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ECONOMIC VALUATION OF THE KLAPANUNGGAL KARST REGION USING THE TRAVEL COST METHOD

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Abstract

Indonesia has Karst areas spread throughout almost the entire archipelago. The Klapanunggal Karst region has been officially designated as a Karst Landscape Area, to emphasize its protected status, in alignment with governmental endeavors aimed at ensuring the long-term preservation of the ecological and human-related significance of this karst ecosystem. The aim of this research is to perform an economic valuation of the Klapanunggal Karst region using the Travel Cost Method. The research conducted intensive field observations within the Klapanunggal Karst area and administered well-structured questionnaires to a sample size of 109 respondents from visitor Klapanunggal Karst region. Base on observations and field data, the Klapanunggal Karst region was partitioned into four distinctive zones. Zone 1 is location within an industrial limestone mining permit area, thus vulnerable to the imminent threat of industrial mining activities. Zone 2 is situated within the precincts of the Klapanunggal KBAK. Zone 3 has been transformed from a former mining site into a tourist destination. Lastly, Zone 4 has earned the coveted status of a tourist village. Subsequently, based on the economic valuation calculations, the Klapanunggal Karst region was found to have an annual economic value of Rp. 4,156,219,112.40, with a visitation rate of 0.006% of the total tourists visiting Bogor Regency. The researchers also recommend the development of tourism in the Klapanunggal Karst region as a means of enhancing the local economy, as well as ensuring the protection and sustainability of the Klapanunggal Karst area, including other critical aspects like water resources and ecosystem values.

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INTRODUCTION

Indonesia is an archipelagic country that has a karst area stretching from the east to the west. The Indonesian government determines karst landscape areas based on the regulation of the Minister of Energy and Mineral Resources of the Republic of Indonesia Number 17 of 2012. This determination aims to protect karst areas and limit the exploitation of karst areas as raw materials for the cement industry. One of the Karst landscape areas adjacent to the cement industrial area is KBAK Bogor. The Bogor Karst Landscape area consists of the Klapanunggal zone, Ciampea zone, and Cigudeg zone. The Klapanunggal Karst region is part of the Karst Natural Landscape Area in Bogor, Indonesia. Administratively, it falls under the Klapanunggal sub-district within Bogor Regency. This area is home to the largest cement industry in Indonesia. Currently, the Klapanunggal Karst region is designated as a protected zone, as per the decision of the Ministry of Energy and Mineral Resources, Number 24.K/40/MEM/2020.

This protection policy has encouraged the cement industry operating in the karst region to engage in conservation efforts and adopt sustainable cement production practices. Moreover, the Klapanunggal Karst region is a sought-after destination for special interest tourism activities such as rock climbing and caving activities. Additionally, the Klapanunggal Karst area serves as a location for scientific research. One notable cave, Gua Cikarae, is famous for being the habitat of Stenasellus javanicus, a stygobiotic isopod that was initially discovered within the cave (Kurniawan et al., 2023).

Karst regions hold substantial potential for ecosystem sustainability. Karst is defined as postgenetic when karstification occurs after rock formation, whereas it is considered syngenetic when it happens concurrently (Veress, 2020). According to the Minister of Energy and Mineral Resources Regulation No. 17 of 2012 concerning the Designation of Karst Natural Landscape Areas (KBAK), karst natural landscapes are defined as landforms resulting from the dissolution of limestone and/or dolomite rocks. Karst Natural Landscape Areas exhibit specific exokarst and endokarst forms. These areas are of vital importance for both human livelihood and environmental (Y. Li et al., 2022). Karst regions serve as reservoirs for water sources and provide other ecosystem services beneficial to the surrounding communities. Karst regions are characterized by porous limestone rocks that facilitate the absorption of surface water into the ground, as the bare soil lacks vegetation (Soedwiwahjono & Pamardhi-Utomo, 2020). Karst regions are distributed globally, covering approximately 15% of the Earth's surface, and they supply drinking water to more than 20% of the world's population (S.-L. Li et al., 2021).

Karst regions are characterized by unique geological features, including soluble carbonate rock formations, elongated soil development, discontinuous thin soil layers, and a rapid-response hydrological system (Zhou et al., 2022). These areas offer numerous benefits to human life. Currently, karst regions are extensively utilized for mineral extraction, hydrocarbon resources, and construction materials. However, beyond these utilitarian functions, karst regions hold another significant value as natural heritage, which necessitates precise conservation measures to serve as a foundation for sustainable tourism development that can provide both social and economic benefits (Ruban, 2018). This perspective is championed by The United Nations Educational, Scientific and Cultural Organization (UNESCO), which spearheads the conservation of geological heritage for tourism. One of the karst areas in Indonesia selected by UNESCO for conservation and development is the Sangkulirang-Mangkulihat Karst region in East Kalimantan Province.

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This particular area is being developed based on its rich biodiversity and the unique natural geological heritage it possesses (Sunkar et al., 2022).

The existence of karst regions is currently threatened by the increasing global population growth. World population growth is projected to rise by 22% by 2050, from 7.6 billion to 9.7 billion people (Petroche & Ramirez, 2022). This population increase is driving the demand for housing, leading to a surge in the use of cement as a building material. Cement is a vital raw material for concrete production, the second most widely consumed material globally (Winter et al., 2022). The cement industry relies heavily on limestone as its primary raw material. However, the cement industry is responsible for significant energy consumption and raw material usage in the production of clinker (de Siqueira & Cordeiro, 2022). The excessive consumption of limestone as a raw material detrimentally impacts the degradation of karst ecosystems.

On the contrary, the preservation of karst regions is viewed as a natural resource with the potential to sustain a robust economy. The world's ecosystems provide life support to humans, including protection from natural hazards and the impacts of climate change (Caranza & Calderon, 2022). Karst ecosystems are no exception, as they, which offer benefits to human life in the form of a water source and various other ecosystem services, contributing to long-term economic development through tourism. Karst landscapes hold ecotourism potential due to their cave systems and unique forest cover that can be explored and enjoyed. They are also among the ecosystems experiencing extreme pressures from over exploitation (Caranza & Calderon, 2022).

The Ecosystem Service Value (ESV) represents the monetary embodiment of services provided by natural ecosystems and is considered a valuable indicator for assessing regional sustainable development (Jiao et al., 2022). In another definition, ecosystem service value is an approach to measure and assign economic value to ecosystem goods and services, along with their functions (Sannigrahi et al., 2019). The ecosystem service value of karst regions extends beyond serving as a raw material source for cement; it also encompasses environmental and ecological benefits, both within the karst areas themselves and in the surrounding buffer zones (Wisnuaji & Fauzi, 2022). Economic valuation is commonly used as an approach to assess ecosystem services. In a study conducted in Ecuador, economic valuation was employed to assess the ecosystem services provided by coastal areas (Zambrano-Monserrate et al., 2018).

According to research, there are three fundamental approaches to assessing ecosystem services or economic valuation: the hedonic pricing approach, the Travel Cost Method (TCM), and the Contingent Valuation Method (CVM) (Zambrano-Monserrate et al., 2018). However, other studies have mentioned additional assessment methods, including Contingent Value (CV), Avoided Cost (AC), Reclamation Cost (RC), Production Approach (P), Hedonic Pricing (HP), Conjoint Analysis (CA), Travel Cost (TC), Replacement Cost (RC), and explicit spatial biophysical modeling approach (Sannigrahi et al., 2019). These assessment methods are employed to understand the benefits derived from ecosystem services. One commonly used approach in assessing a region is the Travel Cost Method (TCM). TCM is classified into three different categories: Individual Travel Cost Method (ITCM), Zonal Travel Cost Method (ZTCM), and the Random Utility Model (RUM), which combines TCM with Contingent Value (Torres-Ortega et al., 2018). In several studies, TCM is defined as a revealed preference method that links the costs of recreational activities to resource characteristics. The method is based on demand theory,

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which assumes that demand for a location is inversely related to travel costs (Torres-Ortega et al., 2018). In other research, it's explained that travel costs are based on the concept that the expenditures and time individuals spend during recreational trips to natural open spaces can be used to derive the value of those sites (Caranza & Calderon, 2022).

Assessing ecosystem services through economic valuation is regarded as an indicator measuring an ecosystem service in monetary terms, reflecting its value in economic units. Therefore, research emphasized that when the economic value of an ecosystem service exceeds the cost of its mismanagement, this economic valuation data can be utilized to safeguard and sustainably manage the ecosystem (Zambrano-Monserrate et al., 2018). Given the crucial importance of karst regions for both human and other life forms, it is essential to conduct economic valuation of these areas. The objective is to offer guidance to policymakers for the conservation of karst regions. In practical terms, the Travel Cost Method (TCM) is employed to establish connections between the expenses incurred during recreational activities and the specific attributes of the natural resource. These attributes encompass a range of factors such as fuel costs, admission fees, and travel duration (Torres-Ortega et al., 2018). Another study that employed TCM to economically evaluate karst regions focused on the assessment of the Capisaan Cave System in Nueva Vizcaya, Philippines (Caranza & Calderon, 2022). Researchers applied the Zonal Travel Cost Method (ZTCM) to assess this tourist destination, taking into account factors like travel expenditures, access charges, equipment costs, and the time spent. The outcomes of this investigation revealed that the ZTCM approach is particularly suitable for single visitation trips. Additionally, the transformation of data into natural logarithms enhanced the linearity between variables, specifically between recreational value and access value (Caranza & Calderon, 2022).

This study aims to assess the economic value of the Klapanunggal Karst region by applying the Travel Cost Method (TCM). Economic valuation of the Klapanunggal Karst zone using the Travel Cost Method (TCM) is expected to protect the Klapanunggal karst area from exploitation of cement raw material mining activities. In this research, the economic valuation of the Klapanunggal karst area is novelty compared to previous research. The outcomes of this economic evaluation pertaining to the Klapanunggal Karst area are anticipated to offer crucial insights to a wide array of stakeholders, encompassing governmental bodies and industrial entities. This invaluable data serves as a guiding resource to assist them in devising pertinent strategies for the administration and preservation of the Klapanunggal Karst region.

METHODOLOGY

This research utilizes a mixed-method approach, combining both quantitative and qualitative research techniques. The methodology encompasses on-site observations, the dissemination of questionnaires, and the application of the Travel Cost Method to assess the economic value of the Klapanunggal Karst region. The Travel Cost Method is a recognized approach for estimating economic value, taking into account the travel costs incurred by visitors.

This research utilizes a combination of primary and secondary data sources. Primary data is gathered through direct observations conducted at the research site and the administration of questionnaires. In contrast, secondary data is derived from reports

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provided by the Bogor Regency Tourism Office, prior research outcomes, and a comprehensive review of relevant literature. The Klapanunggal Karst area is subdivided into four distinct zones by the researcher, specifically Zones 1 and 2 within the Leuwikaret Village, Zone 3 situated in the Klapanunggal Village, and Zone 4 located within the Ligarmukti Village. Following this categorization, the researcher employed a Google Form questionnaire, randomly distributed to respondents who had previously visited the Klapanunggal Karst region, using a random sampling method. The questionnaire collected a range of demographic information from respondents, encompassing age, gender, marital status, place of residence, educational background, occupation, income, annual visitation frequency, travel expenditures, accommodation preferences, distance traveled from their place of origin, and their awareness of the Karst Natural Landscape Area (KBAK). To determine the necessary number of respondents for this study, the Slovin formula was applied. With a margin of error set at 5%, the minimum requisite number of respondents for this research was calculated to be 100 participants.

In the process of determining the economic worth of the Klapanunggal Karst area, the researcher employed the Travel Cost Method for analysis. Subsequent to gathering primary data from respondents, data input and validity and reliability tests are conducted. Following this, a regression analysis of the data is executed using SPSS 26 software. The regression analysis, alongside a suitable functional format, is employed to estimate the demand function or equation connecting per capita visits with travel expenditures and other pertinent variables (Caranza & Calderon, 2022). The regression analysis was employed to investigate the correlation between the variable of the number of tourist visits, serving as the dependent variable, and the independent variables. In a general sense, the linear regression equation concerning the number of tourist visits is as follows:

Linear Model Equation

$$Y = a + b\,(TC) \qquad \text{...(1)}$$

Y = The annual number of visits
TC = The total expenses incurred by respondents

In calculating economic valuation using the Travel Cost Method, the researcher compute consumer surplus. By performing this calculation of consumer surplus, the researcher can ascertain the willingness to pay (WTP), as these two measures can be considered synonymous. The formula employed for determining the consumer surplus is as follows:

Consumer Surplus Formula

$$WTP \approx CS = \frac{Y^2}{2\beta} \qquad \text{...(2)}$$

Y = The number of visits made by an individual
CS = Consumer surplus
β = Regression coefficient for travel cost

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Once the consumer surplus is determined, the researcher proceed to calculate the economic valuation by multiplying the consumer surplus per visitor by the total actual number of visits as indicated in the secondary data acquired.

FINDINGS AND DISCUSSION

This research was conducted in the Karst Natural Landscape Area (KBAK) of Bogor, specifically in the Klapanunggal zone, which is situated in Leuwikaret Village and Ligarmukti Village, Klapanunggal Subdistrict, Bogor Regency, West Java Province. The research location falls within the Klapanunggal Subdistrict, Bogor Regency, covering an area of 90.82 square kilometers. Geographically, the Klapanunggal Subdistrict is located between 6°32'36" Southern Latitude and 6°44'36" Southern Latitude and 106°33'54" East longitude and 106°39'17" East longitude.

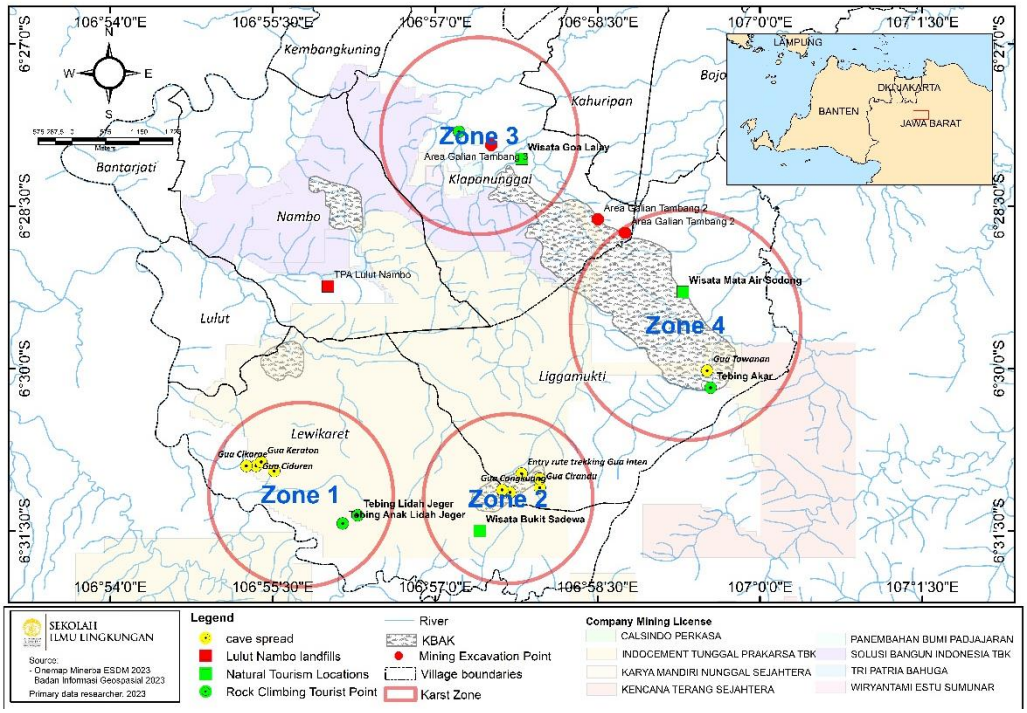

Figure 1. Research Site Map and Zoning of Potential Tourist Areas in the Klapanunggal Karst Region
Source: Primary data researcher, 2023

According to data obtained from the Bogor Regency Central Statistics Agency (BPS), the Klapanunggal Subdistrict is situated in the eastern part of Bogor, with an area of 70.57 square kilometers as of 2021, accounting for 2.36% of the total area of Bogor Regency. Furthermore, the administrative boundaries of this area are as follows.

a. To the north: Gunung Putri Subdistrict, Bogor Regency
b. To the east: Jonggol Subdistrict, Bogor Regency
c. To the south: Babakan Madang Subdistrict, Bogor Regency
d. To the west: Citeureup Subdistrict, Bogor Regency

According to the Minister of Energy and Mineral Resources of the Republic of Indonesia Decree Number: 24.K/40/MEM/2020 Regarding the Designation of the Bogor

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Karst Natural Landscape Area (KBAK), the Klapanunggal zone covers an area of 663.65 hectares. KBAK in the Klapanunggal zone encompasses four villages, namely Leuwikaret Village, Ligarmukti Village, Klapanunggal Village, and Nambo Village. The research focus, guided by field observations conducted by the researcher and spatial analysis using spatial data acquired by the researcher, centers on three of these villages: Leuwikaret Village, Klapanunggal Village, and Ligarmukti Village. These villages house numerous established tourist destinations, offering both natural attractions and special interest sites. Notable among them are Sodong Spring for nature-based tourism, Lalay Cave for cave exploration, rock climbing areas like Akar Rock, Anak Lidah Jeger Rock, and Lidah Jeger Rock, along with cave exploration at Cikarae Cave, and nature-based tourism at Sadewa Hill. The selection of these locations is predicated on secure access routes that avoid mining areas. For a comprehensive overview, Figure 1 illustrates the distribution of tourist sites, mining sites, and the regional waste processing and final disposal site in Lulut Nambo.

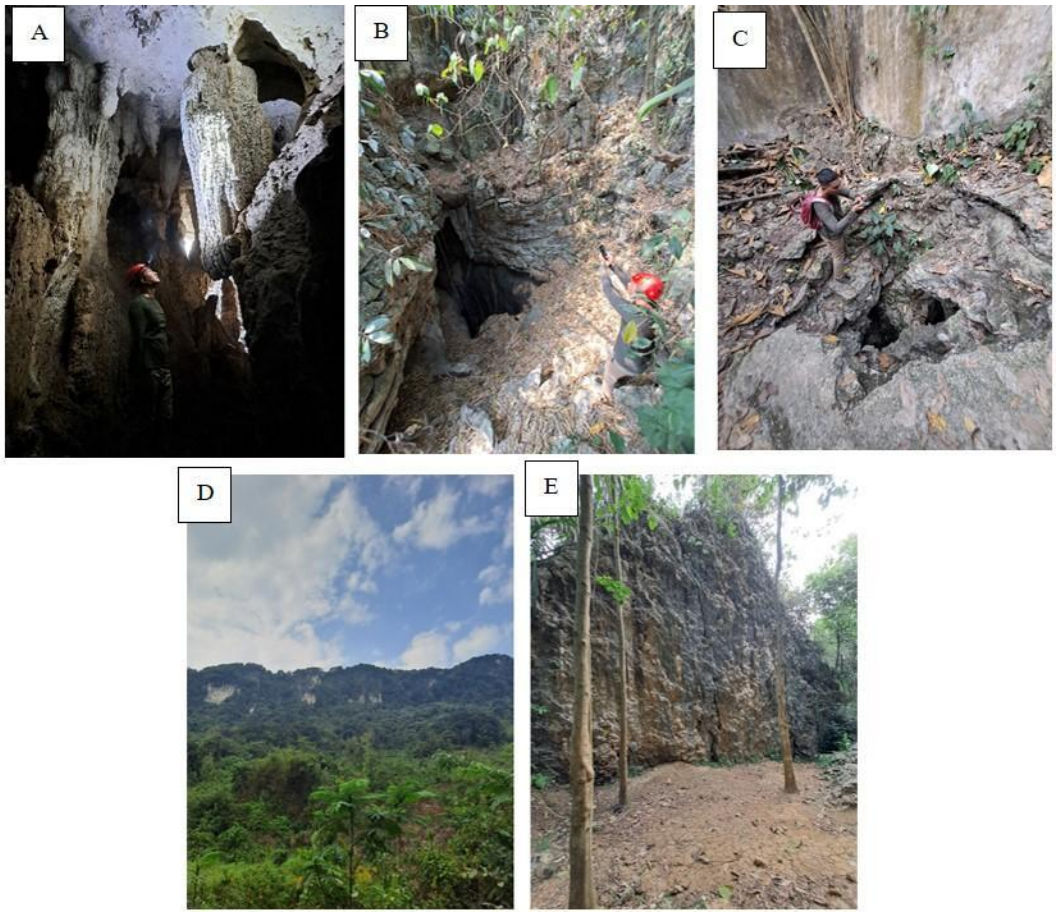

Figure 2. Tourist Attractions in Zone 1 of Klapanunggal Karst, Kampung Guha Siangin. (A) Keraton Cave; (B) Cidomba Cave Entrance; (C) Ciduren Cave Entrance; (D) Karst Hill Lidah Jeger Cliff; and (E) Anak Lidah Jeger Cliff
Source: Primary data researcher, 2023

During the research period spanning from June to September 2023, the researcher conducted on-site visits to explore the tourist sites within the Klapanunggal Karst area. Drawing from these field observations, the researcher partitioned the Klapanunggal Karst region into four distinct zones, each centered around specific tourist attractions. Zone 1

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emerged as a focal point for special-interest tourism activities, encompassing cave exploration and rock climbing adventures, and is primarily located within Kampung Guha Siangin, situated in Leuwikaret Village. Within Zone 1, several caves of tourist interest are characterized by unique features, including both vertical and horizontal cave structures (Figure 2). A notable example is the Keraton Cave, distinguished by a horizontal entrance leading to a vertical section typically navigated using the single rope technique (SRT). Furthermore, the closely situated caves in this area facilitate convenient access via trekking routes. Zone 1 also encompasses a cluster of cliffs that attract rock climbing enthusiasts, prominently including the Lidah Jeger Cliff and the Anak Lidah Jeger Cliff. However, the spatial analysis, involving an overlay of the map delineating cement industry concessions with that of the Klapanunggal Karst Natural Landscape Area (KBAK) within the Klapanunggal zone, indicates that this area falls within the jurisdiction of the cement industry for licensing purposes. Consequently, it holds the potential to serve as a source of raw materials for cement production.

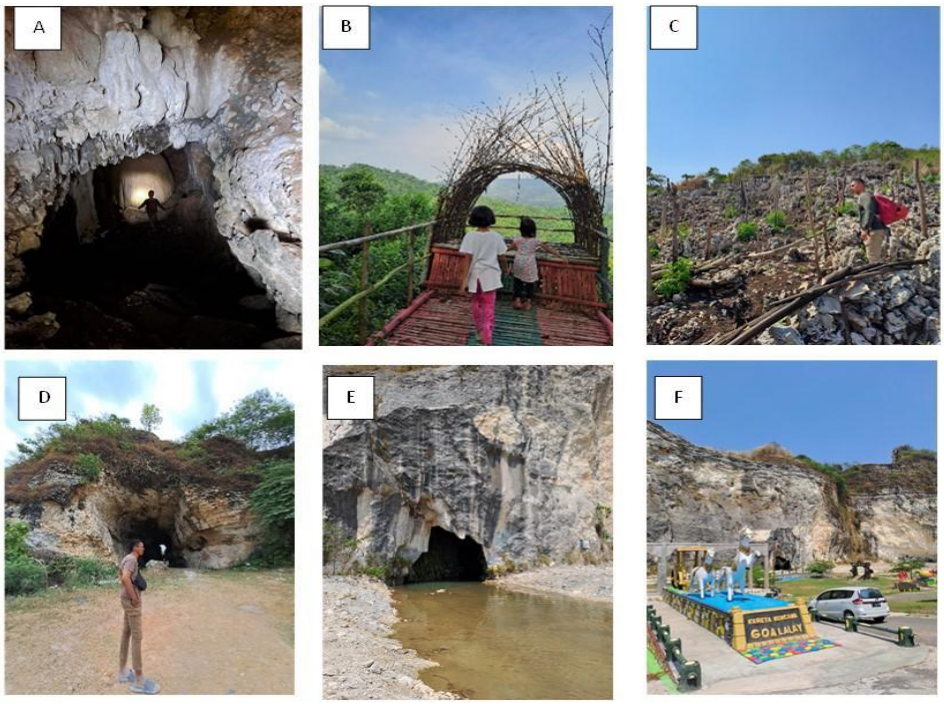

Figure 3. Tourist Attractions in Zone 2 of Klapanunggal Karst, Kampung Cioray, and Zone 3 of Klapanunggal Karst in Klapanunggal Village. (A) Inten Cave; (B) Sadewa Hill Tourist Park; and (C) Karst Hill Landscape in Kampung Cioray; (D) Arpam Cliff; (E) Lalay Cave; and (F) Lalay Cave Tourist Park. Source: Primary data researcher, 2023

Zone 2 in Klapanunggal features several cave potentials, including Inten Cave, Cirandu Cave, and Cangkuang Cave (Figure 3). However, most of these caves are characterized by their vertical attributes, requiring Single Rope Technique (SRT) for exploration. This zone exhibits higher tourism potential compared to other zones within Klapanunggal Karst. Spatial analysis places Zone 2 within the Klapanunggal Karst Natural Landscape Area (KBAK), where the impacts of the cement industry are minimal, resulting in a non-dusty environment. To reach this area, researchers must pass through the dusty cement factory zones in Lulut Village and Tajur Village. On the other hand, Zone 3 in

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Klapanunggal is an area known to special interest tourism enthusiasts. It is a karst region formerly utilized as community mining land and is currently within the cement industry's concession. Presently, the community has developed this region into a tourist attraction on former mining land. The notable attractions in this area are the natural tourism sites Lalay Cave and Arpam Cliff. Among the four zones of Klapanunggal Karst, Zone 3 is the most heavily contaminated by dust from mining activities.

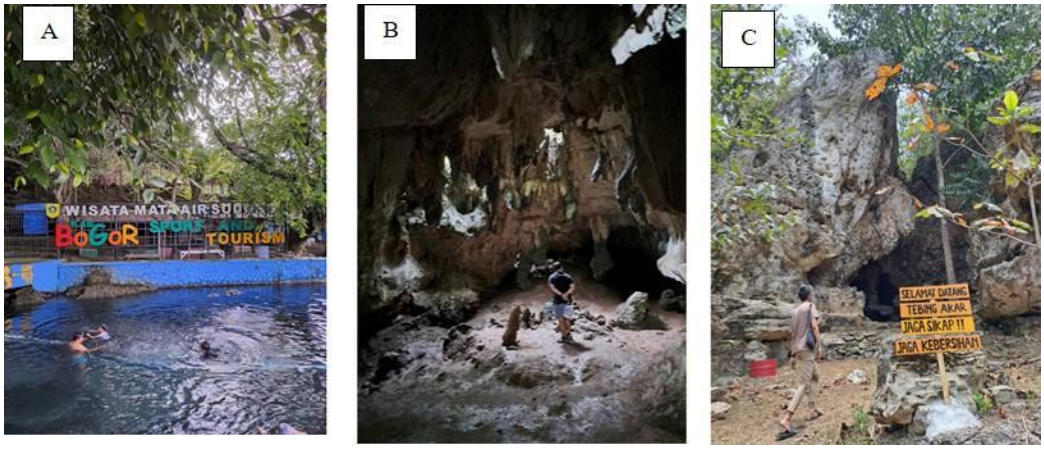

Figure 4. Tourist Attractions in Zone 4 of Klapanunggal Karst, Ligarmukti Village. (A) Mata Air Sodong Tourism Park; (B) Tawanan Cave; and (C) Akar Cliff.
Source: Primary data researcher, 2023

The last subdivision of the Klapanunggal Karst area is Zone 4, located in Ligarmukti Village. This zone is unique as it has been developed into a tourism village. Within Zone 4, prominent attractions include the Mata Air Sodong Bathing facility, which is supported by the Bogor Regency Tourism Office (Figure 4). This area also features Tawanan Cave and Akar Cliff. Zone 4 is notably the most secluded zone and least impacted by cement industry operations.

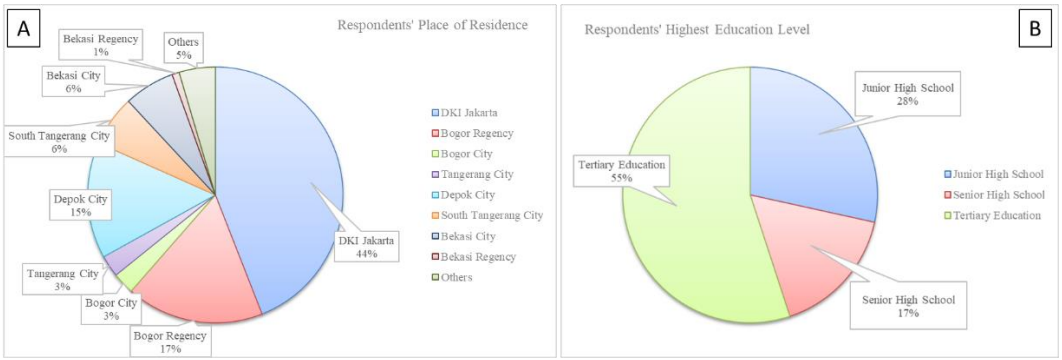

Figure 5. Pie Charts (A) Respondents' Place of Residence and (B) Respondents' Highest Education Level
Source: Primary data researcher, 2023

The primary criterion for visitors, based on their place of residence, reveals that the majority of respondents, 44%, come from the Jakarta Special Capital Region (DKI Jakarta), while the second-largest group comprises 17 respondents originating from the Bogor Regency (Figure 5). Regarding the educational background of respondents, those with tertiary education qualifications constitute the largest group at 55%, followed by

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individuals with secondary education or its equivalent, constituting 28% of the respondents, and those with a high school or equivalent level of education, totaling 17%. Examining income data, 68.8% of the total respondents, which amounts to 75 individuals, have an income exceeding IDR 3,500,001. Another group of 19 respondents, or 17.4%, falls within the income range of IDR 2,500,001 to IDR 3,500,000. Subsequently, 11.9% of the respondents, accounting for 13 individuals, have an income below IDR 1,500,000. Finally, 1.8% of the total respondents, equivalent to 2 individuals, falls within the income range of IDR 1,500,001 to IDR 2,500,000. In summary, it is evident from Table 1 that the Klapanunggal Karst region predominantly attracts visitors with the financial capacity and high purchasing power.

Table 1. Respondents' Income Range

No.	Respondent's Income	Frequency	Percent	Valid Percent	Cumulative Percent
1.	Under IDR 1,500,000	13	11.9	11.9	11.9
2.	IDR 1,500,001 - IDR 2,500,000	2	1.8	1.8	13.8
3.	IDR 2,500,001 - IDR 3,500,000	19	17.4	17.4	31.2
4.	Above IDR 3,500,001	75	68.8	68.8	100.0
Total		109	100.0	100.0	

Source: SPSS 26 processed results modified by researchers, 2023

Based on the research data, the majority of respondents exhibit a strong inclination towards sports tourism. Rock climbing emerges as the most popular form of tourism, attracting 71 respondents, constituting 69.7% of the total respondents, who display a considerable enthusiasm for this pursuit. The second most preferred type of tourism is nature conservation tourism, with 61 respondents, or 56% of the total respondents. The third most sought-after type of tourism is shopping tourism, with 9 respondents, representing 8.3% of the total respondents. Lastly, hunting tourism attracted 7 respondents, accounting for 6.4% of the total respondents. This emphasizes the dominant characteristics of respondents visiting the Klapanunggal Karst area, mainly comprising individuals with a tendency for sports and nature-based tourism (Table 2). Typically, tourists with a strong interest in nature-based and sports tourism are categorized as special-interest tourists. Nature-based and sports tourism can also be referred to as hobby tourism, with tourists making recurrent visits to partake in these activities.

Table 2. Types of Tourism That Respondents are Interested in

No.	Type of Tourism You are Interested in	Frequency	Percentage	Percentage of Total Respondents
1.	Beach tourism	38	9.5	34.9%
2.	Ethnic Tourism	29	7.3	26.6%
3.	Nature Reserve Tourism	61	15.3	56.0%
4.	Hunting Tourism	7	1.8	6.4%
5.	Sports Tourism	76	19.0	69.7%
6.	Culinary tour	37	9.3	33.9%
7.	Religious Tourism	13	3.3	11.9%
8.	Agro Tourism	23	5.8	21.1%
9.	Cave Tourism	47	11.8	43.1%
10.	Shopping tour	9	2.3	8.3%
11.	Ecological Tourism	21	5.3	19.3%
12.	Culture tour	38	9.5	34.9%

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No.	Type of Tourism You are Interested in	Frequency	Percentage	Percentage of Total Respondents
Total		399	100.0	366.1%

Source: Results processed by researchers, 2023

Based on the research findings, the predominant activity among respondents during their visits to the Klapanunggal Karst area is rock climbing tourism, with 88 respondents (constituting 80.7% of the total respondents) participating in this activity (Table 3). Additionally, cave exploration tourism attracted 48 respondents, accounting for 44% of the sample. Ecotourism was the choice of 21 respondents, making up 13.2% of the respondents. A smaller fraction, specifically 2 respondents (or 1.8% of the total), engaged in alternative forms of tourism, including research and family visits, primarily because they resided in the proximity of the Klapanunggal Karst area.

Table 3. Types of Tourism Undertaken by Respondents in the Klapanunggal Karst Area

No.	Type of Tourism	Number of Respondents	Percentage	Percentage of Total Respondents
1.	Caving	48	30.2	44.0%
2.	Rock_Climbing	88	55.3	80.7%
3.	Ecotourism	21	13.2	19.3%
4.	Other	2	1.3	1.8%
Total		159	100.0	145.9%

Source: Results processed by researchers, 2023

Base on the research data, it becomes evident that the predominant choice among respondents was to partake in group visits during their trips to the Klapanunggal Karst area (Table 4). Specifically, 34 respondents, constituting 31.2% of the total sample, visited with friends from their community. Furthermore, 23 respondents, or 21.1%, conducted their visits with friends from their educational institution, be it campus or school. Family trips involving immediate family members were undertaken by 21 respondents, making up 19.3% of the total. In contrast, 18 respondents, or 16.5%, preferred visiting with friends from their workplace. Additionally, 10 respondents, or 9.2%, enjoyed their visits with friends at home. Only a small fraction of 3 respondents, equivalent to 2.8% of the total, opted for solitary travel. These data demonstrate that the vast majority, 97.8% of respondents, conducted their visits to the Klapanunggal Karst area in groups, typically consisting of more than 2 individuals.

Table 4. Method of Visiting by Respondents

No.	How to Visit	Number of Respondents	Percent	Valid Percent	Cumulative Percent
1.	Alone	3	2.8	2.8	2.8%
2.	Main family	21	19.3	19.3	22.0%
3.	Friends At Home	10	9.2	9.2	31.2%
4.	Friends at Campus or School	23	21.1	21.1	52.3%
5.	Friends in the Office or Workplace	18	16.5	16.5	68.8%
6.	Community Friends	34	31.2	31.2	100.0%
Total		109	100.0	100.0	

Source: Results processed by researchers, 2023

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In the analytical phase, the researcher employed a multiple regression analysis and made use of SPSS 26 software. The primary objective of this analysis was to determine the economic valuation through the application of the Travel Cost Method (TCM). The primary focus of the analysis rested on the examination of the dependent variable, which pertained to the count of visits respondents made to the Klapanunggal Karst area within a one-year timeframe. In addition to this, the researcher conducted a comprehensive examination of various independent variables. These encompassed factors such as the respondents' highest level of education (X1), their average income (X2), the expenses they incurred (X3), the distance traveled from their place of origin (X4), and their familiarity with the Klapanunggal Karst Natural Landscape Area (KBAK) (X5).

Table 5. Research Data Validity Test Results

Code Variable	Variable	r count	Say. (2-tailed)	Valid if item significance < 0.05	Valid If r count > 0.1584 (r table)
X1	Last education	0.590	0.000	Valid	Valid
X2	Average income	0.697	0.000	Valid	Valid
X3	Cost incurred	0.642	0.000	Valid	Valid
X4	Distance traveled from the origin location	0.632	0.000	Valid	Valid
X5	Knowledge related to Klapanunggal Zone KBAK	0.126	0.191	Invalid	Invalid

Source: Results processed by researchers, 2023

In accordance with the existing literature on the Travel Cost Method (TCM), it is customary for researchers to incorporate variables such as the highest level of education attained, income, and travel expenses into their analyses. The selection of these variables is predicated on an extensive review of previous research, including economic assessments in tourism contexts like Capisaan Cave, natural springs in Florida, and Prespa National Park in Greece (Table 6). The findings of the validity test conducted using SPSS 26 indicated that the variable associated with respondents' knowledge of the Klapanunggal Karst Natural Landscape Area (KBAK) lacked validity (Table 5). This determination was founded on a significance level exceeding 0.05, specifically registering at 0.191. As a result, the researcher opted to exclude this variable from subsequent analyses.

Table 6. Economic Valuation Variables with TCM in Previous Research

Tourist Destination	Method	Variable	Reference
Capisaan Cave System, New Vizcaya, Philippines	*Zonal Travel Cost method* (ZTCM)	● Travel expense ● Access Fees ● Equipment Costs ● Time Cost	Caranza and Calderon (2022)
Natural Spring in Florida	*Travel Cost Method*	● Journey ● Household Income ● Travel expense ● Replacement ● Personal ● Perception for facilities ● Perception for water clarity ● Past experience	Wu et al. (2018)

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Tourist Destination	Method	Variable	Reference
Prespa National Park in Greece	*Travel Cost Method*	● Gender ● Age ● Income ● Education ● Travel time ● Travel expense	Latinopoulos (2020)

Source: Results of processed researcher data, 2023

In the following step, the researcher conducted a reliability assessment to ascertain that the questions presented to the respondents in the questionnaire were reliable and possessed a high level of confidence. Based on the results of the reliability test conducted using SPSS 26, it was found that 109 respondents achieved a 100% reliability rate. With 109 respondents, and employing a two-tailed significance test with a significance level of 0.05, the critical r value was determined to be 0.1584.

Table 7. Reliability Test Sesults with Values *Cronbach's Alpha* Before and After Removing Variables

Reliability Statistics (before)		Reliability Statistics (after)	
Cronbach's Alpha	**N of Items**	**Cronbach's Alpha**	**N of Items**
0.113	4	0.169	2

Source: Results processed by researchers, 2023

Subsequently, the researcher conducted a reliability test by examining the Cronbach's Alpha value, which yielded a result of 0.114 (Table 7). This outcome falls below the critical r value of 0.1584. This value indicates that all the utilized variables lack reliability, meaning they are not reliable and consistent, and therefore, cannot be employed in the subsequent analysis stages.

Table 8. Reliability Test Results Using SPSS 26

Item-Total Statistics				
	Scale Mean if Item Deleted	**Scale Variance if Item Deleted**	**Corrected Item-Total Correlation**	**Cronbach's Alpha if Item Deleted**
X1	3,480,167.50	513,525,446,371.881	0.445	0.127
X2	333,394.30	28,792,464,603.582	0.193	0.002
X3	3,147,155.77	441,279,906,176.807	0.193	0.000
X4	3,479,832.31	513,433,127,249.549	0.286	0.127

Source: Results processed by researchers, 2023

Accordingly, the researcher eliminated two variables, namely the highest education level (X1) and the distance traveled from the place of origin (X4), in order to enhance the reliability value. With only two remaining variables, which are income (X2) and visitor expenses (X3), a Cronbach's Alpha value of 0.169 was obtained (Table 7). This value exceeds the critical r value of 0.1584, indicating that the data employed for analysis is considered reliable, trustworthy, and consistent (Table 8). The researcher proceeds to the next analytical phase, which involves conducting multiple linear regression to establish a model for the equation representing the number of tourist visits to Klapanunggal in a year (Y).

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The research findings, obtained from 109 respondents who have visited the Klapanunggal Karst area using two independent variables at a 0.05 probability level, show a t-table value of 1.65895 and an F-table value of 3.08. The regression analysis conducted using SPSS 26 produced an F-value of 0.901, which is smaller than the critical F-table value (Table 9). This outcome suggests that neither the variable of average income (X2) nor the expenditure amount (X3) exerts a statistically significant influence on increasing the number of tourist visits to the Klapanunggal Karst area. Based on this analysis, the Klapanunggal Karst area remains highly attractive to tourists. The characteristics of respondents visiting this area are not influenced by income levels or the amount of expenses incurred.

Table 9. Linear Regression Results Using SPSS (ANOVA)

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	18.768	2	9.384	0.901	.409[b]
	Residual	1,104.205	106	10.417		
	Total	1,122.972	108			

a. Dependent Variable: Number of Visits to the Klapanunggal Karst Area in a Year (Y)
b. Predictors: (Constant), X2, X3

Source: Results processed by researchers (2023)

A linear regression analysis was performed by the researcher, resulting in a constant value of 6.032 (Table 10). Consequently, it can be concluded that the variables X2 and X3 maintain a constant value. Thus, the annual number of visits to the Klapanunggal Karst area is established at 6.032 times.

Table 10. Results of SPSS Linear Regression Data Processing (Coefficients Values)

Coefficients[a]						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**t**	**Sig.**
		B	**Std. Error**	**Beta**		
1	(Constant)	6.032	1.540		3.918	0.000
	X2	-2.960E-07	0.000	-0.061	-0.621	0.536
	X3	-1.955E-06	0.000	-0.103	-1.048	0.297

a. Dependent Variable: Number of Visits to the Klapanunggal Karst Area in a Year

Source: Results processed by researchers (2023)

Following the outcomes of the regression analysis, the equation representing the model for the quantity of visits to the Klapanunggal Karst area is presented below. The linear model formula for the number of visits to the Klapanunggal Karst area in a year is as follows:

$$Y = 6.032 - 2.960X2 - 1.955X3 + 0.05 \quad \ldots(3)$$

Y = the number of visits per year
X2 = average monthly income
X3 = the amount of expenses incurred

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The interpretation of the variables, average income (X2) and visitor expenses (X3), based on the data processing results of the equation for the number of visits to the Klapanunggal Karst area (Y), is outlined as follows:

Constant Value

The constant within the equation stands at 6.032. This value signifies that when the variable for average income is considered either equal to zero or non-existent, the estimated number of visits amounts to 6.032 times per year.

The Impact of Average Income on the Number of Tourist Visits to the Klapanunggal Karst Area

In this research, respondents' average income pertains to their monthly earnings or income. Data on this variable was obtained through the completion of questionnaires. The study delineated various income ranges, which are detailed in Table 1. The outcome of the multiple regression analysis revealed a coefficient of -2.960 for the income variable. The negative coefficient implies that with an increase in income, the number of visits tends to decline. Specifically, a one-unit increment in income results in a reduction of 2.960 visits annually. Subsequently, to evaluate the statistical significance of income growth in relation to the number of visits, the significance value (sig) for the income variable was computed as 0.536, exceeding the 0.05 threshold. These findings indicate that the effect of income on the number of visits is not statistically significant.

The Influence of Visitor Expenses on the Increase in the Number of Tourist Visits

The multiple regression analysis ascertained that the coefficient for the expense variable is -1.955. This negative coefficient implies that an upsurge in visitor expenses leads to a decline in the number of visits. To be precise, a one-unit augmentation in visitor expenses results in a reduction of 1.955 visits per year. Subsequently, in the evaluation of the statistical significance of heightened visitor expenses in relation to the number of visits, the significance value (sig) for the expense variable was computed as 0.297, exceeding the 0.05 threshold. These results suggest that the impact of increased visitor expenses on the number of visits is not statistically significant.

According to Sannigrahi et al. (2019), the economic value of ecosystem services involves a methodology to quantify and evaluate the economic worth of ecosystem products and services, along with their associated functions. In this investigation, the calculations were obtained through the regression equation, resulting in a consumer surplus of IDR 7,696,702.06 annually per tourist, equivalent to IDR 15,869.49 for each individual visit, as seen in Table 11.

Table 11. Average Consumer Surplus Calculation Results

Variable	Amount	Notes
Total Respondent Visits in 1 Year ($Y_{respondent}$)	485	MS Excel calculation results
Consumer Surplus Per Tourist	IDR 7,696,702.06	MS Excel calculation results
Average consumer surplus / tourists / number of respondents' visits 1 year	IDR 15,869.49	MS Excel calculation results

Source: Results processed by researchers, 2023

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To obtain the economic value of the Klapanunggal Karst area using the Travel Cost Method (TCM), the researcher computed the consumer surplus value multiplied by the actual number of visits over the course of one year. Based on the secondary data acquired, visitation to the Klapanunggal Subdistrict is relatively low. In 2019, there were only 540 visits throughout the year. Consequently, the economic valuation of the Klapanunggal Karst area is determined to be IDR 4,156,219,112.40 annually (Table 12).

Table 12. Calculation Results of the Economic Value of the Klapanunggal Karst Area Using TCM

Variable	Amount	Notes
Number of Research Respondents	109	
Average Consumer Surplus (CS) /Tourists/Year	IDR 7,696,702.06	$CS = \frac{AND^2}{2\beta}$
Travel Cost Coefficient (β)	-1.95	SPSS Regression Results
Total visits to tourist areas in 1 year (Y_{2019})	540	Data Seconds (2019)
Economic Value of the Klapanunggal Karst Area	IDR 4,156,219,112.40	EV = CS x Y_{2019}

Source: Results processed by researchers, 2023

Currently, the Klapanunggal Karst area can be characterized as an underdeveloped tourist destination, primarily owing to the scarcity of information and data pertaining to tourism visits in this region. The researcher obtained valid secondary data from the Bogor Regency Tourism Office, including data from 2016 to 2017, as well as actual visitation data for the year 2022 up to August 2023 (Table 13). The data from 2016 to 2017 were gathered by the office during a cave inventory in the sub-districts of Babakan Madang, Citeureup, and Klapanunggal. Additionally, other secondary data from the year 2019 were sourced from the BPS (Central Statistics Agency). In order to analyze the annual visitation patterns, the researcher made the assumption that the percentage of tourist visits to the Klapanunggal Subdistrict carries equal significance to the overall tourism visitation numbers for the entire Bogor Regency.

Table 13. Secondary Data Number of Tourist Visits to Klapanunggal

Year	Number of Visits	Total Visits (people)	Percentage (%)
2016	Klapanunggal District[1]	532	0.006%
	Total Tourist Visits for Bogor Regency[2]	8,791,300	
2017	Klapanunggal District[1]	844	0.012%
	Total Tourist Visits for Bogor Regency[2]	7,300,134	
2019	Klapanunggal District[3]	540	0.006%
	Total Tourist Visits for Bogor Regency[2]	9,484,957	
2020	No data		
2021	No data		
2022	Klapanunggal District[4]	464	0.006%
	Total Tourist Visits for Bogor Regency[5]	8,157,531	
2023	Klapanunggal District[4]	441	0.006%
	Total Tourist Visits for Bogor Regency[5]	7,740,203	

Information:

[1] Bogor Regency Cave Inventory Data 2017

[2] Bogor Regency BPS data 2014 - 2019

[3] BPS data on number of tourists visiting tourist attractions per sub-district 2019

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[4] Data on tourist visits to Klapanunggal is based on estimates with the assumption that there will be no increase in the percentage of visits
[5] District Culture and Tourism Department. Bogor As of August 2023
Source: Results processed by researchers, 2023

On the basis of this premise, it can be inferred that tourist visits to the Klapanunggal Subdistrict between 2016 and 2023 are remarkably scarce, constituting a mere 0.006% of the total count of annual international and domestic tourists in Bogor Regency. The economic assessment of the Klapanunggal Karst area is anticipated to offer guidance to stakeholders concerning tourism development in the locale, with the potential to invigorate increased tourism. The progression of tourism is foreseen to play a role in preserving the ecological functions of the karst region. Previous research has highlighted the economic significance of karst areas, serving as a direct source of water resources and other natural assets for the community (Wisnuaji & Fauzi, 2022). This investigation highlights that any harm inflicted upon the karst area will consequently erode the value of its direct utility.

Karst regions play a vital role in the ecosystem, offering direct benefits through the utilization of water resources and other natural assets. Additional research has highlighted other essential functions of karst regions, such as their capacity to store significant quantities of organic and inorganic carbon (Danardono et al., 2019). The study aimed to estimate the economic value of carbon in the Biduk-biduk karst region. Researchers identified the value of carbon reserves and calculated carbon biomass stocks above and below the soil surface, as well as in litter. Additionally, they assessed carbon concentrations in carbonate rock formations, representing inorganic carbon reserves, using the cost-benefit transfer method (Danardono et al., 2019).

At present, the Klapanunggal karst area is being utilized for limestone extraction, mainly as a fundamental resource for cement manufacturing. When conducting a comprehensive economic assessment, the continued mining operations lead to a depletion of the economic value associated with the functions of the karst ecosystem. This includes the direct utility derived from water resources, the direct utility stemming from land coverage, and the economic worth of the karst region as a carbon reservoir.

CONCLUSION

Based on the research findings gathered through observational analysis, the Klapanunggal karst region is presently categorized into four distinct karst zones. The first zone, known as Klapanunggal Karst Zone 1, exhibits potential for specialized tourism activities, including cave exploration and rock climbing. However, this zone is currently under cement industry permits. Following this, Klapanunggal Karst Zone 2, situated within the Klapanunggal Karst Natural Landscape Area (KBAK), experiences challenges related to limited accessibility. Moving on to Klapanunggal Karst Zone 3, this zone has been significantly impacted, having once served as a limestone mining site, but has since been repurposed into a tourism destination. Finally, Klapanunggal Karst Zone 4 stands as the sole area officially designated as a tourist village, having received support from the Tourism Office of Bogor Regency.

The researcher also conducted an economic evaluation of the Klapanunggal Karst area. The results of this assessment, which utilized the Travel Cost Method (TCM), indicated that the Klapanunggal Karst area possesses an annual economic value of IDR

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4,156,219,112.40. This valuation was based on the expenses incurred by respondents during their visits to the Klapanunggal Karst area. Additionally, the regression analysis concerning the number of tourist visits to the Klapanunggal Karst area led to the conclusion that neither income nor visitor expenses significantly impacted the visitation increase. Consequently, it can be inferred that the Klapanunggal Karst area holds a substantial economic value, as visitors do not take into account their income or the costs incurred during their visits. Furthermore, respondents predominantly exhibit an interest in nature conservation and sports tourism according to the criteria. The respondents also display a tendency to make repeat visits, underscoring the Klapanunggal Karst area's appeal as a destination for sports and nature tourism.

This research aims to provide stakeholders with valuable insights for crafting policies aimed at the development of the Klapanunggal Karst area. Transforming the karst region into a tourist destination holds the potential to uphold the sustainability of its vital ecosystem functions, which encompass its role as a water resource provider, contributor of various natural resources like land cover, and its significance as a carbon reservoir. In this study, the researcher restricted the economic evaluation of the karst area to the travel cost method, which is a recommended approach for considering its development as a tourist destination. As a result, it is essential to conduct further research to estimate the comprehensive economic worth of karst areas using alternative methodologies. These may involve resource benefit valuation, production-oriented models tailored to mining and agriculture, cost-benefit transfer techniques, and other diverse economic valuation approaches.

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