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Eco-lodging as a Solution for Sustainable Ecotourism Development in Al-Fayoum Egypt: Indoor Air Quality Simulation

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ABSTRACT

Ecotourism development provides opportunities to diversify the tourist base, particularly in desert areas such as Egypt's Al-Fayoum Oasis. Therefore, the study's aim is to enhance Ecotourism in Al-Fayoum, Tunis Village, by providing environmental Eco-lodges, which are an important aspect of sustainable ecotourism development process. Thus, the study investigates three successful examples for Eco-lodges that clarify key principles for Eco-lodging design guidelines with respect to pillars of sustainability. Moreover, a concluded framework is proposed as assessment tool for new or renovated Eco-lodges in Al-Fayoum. The study focuses on Tunis village Eco-lodges' rooms indoor air quality and the excessive use of air-condition units, therefore the study examines the natural cross-ventilation airflow circulation system for two Eco-lodge's indoor rooms using Ansys Fluids/ computational fluid dynamics (CFD) simulation program. The simulation embodied the indoor air movement of each room thus the final configurations of contour lines of parameters, such as velocity and pressure, are observed. Based on simulation results, Kom El-Dikka is estimated to provide for approximately 57% of total internal ventilation performance, whereas Zad El-Mosafer accounts for around 42%, implying that the Kom El-Dikka room is better ventilated. The study proposes recommendations for optimizing thermal comfort in Ecolodges in Al-Fayoum through natural ventilation patterns.

KEYWORDS: Sustainable Ecotourism, Ecolodge, Energy Conservation, Indoor Air Quality; Passive Design Solutions, Ansys Fluids / CFD Simulation Program.

1. INTRODUCTION

Ecotourism as a very specific form of nature-based tourism, or it can be said that ecotourism describes a nature-based operation in the field of tourism [1]. Sustainable ecotourism growth is an important issue today in the world [2]. Ecotourism growth dimensions apply to both environmental, economic and social aspects of the tourism development [3]. Egypt has a host of unique ecosystems and natural attractions in the world [4]. Al-Fayoum oasis is a promising area that has all potentials to be a famous ecotourism area in Egypt [26]. The study thus argued that growth of ecotourism in the longer term would be more economical, protect and maintain the natural environment and retain its socio-cultural capital [4, 5]. Ecotourism provides a rapidly developing form of tourism that fits what El-Fayoum

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has to offer. Ecotourism would make excellent use of El-Fayoum's most important asset: authentic natural and cultural resources. Investments will have revenues for a long period, if the most important assets of El-Fayoum are preserved [26]. The diverse environment in El-Fayoum governorate provides an expressive sample of the diverse Egyptian environment reflecting in the form of activities and different cultures [26]. This paper principally attempts to highlight the major potentials in the Fayoum oasis as well as the constraints that hinder its progress to occupy a distinguishable position on the Ecotourism map of Egypt. Al-Fayoum is a beautiful oasis that is endowed with rich natural and cultural heritage, and one of the most valuable touristic areas is Tunis Village [20]. Since sustainability is considered as an umbrella that covers all human activities and products, in this paper discusses the sustainability and its policies and principles for sustainable development are considered as factors that make a link between Ecotourism and the Eco-lodge in Egypt's protected areas for energy efficiency [12]. The purpose is to determine the most important sustainable techniques 'Interior Green Principles' for constructing & designing Eco-lodges to reduce energy consumption, which should be done in a way that presents the site's cultural & heritage resources, that gives the Eco-lodge's a strong sense of place & reduces the potential impacts on the environment, and for guaranteeing ecotourism development in Egyptian desert context 'Al-Fayoum Oasis,Tunis village'.

As energy, is one of vital elements in tourism activities, therefore the research main approach will focus on energy efficiency and its relation with ecotourism [11]. El-Fayoum climate condition is a hot desert climate, therefore, ventilation is the most essential building function for indoor air quality management to provide a safe and relaxing atmosphere. Natural ventilation is a technique suitable for use in "warm or hot environments" during the year [31]. Accordingly, the best way to improve the indoor air quailty of the space atmosphere is to focus on applying wind-driven natural cross-ventialtion. However, accommodation is an essential element in tourism growth and promotion in any region [10]. The energy cost in recent years has risen so much that accommodation buildings now have ways to use natural lighting and construct energy-effective buildings [15]. As sustainability of tourism in the Middle East expands, the high demand for ecologically sensitive well-planned facilities meets "Ecological lodges" [14]. Ecolodges are described as "the accommodation facilities and services established in, or very near, natural areas visited by ecotourists" [18]. Eco-lodges have a special interest in sustainable development as they are small, medium, and micro-enterprises that can produce many positive results in highly rural areas of biodiversity, where other kinds of innovation are under way or are often environmentally harmful [16]. Unlike traditional lodging, one of the most important distinctions with Ecolodges is that they give travellers the chance of a responsible and positive experience [16]. Ecolodges provide an exclusive holiday with nature to their environmental conscious customers and thus obtain a significant competitive advantage [17]. This suggests that an Ecolodge should seek environmental, social, and economic sustainability according to the literature [19]. Hence, the study's main problem definition is the indoor air quality (IAQ) and the excessive use of air-conditioning units of the Eco-lodge rooms in Al-Fayoum, Tunis village.

The approach in the paper consists of multiple sections. Section 1 Overview of the Eco-lodge overview approach & Interior eco-design principles. The rest of the paper is structured as follows. Section 2 showcases three Eco-case Studies examples & final guidelines results. A case study application details, & sustainable assessment for the two comparison Eco-lodges' case studies in El-Fayoum, Tunis village, environmental evaluation on Energy Survey, and finalizes the experimental study method is adopted in section 3. The Simulation results are explained in section 4 depending on the evaluation scaling parameters. The Simulation Discussion results & final eco-criteria formal assessment are clarified in Section 4. Finally, Section 5 concluding and modifying further recommendation of this work.

2. THEORY AND METHODS

2.1 Eco-lodge's Green Principles Of Interior Design For Egyptian Context

The fundamental definition for an Eco-lodge "It is a five – to 75 – room, low-impact, nature-based, financially sustainable accommodation facility that helps protect sensitive neighbouring areas; involves and benefits local communities; offers tourists an interpretive and interactive participatory experience; provides a spiritual communion with nature and culture; and is planned, designed, constructed and operated in an environmentally and socially sensitive manner" [17]. At the core of providing the consumer with an environmentally friendly travel experience is a responsive architecture of Eco-lodge [18]. There are architectural features that must be sustainably incorporated in each Eco-lodge such as, "physical context, indigenous architectural styles, facilities and interior design elements" [21].

Conferring to the Egyptian context, four key green principles of interior design are established and deliberated in the spacious rooms for the Eco-lodge [37]: (1)Site & environmental analysis: The fundamental concept here is to create a connection between facts of the site and all aspects of regional environmental conditions in order to initiate the green interior design process in the eco-lodge [21, 22], such as location, natural light, & natural ventilation; (2) local culture & authenticity: The distinctive characteristics of local culture and cultural heritage are the basic ecological values which can be provided to visitors by the local community so that they have a strong connection with regional traditions. From an authentic cultural perspective ecolodge is built to encourage an exchange of rich natural and cultural heritage of the region [22]; (3) Maximizing the use of organic building materials: Throughout this context, the key primes of ecological activity are the use of local organic materials that friendly to the environment and that form part of the landscape. The eco-lodge building and the local materials seem to expand the natural environment and to evolve from the climate [22]; (4) Sustaining the aesthetic quality of the local surroundings: This can be illustrated with a special focus on interior shapes, colors and textures in the context of eco-friendly interior design. Internal wall and ceiling shaped forms are important elements of the Ecolodge interior to make the essence of the outside feel an intense experience. The beauty of the exciting landscape should be used as a special and essential characteristic of the region and of the ecosystem in interior areas [23].

2.2 Analytical Case Study Examples

A successful scenario for the Eco-lodge can include the combination of the most environmentally sound and sustainable traditional and modern building technologies and materials. The foundation of effective sustainable development can be called carefully planned and implemented construction [24]. There are significant factors that must be carefully taken into consideration for the design of the Eco-lodge's interior spaces, such as an "Ecotourist perspective, furniture design & materials, indoor air quality and the green principles of interior design" in order to create a better and comfortable indoor environment [24]. Referring to the literature review in the study approaches, the three case study examples have been carefully chosen following precise criteria, which follows the green principles of interior design for Eco-lodges and under the predominant aspects of the three pillars of sustainability. The design criteria & guidelines of Eco-lodges have been emphasized clearly to be as a structure for the studied case study in the following Table 1. For such examples, the descriptive data are obtained and classified into major categories under the three aspects. To be more precise these Eco-lodges have been selected, in & outside of Egypt, in order to obtain a heterogeneous perspective. The selection was based on:

(1) All examples have the same climate condition "*hot/dry desert climate*".

(2) Their great attraction for tourists; having natural culture and world heritage site.
(3) Applying Ecotourism to conserve the natural heritage or the need to integrated tourism strategies which consider the environment, local communities' benefits, and long-term sustainability.

Table 1. Design categories & classification for selected examples, & Final Guidelines Outcome [24].

Aspects	Category	Classification	Guidelines
Environment Aspect	• Surrounding environment, Site & Infrastructure: • Architectural features & Technical aspects:	(Preserve settings, landscape, vegetation, wildlife, technical elements installed in the site as basic infrastructure). (Site area (description) & landscaping, number of rooms & facilities /spaces (interior & furniture), construction systems & materials, waste & water sources management, energy systems (energy efficiency & climate description), architectural design, sanitation & solid waste management).	**Environmental Objectives:** • Provide the simplest technology that incorporates energy conserving strategies. • Knowledge visitors about local environment & valuable experience. • Visitors' awareness on traditional & natural features, wildlife & local people.
Socio-Cultural Aspect	• Activities & People:	(Activities for tourists, type of local population, residents' employment & local crafts, cultural life & heritage, nature protection, tourist education).	**Socio-Cultural Objectives:** • Provide a sense of belonging & ownership among tourists. • Provide relaxing environment. • Provide opportunities of local crafts & traditional arts of the region.
Economic Aspect	• Investment income:	(Marketing & product development, local resources, total investment income cost for local community & people's benefits).	**Economic Objectives:** ◎ Raise local standards of living by involving local population in ecolodge's operation. ◎ Enhance awareness for the use of local resources.

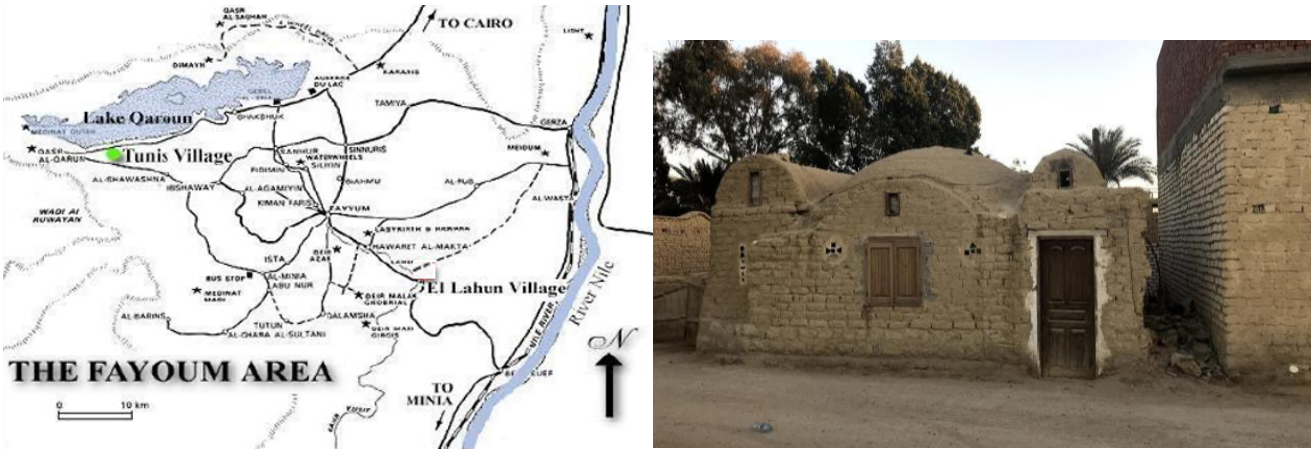
A successful scenario for the Eco-lodge can include the combination of the most environmentally sound and sustainable traditional and modern building technologies and materials. The foundation of effective sustainable development can be called carefully planned and implemented construction [27]. As successful cases, 'Al-Karm, St. Katherine,' 'Adrere, Siwa,' and 'Feynan, Jordan,' demonstrated that they all achieved all areas of sustainability and particularly the green interior concepts of Eco-lodges. There are significant factors that has been carefully taken into consideration for the design of the Eco-lodge's interior spaces, such as an "Ecotourist perspective, furniture design & materials, indoor air quality and the green principles of interior design" to create a better and comfortable indoor environment. The environmental feature of El- Karm Eco-lodge Case 1 is that it uses eco-technology, a sustainable low-tech alternative using local and natural resources, and it adopts a bio-climatic Passive Architectural Design (local Bedouin vernacular architecture) [47]. Adrere Amelia Eco-lodge Case 2 utilized Climatic sensitive materials, as well as passive cooling and cross ventilation (natural approaches) for energy efficiency, and the lodge design incorporated sustainable and unique architecture (traditional Siwan building techniques) [40]. The energy system at Feynan Eco-lodge Case 3 is 100% sustainable solar power, with rooftop (PV) panels (electricity) and a solar heating system, and the building was developed using desert architecture (ecologically shaped elements from Jordanian traditional buildings) [48]. According to final assessment framework of examples, the main experimental study focus will be in the "Environmental Aspect", conferring to the major issue of Tunis village Eco-lodge's indoor rooms. Eco-lodging facilities over there do not meet the criteria but are still branded as "natural".

However, eco-lodges should be different from tourist hotels because they strive to respect ecotourism principles [16]. The lack of knowledge and/or expertise in dealing with the natural resources, the environment and local culture leads to this problem. Therefore, "well-designed" Eco-lodges can maintain comfortable indoor temperatures, minimizes additional heating in hot climate conditions, and operate without air conditioning. The design should be settled and oriented to minimize the indoor energy consumption for each room [38] Now days, the Eco-lodges' issue of indoor air quality (IAQ) is among other indoor problems that need to be tackled to prevent negative safety and well-being impacts for

occupants. The best solution for certain weather conditions for not using AC indoors, is to enhance IAQ by incorporating the ventilation system, which is the passive cooling system to enhance and reduce energy usage [33]. Natural ventilation is widely understood to allow the natural airflow at the discretion of the occupants through the operable sections of the building envelope "windows" [28]. To move air flow through the vertical shaft, the prevalent wind and temperature variations may be applied; multiple stack designs may be implemented to monitor or enhance local environment performances [28].

2.3 Local Case Study Application

Fayoum profits from its location near Cairo and convenient access for local and foreign visitors to many well-paved [20]. The governorate of El-Fayoum is one of the governorates of Egypt, located geographically in the middle of the country [25]. Fayoum is divided into three main destinations; Tunis Village, Lake Qaron, and Wadi El Rayan, from which we can delve into all sorts of activities that you can enjoy. One of the most valuable touristic areas at Fayoum is the "*Tunis Village*", it is a small village which is situated on the Southwest end of Lake Qaron, in the midst of a high palm tree, and an agricultural land decorated with olive and rose branches together, inhabited by hundreds of pioneers of pottery, illlusrtated in fig.1(a) [25]. Locals recount the village's history, explaining that it evolved from the establishment of a wealthy family, the Abd al Basseir family and was not long before the beginning of the 20th century [49]. The family began cultivating and building on the no-land, man's employing local villagers and builders. Ownership laws did not apply to uninhabited land at the time. In a few decades, the settlement grew to become Tunis village, transforming the area. Tunis remained a small, secluded community until the late 1960s. It was a poor town. Simple adobe carrying walls were its initial traditional architecture and the roof was made of palm tree beams shown in fig.1(b)[49]. As a result, Al-Fayoum vernacular architecture refers to the use of natural materials from the surrounding environment, natural resources, and passive solutions, as illustrated in fig.1(b), which compares an old house using those environmental aspects to a new house using concrete building materials that violates the village's traditions.

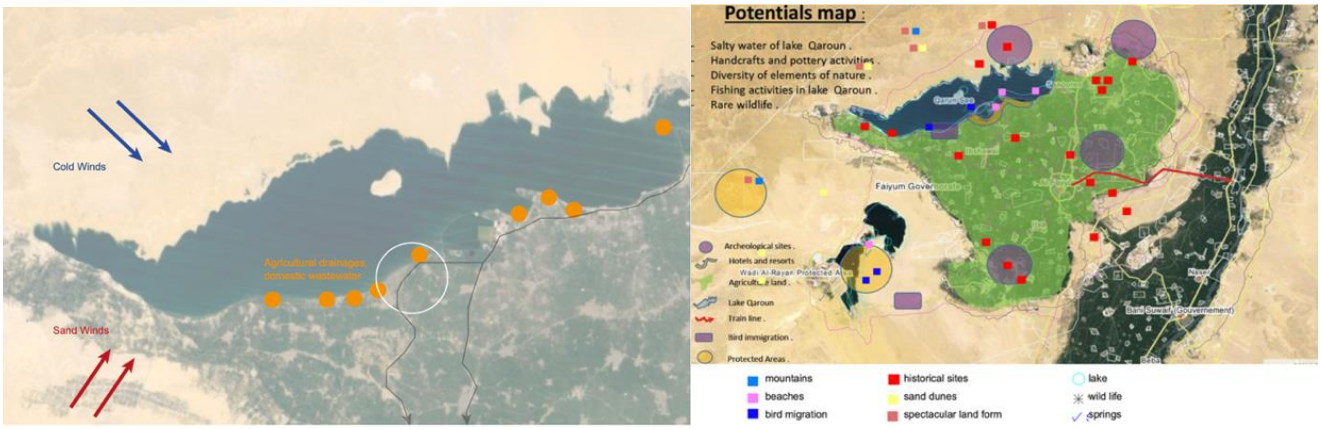


(**a**) (**b**)

Fig.1. (**a**)Sketch map of the Fayoum depression with the location of Tunis Village [49]; **(b)** The old mud brick house of Ahmed Abdallah stands next to the new concrete building of his extended family's house, 1990 [49].

Ecotourism opportunities as well as opportunities for Eco-lodge development are made possible. Fig.2 shows the potential map and lake site analysis that characterises the wind direction of the village. Nowdays, Tunis village is considered as a specialist pottery center for artists, whose designs are

commonly exhibited in Cairo's shops. The village of Tunis is a peaceful place to relax and enjoy rural life; with a number of attractive ecolodges which offers good accommodation [26]. The village is characterized by its special architectural style. Famous architects designed traditional buildings in this place to preserve the cultural heritage and the identity of El-Fayoum [26].



(**a**) (**b**)

Fig.2. (a) Analysis of the lake site; (b)Potential's map of Al-Fayoum[26].

Tourists are attracted to the area, as an "Eco-lodges" culture exists in this place. Most of the owners and residents are University professors and writers, who feel the value of this space. This is probably the reason for the cultural and heritage persistence. The natural environment and environment-friendly usage is a dominant aspect of the village. Walking through Tunis village, and passing by the existing hotels, the same architectural style is found everywhere, which is applied in a special urban style [25]. The rural lifestyle attracts a lot of tourists and even Egyptians living in cities to spend calm and comfortable days in El-Fayoum. The "selection of the case study area Tunis Village" to be considered the zone of eco-development site, was based on many aspects [25]:

- Its unique location very near to the capital 'Greater Cairo Region' in the Western desert, in the Western South of Cairo governorate.
- The proximity to the shoreline offers a linear expansion in the future for more ecolodges along lake.
- The significant climate condition and beautiful views over the lake shoreline.
- It rich natural resources and features; for example, it's one of the best places to observe bird migration or other rare species.
- The current presence of Eco-architecture, vernacular architecture, and ecotourism activity.

An analysis of Tunis village hotel in Fayoum governorate as one of the most important Eco-coastal villages in Egypt. One of the most important considerations is the design and planning of the Eco-hotel (Eco-lodge), is to understand local culture and avoid introducing strange values: which has been achieved by the village of Tunis, where hotels established architectural designs compatible with the architectural character of the village to develop their sense of participation, with the introduction of crafts and handicrafts in the work of interior design, as well as providing the necessary places to display local crafts and the practice of folk art through open squares and main squares. It also appears in the pictures where the spread of the craft of ceramic industry, kilim, and palm leaves works and other crafts to protect the cultural and historical heritage and natural resources [20]. Tunis village offers several guest houses and lodges for visitors to stay. Tunis village is easily accessible from Cairo; the journey takes approximately one hour by car or by public transportation: Using a car from Cairo- Fayoum (from pyramids), 20 km

before the Fayoum City, turn right towards Qaron lake, driving along Lake Qaron around 40 km, then turn left around 1 km before the crossroad to the Wadi El- Rayan protectorate area [26]

2.4 Evaluation & Data Collection

According to a study conducted in this field, safe interior environments are extremely important by ensuring that the architecture of the building from the outside and from the inside does not emit substances and gases into the interior atmosphere. The main feature of an Eco-lodge's interior space is that the orientation and location of functions in the space and their relation to natural ventilation and daylight [27]. As towards case study selection shown in the following fig.3, the two most popular eco-lodges in Tunis village were evaluated as being the most applicable according to the paper's literature study. The goal of preferring these two eco-lodges, as associated their parameters and examined them, in order to determine which would be the ultimate example of the ecolodge in the area and come out with as a former checklist assessment as a basis for new or renovated ecolodges for the future linear expansion along the lake shoreline network development in Tunis village. Kom El Dikka Agri-lodge; the first selected ecolodge, which is built with Islamically inspired architecture, and it is 30-year-old private olive farm that was recently developed into an Agri-tourism lodge. Kom El Dikka is a 45-acre olive farm on the hills of Tunis Village in Fayoum overlooking Lake Qaron. An Agri-tourism lodge, overlooking lake Qaron, this property occupies a beachfront location [25]. Zad El Mosafer Eco-lodge; is the second selected ecolodge, which is the first lodge that was established in the Fayoum province (opened 2004). It provides its visitors with a calm, tranquil environment full of authentic activities by which to create lasting memories and experiences [26].

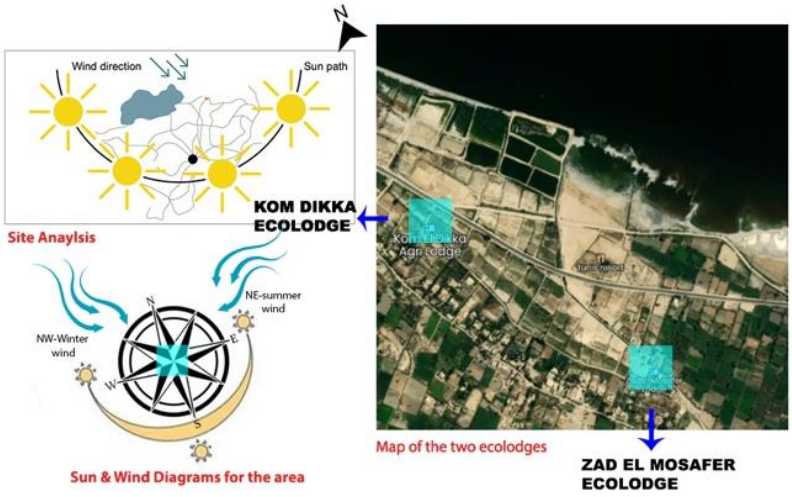


Fig.3. Location of the Case Studies & Site Analysis.

2.5 Sustainable Assessment

According to the literature review concluded framework, there are three pillars of sustainability, environmental, socio-cultural, & economic aspects that has been briefly studied & surveyed. These aspects have been analyzed for both ecolodges case studies to address the key issue, throughout research and actual site survey visit. As for socio-cultural aspect for both ecolodges "Local culture & traditional crafts", the lodges were built by local people, & it continues to provide employment for many villagers, thus contributing to the energization of the Tunis economy. Hence, hiring employees for lodge from the community & engage with the locals to exploit & support their crafts & culture (local craftsmanship).

"Activities", both offer on-site activities for the ecotourists' benefits and entertainment [26, 41]. Zad El-Mosafer eco-lodge offers, fishing, billiards, darts, canoeing, hiking, cycling, horse riding, bird watching, camel safaris, and water sport facilities. Kom El-Dikka Agri-lodge offer, Bird watching, sailing, horseback riding, fruit and vegetable picking, animal petting in their very own zoo, hiking, jogging, sailing, duck migration observation, pottery schools, planting, arts and crafts, mountain bike riding, and boat rides on the lake [26, 41]. For the economic aspect, both ecolodges enhance and provide opportunities self-reliant local economy by only hiring local village people for employment. For instance, Kom El-Dikka own olive farm, which this farm added vegetable & fruit organic agriculture to its program to benefit the local families, occupants need and has since expanded to include selling Certified organic products to Tunis village and Cairo residence. Accordingly, Eco-lodges sources of goods and services increase income for locals and the entire village. Consequently, it was decided after observing both lodges on live visits that a deluxe bedroom (double room) examination would be carried out provided that they have almost the same room areas, the same room facilities services, same orientation and a similar capacity of people as rooms can serve. The analysis and evaluation, of the interior rooms, of these two ecolodges should at least has one similar parameter, so that a comparison outcome can be successfully obtained. According to fig.4., environmental aspect has been briefly discussed for the two eco-lodges.

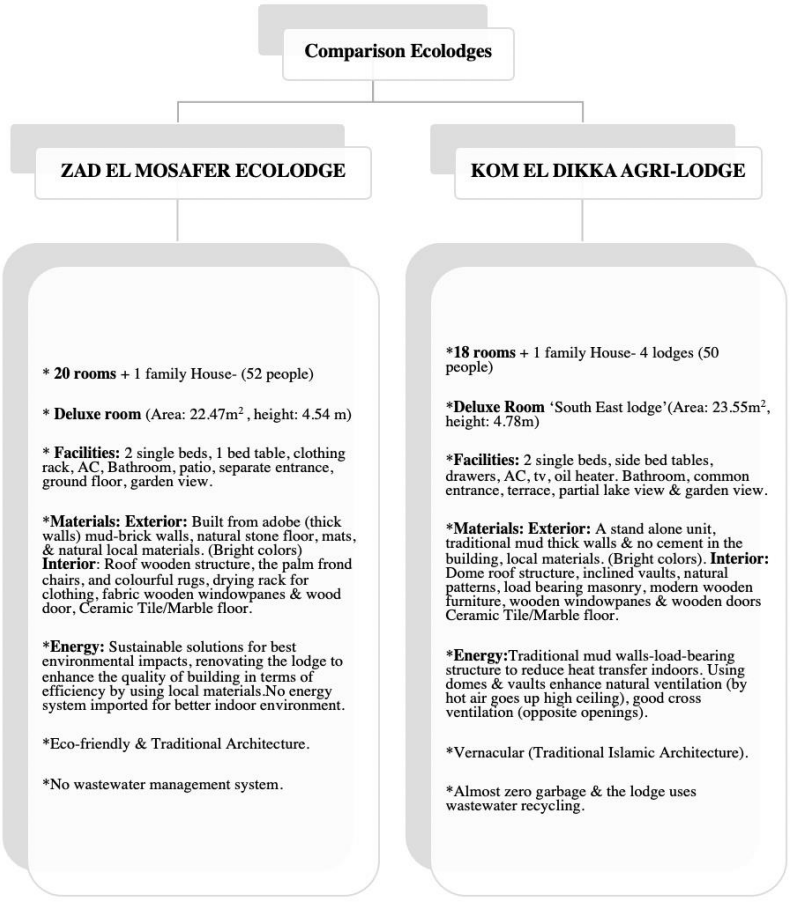


Fig.4. Eco-lodges' Case studies environmental aspect comparison chart.

2.6 Environmental Evaluation Focus on Energy Survey (IAQ)

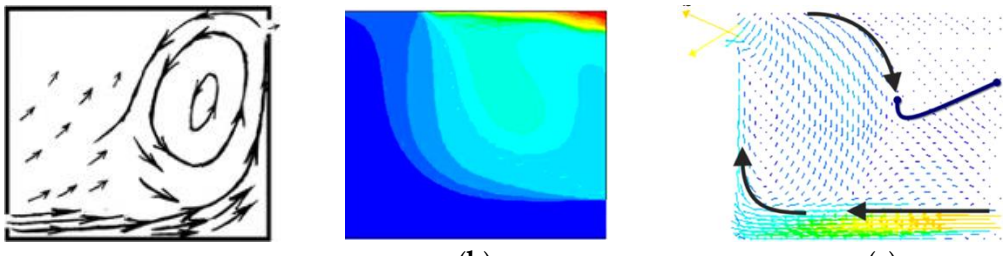
After survey, the main experimental study focus will be in the environmental aspect, according to the major issue of Tunis village eco-lodge's indoor rooms. Eco-lodging facilities over there do not meet

the criteria but are still branded as "natural". However, ecolodges should be different from tourist hotels because they strive to respect ecotourism principles [17]. The lack of knowledge and/or expertise in dealing with the natural resources, the environment and local culture leads to this problem. Therefore, "well-designed" eco-lodges can maintain comfortable indoor temperatures, minimizes additional heating in hot climate conditions, and operate without air conditioning. The design should be settled and oriented in order to minimize the indoor energy consumption for each room [34].

Nowdays, Al-Fayoum Tunis village eco-lodges' major issue of indoor air quality (IAQ) are among other indoor problems that need to be tackled to prevent negative safety and well-being impacts for occupants [28]. The best solution for certain weather conditions for not using AC indoors, is to enhance IAQ by incorporating the ventilation system, which is the passive cooling system to enhance and reduce energy usage [32]. Natural ventilation is widely understood in order to allow the natural airflow at the discretion of the occupants through the operable sections of the building envelope "windows" [29]. In order to move air flow through the vertical shaft, the prevalent wind and temperature variations may be applied; multiple stack designs may be implemented to monitor or enhance local environment performances [36].

2.7 Experimental Study Method

The implications of such a high energy consumption are concerning for a populous country such as Egypt [9]. Therefore, it is now unquestionable that innovative cheap and sustainable technology should be adopted for more effective and convenient buildings [30]. A good understanding, prediction and relation of natural ventilation phenomena in buildings to external environment will help overcome problems. People spend as much time indoors as possible. Under favourable outdoor climate conditions, efficient natural ventilation can provide thermal comfort for building occupants [30]. The cross ventilation has greater cooling potential than the simple ventilation, up to 3 times higher with the same openable surface as described on the following Fig.5(a). Although, Fig.5(b) & 4(c) illustrates how the two-dim simulation result will be. Passive ventilation systems share with infiltration the use of renewable energy to provide ventilation. Yet unlike air leakage and open windows, passive ventilation systems are designed to provide precise quantities of ventilation to eliminate both energy burden and air quality times due to inadequate ventilation [32]. Natural wind-driven ventilation is an interesting and passive alternative in view of climate change's issues and sustainable objectives. In order to be efficient, the approach must deliver the airflow required to meet the indoor air quality criteria and external air thermal comfort parameters. However, natural ventilation is very variable, due to the climate force of wind (wind effect) and temperature (stack effect), which is an essential element for evaluating natural ventilation rates [46].



(**a**) (**b**) (**c**)

Fig.5. **(a**) Sketch generated by the observation of the phenomenon of natural ventilation of buildings [30]; (**b**) Illustrates the Contours of temperature [30]; (**c**) Velocity vectors with note of curves showing the main flow field [30].

Envelope design is an important factor in deciding the energy usage in service of a building, and choices on its components often play a critical role in the energy costs needed for cooling as well as the necessary passive cooling [33]. Passive design involves the use of natural flows of energy to preserve thermal comfort: 1-Great orientation selection. 2-Promoting natural ventilation and shade during summer and transitional seasons. 3-Choosing a building envelope material of high heat capacity and low heat transfer coefficient. To find specific requirements for cross ventilation is necessary to use tools or guidelines for evaluating sustainable buildings such as the "Guide to Sustainable Building of the Basque Country, GREEN, LEED, RESET, PASSIVHAUS or BREEAM". These methods combine the effects of wind and temperature, so they do not have the limitations of the previous ones [45]. They are methods for predicting the behaviour of air in rooms using a computer. Currently, CFD tools are the most used methods for calculating ventilation flow rates compared to other analytical, empirical or scale models methods. Ansys Computational-Fluid-Dynamics Methods, 'CFD' solve the Navier-Stokes equations for flows. For laminar flows, the computed results are accurate and reliable. The CFD program with eddy-viscosity models solves air velocities, temperature, contaminant concentration, and turbulent quantities in a space [42].

3. RESULTS

Furthermore, ventilation is extremely important in the sustainable design of buildings. With proper location of inlet and outlet windows, uniform flow is possible at working area. With availability of advance computing hardware and software, it is possible to model the air flow on desktop computer [34]. CFD has opened new doors for researchers to simulate practical computer problems. Researchers and software developing company validated the software with experimental results [35]. For two Eco-lodges' rooms the indoor air circulation flow of heat and air transfer has been studied. The simulation result provides guidance for the design of the indoor ventilation system in the densely populated area of Al-Fayoum Tunis Village. In order to understand air flow with natural ventilation, and to study thermal comfort by wind-driven cross ventilation inside the room, the stagnation and venturi conditions of cross ventilation were studied. Model rooms air circulation were performed and experimented using the software CFD (fluid flow) completely incorporated into the ANSYS Workbench environment [43].

As for Experimental setup to study the air circulation in full scale model was very expensive. Therefore, the Ansys/ CFD method is the best option for airflow studies because it is inexpensive. It also allows flexibility to study the effect of various parameters on output results. It has been found that the results of experimental and numerical simulation are fairly balanced [44]. Correct design of windows, proper orientation and shadow design is important for reduction of energy consumption in building. Increased building ventilation demands with the exposure of a window to solar radiation. Optimum window configuration eliminates heat and air conditioning costs [34]. The ventilation system of the Eco-lodges' room was studied using Ansys Fluids computational fluid dynamics (CFD). Simulation offers an understanding of ventilation system performance, reliability and adequacy. It also offers significant proposals to regulate electricity, comfort and air quality in the room for occupants

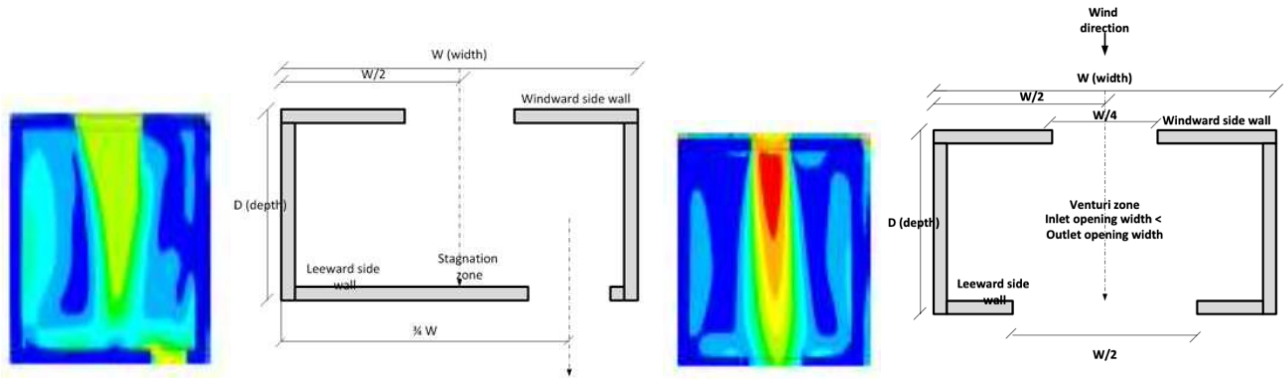
3.1 Case Study Outcome

3.1.1 Validity Research Example

Inputs of the Simulation Analysis, which is made through the program to improve natural ventilation via windows, went through several steps for the validity [45]. 'First', the natural cross ventilation options that is possible to apply in the existing building are evaluated, considering the following aspects: Building typology and morphology (opposing facades), Climatic zone: warm humid climate (It is favourable for natural ventilation during the day in warm periods, depending on outdoor temperature), Dominant wind

direction: velocity, frequency and wind direction obtained from the compass rose of Málaga (Pressure zones (windward) and suction (leeward) in building are determined, considering also the obstacles to the arrival of the wind), Distribution, size of openable windows, opening systems and complementary elements. 'Second', Geometrical definition of the different facade openings configurations: To enhance natural ventilation, it is proposed to open new openings in the interior facade, facing those of exterior facade. The size of the new openings fulfils the minimum openable surface required, 'Third', the orientation of the building with respect to the dominant wind direction is checked [45]. Then, the direction and characteristic intensity of the wind is determined from the compass rose. Finally, the pressure coefficient applied to the opening is calculated in vector form. The different ecolodge room cases presented in location and sizes of windows aim to analyze different possible circulation of air flow inside the lodges' rooms to select the one that meet best the needs of the user. To sum it up, the simulation parameters input to conduct the rooms air circulation are, 'weather data' which includes Temperature Data, Humidity Data, Wind Speed, Solar Radiation, Cloud Cover. For simulation of windows location, weather data of wind speed is important. Windrose diagram defines the direction and speed of wind speed from different direction throughout the year Although, the location, room size, floor height, windows size, walls, boundary condition, and mesh sizing [29, 45].

As for the study methodology's validity, similar case study examples were analyzed and obtained with the Ansys/CFD software that is used for measuring the airflow patterns and velocity contours. The studied example aimed to study thermal comfort by wind-driven cross ventilation inside two single rooms by using stagnation and venturi conditions of cross ventilation [50]. Stagnation and venturi conditions are techniques used to obtain cross-ventilation that can adjust wind velocity inside a single room illustrated in fig.6. These methods are based on the relationships between inlet and outlet openings, as well as internal faced walls. The Venturi result can be used to increase indoor air velocity by using narrow opening widths, whereas the stagnation result can be used to decrease indoor air velocity by designing walls facing inlet openings [50]. One way to measure the performance of a naturally ventilated space is to measure the air changes per hour in an interior space. The best way to ensure effective ventilation is to allow for an exchange of outdoor and room air.

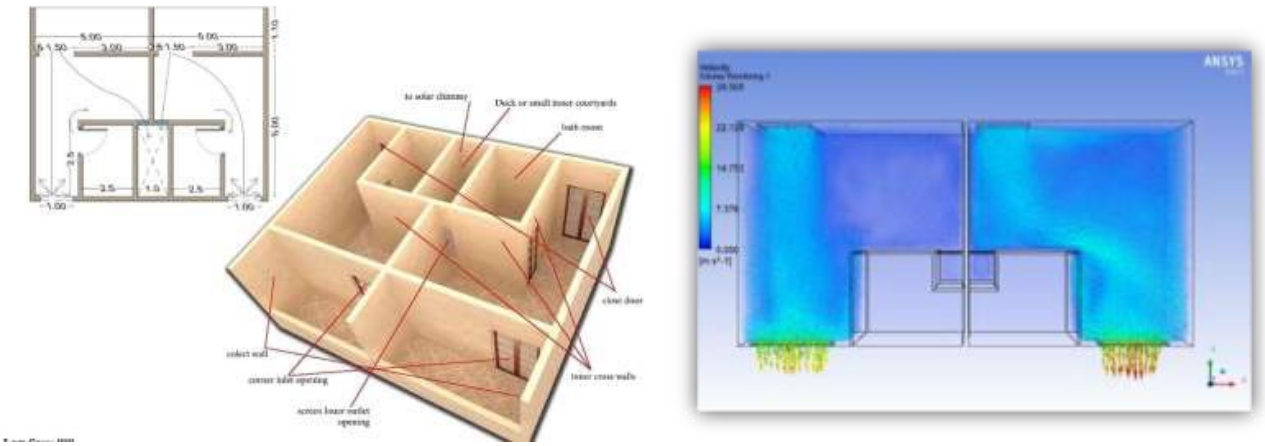


(**a**) (**b**)

Fig.6. (a) Stagnation condition inside cross-ventilation single rooms;(b) Venturi condition inside cross ventilation single room & the Simulation results examples with their velocity [50].

In cross ventilation at opposite side walls inside single rooms, a stagnation condition occurs when the center of the inlet opening at the windward side wall faces the center of the inside leeward sidewall [36]. The goal of the stagnation condition in cross-ventilation is to reduce wind velocity and distribute air movements within indoor spaces. As a result, this condition is appropriate for windy regions with wind speeds greater than 5 m/s on the Beaufort scale. The goal of Venturi's condition in cross-ventilation at opposite wall sides is to increase wind velocity inside indoor spaces or between inlet and outlet openings [50]. This condition is appropriate for low and moderate wind velocity regions with wind speeds less than 5 m/s on the Beaufort scale. It is necessary to face the inlet and outlet openings for venturi conditions to occur within a single room. Furthermore, the widths of inlet openings must be less than the widths of sidewalls and outlet openings [50].

Utilizing driven wind to improve passive cooling in any environment relies on whether the cooling is direct or indirect. Cross-ventilation techniques, which consist of two openings on opposing side walls inside a single space, can produce thermal comfort by increasing airflow patterns that differ in direct and indirect cooling [36]. Simulation utilizing ANSYS software is used to produce contours lines of indoor air velocity and their indoor ventilation area. Consequently, a simulation experiment was conducted to evaluate the four case studies in terms of stagnation and venturi performance, as well as suitability for various wind speeds according to the Beaufort scale [50]. The findings can be used to create distinct room function prototypes that are appropriate for low and high wind speeds. Thus, the dimensions of the single room are 5 m (width) * 5 m (length) * 3 m (height). The dimensions and positions of the openings are provided based on a basic living room design. The proportions and placements of the inlets and outlets, though, vary from case to case, as the ratios of the widths and the heights were the main subject of the study. According to studies, the size and position of both the inlet and outlet openings, as well as the wind direction, all contribute to adequate ventilation. When the dimension and position relationship between inlet and outlet apertures is analyzed, stagnation and venturi circumstances can produce superior ventilation results [50]. A proposed prototype for two different hotel rooms in a windy moderate hot zone climate were examined. Simulation results for the stagnation room should be suitable for high and moderate wind velocity that is over 6 m/s, and the venturi room should be suitable for low wind velocity that is under 6 m/s according to the Beaufort scale illustrated in fig.7. As a conclusion, the example findings validated and demonstrated the concept research case study and its outcome result in a hot climatic environment.

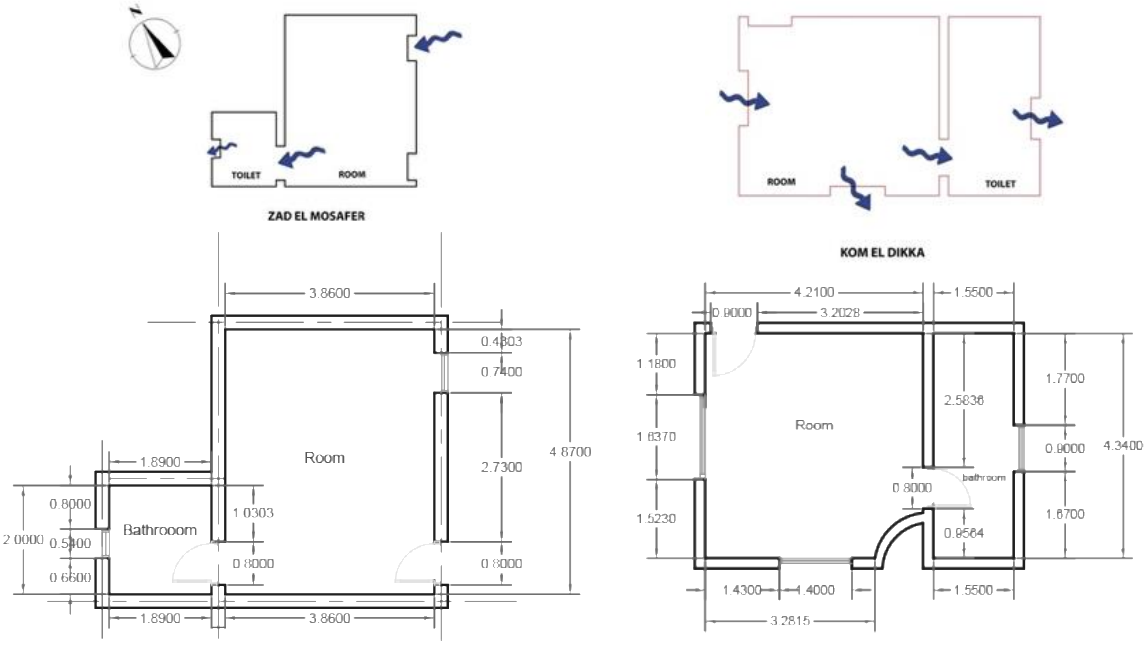


(**a**) (**b**)

Fig.7. (a) Two different hotel room prototypes; (b) Plan of the simulation results for two types of hotel rooms [50].

3.1.2 Examined Rooms Analysis

The building model plan was built in CAD program as a single line polygon, exported as a SAT file and imported to the Ansys computational fluid dynamics (CFD) software to simulate the ventilation air flow in the rooms. The fig.8., below shows the plans in both rooms with indication of the wind enters and exits from the opposite windows. As for kom El-Dikka room, the prevailing wind enters from north/west window and exhaust from South/East window, and the total area is 23.55m^2. The room windows dimensions are 1.65m width & 1.7m height and the opposite window (bathroom) is 0.9m width & 1.2m height. Zad El-Mosafer room wind enters from North/East and exists from South/West, and the total area is 22.5m^2. The room window dimensions are 0.74 width & 0.8m height and the opposite window (bathroom) is 0.54m & 0.65 height. The two room cases vary in the location of the windows and the size to decide the different possible circulation of air flow in each room to choose the room that best meets users' requirements. First, the orientation of the Ecolodges with respect to the dominate wind direction is checked. The wind is, 23 km/h from N, North/west winter wind direction and north/east summer direction.



(**a**) (**b**)

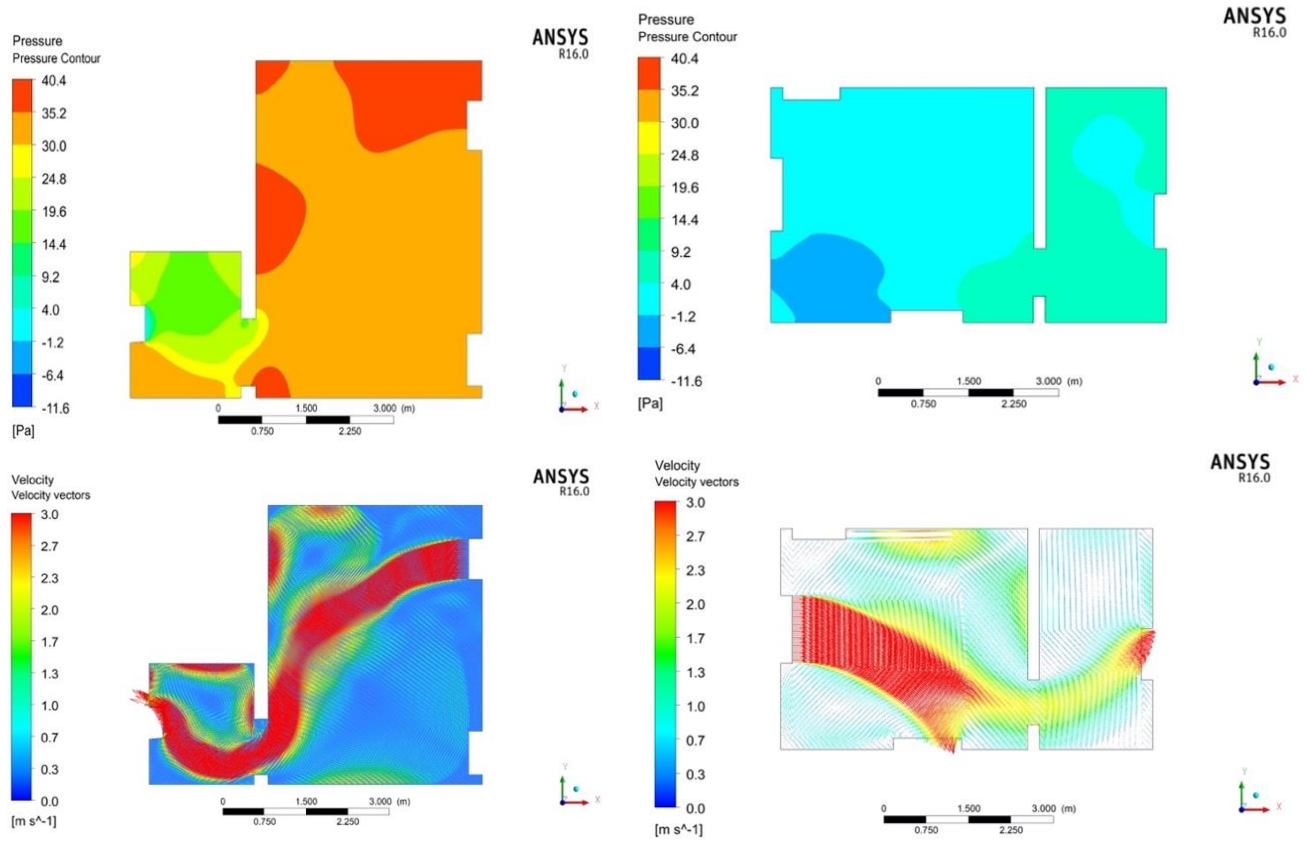
Fig.8. Zad El-Mosafer studied room plan that shows wind direction coordination & detailed room dimensions; (b) kom El-Dikka studied room plan that shows wind direction coordination & detailed room dimensions.

3.2 Ansys Fluids/CFD-Simulation Results

Mean wind pressure co-efficient (Cp) is one of the major input data for natural ventilation study using building energy simulation approach. Due to their importance, they need to be accurately determined [34]. Therefore, the pressure coefficient applied to the opening is calculated in pressure contour and velocity vector form, using the CFD program, which will provide a means for an accurate and detailed assessment of Cp. For the optimal interior ventilation efficiency, studies show that as the "Velocity of fluid flow increases, its Pressure decreases" [36]. The fundamental application of CFD to the design of naturally ventilated structures is the calculation of velocity and temperature fields in rooms and buildings, the calculation of envelope flows, and the computation of surface wind pressure

distribution. The role of CFD in natural ventilation is to reduce the usage of the analytical methods of solution. Final Ansys computational fluid dynamics outcome of the comparison rooms was presented in the form of velocity vectors and pressure contours in the preceding comparison diagrams illustrated in fig.9(a) Zad El-Mosafer & (b) Kom El-Dikka.

Pressure Contours are used to represent the varying magnitude on the surface. Red is the highest pressure and blue is the lowest pressure and a linear color variation to depict the interval [44]. Kom has low pressure numbers of the indoor airflow and Zad has high pressure numbers of its indoor airflow. The pressure contour numbers low which indicates that the room is well ventilated (indoor airflow movement in two-dimensions are presented and that some from contour lines of parameters as pressure is observed). The average pressure contour findings for Zad are between {30-40 Pa}, whereas the average pressure contour findings for Kom are between {-1.2-9.2 Pa}. As a result, Kom pressure contour ratio is lower than Zad ratio, indicating a better ventilated environment. Furthermore, this careful observation provides architects with the opportunity to get into air behavior and realize its tendency.



(**a**) (**b**)

Fig.9. (a) Zad El-Mosafer studied room plan that Clarifies Pressure Contours (Pascal is the SI unit for pressure equal to (40.4 PA) & Velocity Vectors (wind velocity equal to 3 m/sec; (b) kom El-Dikka studied room plan.

As for the Velocity Vectors are used to illustrate the flow direction (understanding direction of the flow) and magnitude at each point in the mesh. The arrow indicates the flow direction and the length and color indicate the magnitude. The air changes increase as the inlets surface increases. The airflow patterns and velocity vectors contours were analyzed in the research example study to clarify the thermal comfort by wind-driven cross ventilation using Stagnation and Venturi conditions. According to the velocity

airflow pattern, the conditions in both rooms are varied. As indicated, the Zad El-Mosafer room is in a state of stagnation since the inlet opening is larger than the outlet opening, and the two openings are on opposing side walls at different corners (which decrease & distribute wind velocity inside the room space). The Venturi condition applies to the Kom El-Dikka room, with the inlet larger than the outlet and the two apertures facing each other (which increase wind velocity inside the room). Conferring to Beaufort scale of wind speed studies and comfortable velocity areas standards, the initial velocity (u) & final velocity (v) parameters were adapted from the simulation outcomes velocity vectors, to conduct the average indoor air velocity (V) for both rooms, by using the average velocity equation V= (v+u /2). Kom's room (venturi) estimated initial velocity is 1.4 m/s, final velocity is 2.6 m/s, and the calculated average velocity is 2m/s, which gives 57% of the area is ventilated. Zad's room (stagnation), estimated initial velocity is 0.4 m/s, final velocity is 2.9 m/s, and the calculated average velocity is 1.65m/s, which gives 42% of the area is ventilated shown in fig.8. The percentage of kom El-Dikka room air ventilation performance is higher than the percentage of Zad El-Mosafer air ventilation performance, proving the concept of venturi condition as it is best suited for low wind velocity under 6m/s in the hot climate zone. Such natural wind-driven ventilation system prototype can be extremely beneficial for natural human comfort and, as a result, energy savings.

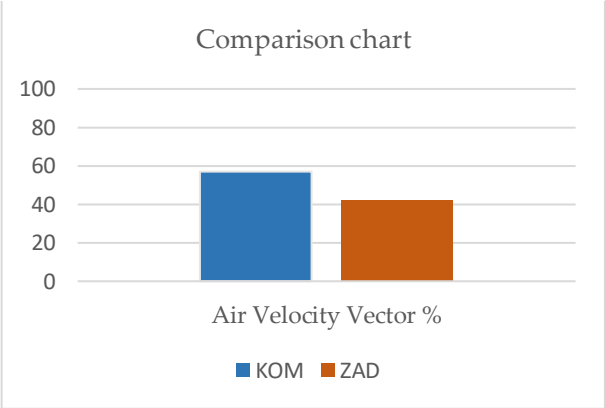


Fig.8. Velocity percentage magnitude performance comparison chart.

4. DISCUSSION

The movement of interior air in the two Eco-lodge rooms has been analyzed, and the results of the simulation have been used to thoroughly understand the internal ventilation system. The analysis discovered that the Venturi condition was monitored in the Kom El-Dikka room and the Stagnation condition was used in the Zad El-Mosafer room, as both are cross-ventilation methods that vary wind velocity inside a space. The Ansys/CFD application was used to simulate the air circulation in the two model rooms in order to determine which had optimal ventilation. The simulation revealed that Kom's room ventilation performance is higher than Zad's. And, according to the Beaufort theory, the venturi state is the most suitable for the village's climate, as evidenced by Kom's room outcome.

The simulation output in the form of vector diagrams is helpful for consultant to understand the air circulation pattern. [36]. The outlet windows should be positioned opposite the wall of the inlet window in order to achieve the optimum air circulation rate, as Kom El Dikka 's room revealed, that further implies the window dimensions, orientation and location are most critical in order to sustain indoor cross-ventilation. Therefore, the enhancement of the eco-lodges of Tunis village must improve the natural ventilation in order to satisfy the sustainable requirements and overcome the high temperature of the

room and reduce the use of ACs during the summer. Natural ventilation is the best solution to reduce electricity consumption. It is also a good technique to decrease the impact of the mechanical and HVAC systems on environment [42]. The beauty and recreational opportunities created by the diverse character of El-Fayoum's environment also constitute substantial concerns and constraints for tourism development. With careful planning and consideration, all of these challenges can be successfully accommodated [25]. Proper placing of the buildings, facades and gable walls, in a way to diminish the exposure to radiation and winds. Reduce the height of buildings to decrease the exposed exterior surfaces and proceed as much as possible to arrangements (grouping, organization of buildings, etc.) towards relatively compact solutions that increase the shadows available and the natural ventilation mechanisms. The multiplication, in the concept of designing the buildings, of compositions that enhance natural ventilation and natural refreshment, must also be able to rely as much as possible on the use of low-cost materials and high thermal inertia seeking an aesthetic reminiscent of the regional cultural context [26].

Concluding, the government and the developer play an important role in the adoption and implementation of environmentally sound policies and practices to prevent the deterioration of Egypt's natural heritage for the sake of present and future generations [37]. Several Ecolodging facilities do not meet the criteria but are still branded as "natural." The certification of goods and services by ecotourism is now seen as a symbol of high overall product quality and an indication of products that are environmentally, economically and socially sound. Throughout the past, ecotourists had few facilities and the most common term for describing the accommodation they wanted was rustic [25, 26]. Ecotourism can bring Egypt many socio-economic advantages. It generates foreign exchanges, creates local employment, and stimulates domestic and local economics and raise awareness and education about the environment while preserving tourists' own resources [12]. El-Fayoum oasis region is classified as Egyptian's Desert environment which has specific materials to be used with best form & orientation according to its hot/dry climate, to prevent the excessive energy use [26]. So, all Eco-lodges in this area be using should green & local materials such as thick walls of natural limestone (walls, foundations, floors, & claddings), Palms (shading & decoration), and mud (bricks, blocks, finishes, floors & rammed earth), wood & rope for furniture & for ceilings, also natural patterns, dome & vaults structures are popular over there. El-Fayoum Governorate offers significant opportunities for tourism development because of its unique natural and cultural attractions [38, 41].

To achieve the long-term goal of a sustainable El-Fayoum it is important to give the people as much freedom as possible. But it understood that there is also the need for strict policies, regulations, and guidelines for the development [26]. Eco-lodges should offer units and stations for solid waste management [39]. This can be set as one of the regulations and rules for developing ecotourism. Creating a strong sustainable energy system using a variety and mixture of renewable energy resources in a transition phase towards replacing the non-renewable resources with more renewable ones to reinforce the system's resiliency [38]. The interior designer plays a major role in contributing to tourism development, as they are responsible for the tourist's comfort in residence through functional designs compatible with the environment and heritage expressing the Egyptian personality [39]. Sustainable ecotourism facilities are more attractive to tourists using local environment materials [40]. The aim is to make El-Fayoum an eco-attraction point for residents from all over Egypt and the international tourists. The eco-development should create a sustainable and durable development which brings people together, creating strong communities, makes them participate in planning processes and makes them aware of the potentials of the area. The guidelines are on the one hand is how to build or what to build and on the other hand planning guidelines for the local government. It was clear that these guidelines should achieve goals on the short term as well as the middle and long term. As for the "Environmental Aspect", which is the major issue of the study (IAQ), a successful approach to new, or existing ecolodges has been demonstrated to solve this issue. Therefore, Kom El Dikka Eco-lodge proven to be the best sustainable

example, especially in the desert environment of Fayoum Tunis village, that can be used as a former checklist assessment summarized in fig.10.

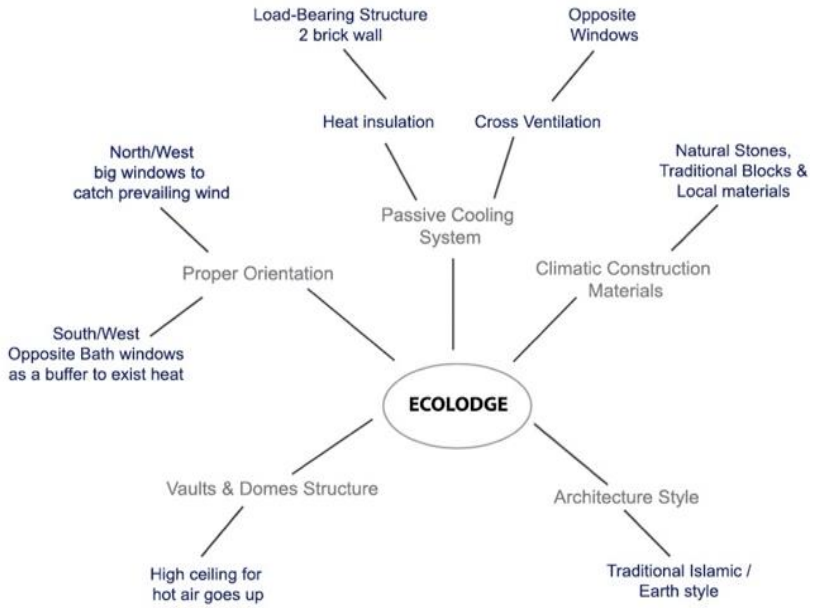


Fig.10. Final Eco-Criteria Assessment that can be used in EL-Fayoum Ecolodges.

5. CONCLUSION

The room simulation results of Kom El Dikka are demonstrated, since the North/West window input vectors (red vectors) is very high and even the others room sections have high-speed vectors that means that the room is ventilated significantly. Because of the window installed in the best position that gave the best flow pattern. In addition, it was evident for the pressure contour that the interior of the room is well ventilated with low numbers of pressures. To summarise, Kom's room has an estimated average velocity of 2 m/s, which means 57% of the space is ventilated, whereas Zad's room has an estimated average velocity of 1.65 m/s, which means 42% of the space is ventilated. The percentage of kom El-Dikka room air ventilation performance is higher than the percentage of Zad El-Mosafer room air ventilation performance, demonstrating that the concept of venturi condition is better suited for low wind velocity in a hot climate zone. Through the theoretical and practical knowledge, it was concluded that production of eco-friendly design elements in tourist establishments in line with the modern times through the promotion and development of traditional design patterns of environmental facilities [8]. In addition to attracting visitors to Eco-lodges more than any other facilities, the benefits stated from research are geared towards ecotourism facilities in terms of maintaining legacy, low construction costs and energy saving, and have embraced a philosophy of sustainable interior design and architectures. The study provides detailed insights into practice of sustainable Ecotourism in protected areas. Additionally, case studies conclude that the Egyptian protectorates have several attractions and characteristics. Sustainable ecotourism in these destinations can be developed if they establish a strong ecotourism marketing that promotes their attractions [6]. Tourists have trends to travel more widely, seeking natural and cultural destinations and prefer to stay in Eco-lodges. This makes them ideal Eco-tourists for protected areas [7]. In addition, they benefit these destinations. Fortunately, for Tunis Village, Al-

Fayoum Eco-lodges, the "Future Recommendation Policies" that are environmentally friendly aspect of energy conservation for indoor climate comfort:

- Courtyard structures for shadowing and cooling down the inner space. Chimney structures to enhance the pressure difference between the inner space and outer space. The higher the chimney, the better the circulation'. Such structures are implemented to facilitate more air circulation inside the buildings and the small urban spaces between the campus buildings.
- Wind catcher's usage, these techniques are commonly used in Iran and were also locally and traditionally used in Egypt and hot climatic regions. The climatic conditions of the region make such techniques possible.
- To further preserve the natural assets of the El-Fayoum region grey water must be reused in newly built projects and it should be forbidden to build neither on farmland nor on protected land.

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السكن البيئي كحل للتنمية المستدامة للسياحة البيئية في الفيوم مصر: محاكاة جودة الهواء الداخلي

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الملخص

يوفر تطوير السياحة البيئية فرصًا لتنويع القاعدة السياحية، لا سيما في المناطق الصحراوية مثل واحة الفيوم في مصر. لذلك، تهدف الدراسة إلى تعزيز السياحة البيئية في الفيوم، قرية تونس، أثناء توفير مساكن صديقة للبيئة، التي تعد جانبًا مهمًا من عملية تطوير السياحة البيئية. وبذلك، ويتم تحليل ثلاث أمثلة ناجحة للسكن البيئي لتوضح المبادئ الرئيسية لإرشادات تصميم للسكن البيئي فيما يتعلق بأركان الاستدامة. إضافةً إلى ذلك، تم اقتراح إطار عمل نهائي كأداة تقييم للمناطق البيئية الجديدة أو المجددة في الفيوم .تركز الدراسة على جودة الهواء الداخلي لغرف الفندق البيئية في قرية تونس والاستخدام المفرط لمكيفات الهواء من أجل تهوية أفضل للمساحات الداخلية للغرفة، وعلى هذا تفحص الدراسة نظام التهوية الطبيعية الداخلية لغرفتين من غرف السكن البيئي المزدوجة، ولصحة تجربة الدراسة تم استخدام برنامج محاكاة "Ansys Fluids/CFD" لقياس أداء الهواء الداخلي للغرفة. ونتيجة لذلك، قام برنامج المحاكاة بتوضيح حركة الهواء الداخلية لكل غرفة، من خلال توفير تقييم التصاميم النهائية للخرائط الكنتورية الإحصائية، مثل قياس أنماط تدفق الهواء وخطوط تحديد السرعة. بناءً على النتيجة النهائية للمحاكاة، يقدر أن كوم الدكة توفر ما يقرب من ٥٧٪ من إجمالي أداء التهوية الداخلية، بينما يمثل زاد المسافر حوالي ٤٢٪، مما يعني أن غرفة كوم الدكة هي الأفضل للتهوية الطبيعية. تقترح الدراسة توصيات لتحسين الراحة الحرارية في السكن البيئي بالفيوم أثناء أنماط التهوية الطبيعية.

الكلمات الدالة: السياحة البيئية المستدامة، السكن البيئي، الحفاظ على الطاقة، جودة الهواء الداخلي، حلول التصميم السلبي، برنامج محاكاة Ansys Fluids/CFD.