such as the unconscious use of natural resources, industrialization and unplanned urbanization cause the rapid destruction of natural habitats and even the extinction of some species. Today, as the importance of sustainable architecture has increased, architectural approaches that are compatible with nature have been adopted and thus the protection of natural life has been tried to be supported. As a definition, sustainability is a form of practice that aims to harmonize the built environment with natural life. In this context, the impact on animals whose habitats we are destroying is a significant topic within sustainability discussions. Studies show that the role and importance of human-animal based sustainable architectural habitats for enhancing animal welfare have not been extensively investigated. This study aims to discuss the importance of animal-aided designs within the sustainability approach. In addition, it is to carry out studies to improve the quality of life in society by strengthening the human-animal bond. In line with this purpose, animal-aided designs at urban, infrastructure, and building scales were analyzed within sustainability approaches, and their contribution to the sustainability approach was evaluated. As a result, it is emphasized that the sustainable animal-aided design approach provides innovative solutions for structures to be designed for animals and it also contributes to environmental, social, and economic sustainability, but in order for these designs to be successful, it is underlined that living spaces suitable for the needs of animals should be created and the negative effects of environmental impacts on animals should be considered. It is also emphasized that in addition to the principles of sustainability, factors that pay regard to the lives of animals contribute to the understanding of sustainability. It is expected that the discussion of the relationship between sustainability and animal-aided design, which is put forward through this study, will create an important discussion ground for future research and application examples.

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1. Introduction

This study investigates the place of animal-aided designs in the understanding of sustainable architecture. The basis of the study is how a concept such as sustainability, which should be handled in a multifaceted and comprehensive manner, will be related to animal-aided designs. Sustainability is a concept that emerged in the 1970s in order to reduce the adverse effects of urban density on living things. It is an ecological term that has been used since the early 1970s with the meaning of 'ensuring a continuous flow of what each part of the system needs for a healthy existence and maintaining the adequacy of the system'. When applied to an ecosystem inhabited by humans, the term implies certain limitations on the ability of the biosphere to absorb the impacts of human activities (Madge, 1997).

Analyzing the relationship between animal-aided designs and sustainability also addresses the problems created by the rapidly increasing human population. While industrial and construction activities have significantly damaged the nature we live in, such issues as environmental problems, depletion of natural resources, decrease in biodiversity, pollution, and energy use have come to the forefront. While the environmental impacts created by humans are increasing rapidly today, the living population is also gradually decreasing. According to the 'Living Planet' report of the World Wide Fund for Nature, the population of other living things decreased by 60% between 1970 and 2014 (McLellan et al., 2014: 9).

Conservation of biodiversity helps to keep natural ecosystems healthy and thus helps us to have a sustainable future. In many developed countries, the approach of planning for the sustainability of urban systems by utilizing the ecosystem services of the natural environment and green infrastructure has become an important component of urban planning efforts (Apfelbeck et al., 2020). However, current urban planning and architectural design practices often ignore biodiversity in the general sense and wildlife in particular. Furthermore, the destruction of habitats results in increased competition between species, ultimately leading to a decline in the number of species. To mitigate these negative impacts on urban wildlife, it is of necessity to develop wildlife-integrated planning strategies (Hess et al., 2014).

This study focuses on the significance of animal-aided designs in comprehending sustainable architecture. It provides a framework for understanding the connection between sustainable architecture and animal-aided designs that do not include humans. In this way, it is aimed to contribute to making future designs more sustainable for humans and other living beings.

2. Literature Review

2.1 Sustainable Architecture Approach and Animal-Aided Design

In the second half of the 18th century, the Industrial Revolution caused a rise in the number of people living in cities. Uncontrolled population growth brought along significant problems; rapidly increasing industrial and construction activities led to considerable damage to the environment. Toxic gases, fumes, and wastes from factories polluted water resources and reduced soil fertility. It was only in the 20th century that the importance of the issue was realized (Ciravoğlu, 2006). After the 1980s, researchers and planners working on environment and environmental problems developed strategies for the sustainability of society and the environment.

Due to the multidimensional nature of the concept of sustainability, different disciplines working on this subject have developed various definitions. Meadowcroft (1997) defines sustainability simply as a concept that can be sustained, that is, that can be continued; Tekeli (2001) defines sustainability as the correct establishment of the relationship between society, which is the socio-economic system formed by humans, and the environment of the ecological system consisting of non-human living things and non-living things, which constitute the two subsystems of the ecological system.

After the 1970s, sustainability discussions have generally been shaped within the framework of sustainable development. The most accepted definition of the concept of sustainable development in the international arena is the definition in the Our Common Future report published by the World Commission on Environment and Development in 1987, which states that "sustainable development is the ability to meet the needs and expectations of today without compromising the ability of future generations to meet their own needs and expectations" (WCED, 1987). As a continuation of the steps taken towards sustainable development, "Agenda 2030: UN Sustainable Development Goals/Aims" was adopted (MFA, 2022). The 2030 Sustainable Development Goals basically reflect these expectations by aiming to stop the destruction of the natural and social habitats of the global community and to achieve the welfare of all segments in a more balanced and fair manner (Messerli et al., 2019). In this regard, the 2030 Agenda emphasizes that human well-being depends on the health of the global ecosystem and that the welfare of all animals is essential for a sustainable ecosystem in the future (Folke et al. 2016, as cited in Olmos Antillón et al. 2021).

Visseren-Hamakers (2020) states that animals are ignored in sustainable development discussions, because sustainable development is a very human-centred concept. Maulana (2018) emphasizes that the practice of sustainability is generally human-oriented, and in fact, the basis of sustainability should be a continuous harmony between human and nature. On the other hand, Apfelbeck et al. (2020) point to the relationship between biodiversity, ecosystem services and sustainable and healthy cities and clearly state that urban design focuses on the needs of all living things, including wildlife.

Sustainability in the context of building construction refers to the understanding of balancing economic, environmental, and social factors from the design of the buildings to their construction, from their use to maintenance (Aghimien et al., 2018). Today, sustainability has become a priority in the field of architecture. The impact of a building is not only limited to its users and its immediate surroundings, but also includes societies and nature. The building's construction, operation and demolition can

consume natural resources and increase environmental impacts. Therefore, a sustainable design should consist of factors such as energy efficiency, waste management and water saving.

The role of animal-aided designs within the sustainable architecture approach has an important place both in reducing the environmental impacts of buildings and in protecting the habitats of animals. Throughout history, unplanned human construction has damaged the habitats of animals, disrupted the natural balance, and increased the risk of species becoming extinct. Moreover, the human-animal relationship is generally shaped by a human-centred approach, and studies into animals aim to increase the yield to be obtained from them in almost all disciplines. Instead of focusing only on efficiency and usefulness in animal studies, a broader perspective such as the continuation of the species and the balance of ecosystems should be adopted. For this purpose, interdisciplinary studies are carried out to protect/enhance the natural ecosystems of animals (Clevenger and Huijser, 2011; Weisser and Hauck 2017; Apfelbeck et al. 2020).

Animal-Aided Design (AAD), developed by Weisser and Hauck (2015), focuses on the protection of natural ecosystems and the improvement of animal habitats. AAD is a species-centred conservation approach that aims to increase the habitats of animal species and combines this effort with space design. It is also applied in urban areas where people live, aiming to design spaces that are suitable for both the needs of people and the needs of local wildlife. Weisser and Hauck (2017) state that the essential requirement of AAD in a design process requires knowledge of all the needs that arise throughout the life cycle of a species from birth to reproduction. Another study involves the design of so-called "animal lines" to provide a connection to the old city centre of Lucca, which surrounds the ancient city walls and disused green spaces. Different zones are created along these lines, accessible to both humans and animals. This approach aims to increase the interaction between humans and animals in urban areas (Granai et al., 2022).

Articles carried out into animal-aided design show that projects can be realized in urban areas that make it possible to both sustain the existence of local wildlife and design suitable spaces for humans. For the successful realization of animal-aided design, cooperation and communication between different disciplines is of great importance from the first design stage. In this way, it is aimed to design the most suitable living spaces by considering the protection of natural life and the welfare of animals.

3. Methodology

As a result of the sustainability literature review, certain common concepts were identified between the sustainable architecture approach and animal-aided designs in terms of functional and structural aspects. The functional design dimension of animal-aided designs with the understanding of sustainability aims both to increase the welfare of animals and to consider sustainable architectural approaches. Functionally, sustainable animal-aided designs within the scope of the study were evaluated under thirteen headings as a result of the literature analysis (Figure 1).

The structural design dimension of animal-aided designs with sustainability understanding aims to consider sustainable architectural approaches in the building production process and to minimize environmental impacts. From a structural point of view, both sustainability principles and the life cycles of animals have been effective in the issues to be considered in sustainable animal-aided designs (Figure 2).

FUNCTIONAL PARAMETERS	GENERAL EXPLANATION
That it is a structure suitable for the natural life cycle of the animal	In order for the species to survive and continue its generation, meeting all of the critical needs in the life cycle should be determined as a priority goal (nutrition, reproduction, etc.) (Weisser & Hauck, 2017).
That it is an environment suitable for animal welfare (*five domains)	Considering the physiological, behavioural and psychological needs of animals, it is important to create environments that can sustain and support their lives in sustainable animal-aided designs. In order to improve the welfare of animals, five basic welfare dimensions to be considered are: 1- Nutrition 2- Environment 3- Health 4- Behaviour 5- Mental State (Mellor et al., 2020; Salgırlı Demirbaş, 2023).
That it is made in accordance with the environment	It should be suitable for the local texture (topography) where it is located, it should be designed considering the climatic conditions and the structure should be positioned according to the current sun-wind situation (Emekci, 2021).
Use of materials resistant to environmental conditions	It should also care about the safety of animals and their protection from environmental factors. The health of animals is directly or indirectly affected by the effect of increasing temperatures, especially due to climate change (Nardone et al. 2010 cited in Rojas-Downing et al. 2017).
Providing adequate natural lighting	Natural lighting is important for animals to maintain their natural behaviour, regulate their sleep patterns in a healthy way and reduce their stress. In addition, it should be kept in mind that ecological light pollution has negative effects on living things (Longcore and Rich, 2004).
Ensuring natural ventilation and indoor air quality	Natural ventilation can provide effective cooling by taking into account the land structure surrounding the building, its location and surrounding areas, as well as air movements at different times of the day and the direction of wind flow (Özmehmet, 1999).
Ensuring acoustic performance	For the health and welfare of animals, it is of great importance that the acoustic performance of the environment is appropriate (Newbury et al., 2010: 17).
That it is an environment suitable for health conditions and animal comfort	It has been revealed that the most important environmental factor affecting the health and physiological functions of animals is temperature (Bengtsson and Whitaker, 1986). Temperature stress in animals varies depending on temperature, humidity, species, genetic potential, age and nutritional status (Rojas-Downing et al., 2017).
Use of natural / local materials	It is associated with animals' preference for living spaces made of natural materials (Denneboom et al., 2021).
Effective use of material	In resource management, which is one of the basic principles of sustainable architecture, it is aimed to reduce environmental pollution and create healthier living environments through the effective use of materials such as the reuse of existing buildings, material-saving design and construction, the use of renewed and recycled materials (Zindane, 2010).
Use of renewable energies	The use of renewable energy in animal-supported designs provides a more effective and efficient use of energy resources.
Preservation of existing vegetation	As a requirement of sustainable design, it should be aimed to ensure the continuity of plant and animal species in the area by protecting the existing vegetation and increasing the amount of green space. The use of green tissue in the appropriate direction, spacing and type in the design plays an important role in the control of climatic elements (Colombo et al., 1994: 37).
The design suitable for human-animal interaction	The human-animal bond, as defined by the American Veterinary Medical Association, is a mutually beneficial and dynamic relationship between humans and animals. This relationship is influenced by behaviours that are important for the health and welfare of both parties. It includes emotional, psychological and physical interactions between humans, animals and the environment (Avma, ?). The human-animal bond is an important relationship that has positive effects at both individual and societal levels and improves the health and well-being of humans and animals.

Figure 1 AAD Functional Design Dimension

STRUCTURAL PARAMETERS	GENERAL EXPLANATION
Modular and repetitive	It is observed that in environments where animals are housed in an excessive way densely, dominance behaviours occur between species from time to time. For this reason, it should be ensured that sufficient space can be created in case of an increase in the number of animals (Salgırlı Demirbaş, 2023).
Fast and easy construction and installation	This approach ensures more efficient use of resources as it requires less time and labour. This makes a significant contribution to reducing environmental impacts and protecting existing natural resources.
Establishment with a small number of technical staff	Building installation with a small number of technical staff reduces labour costs and makes designs more economical. It also minimises environmental impacts such as noise, waste and energy consumption.
Long service life	The longevity of the building is possible with the right material selection, the use of quality construction methods, and the design in accordance with local data and climatic conditions.

Figure 2 AAD Structural Design Dimension

The research content consists of international and national animal-aided design examples in relation to sustainability. The selected urban, infrastructure, and building scale projects will undergo detailed analysis with a sustainable design perspective. The study examines urban planning initiatives in the Ruhr-Germany region, which prioritize the protection and enhancement of natural habitats, the Trans-Canada Highway wildlife crossings, which boast the world's highest number and diversity of wildlife crossings, and the Bat Bridge, which enables shared use by humans and bats. Additionally, the research encompasses nine buildings across various typologies, including shelters, refuges, and farms, situated in varying geographies and countries.

3. Evaluation of the Place of Animal-Aided Designs in Sustainable Architecture Approach at Urban, Infrastructure and Building Scales

In the sustainable architecture approach, the importance of animal-aided designs is linked to protecting the natural environment, strengthening the human-animal relationship, and improving the quality of life. These designs encourage people to live in harmony with nature while helping animals to live a healthy and happy life similar to their natural environment.

3.1 An example of Animal-Aided Sustainable Approach At The Urban Scale: Ruhr Region

The Ruhr Region Urban Regeneration Project makes significant contributions to region's sustainability by bringing abandoned industrial areas back into the use of society. When it comes to sustainability, the reuse of buildings plays an important role in terms of protecting the city's integrity (Takva Y et al., 2023). In the applications in this region, the textures of the industrial period of the past are evaluated by attributing new meanings (Dağ and Özberk, 2012).

The Ruhr Region Urban Regeneration project in Germany includes many measures for the protection of animals and the expansion of their habitats and contributes to protecting the ecological integrity of the region. Many projects have been implemented in urban areas called 'industrial nature' where nature develops freely, and important arrangements have been made to develop unique biotopes and rare species (Kurtay and Sağlam, 2011). In the implementation phase of the project, measures such as combining green areas to form a network, taking natural landscape features into account during the reuse of industrial areas, and cleaning the Emscher River were taken to create a healthier and more livable environment for people, animals, and plants in the region (Figure 3).

Figure 3 Ruhr Region (YouTube, 2021a)

This project provides significant environmental benefits through the restoration or conversion of existing buildings. This approach minimizes negative environmental impacts by reducing the use of raw materials and energy required to construct new buildings. It contributes to a more efficient use of natural resources by reducing waste production and enables more economical use of energy resources. The Ruhr region offers areas compatible with the natural life cycles of living organisms. With the sustainable protection and utilization of natural areas in the region, the existing vegetation cover has been preserved, thus ensuring the continuity of plant and animal species. In addition, the presence of areas suitable for human-animal interaction contributes significantly to increasing social welfare. The project adopts an economically cost-effective approach by saving on material and construction costs through the reuse of industrial areas.

3.2 Examples of Animal-Aided Sustainable Approach At The Infrastructure Scale

The increasing population and the resulting need for settlement and transport directly affect natural areas and wildlife habitats,

leading to habitat fragmentation, isolation of populations and destruction of important habitats (Whittington et al. 2019). In this context, ecological bridges have emerged as structures that provide wildlife crossings (Doğan and Şahin, 2015). In order for these crossings to be effective, objectives should be determined and monitored.

3.2.1 Trans-Canada Highway Wildlife Bridges, Canada

Wildlife bridges linking Banff National Park and Lake Louise are located on the Trans-Canada Highway (Parks.canada.ca, 2022). These crossings provide wildlife conservation by connecting fragmented habitats (Figure 4). Also, fences are installed to prevent wild animals from interacting with traffic. Infrared cameras, tracking devices, and other technologies are used to monitor the passage habits of animals and the effectiveness of corridors (Alexander and Waters, 2000; Sawaya et al., 2019; Barrueto et al., 2020). In addition, vegetation sustainability is targeted through ecosystem protection and restoration.

Figure 4 Wildlife bridges (Clevenger, 2007)

3.2.2 Bat Bridge, Hollanda

Bat Bridge is part of Park Poelzone, an ecological corridor in the Netherlands. The bridge is characterized by being located on the flight route of several bat species, providing suitable habitats for different bat species in different seasons, and being suitable for shared use by humans and animals (Lola.land, 2015).

For hibernating bats, there is an empty area designed from reinforced concrete in the lower section of the bridge. The bridge deck and under the masonry parapet are designed as suitable areas for breeding. The openings have a rough surface for bats to cling to. Openings for roosting bats have been created on the bridge along the red brick wall line (Figure 5) (Archdaily, 2015).

Figure 5 Bridges sections and façades (Archdaily, 2015)

The wildlife crossings on the Trans-Canada Highway and the Bat Bridge projects were designed by interdisciplinary teams in accordance with the natural life cycles and behaviour of animals. These examples can be considered as critical corridors to prevent habitat fragmentation and thus protect biodiversity. In order to prevent wild animals from being affected and stressed by vehicle noise and headlights, local vegetation has been emphasized at the crossings. The vegetative design of the habitat passages allows animals to pass through passages similar to their natural habitats. Both examples are built according to climatic data in accordance with the environment and consist of structures and materials resistant to environmental conditions. In addition, it is likely that there is sufficient natural ventilation and lighting so that the ambient air quality can be provided for animals. It is also likely to mention the use of natural/local materials with the use of local vegetal elements and the use of wooden materials as seen in the Bat Bridge example. In the studies conducted for wild animal crossings on the Trans-Canada Highway, it was pointed out that animal crossings were recorded less at crossings open to human use and that these crossings were not suitable for human-animal interaction. In the Bat Bridge project, spaces suitable for the life cycle of bats were created and designed to encourage human-animal interaction. Repetitive structures and materials in these projects enabled rapid installation and low-cost construction. Research has shown that Trans Canada wildlife bridges reduce animal-vehicle collisions and increase the cost-effectiveness ratio in the long term (Conteches, 2017). In this respect, wildlife crossings on the Trans-Canada highway have provided low-cost projects in the long time from a structural point of view. There needs to be a study on the cost comparison of the Bat Bridge project.

3.3 *Examples of Animal-Aided Sustainable Approach At Building Scale*

By analyzing the different types of buildings constructed in detail in various countries, the study will provide results that are to play a critical role in the planning of sustainable animal-aided projects. The analysis of building types in different climatic zones aims to provide valuable information for the design of environmentally and climate change friendly buildings in future urban developments.

3.3.1 Petting Farm, Almere/ Netherlands (2008)

The farm in Almere, the Netherlands, is used as a children's farm (Figure 7) (Stadennatuur, 2008).

Figure 6 Petting farm (Archdaily, 2009)

Figure 7 Petting farm (Archdaily, 2009 and Stadennatuur, 2008)

Thanks to the open façade system of the upper half of the building, the air circulation in the building is provided naturally and the whole farm is ventilated. The barn section was built as a single storey building with two floors in height. In the other half of the building, the toilets and storage are located on the first floor, while the office and hay storage are located on the second floor (Figure 8). Access to the building is provided by six shutters. The shutter system can be opened automatically or manually with the effect of the morning sun (Figure 6) (Archdaily, 2009). Salgırlı Demirbaş (2023) emphasized the suitability of the project for animal welfare and stated that the design was arranged to meet the needs of animals.

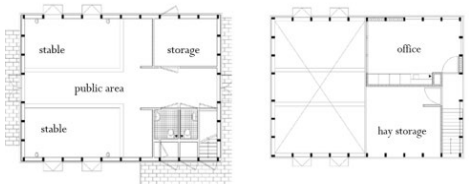


Figure 8 Petting farm floor plans (Archdaily, 2009)

It is clear that the spaces in the farm are built in a way that allows the animals to live in a comfortable and healthy way and thus support the natural behaviour of the animals. In the barn sections, animals have enough space for their natural movements. Thanks to the fact that the barn section is a single storey with a height of two storeys and the overall structure is designed with intermittent wooden panels, good ventilation, and sufficient natural light environment is provided. Thus, the risk of respiratory diseases of animals is minimized. Providing sufficient natural light also helps to maintain the biological rhythms of the animals. The renewable energy source and solar-powered modular wooden panels used in the building have increased energy efficiency and contributed to environmental sustainability. Tall thuja, a tree species that does not grow naturally in the Netherlands, was used on the facades. This may have caused the construction cost to increase. Modular natural wood elements in the form of panels used in facades contribute significantly to speeding up the construction and installation processes. The use of panel systems makes the construction process more efficient by requiring fewer technical staff. Looking at the project in general, it is observed that the material is used effectively and therefore resources are used efficiently. Within the scope of the project, the existing vegetation cover has been preserved with the sustainable protection and utilization of natural areas in the region, thus ensuring the continuity of plant and animal species. In addition, the presence of areas suitable for human-animal interaction contributes to the increase in social welfare. The longevity of the structure is ensured by designing the farm in accordance with the climatic conditions of the period when it was built, selecting the right materials, and constructing it with quality construction methods.

3.3.2 Women and Children Therapy Centre, Iraq (2016)

Located in Iraq, this centre is a modern therapy centre for children and women victims of war. By emphasizing the importance of using traditional building materials and techniques, the project aims to reduce the effects of trauma by identifying with the past (Zrsa, 2019). The centre, which is made up of eleven simple earthen volumes, is arranged around a series of courtyards, creating a village-style atmosphere. Light shading elements connecting the different volumes increase the comfort of the users (Figure 9) (Archdaily, 2017). Salgırlı Demirbaş (2023) emphasized the project's compliance with animal welfare and stated that the design is organized to meet the needs of animals.

Figure 9 Women and Children Therapy Centre (Archdaily, 2017)

The Women's and Children's Therapy Centre is designed to provide animals *a comfortable and healthy environment that supports their natural behaviour*. In the pens in the example, animals have enough space for their natural movements. Designed with a courtyard plan scheme, it also improves the ambient air quality by *providing adequate natural lighting (as well as the use of renewable energy) and ventilation.* This project emphasizes not only the *importance of traditional building materials and techniques* but also *the importance of human-animal interaction,* providing a design that meets the needs of both users. *Thanks to the use of adobe material, the temperature inside the building is regulated naturally, which is beneficial for energy saving.* Furthermore, the adobe material is vital for the users' health by preventing dampness inside the building. It *is also an environmentally friendly material as it is reusable and recyclable. The use of traditional materials in the building has ensured that construction costs are low and technically, a structure that anyone can easily build has emerged.* The spaces in the project have a modular and repetitive structure. This approach helps to reduce maintenance and repair costs and allows the building to be built quickly. The longevity of the building was ensured *by designing the facility by the climatic conditions of the period in which it was built, selecting the suitable materials, and constructing it with quality construction methods.*

3.3.3 Bear Sanctuary, Vietnam (2018)

The bear sanctuary, located in Cát Tiên National Park in Vietnam, was built to protect bears victimized by the illegal bear trade. It is a naturally ventilated and environmentally friendly structure built with modular design, local materials, and an eco-friendly approach (Figure 10). The shelter comprises six bear houses, a training centre, a hospital, a quarantine section, and an administrative office (Archdaily, 2019a).

Figure 10 Bear Sanctuary (Archdaily, 2019a)

It is observed that the spaces in the Vietnam Bear Shelter are built in a way that allows the animals to live comfortably and healthily and thus support the natural behaviour of the animals. There is a large area in the project where they can move freely. In addition to free movement opportunities, the shelter lacks areas covered with trees, bushes, etc. where they can hide. It can be stated that the living conditions for bears rescued from their previous inadequate cage environment have been enhanced in this area. They are given the opportunity to live in a large area where they can sunbathe. They are also provided with natural ventilation instead of tiny cages where they are deprived of sunlight and health. With the provision of natural ventilation, the risk of respiratory diseases is minimized. The provision of sufficient natural light also helps to maintain the biological rhythms of the animals. The use of traditional materials in the building ensures that construction costs are low and technically it is a structure that can be built easily by anyone. This project emphasizes not only the importance of traditional building materials and techniques but also the importance of human-animal interaction, offering a design that meets the requirements of both users. The spaces in the Vietnam Bear Sanctuary have a modular and repetitive structure. This approach helps to minimize maintenance and repair costs and allows the building to be constructed quickly. The longevity of the building is ensured by designing the building by the climatic conditions of the period in which it was built, selecting the suitable materials, and constructing it with quality construction methods. In addition, with the integration of the green roof into the building, energy efficiency has been increased, the surrounding air quality has been improved thanks to the plants, and a positive contribution has been made to local biodiversity.

3.3.4 Haven the Eternal Experience Pavilion, India (2022)

The cow shelter is located in the village of Peermade, India (Earthscapestudio, 2022). The most important aspect of this project is that the architect has preserved the concept of "the idea of protecting nature" from selecting materials to the constructing building. The shape of the building follows the natural landform without disturbing the natural landscape and the surrounding trees (Figure 11).

Figure 11 Cow Shelter (Earthscapestudio, 2022)

In the Cow Shelter, it is seen that spaces that allow animals to live comfortably and healthily are created in a way to support the natural behaviour of animals. The purpose of the building is to provide protection for animals from heavy rainfall or other bad weather conditions. The façade design has been shaped by paying attention to the climatic data and the needs of the animals. Considering the cases of the heavy wind and precipitation, the building has a sloping form and openings are designed to help direct the flow of rainwater into the deep valley. The air circulation inside the building is provided naturally through the openings in the facade, thus minimizing the risk of respiratory diseases for the animals. The building is situated in an area that affords animals more leisure time to graze and play freely. Both the façade and the carrier system have been created by using a small number of materials. It is also designed to maximize the use of natural ventilation and natural light. The land where the building is located has a very green environment. Thanks to this green area, it is ensured that the sounds that may occur in the environment are absorbed, and their effect is reduced so that the animals will not get stressed. The use of traditional materials in the building has ensured that the construction costs are low and technically, a structure that anyone can easily build has emerged. Since it is a suitable environment for animal carers, human-animal interaction is favourable for both. The longevity of the building is ensured by designing the building by the climatic conditions of the period in which it was built, selecting the suitable materials, and constructing it with quality construction methods.

3.3.5 Palanga Art and Architecture Farm, Turkey (1888)

Kutluğ Ataman spearheaded the project to revitalize the farm established in 1888 (Soistanbul, 2018). Aiming for a sustainable agriculture and animal husbandry model with animals using biodynamic methods, the farm also aims to maintain environmental sustainability (Attec.design, 2019). The project was shaped by Kutluğ Ataman's love of nature and Hasan Çalışlar's collaboration.

3.3.5.1 Palanga House of Chickens (2018)

The most important aspect of the Chicken House is that the design team created the structure according to design principles based on the daily routines of the chickens. Each design principle is based on the observation of chickens and the previous

experiences of local people. At each stage of the design, design diagrams were created to reveal whether they meet the daily routines of the chickens. Another critical factor affecting the design was the behavioural relationship between humans and animals. A corridor was created on the centre axis of the building so that people could collect eggs without disturbing the chickens. The side parts serve basic needs such as shelter, incubation, rest, and sleep (Figure 12). After collecting the data resulting from all these studies, low-cost materials and traditional construction techniques that are easy to maintain according to the climatic and regional characteristics of the region were preferred. Reinforced concrete was used for the foundations, wood for the carcass and cladding elements, and sheet metal for the roof (YouTube, 2021b).

Figure 12 Chicken House images (Archdaily, 2019b)

The design of the Palanga Chicken House is to support the natural behaviour (daily routines) of the animals, allowing them to live in a comfortable and healthy way. In the poultry house sections in the example, animals have enough space for their natural movements. The semi-open space located on the central axis of the building allows animals to socialize even in bad weather conditions. In addition, this space provides shading in hot weather conditions. Thanks to the pivot panels used in the facade design, good ventilation and a sufficient natural light environment are provided. Thus, the chickens are not exposed to heat stress and the risk of respiratory diseases is minimized. The balanced use of pivot panels ensures a homogeneous distribution of light entering the space. Providing sufficient natural light helps to maintain the biological rhythms of the animals. The raised structure and the large sloping roof form allow the chickens to spend time outside on hot days. The nesting boxes are connected to the outside so that people can collect eggs without disturbing the chickens. The other most important factor that influenced the design was the behavioural relationship between humans and animals. The nesting boxes are connected to the outside so that people can collect eggs without disturbing the chickens. The use of traditional materials in the building has ensured that construction costs are low and technically, a structure that anyone can easily build has emerged. The spaces in the Palanga Chicken Coop have a modular and repetitive form. This approach helps to reduce maintenance and repair costs and allows the building to be built quickly. The longevity of the building was ensured by designing the facility by climatic conditions of the period in which it was built, selecting the right materials, and constructing it with quality construction methods.

3.3.5.2 Palanga Newborn Calf Shelter (2019)

The Calf Shelter is a shelter that meets the needs of the calves by selecting materials that are compatible with the environment. (Figure 13) (YouTube, 2021b).

Figure 13 Newborn Calf Shelter (Nsmh, 2019)

The aim of the project is to create a shelter that will provide health care for newborn calves (Nsmh, 2019). The building is mostly designed as an open space, especially suitable for harsh climatic conditions, and aimed to make the best use of sunlight. The building has an open side for animals to enter comfortably, while the roof slope is designed to provide protection against harsh weather conditions. The walls are made of robust and maintenance-free materials and have a rough surface to meet the scratching needs of the animals. In this way, they are allowed to exhibit their natural behaviour (YouTube, 2021b).

The design of the Palanga Calf Shelter is to support the natural behaviour (daily routines) of the animals, allowing them to live in a comfortable and healthy way. In the pens in the example, animals have enough space for their natural movements. As the façade design is shaped according to climatic data and animals' needs, the south façade's open design provides natural ventilation and a sufficient natural light environment. Thus, the risk of respiratory diseases is minimized. Providing sufficient natural light also helps to maintain the biological rhythms of the animals. The use of traditional materials in the building has ensured that construction costs are low and technically, a structure that anyone can easily build has emerged. The longevity of the building is ensured by designing the building by the climatic conditions of the period in which it was built, selecting the suitable materials, and constructing it with quality construction methods.

3.3.5.3 Palanga Goat Shelter (2021)

In the design process, user requirements were taken into consideration and in this context, goat physiology was given importance. In addition to other factors such as the geographical characteristics and climate of the project location, the seismic requirements of the building were taken into consideration due to its location in an earthquake zone. In addition, it is aimed to seek sustainable solutions, ensure compliance with today's conditions, use natural materials, and adopt traditional stone-earth-wood workmanship as a construction technique (Figure 14). The building was constructed entirely using local and natural materials. The foundation of the building was constructed using stones from the stream in the farm (YouTube, 2021b).

Figure 14 Goat Shelter (Ecarch, 2021)

The design of the Palanga Goat Shelter is to support the natural behaviour (daily routines) of the animals, allowing them to live in a comfortable and healthy way. In the pens in the example, animals have enough space for their natural movements. The façade design is shaped by considering the climatic data and the needs of the animals. It is designed to protect the goats from harsh weather conditions and a chimney form has been considered considering the health of the animals. In this way, natural ventilation is provided, and the risk of respiratory diseases is minimized by increasing the air circulation inside the building. It is a structure that allows the animals to spend more free time and an area where they can freely graze and play around. The existing vegetation has been preserved in these areas. The use of traditional materials in construction has ensured low construction costs. In today's architecture, the importance of methods such as rammed earth and adobe, which were frequently used in ancient times, has unfortunately decreased. For this reason, it has become a structure that cannot be easily applied by everyone because it is a structure that requires technical competence to learn about these methods. The building is a structure that fits the climatic conditions of its location and responds to the user' needs. The longevity of the building is ensured by designing the building by the climatic conditions of the period in which it was built, selecting the suitable materials, and constructing it with quality construction methods.

4. Evaluation and Conclusion

Today, architectural design approaches have been transformed due to the emergence of various environmental problems such as climate change, population growth, unplanned urbanization, pollution, and depletion of natural resources (Aslan, Selçuk and Avinç, 2022). This has resulted in the development of architectural approaches that are compatible with nature through the adoption of environmentalist techniques in the selection of building materials and construction techniques. The significance of sustainable architecture is on the ascent, as it seeks to harmonize building practices with the natural environment, supporting the protection and longevity of natural life. In this context, the role of animals whose natural habitats are being destroyed has an important role in sustainability debates.

The aim of sustainable animal-aided design is to create habitats where animals can live healthily and comfortably, suited to their natural life cycle. These habitats should be designed according to local climate, well-ventilated with natural lighting, and constructed from materials that can withstand natural and environmental conditions. Before designing animal shelters, it is crucial to comprehend the specific climatic requirements of each animal species and the negative impacts environmental factors can have on them. For instance, regions with cold winters require animal shelters to have sufficient heating systems and accessible areas that are shielded from temperature drops. Similarly, animals located in hot regions should have access to cooling systems and shaded areas. To avert negative environmental impact on animals, specific measures should be taken when designing their habitats. For instance, shelters to address water pollution concerns should be equipped with effective treatment systems to prevent harm to water resources caused by animal waste. Designs that do not consider the environmental needs of animals can harm their health. This can result in the use of additional resources such as veterinary services, improved building heating-cooling systems, and re-evaluating the building waste system. As a result, more materials are used, and construction costs increase. For sustainable animal-aided building designs to work, create living spaces that meet animal needs, fully understand the impacts of the environment on animals, and adapt designs accordingly. These structures shield animals' welfare and health while promoting the efficient use of resources.

In this study, focusing on the importance of sustainability in animal-aided building design, the Ruhr Region example at the urban scale, examples at the infrastructure scale, and nine selected building scale sample projects from Turkey and around the world are analyzed comparatively.

The comparative analysis is based on interdisciplinary studies, and the findings highlight the benefits of animal-aided sustainable designs at urban, infrastructural, and building scales. Technical term abbreviations are explained when first used. Consistent citation and footnote style are followed. Quotations are clearly marked, and filler words are avoided. The building-scale findings reveal that animals' welfare and quality of life improve in spaces tailored to their natural behaviours and needs. The use of natural materials, lighting, and ventilation in design heightens animal comfort and diminishes stress levels. Such architectural features positively influence the animals' well-being.

Findings at the urban and infrastructure scale demonstrate that the inclusion of animals in urban areas has a positive impact on environmental balance and contributes to biodiversity conservation. It is important to recognize these benefits to facilitate their adoption and expansion in urban planning. The implementation of such designs yields numerous beneficial effects, including the expansion of green spaces, diversification of ecosystem services, and safeguarding of natural habitats. The examined instances have a crucial function in preventing species extinction, facilitating scientific inquiry, establishing spaces for human-animal interaction, promoting social consciousness, and emphasizing its significance in the sustainable architecture approach. Despite this, the scarcity of animal-aided sustainable designs, especially at the national level, is noteworthy. Increasing the number of animal-aided sustainable designs at

urban, infrastructure, and building scales is deemed a vital measure in safeguarding environmental and ecological harmony. Addressing this issue shall not only bridge a scientific gap but also promote the adoption of sustainable animal-aided designs that benefit humans and animals alike.

The parameters evaluated in the urban, infrastructure and building scale examples selected within the scope of the study reveal the main elements that need to be considered in order to design animal-aided buildings in a sustainable and animal welfare-oriented manner. Consideration of these elements helps designers to construct spaces that are designed in accordance with the needs of animals and thus help the sustainability of the species. Furthermore, these parameters ensure the environmental, social, and economic sustainability of the buildings. Therefore, it is extremely important to consider these parameters in the design of animal-friendly buildings and thus, sustainable-animal welfare-oriented buildings and urban areas can be built. The discussion of the relationship between sustainability and animal-aided design, which has been put forward through this study, constitutes an important discussion ground for future research and application examples.

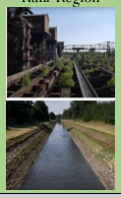
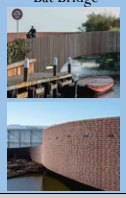
Animal Aided Design Parameters in Sustainable Architecture Approach	**Animal-Aided Design at the Urban Scale**	**Animal-Aided Design at Infrastructure Scale**		**Animal-Aided Designs at the Building Scale**	
	Ruhr Region 	Trans Canada Highway 	Bat Bridge 	Petting Farm 	Thearpy Centre 
FUNCTIONAL					
That it is a structure suitable for the natural life cycle of the animal	-Suitable habitat environment -Beginning of species appearance	-Ecological bridges made from natural materials -Variation of genre-specific bridge characteristics	-Suitable environment for different bat species in four seasons -Rough interior surfaces for their attachment	Suitable habitat environment	Suitable habitat environment
That it is an environment suitable for animal welfare (*five domains)	Nutrition, environment, health, behaviour and mental state	Nutrition, environment, health, behaviour and mental state	Nutrition, environment, health, behaviour and mental state	Nutrition, environment, health, behaviour and mental state	Nutrition, environment, health, behaviour and mental state
That it is made in accordance with the environment	Suitability to local color	Suitability to local color	Suitability to local color	Suitability to local color	Suitability to local color
Use of materials resistant to environmental conditions	Selection of the right materials suitable for the climate	Selection of the right materials suitable for the climate	Selection of the right materials suitable for the climate		Selection of the right materials suitable for the climate
That it is suitable for the climate (insulation details suitable for the climate)	Selection of plants suitable for the climate	Selection of plants suitable for the climate and structural details	Selection of the details suitable for the climate	Selection of the details suitable for the climate	Selection of details and materials suitable for the climate
That it is suitable for the topography (local color)	Suitability to local color	Suitability to local color	Suitability to local color	Suitability to local color	Suitability to local color
Positioning of the structure according to the sun and wind				Design according to climatic elements	Design according to climatic elements
Providing adequate natural lighting	Wide openings	Open / semi-open areas	Open / semi-open areas	-The upper half of the structure is open -Facade panels that move with the sun	-Open / semi-open spaces -Courtyard design
Providing natural ventilation	Wide openings	Open / semi-open areas	Open / semi-open areas	The upper half of the structure is open	Open / semi-open areas
Monitoring indoor air quality	Adequate natural ventilation	Adequate natural ventilation	Adequate natural ventilation	Adequate natural ventilation	Adequate natural ventilation
Ensuring acoustic performance	Adequate use of plant elements	Use of herbal elements to prevent stress from vehicle noise			
That it is an environment suitable for health conditions and animal comfort	Adequate natural ventilation and lighting	Application of type-specific architectural details	Application of type-specific architectural details	Application of type-specific architectural details	Application of type-specific architectural details
Use of natural materials	Vegetation suitable for the local color	Vegetation suitable for the local color	Use of wood on the façade	Use of wood on the facade	Use of adobe
Use of local materials	Vegetation suitable for the local color	Vegetation suitable for the local color			Use of earth-straw mixture bricks
Use of renewable energy	Open / semi-open areas	Open / semi-open areas	Open / semi-open areas	Open / semi-open areas	Open / semi-open areas
Effective use of material	Utilisation of existing structures	Preservation of existing vegetation		Preservation of existing vegetation	Preference for local ingredients
Preservation of existing vegetation	Protection of existing natural areas	Protection and interconnection of existing natural areas	Protection and interconnection of existing natural areas	Protection of existing natural areas	Protection of existing natural areas
Efficient use of resources	-Utilisation of existing structures -Preservation of the existing green field	Preservation of the existing green texture Effective use of material	-Preservation of the existing green texture -Effective use of material	-Preservation of the existing green texture -Effective use of material	-Preservation of the existing green texture -Effective use of material
Design suitable for human-animal interaction	-Ecosystem protection -Increased social welfare	-Decrease in traffic accidents caused by wildlife -Increased social welfare	-Multi-purpose wooden platfrom -Increased social welfare	-Use as a child farm -Increased social welfare	-Keeping the village atmosphere alive -Increased social welfare
STRUCTURAL					
Modular and repetitive	Modular natural landscape elements	Modular structural elements	Modular structural elements	Modular structural elements	Modular plan scheme and structural elements
Fast and easy construction and installation	Modularity	Modularity	Modularity	Having modular façade elements	Modularity
Establishment with a small number of technical staff	Modularity	Modularity	Modularity	Modularity	Modularity
Simple yet high strength of the load-bearing system					Use of sun-dried bricks
Long service life	Design according to local data	Design according to local data	Design according to local data	Design according to local data	Design according to local data
Low cost	Protection of existing structures	Decrease in traffic accidents			Use of local materials

Figure 15 Evaluation table of selected samples over the determined parameters - 1

Animal Aided Design Parameters in Sustainable Architecture Approach	Animal-Aided Designs at the Building Scale				
	Bear Sanctuary 	Cow Shelter 	Palanga 1888, Erzincan, Turkey		
			House of Chickens (2018) 	Newborn Calf Shelter (2019) 	Goat Shelter (2021) 
FUNCTIONAL					
That it is a structure suitable for the natural life cycle of the animal	?	-Suitable habitat environment -Having a shelter to protect them from heavy rainfall	-Suitable habitat environment -Having both roosting and resting areas	-Suitable habitat environment -Provision of scratching needs with materials from the front line	-Suitable habitat environment -Ensuring the release of toxic gases into the air by leaving the centre axis of the building open
That it is an environment suitable for animal welfare (*five domains)	Nutrition, environment, health, behaviour and mental state	Nutrition, environment, health, behaviour and mental state	Nutrition, environment, health, behaviour and mental state	Nutrition, environment, health, behaviour and mental state	Nutrition, environment, health, behaviour and mental state
That it is made in accordance with the environment	Suitability to local color	Suitability to local color	Suitability to local color	Suitability to local color	Suitability to local color
Use of materials resistant to environmental conditions	Selection of the right materials suitable for the climate	Selection of the right materials suitable for the climate	Selection of the right materials suitable for the climate	Selection of the right materials suitable for the climate	Selection of the right materials suitable for the climate
That it is suitable for the climate (insulation details suitable for the climate)	Selection of details and materials suitable for the climate	Selection of details and materials suitable for the climate	Selection of details and materials suitable for the climate	Selection of details and materials suitable for the climate	Selection of details and materials suitable for the climate
That it is suitable for the topography (local color)	Suitability to local color	Suitability to local color	Suitability to local color	Appropriate to the local color Earthquake resistant building	Appropriate to the local color Earthquake resistant building
Positioning of the structure according to the sun and wind	Design according to climatic elements	Design according to climatic elements	Design according to climatic elements	Design according to climatic elements	Design according to climatic elements
Providing adequate natural lighting	Open / semi-open spaces Courtyard design	Having catenary arched facades	Open / semi-open spaces Courtyard design Balanced use of facade panels on the facade	Open / semi-open areas	Semi-open spaces
Providing natural ventilation	Open / semi-open areas	Semi-open spaces	Open / semi-open areas	Open / semi-open areas	Semi-open areas
Monitoring indoor air quality	Adequate natural ventilation	Adequate natural ventilation	Adequate natural ventilation	Adequate natural ventilation	Adequate natural ventilation
Ensuring acoustic performance		Adequate use of plant elements			
That it is an environment suitable for health conditions and animal comfort	Application of type-specific architectural details	Adequate natural ventilation and natural lighting	Adequate natural ventilation and natural lighting	Adequate natural ventilation and natural lighting	Adequate natural ventilation and natural lighting
Use of natural materials	Made with gobion wall technique	Local brick for the façade and load-bearing system; use of recycled sticks and local plants in the mortar mix for rigidity	Use of wood in the load-bearing system and facades	-Use of wood in the roof carrier system -Using straw-soil mixture for floor insulation	-Use of river stones in building foundations -Use of adobe -Use of lime and horasan mortar
Use of local materials	Using natural stone	Using 'Sithu kal' brick consisting of three layers	Use of wood	Use of wood and straw-soil mixture	Use of stream stones, soil-straw mixture
Use of renewable energy	Open / semi-open areas	Semi-open areas	Open / semi-open areas	Open / semi-open areas	Semi-open areas
Effective use of material	Preference for local ingredients	The fact that the load-bearing system and the facade are solved at the same time, Preference for local ingredients	Preference for local ingredients	Preference for local ingredients	Carrier system and facade are solved at the same time
Preservation of existing vegetation	Protection of existing natural areas	Protection of existing natural areas	Protection of existing natural areas	Protection of existing natural areas	Having a genre-specific design Effective use of material
Efficient use of resources	-Preservation of the existing green color -Effective use of material	-Preservation of the existing green color -Effective use of material	-Preservation of the existing green color -Effective use of material	-Having a genre-specific design -Effective use of material	-Having a genre-specific design -Effective use of material
Design suitable for human-animal interaction	Having indoor and outdoor areas that can be used together for both species	-Design in accordance with the local color -Increased social welfare	-The connection of the nesting boxes with the outside -Semi-open social area in the centre axis of the building	Having wide open spaces	Having wide open spaces
STRUCTURAL					
Modular and repetitive	Modular plan scheme and structural elements	Modular plan scheme and structural elements	Modular plan scheme and structural elements	Symmetrical plan scheme	
Fast and easy construction and installation	Modularity	Modularity	Modularity	Modularity	Using traditional construction techniques
Establishment with a small number of technical staff	Modularity	Modularity	Modularity	Modularity	Using traditional construction techniques
Simple yet high strength of the load-bearing system	Gobion wall technique	Surprisingly placed local bricks	Use of modular timber structural system	Earthquake resistance	Using adobe walls
Long service life	Design according to local data	Design according to local data	Design according to local data	Design according to local data	Design according to local data
Low cost	Use of local materials	Use of local materials	Use of local materials	Use of local materials for roofing and flooring	Use of local materials

Figure 16 Evaluation table of selected samples over the determined parameters - 2

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References

Aghimien, D. O., Adegbembo, T. F., Aghimien, E. I., & Awodele, O. A. (2018). Challenges of sustainable construction: a study of educational buildings in Nigeria. *International Journal of Built Environment and Sustainability,* 5(1): 33-46.

Alexander, S. M., & Waters, N. M. (2000). The effects of highway transportation corridors on wildlife: a case study of Banff National Park. *Transportation Research Part C: Emerging Technologies*, 8(1-6): 307-320.

Apfelbeck, B., Snep, R. P., Hauck, T. E., Ferguson, J., Holy, M., Jakoby, C., Scott Maclvor J., Schar L., Taylor M., and Weisser, W. W. (2020). Designing wildlife-inclusive cities that support human-animal co-existence. *Landscape and Urban Planning,* 200: 103817.

Aslan, D., Selçuk, S. A., & Avinç, G. M. (2022). A Biomimetic Approach to Water Harvesting Strategies: An Architectural Point of View. *International Journal of Built Environment and Sustainability*, 9(3): 47-60.

Barrueto, M., Sawaya, M. A., & Clevenger, A. P. (2020). Low wolverine (Gulo gulo) density in a national park complex of the Canadian Rocky Mountains. *Canadian Journal of Zoology*, 98(5): 287-298.

Bengtsson, L. P., & Whitaker, J. H. (1986). *Farm Structures in tropical climates: A textbook for structural Engineering and Design.* FAO/SIDA Cooperative Programme. Rome: Food and Agricultural Organization.

Ciravoğlu, A. (2006). *Sürdürülebilirlik Düşüncesi-Mimarlık Etkileşimine Alternatif Bir Bakış: "Yer"in Çevre Bilincine Etkisi.* Doktora Tezi, Yıldız Teknik Üniversitesi Fen Bilimleri Enstitüsü, İstanbul.

Clevenger, T. (2007). Highways Through Habitats. *TR news 249*: 14-17.

Clevenger, A. P., & Huijser, M. P. (2011). *Wildlife crossing structure handbook: design and evaluation in North America* (No. FHWA-CFL-TD-11-003). United States. Federal Highway Administration. Central Federal Lands Highway Division.

Colombo, R., Landabaso, A., & Sevilla, A., (1994). Passive Solar Architecture for Mediterranean Area Design Handbook, *Joint Research Centre,* 8-127. Commission of the Europen Communities,

Dağ, H., & Özberk, S. (2012). Eski Sanayi Kentlerinde 'Kentsel Dönüşümden Kültürel Dönüşüme: Ruhr Bölgesi Örneği. *Kahramanmaraş Sütçü İmam Üniversitesi Sosyal Bilimler Dergisi*, 9(2): 147-166.

Denneboom, D., Bar-Massada, A., & Shwartz, A. (2021). Factors affecting usage of crossing structures by wildlife–A systematic review and meta-analysis. *Science of the Total Environment*, 777: 146061.

Doğan, D., & Şahin, Ş. (2015). *Yaban Yaşamı Koridorları Olarak Ekolojik Köprüler.* 3. Köprüler Viyadükler Sempozyumu, İnşaat Mühendisleri Odası Bursa Şubesi.

Emekci, Ş. (2021). Korunan Alanlarda Sürdürülebilir Mimari Tasarım Kriterlerinin Belirlenmesi: Odak Grup Metodu. *Tasarım+ Kuram*, 17(33).

Folke, C., Biggs, R., Norström, A. V., Reyers, B., & Rockström, J. (2016). Social-ecological resilience and biosphere-based sustainability science. *Ecology and Society*, 21(3).

Granai, G., Borrelli, C., Moruzzo, R., Rovai, M., Riccioli, F., Mariti, C., … & Di Iacovo, F. (2022). Between Participatory Approaches and Politics, Promoting Social Innovation in Smart Cities: Building a Hum–Animal Smart City in Lucca. *Sustainability*, 14(13): 7956.

Hess, G. R., Moorman, C. E., Thompson, J., & Larson, C. L. (2014). Integrating wildlife conservation into urban planning. *Urban wildlife conservation: Theory and practice*, 239-278.

Kurtay, C., & Sağlam, H., (2011). Ruhr Metropolitan Bölgesi Gelişim Projesi. *Serbest Mimar Dergisi,* (6-7): 71-76.

Longcore, T., & Rich, C. (2004). Ecological light pollution. *Frontiers in Ecology and Environment*, 2(4): 191-198.

Madge, P. (1997). Ecological design: a new critique. *Design issues,* 13(2): 44-54.

Maulana, R. (2018). *Architecture for animals:* the expanding challenges of sustainable development. In *IOP Conference Series: Earth and Environmental Science*. 195(1): 012079. IOP Publishing.

McLellan, R., Iyengar, L., Jeffries, B., & Oerlemans, N. (2014). *Living Planet Report 2014: Species And Spaces, People And Places*. WWF International.

Meadowcroft, J. (1997). Planning, democracy and the challenge of sustainable development. *International Political Science Review*, 18(2): 167-189.

Mellor, D. J., Beausoleil, N. J., Littlewood, K. E., McLean, A. N., McGreevy, P. D., Jones, B., & Wilkins, C. (2020). The 2020 five domains model: Including human–animal interactions in assessments of animal welfare. *Animals*, 10(10): 1870.

Messerli, P., Murniningtyas, E., Eloundou-Enyegue, P., Foli, E. G., Furman, E., Glassman, A., Hernández Licona, G., Kim, M. E., Lutz, W., Moatti, J. P., Richardson, K., Saidam, M., Smith, D., Kazimieras Staniškis, J., & van Ypersele, J. P. (2019). *Global sustainable development report 2019: the future is now–science for achieving sustainable development*. United Nations, 1-25.

Nardone, A., Ronchi, B., Lacetera, N., Ranieri, M. S., & Bernabucci, U. (2010). Effects of climate changes on animal production and sustainability of livestock systems. *Livestock Science*, 130(1-3): 57-69.

Newbury, S., Blinn, M. K., Bushby, P. A., Cox, C. B., Dinnage, J. D., Griffin, B., Hurley, K. F., Isaza, N., Jones, W., Miller, L., O'Quin, J., Patronek, G. J., Smith-Blackmore, M., & Spindel, M. (2010). Guidelines for standards of care in animal shelters. *Association of Shelter Veterinarians,* 1-64.

Olmos Antillón, G., Tunón, H., De Oliveira, D., Jones, M., Wallenbeck, A., Swanson, J., Blokhuis, H., & Keeling, L. (2021). Animal welfare and the United Nations' sustainable development goals-broadening students' perspectives. *Sustainability*, 13(6): 3328.

Özmehmet, E. (1999). *Doğaya duyarlı mimarlıkta çağdaş teknolojilerden yararlanılması üzerine bir araştırma*. Yüksek Lisans Tezi, Dokuz Eylül Üniversitesi Fen Bilimleri Enstitüsü, İzmir.

Rojas-Downing, M. M., Nejadhashemi, A. P., Harrigan, T., & Woznicki, S. A. (2017). Climate change and livestock: Impacts, adaptation, and mitigation. *Climate Risk Management,* 16: 145-163.

Salgırlı Demirbaş, Y. (2023, 23 Mart). *Hayvan Destekli tasarımlar üzerine söyleşi*. Çevrimiçi, Ankara.

Sawaya, M. A., Clevenger, A. P., & Schwartz, M. K. (2019). Demographic fragmentation of a protected wolverine population bisected by a major transportation corridor. *Biological Conservation*, 236: 616-625.

Takva, Y., Takva, Ç., & İlerisoy, Z. (2023). Sustainable Adaptive Reuse Strategy Evaluation for Cultural Heritage Buildings. *International Journal of Built Environment and Sustainability*, 10(2): 25-37.

Tekeli, İ. (2001). Sürdürülebilirlik Kavramı Üzerinde İrdelemeler. *Cevat Geray'a Armağan, Mülkiyeliler Birliği Yayınları*, 25: 729-746.

Tüzen, M. (2023). *Sürdürülebilir Mimarlık Yaklaşımında Hayvan Destekli Tasarımların Yeri [The Role of Animal-Aided Design in Sustainable Architecture]*. Yüksek Lisans Tezi, Gazi Üniversitesi Fen Bilimleri Enstitüsü, Ankara.

Visseren-Hamakers, I. J. (2020). The 18th sustainable development goal. *Earth System Governance*, 3: 100047.

WCED. (1987). Report of the World Commission on Environment and Development: Our Common Future. *WCED Report*, 40-46. Oxford.

Weisser, W., W., & Hauck, T., E. (2015) *AAD Animal-Aided Design*. ISBN 978-3-00-047519-1.

Weisser, W., W., & Hauck, T., E. (2017). Animal-Aided Design–Using a species' life-cycle to improve open space planning and conservation in cities and elsewhere. *BioRxiv,* 150359.

Whittington, J., Low, P., & Hunt, B. (2019). Temporal road closures improve habitat quality for wildlife. *Scientific reports*, 9(1): 3772.

Zindane, D. (2010). *Yüksek Yapı Tasarımında Sürdürülebilirlik Boyutunun İrdelenmesi*. Yüksek Lisans Tezi, İstanbul Teknik Üniversitesi Fen Bilimleri Enstitüsü, İstanbul.

Archdaily, (2009). Petting Farm / 70F Architecture. Retrieved June, 2023, from https://www.archdaily.com/29965/petting-farm-70f-architecture

Archdaily, (2015). Vlotwateringbrug / NEXT architects. Retrieved June, 2023, from https://www.archdaily.com/775941/vlotwateringbrug-next-architects?ad_medium=gallery

Archdaily, (2017). Jiyan Healing Garden / ZRS Architekten Ingenieure. Retrieved June, 2023, from https://www.archdaily.com/883358/jiyan-healing-garden-zrs-architekten-ingenieure

Archdaily, (2019a). BEAR Sanctuary / COLE. Retrieved June, 2023, from https://www.archdaily.com/912023/vietnam-bear-sanctuary-cole

Archdaily, (2019b). House of Chickens / SO? Architecture and Ideas. Retrieved June, 2023, from https://www.archdaily.com/912475/house-of-chickens-so-architecture-and-ideas

Attec.design, (2019). Han-Dam. Retrieved June, 2023, from https://attec.design/tr/project/han-dam/

Avma, (?). AVMA (American Veterinary Medical Association). Human-animal bond. Retrieved July, 2023, from https://www.avma.org/one-health/human-animal-bond

Conteches, (2017). Design Considerations for Wildlife Crossings. Retrieved June, 2023, from

https://www.conteches.com/Knowledge-Center/PDH-Articles/Design-Considerations-for-Wildlife-Crossings

Earthscapestudio, (2022). The Eternal Experience Pavilion. Retrieved June, 2023, from https://www.earthscapestudio.com/thehaven.html

Ecarch, (2021). Erkinoğlu and Çalışlar – Palanga Keçi Korunağı. Retrieved June, 2023, from https://ecarch.com/works/palanga-keci-korunagi/

Lola.land, (2015). Park Poelzone Westland, NL. Retrieved June, 2023, from https://lola.land/project/park-poelzone/
MFA, (2022). Dünya Sürdürülebilir Kalkınma Zirvesi. Retrieved August, 2023, from https://www.mfa.gov.tr/surdurulebilir-kalkinma.tr.mfa

Nsmh, (2019). Nevzat Sayın Mimarlık Hizmetleri- Palangada Barınak. Retrieved June, 2023, from https://www.nsmh.com/Palangada-Barinak

Parks.canada.ca, (2022). Wildlife crossing structures and research – Banff National Park. Retrieved June, 2023, from https://parks.canada.ca/pn-np/ab/banff/nature/conservation/transport/tch-rtc/passages-crossings

Soistanbul, (2018). House of Chickens. Retrieved June, 2023, from https://www.soistanbul.com/house-of-chickens

Stadennatuur, (2008). Stad Nature Almere – Den Ulypark. Retrieved July, 2023, from https://www.stadennatuur.nl/den-uylpark.nl/?gclid=CjwKCAjwlJimBhAsEiwA1hrp5gS1rnVzHNxZ9b6Ep_ceKFjor9MQAQOoReGM9N0o7LWWus1RjV-TRBoCnxEQAvD_BwE

YouTube, (2021a). Iron Jungle- Nature's Return to the Ruhr Valley – Go Wild. Retrieved June, 2023, from https://www.youtube.com/watch?v=usFRjQXnvw4andab_channel=GoWild

YouTube, (2021b). Palanga 1888. Retrieved June, 2023, from https://www.youtube.com/watch?v=dEw0u8KaW9gandab_channel=Arkitekt

Zrsa, (2019). Therapy Centre for Women and Children - Chamchamal, Kurdistan-Iraq. Retrieved June, 2023, from https://www.zrs.berlin/project/jiyan-healing-garden-2/