INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN ECONOMICS & MANAGEMENT SCIENCES

OPEN ACCESS JOURNAL

Vol 13, Issue 2, (2024) E-ISSN: 2226-3624

The Role and Impact of Traditional Building Techniques in The Sustainable Economy

Zhang Xuan, Mohd Shahrudin Abd Manan

Faculty of Design and Architecture, University Putra Malaysia, Serdang 43400, Selangor, Malaysia

To Link this Article: http://dx.doi.org/10.6007/IJAREMS/v13-i2/21434 DOI:10.6007/IJAREMS/v13-i2/21434

Published Online: 07 May 2024

Abstract

Traditional construction technology is a construction method and technology acquired by mankind through historical accumulation and practical verification. It respects local culture, environment, and resources, utilizes natural ventilation and lighting, and relies on topography and climate to achieve sustainable construction. Through literature review and case analysis, this article explores the role and impact of traditional construction technology in the sustainable economy, defines traditional construction technology, and analyzes its advantages in the sustainable economy, including resource conservation, environmental friendliness, Cultural promotion effect, etc. We then demonstrate the application of traditional construction techniques in modern construction practices through case studies and explore their multiple economic, social, and environmental impacts. Finally, we point out that promoting traditional construction technologies to play a greater role in a sustainable economy requires policy support, technological innovation, and market recognition.

Keywords: Traditional Construction Technology, Sustainable Economy, Resource Conservation, Environmental Friendliness, Cultural Promotion

Introduction

Economic development has two aspects. It embodies the positive side of improving human living standards at the social level, but it has a negative side when facing the natural environment. Economic development has brought about problems such as resource depletion Mittal & Gupta (2015), climate warming Diffenbaugh & Burke (2019), and energy shortages Ou et al (2016), which have affected human life. To survive and develop, humans must move towards sustainable economic development (Sahlberg & Oldroyd, 2010). Pay more attention to energy efficiency, climate change, natural resources, daily life production, and other related economic activities. These activities can predict the most vital interests of mankind in the future. To reduce environmental risks for future generations, some actions must be taken to change, and traditional building technology is representative of this action (Watson et al., 2010).

Traditional construction techniques are widely used and highly valued around the world. It represents the wisdom and innovation accumulated by mankind through long-term practice and experience. These technologies are not just methods of building physical

structures, but integrated ideas of interconnectedness with nature, culture, and society. The core of traditional building technology is to respect and adapt to local culture, environment, and resources, and to use natural forces to achieve building sustainability (Rong & Bahauddin, 2023).

First, traditional building techniques emphasize continuity with local culture and traditions. It reflects the history, values and lifestyle of an area or community through the design, structure and decoration of buildings (Dipasquale, 2020). This kind of cultural continuity is not only conducive to the protection and inheritance of cultural heritage, but also enhances people's sense of identity and pride in local culture, and promotes community cohesion and harmonious development. Secondly, traditional construction techniques focus on harmonious coexistence with the environment. It makes full use of natural resources such as natural ventilation, lighting, and temperature regulation to improve the energy efficiency performance of buildings through reasonable architectural design and layout. For example, traditional buildings often feature open interior spaces, high ceilings and wide corridors to promote air circulation and natural lighting, reduce energy consumption and reduce carbon emissions. At the same time, traditional buildings also use terrain and climate conditions such as terrain differences and natural shading to adjust indoor and outdoor temperatures and improve the comfort and adaptability of the building (Fu et al., 2021). In addition, traditional building techniques emphasize the sustainable use of local resources. It usually uses locally available natural materials, such as earth, wood, stone, etc., to reduce dependence on limited and non-renewable resources and reduce the impact of the building life cycle on the environment. The effective use of this resource helps protect ecosystem balance, promotes biodiversity conservation, and supports local economic development (Cao et al., 2021).

Traditional construction technology is a comprehensive, sustainable, and latest construction method and concept (Hossain et al., 2020). It not only reflects human wisdom and innovation in architecture, but also reflects our close connection with nature, culture, and society. In the context of globalization and modernization, traditional construction technology provides valuable perspectives and strategies for us to achieve a balance between environmental protection, cultural inheritance, and social harmony while pursuing economic development (Wang et al., 2022).

Energy Saving Methods of Traditional Buildings

In recent years, there has been increasing interest in the energy-saving performance of traditional buildings because of their potential to provide sustainable solutions for modern buildings. Traditional buildings often have long historical significance and rich cultural value. These characteristics make them an important part of social and cultural heritage. Compared to modern buildings, traditional buildings exhibit some unique characteristics that help increase energy efficiency and reduce environmental impact. As shown in Table 1, there are several factors that affect the energy-saving performance of traditional buildings.

Table 1
Energy-saving characteristics of traditional building energy-saving performance

Factors	Variables	Is machinery needed?	
		Yes	No
Passive Design Strategies	Temperature and Lighting		√
Natural Ventilation	Air Quality		√
Thermal Mass	Temperatures		√
Local Materials	Economy		√

Passive Design Strategies

Passive design strategies are an approach to building design that harnesses the forces and elements of nature to regulate indoor environments, including temperature and lighting. By rationally designing the building's orientation, windows, and shading facilities, sunlight and wind can be utilized to the greatest extent to achieve indoor temperature regulation and ventilation. For example, the orientation and layout of the building can be fully considered during the design process to ensure that sunlight can fully penetrate the interior in winter, thereby improving indoor warmth; in summer, appropriate shading facilities can be used to avoid direct sunlight, thereby reducing indoor warmth. temperature. In addition, by rationally arranging the vents and windows of the building, natural convection of indoor and outdoor air can be achieved, thereby achieving the ventilation effect. Compared with traditional mechanical heating or cooling systems, passive design strategies require no additional energy consumption, have lower operating costs and environmental impacts, and are widely used in sustainable building design.

Natural ventilation

Many traditional buildings are designed to take advantage of natural ventilation through strategic placement of openings such as doors, windows, and vents. This design concept aims to allow fresh air to flow naturally into the building and discharge air pollutants and moisture through natural convection circulation indoors, thereby achieving indoor air circulation and renewal. This natural ventilation design can not only reduce dependence on mechanical ventilation systems and save energy costs but also improve indoor air quality and create a more comfortable and healthy indoor environment for residents. In addition, by rationally designing the location and size of the vents, the ventilation effect can be optimized to ensure adequate ventilation and airflow in all indoor areas, further improving the comfort and quality of the indoor environment.

Thermal Mass

Traditional buildings often use high heat capacity materials such as stone, bricks or adobe, which have good heat storage properties. They can effectively absorb and store large amounts of heat energy during the day and slowly release the stored heat at night. This property helps regulate indoor temperatures so they remain relatively stable, reducing the need for heating and cooling energy. By leveraging the thermal properties of this material, traditional buildings can provide a comfortable indoor environment without relying on additional energy, bringing the dual benefits of comfort and energy savings to occupants.

Local Materials

Traditional buildings are generally constructed using locally sourced materials, which typically have lower energy consumption. The production and transportation process of these local materials consumes less energy than materials that need to be transported over long distances. Since these materials are sourced close to the building site, significant transportation costs are not required, thereby reducing the overall cost of building materials. In addition, choosing local materials can also promote the development of the local economy, as it can support the operation of the local industrial chain, create employment opportunities, and increase the income of local enterprises. At the same time, using local materials also helps reduce the environmental impact associated with material transportation, including reducing CO_2 emissions during transportation and reducing the depletion of natural resources. Therefore, the choice of using locally sourced materials for traditional construction is not only economical but also beneficial to promoting economic development and reducing environmental burden.

Research Methodology

This study uses a case study approach to explore the role and impact of traditional architecture in a sustainable economy. The case study approach provides us with a detailed examination and rich description that contributes to a deeper understanding of the value of traditional architecture in sustainable development (Flyvbjerg, 2011). Therefore, we chose Gaodang Village in Guizhou as the case study object. These ancient buildings are thousands of years old and are still in use today, demonstrating the durability and reliability of traditional building techniques. Through an in-depth analysis of this case, we aim to identify traditional construction techniques and explore their role and potential in a sustainable economy.

Case Study – Gaodang Village

Gaodang Village is located in Ningbuyi and Miao Autonomous County, Anshun City, Guizhou Province, China. It has a long history, dating back to the Ming Dynasty, and has a history of more than 600 years of village construction. One of the village's most striking features is its extensive use of stone. Almost all buildings are carefully built with stone. This unique construction style fully demonstrates the local people's ingenious application of stone and rich architectural wisdom. By making full use of the thermal insulation properties and structural stability of stone, the buildings in Gaodang Village retain their traditional features while also incorporating modern design concepts, achieving the perfect combination of tradition and modernity. Figure 1 shows a typical example of the unique architectural style of Gaodang Village, highlighting the important position and aesthetic value of stone in architecture.

Figure 1: Building groups in the Buyi Settlements.

Village Site Selection

Reasonable selection of village locations can make full use of local natural resources such as solar energy, wind energy, and water resources. The site selection has good sunlight conditions, which is conducive to the adoption of passive energy-saving house principles to minimize energy consumption and improve the energy efficiency of the building. In addition, choosing an area with higher terrain will help avoid being affected by natural disasters such as floods and improve the stability and safety of the building.

The historical development of Gaodang Village was deeply influenced by the military camp, which cannot be ignored. When selecting a village site, defense function is the primary consideration. In addition, traditional Chinese culture has also had an important influence on the development of the village, emphasizing the harmonious relationship between architecture and nature. Therefore, the site selection process was also influenced by traditional Feng Shui principles. Gaodang Village is located at the foothills of the karst mountains in the Baishui River Valley in Guizhou. The terrain is steep, with mountains on its back and valleys on its sides. Surrounded by dense forest vegetation, no cultivated land is occupied, and land resources are rationally utilized. Generally speaking, the construction site selection characteristics of the village mainly include strong defensiveness, harmony with nature, influence of traditional culture, and superior geographical environment. The characteristics of construction site selection are summarized as follows:

1. The structure of the village not only has defensive features and is strategically laid out to protect the inhabitants from potential threats, but also takes into account the rational use of the environment and resources.
2. The village has a unique geographical location, which can not only use the mountains to enhance defense but also maintain contact with the outside world through the layout facing the valley. This geographical layout not only provides residents with good defense conditions but also gives the village unique natural scenery and provides residents with a comfortable and livable living environment.
3. The construction of the village avoids the principle of occupying good farmland and good soil and tries to retain the surrounding cultivated land and natural resources. This strategy is not only beneficial to maintaining ecological balance and protecting farmland resources but also contributes to the sustainable development of villages and the livelihood security of residents.

Building Layout and Orientation

A building's layout and orientation have a significant impact on its sustainability, as they directly impact a building's energy efficiency, indoor comfort, and environmental footprint. First, a well-designed layout and orientation can maximize the use of natural resources such as sunlight and wind. For example, placing a building primarily facing south maximizes winter sunlight and reduces the need for heating energy, while strategically placed windows on the east and west sides promote natural ventilation and reduce cooling loads in the summer. The layout and orientation can minimize the energy consumption of the building during the operational phase. Energy waste can be minimized by carefully arranging internal functional areas, for example, locating office areas in sunny locations to reduce reliance on artificial lighting. In addition, favorable building orientations can optimize the application of Passive design principles and Passive House standards, further increasing the building's energy efficiency.

Optimization of layout and orientation can significantly improve indoor environmental quality and comfort. By maximizing natural light and ventilation, indoor comfort can be improved and help reduce indoor air pollution levels. These measures not only improve the quality of the living and working environment but also help protect the health and comfort of residents. In addition, the optimization of layout and orientation is also an important factor in the sustainable development of buildings. They ensure that the building remains environmentally friendly and cost-effective throughout its life cycle, thereby maximizing the use of resources and reducing negative impacts on the environment.

Gaodang Village is a Buyi village in Guizhou. It is located between karst mountains and hills and canyons. The terrain in this area is varied and often presents natural forms that are consistent with the surrounding mountains and blend into the environment. When selecting the site, the village did not have any specific direction restrictions, but the primary premise was to adapt to the terrain. While a north-south orientation is considered the most ideal, other orientations can be considered.

The architectural form is centered on the square, showing the characteristics of extending from the inside to the outside. Its spatial characteristics can be summarized as follows:

1. The layout of the building complex is freely set according to the terrain contours, fully integrated into the natural terrain, and cleverly utilizing mountains and valleys to integrate the buildings with the surrounding environment and present a landscape that is harmonious and unified with the natural landforms.
2. Maximize the use of vertical space and adopt a multi-level building structure to make the space layout more compact. Through reasonable design of floor height and internal space allocation, efficient use of building space is achieved, while meeting the living and working needs of residents.
3. The facade design of the building complex is rich and diverse, and the main facade and gables are well-proportioned. The facade design incorporates local cultural characteristics and traditional architectural styles, using various decorative elements and materials to create a colorful architectural appearance. The staggered layout that complements the gables gives the building complex a rich sense of layering and three-dimensional beauty in appearance, while also enhancing the coordination and beauty of the building and the surrounding environment.

Interior Space Setting

The design of interior spaces has a profound impact on the sustainability of a building. By optimizing the spatial layout, a building's energy efficiency can be significantly improved. For example, placing high-energy-consuming areas in areas with ample natural light can minimize reliance on artificial lighting and air conditioning systems. In addition, incorporating environmentally friendly materials and energy-saving equipment can further reduce energy consumption. Creating a pleasant, comfortable indoor environment not only improves residents' quality of life but also helps promote their health and well-being. A reasonable indoor layout can ensure good air circulation, and sufficient lighting, avoid the entry of harmful chemicals, and create a healthy and comfortable living environment.

In addition, a flexible space layout can meet various functional needs, extend the service life of the building, and reduce resource waste. For example, using movable partition walls can adjust the size and shape of the space as needed, maximizing space utilization. The floor plan of Gaodang residences reflects its unique physical characteristics, with a rectangular plan with three bays on both sides as the most basic and common form.

In the upper floor layout of the building, the main functions are distributed as follows: the main hall is divided into two rooms, front and rear. The front room is larger and is usually used as the main room. The back room can be used as a heating room, kitchen or bedroom for the elderly; the two sides are usually divided into two rooms, front and rear. The rooms are roughly the same size. The front room can be used as a bedroom or living room, and the back room is generally used as a bedroom and kitchen respectively (as show in Figure 2).

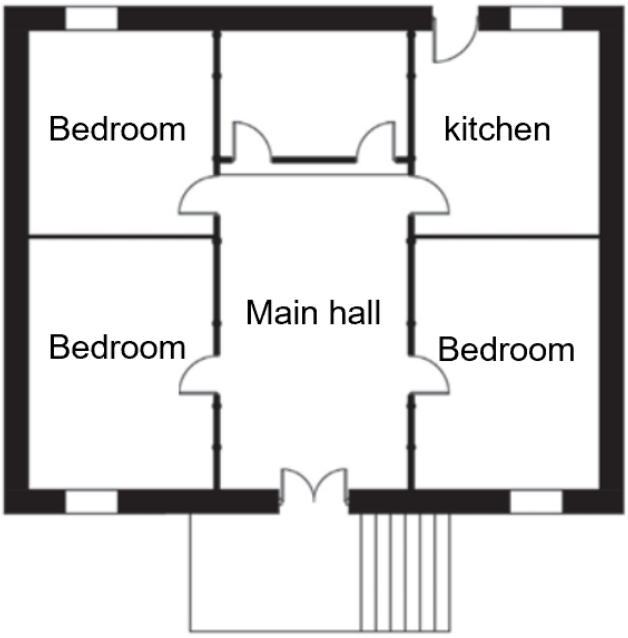

Figure 2: Proto plan layout.

The architectural layout of “one front and two sides” has simple elements and high spatial flexibility. This layout reflects the practicality and adaptability of traditional residential architecture. From a sustainable development perspective, this layout has the following advantages:

1. The architectural layout of Buyi folk houses is simple and clear, and fewer building materials and resources are used in construction. This helps reduce the consumption of natural resources and improve resource utilization efficiency.
2. The layout of residential buildings is relatively flexible and can be adjusted according to different environmental conditions and living needs. For example, the orientation and structure of the house can be optimized to increase comfort and energy efficiency in response to changes in climate and topography.
3. The layout of “one front and two sides” promotes communication and interaction among family members, which is conducive to maintaining family relationships and community cohesion. In addition, this traditional architectural form also reflects the cultural traditions and lifestyle of the Buyi people, and contributes to the inheritance and protection of culture.

Opening Design

Properly designed openings in a building can take full advantage of natural resources such as sunlight and wind. By optimizing the location, size, and orientation of doors and windows, good sunlight and ventilation can be achieved, reducing reliance on artificial lighting and air conditioning systems, thereby reducing energy consumption. Good opening design not only provides sufficient natural light and improves the visual comfort of indoor spaces, but also contributes to the health and well-being of the occupants. Reasonable ventilation design can ensure good indoor air circulation, reduce the growth of moisture and mold, and improve indoor air quality. In addition, well-designed openings can enhance the integration of a building into its surroundings, creating a unique and attractive appearance that increases the value and appeal of the building.

The architecture of Gaodang Village consists of three parts: roof, wall, and foundation. The roof is paved with thin slates to create a sense of lightness; the walls serve as the main component of the facade, with the main entrance as the central axis and each side room with a narrow window. As shown in Figure 3, the doors and windows are made of wood and can be opened according to residents' requirements. Windows are designed to reflect the unique lifestyle of the residents and are often located at elevated locations, both for defensive reasons and to maximize natural light and ventilation. The window glass decoration shows the unique culture and decorative style of the nation, made of wood or bamboo and decorated with exquisite patterns and geometric figures. Windows come in various sizes and shapes, with different functions and preferences. Functional design is also important. Some windows are designed to be openable to facilitate adjustment of indoor temperature and ventilation. Although the window design of Gaodang Village is not unique in aesthetics, it reflects the Buyi people’s sensitivity to the natural environment and respect for traditional culture, and is an important part of their architectural culture.

(a) (b)

Figure 3: (a) Window (b) Facade door

Building Materials

The building materials used in these traditional houses are local resources, such as stone, wood, bamboo, etc. Rocks are an important resource support for the development of karst mountain settlements. Sedimentary rocks (limestone, dolomitic limestone) are widely distributed in Guizhou. They are characterized by exposed rock layers and moderate hardness. Therefore, villagers in Gaodang Village use stones in buildings.

In addition to wooden pillars, the building is made of stone from the foundation to the walls, and the roof is also covered with stone slabs. It is called a stone house as the saying goes. So almost all the spaces in the village are made of stone. Due to the difference in shape and color of the stone, each building presents different characteristics. The stone gives people a kind of honest, simple, and steady temperament, and when viewed from a distance, it gives people a High-end gray, showing the unique architectural texture of stone.

Mining And Construction Simultaneously

Most of the building materials in Gaodang Village are stone excavated by hand. To save labor, local people will choose to do it on the hillside near the base, that is, dig mountains and stones, use local materials, and crush the vacated spaces with stones. Filling, a wall of mountain rock excavated is used as the wall. Due to the layered characteristics of rock joints, the thickness of the quarried stones is similar, making the upper and lower surfaces naturally smooth, without the need for additional work to smooth them. Taking into account the characteristics of the local rocks, a “layer by layer” wall construction method was adopted, that is, after mining a layer of stone, one or more layers of walls would be built. This pick-and-use construction method saves labor and materials and has good economic benefits.

Villagers can easily gather suitable flat and block stones for construction, with flat stones ranging in thickness from 1.5 to 8 centimeters, and block stones approximately 40 to 60 centimeters thick. Depending on the requirements of the building, the Buyi people categorize the stones into different types and sizes. Flat stones, based on their cutting shapes and specifications, can be used for building facades, internal partition walls, roofing, and flooring. When used for walls, large blocks measuring around 0.3 meters by 0.6 meters are typically employed, interspersed with smaller blocks to enhance the defensive capabilities of the structure. Smaller stones, usually measuring 0.2 meters per side, are utilized for flooring,

offering permeability and facilitating plant growth. Additionally, flat stones can also be utilized for roofing, laid out in a diamond-shaped pattern, presenting a free-flowing, diverse, yet orderly appearance.

Analysis

Traditional Method Analysis

Passive design of buildings refers to the strategic use of natural elements and traditional techniques to regulate indoor temperature, lighting, and ventilation, without the need for mechanical systems (Mukhtar et al., 2019). This approach has gained renewed attention in modern architecture due to its sustainability and energy efficiency benefits. Examining the role and value of traditional technologies in passive building design sheds light on how ancient wisdom can inform contemporary practices and contribute to sustainable development.

Traditional societies, including indigenous communities like the Gaodang Buyi people in China, have long relied on passive design principles to create comfortable living environments in harmony with nature. The Buyi people's village of Gaodang stands as a testament to this tradition, where the abundant use of locally sourced stone in construction exemplifies passive design principles. The thick stone walls provide natural insulation, regulating indoor temperatures throughout the year. Furthermore, the careful placement of windows and openings allows for optimal cross-ventilation, ensuring a constant flow of fresh air while minimizing the need for mechanical cooling systems. These traditional techniques not only enhance thermal comfort but also contribute to energy efficiency and environmental sustainability.

In the context of modern architecture, the principles of passive design are being rediscovered and integrated into building strategies to reduce energy consumption and carbon footprint (Cabeza et al., 2018). Architects and engineers are increasingly incorporating traditional technologies, such as natural ventilation systems and thermal mass, into contemporary building designs. For example, in Gaodang Village, the use of locally sourced stone continues to inspire modern architects, who are exploring innovative ways to incorporate this sustainable material into their projects. By blending traditional wisdom with modern technology, architects can create buildings that are both environmentally responsible and culturally resonant.

The value of traditional technologies in passive building design lies in their effectiveness, affordability, and cultural significance (Wallbaum et al., 2012). The Buyi people's reverence for natural materials, such as stone, reflects a deep understanding of their environment and a commitment to sustainable living. The use of locally sourced materials not only reduces carbon emissions associated with transportation but also supports local economies and preserves cultural heritage. Additionally, traditional building techniques foster a sense of community identity and pride, strengthening social cohesion and resilience.

Environmental Friendliness

Gaodang Village is located in the karst landform area of Guizhou Province and is surrounded by rich and diverse natural landscapes. In the design and construction process of traditional building techniques, the rich local natural resources and natural forces were fully utilized, and a strategy of local materials was adopted, such as using local stone, wood, and other materials. In addition, design measures such as natural ventilation and lighting have been adopted to achieve harmonious symbiosis with the surrounding environment.

Most of the buildings in Gaodang Village use local resources such as local stone and wood. This approach effectively reduces dependence on external resources. Adopting simultaneous mining and construction technology, not only effectively saves construction time and materials, but also reduces building material transportation costs and reduces the adverse impact on the environment during the building life cycle.

Cultural Inheritance

The architectural style and structure of Gaodang Village perfectly reflect the traditional culture and lifestyle of the Buyi people. The buildings use traditional layout and decoration methods, continuing the long history and values of the area. By protecting and inheriting these traditional architectural techniques, Gaodang Village not only retains precious cultural heritage but also leaves precious historical relics for future generations.

Community Cohesion

The buildings in Gaodang Village are not only places where residents live but also symbols of community cohesion. Traditional building techniques promote cooperation and mutual assistance among community members, enhancing their sense of identity and pride in their local culture. By jointly maintaining and inheriting traditional building techniques, community members establish close ties and promote the harmonious development of the community.

Comclusion

As a tourist attraction for the Buyi people in Guizhou, Gaodang Village attracts many tourists with its unique geographical location, long history, and eye-catching architecture. However, the prosperity of tourism has had a profound impact on the daily lives of residents. Some villagers have chosen to leave the village and drift away from their traditional way of life. Although the government actively promotes tourism, the village's dependence on seasonal tourism puts it at risk of dwindling, thereby threatening its cultural heritage. To ensure the sustainable development of the village, some people have proposed curbing the exodus and taking measures to protect traditional architecture and technology. Despite the scarcity of land on the Guizhou Plateau and the prevalence of karst mountains composed of calcareous sand and shale, great strides have been made in architectural innovation in different regions. This geographical restriction has inspired diverse architectural innovations that make full use of local abundant natural resources, which is also one of the important factors promoting sustainable economic development. The area is rich in stone resources, favored for its good defensive properties, and often used as the main material in building houses. This approach not only improves the structural stability and safety of the residence but also promotes the development and utilization of stone resources, laying a solid foundation for the economic development of the area. By making full use of local material properties and flexibly selecting building materials and technologies, people promote the rational use of resources and sustainable economic development. This traditional construction technology and material selection not only demonstrate the wisdom and survival philosophy of the Gaodang Buyi people, but also provide important support for the sustainable development of the local economy.

References

Cabeza, L. F., de Gracia, A., & Pisello, A. L. (2018). Integration of renewable technologies in historical and heritage buildings: A review. Energy and buildings, 177, 96-111.

Cao, S., Liu, Z., Li, W., & Xian, J. (2021). Balancing ecological conservation with socioeconomic development. Ambio, 50(5), 1117-1122.

Diffenbaugh, N. S., & Burke, M. (2019). Global warming has increased global economic inequality. Proceedings of the National Academy of Sciences, 116(20), 9808-9813.

Dipasquale, L. (2020). Understanding Chefchaouen: Traditional knowledge for a sustainable habitat: Firenze University Press.

Flyvbjerg, B. (2011). Case study. The Sage handbook of qualitative research, 4, 301-316.

Fu, J., Zhou, J., & Deng, Y. (2021). Heritage values of ancient vernacular residences in traditional villages in Western Hunan, China: Spatial patterns and influencing factors. Building and Environment, 188, 107473.

Hossain, M. U., Ng, S. T., Antwi-Afari, P., & Amor, B. (2020). Circular economy and the construction industry: Existing trends, challenges and prospective framework for sustainable construction. Renewable and Sustainable Energy Reviews, 130, 109948.

Mittal, I., & Gupta, R. K. (2015). Natural resources depletion and economic growth in present era. SOCH-Mastnath Journal of Science & Technology (BMU, Rohtak)(ISSN: 0976-7312), 10(3).

Mukhtar, A., Yusoff, M. Z., & Ng, K. (2019). The potential influence of building optimization and passive design strategies on natural ventilation systems in underground buildings: The state of the art. Tunnelling and Underground Space Technology, 92, 103065.

Ou, P., Huang, R., & Yao, X. (2016). Economic impacts of power shortage. Sustainability, 8(7), 687.

Rong, W., & Bahauddin, A. (2023). Heritage and rehabilitation strategies for confucian courtyard architecture: A case study in Liaocheng, China. Buildings, 13(3), 599.

Sahlberg, P., & Oldroyd, D. (2010). Pedagogy for economic competitiveness and sustainable development. European journal of education, 45(2), 280-299.

Wallbaum, H., Ostermeyer, Y., Salzer, C., & Escamilla, E. Z. (2012). Indicator based sustainability assessment tool for affordable housing construction technologies. Ecological Indicators, 18, 353-364.

Wang, Y., Wang, W., Zhou, H., & Qi, F. (2022). Burning Characteristics of Ancient Wood from Traditional Buildings in Shanxi Province, China. Forests, 13(2), 190.

Watson, R. T., Boudreau, M.-C., & Chen, A. J. (2010). Information systems and environmentally sustainable development: energy informatics and new directions for the IS community. MIS quarterly, 23-38.