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Review Article

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The Contribution of Culture to the Sustainable Development of the Historic City of Eretria through a Mathematical Model: Findings

#### Karagiannis Georgios\* and Xylas Antonios

Statistics and Insurance Science University of Piraeus, MSc Economics and Sustainable Development Harokopio University, Greece

## \*Corresponding author

Karagiannis Georgios, Statistics and Insurance Science University of Piraeus, MSc Economics and Sustainable Development Harokopio University, Greece.

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#### **ABSTRACT**

From the field research conducted in the study area, namely Eretria, the main investigative tool employed was not merely observation but primarily communication with Eretria's residents, organized stakeholders, local government representatives, and museum staff. This interaction positively contributed to the presentation and subsequent evaluation of the current situation, aiding the creation of a sustainable development assessment framework based on Eretria's cultural elements. Secondary sources of information included available sector-specific studies, particularly those focused on culture and sustainable development, obtained from the Prefecture of Chalkida and the Municipality of Eretria. Furthermore, the study incorporated a primary field research survey, yielding findings of exceptional interest.

**Keywords:** Archaeological Monuments, Archaeological Sites, Eretria, Sustainable Development

# Introduction

Through the cultural-historical paradigm of Eretria, the potential for promoting sustainable development in this historic city was mapped. The essential elements for this mapping include more than a century of excavations, revealing traces of the ancient city as a mosaic consisting of scattered monuments. Nevertheless, significant sections of the city remain as "terra incognita," unknown places even today. It should be emphasized that Eretria is one of the few locations in mainland Greece where ancient strata have not been irreversibly obliterated [1].

Concerning the ancient theater of Eretria, the initial construction dates back to the 5th century BC, with a capacity of approximately 6,300 spectators, reaching its peak during the 4th century BC. After its destruction in 198 BC by the Romans, it remains the most impressive monument of the ancient city, displaying

significant architectural similarities to the Theater of Dionysus in Athens.

Unfortunately, the majority of its seating rows have been plundered. Nevertheless, impressive remnants remain, notably the ruins of the stage (skene) and particularly the vaulted underground passage leading to the center of the orchestra. Historically, the theater played an essential role in the performance of ancient Greek tragedies and comedies. Currently, the site is not accessible for public visits as it is undergoing restoration (currently in the first phase). Consequently, theatrical performances are not held, according to sources familiar with the matter (odysseus.culture.gr).

### Variable Analysis

One of the most remarkable monuments of the region is the Temple of Apollo Daphnephoros, built during the 6th century BC and dedicated to Apollo, the city's patron deity. Parts of the columns and foundations still survive today. There is a significant

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interest in visitation; according to data from 2023, approximately 4,000 visitors per year have been recorded during the past five years. Restoration work on the temple was completed in 2004. Notably, this site also includes an earlier structure, a hekatompedon apsidal temple, constructed in the 8th century BC, contemporary with a smaller apsidal building nearby, the "Daphnephoreion," associated with the early worship of Apollo at Delphi. Early in the 6th century BC, an Ionic peripteral temple was built over the geometric structure, and by the late 6th century BC, another peripteral temple was constructed in Doric style, featuring six columns along its shorter sides and fourteen along the longer ones.

This temple was destroyed during the Persian invasion of 490 BC, yet its remains are still visible today. Additionally, excavations in the sanctuary area have uncovered further structures associated with long-standing religious practices. According to local historical testimonies, the sanctuary of Apollo was excavated between 1899 and 1910 by Greek researchers in collaboration with the Swiss School of Archaeology, supervised by the Greek Archaeological Service [2].

Another significant monument is the House of Mosaics, a Roman residence featuring extraordinary mosaic floors depicting scenes from mythology and daily life. It enjoys high visitation rates and is a renowned archaeological site, attracting approximately 10,000 visitors annually.

Lastly, the Ancient Agora demonstrates the historical importance of Eretria as an economic and social center, including shops, public buildings, and sanctuaries. While known to locals and foreign visitors, the Agora itself is not prominently visible nor directly accessible to visitors. However, the ancient "tholos" and the Roman public baths located there are accessible. The Roman baths, dating from the classical and Roman periods, reveal insights into hydraulic engineering and architecture. These facilities remain visible and accessible to visitors today.

# **Definition of Research Objectives**

Given the high popularity of the Temple of Apollo Daphnephoros, we proceeded to construct a mathematical model utilizing linear regression, specifically concerning the visitation of this temple. The mathematical model, in relation to visitation rates at the Temple of Apollo Daphnephoros, was based on historical data, considering temporal trends (e.g., increases or decreases in visitation) and other influential factors such as restoration projects and promotional activities. Utilizing these parameters, visitation forecasts were extended up to the year 2044.

Similarly, for the House of Mosaics, a Roman residence known for its remarkable mosaic floors depicting scenes from mythology and daily life, which currently attracts approximately 10,000 visitors per year, it was deemed necessary to create an additional mathematical model. This model aimed to analyze whether the existence of this Roman house with its exceptional mosaics and its high annual visitation rate can effectively contribute to sustainable cultural development, taking into account various relevant parameters.

According to our analysis, this model can be adapted and expanded for studies and evaluations within similar scientific fields and contexts.

#### Methodology

The research methodology initially focused on gathering reliable secondary-source data. These secondary sources included sector-specific studies and reports, alongside particularly useful material provided by numerous organizations and institutions based in Eretria and Chalkida, with an emphasis on cultural topics and sustainable development. The study was further enriched by a primary field survey, which yielded findings of considerable interest.

The research location was the city of Eretria, and the period of data collection extended from June-July to August 2024. The survey sample comprised 33 local residents of Eretria (18 men and 15 women). Initially, contacting local residents proved somewhat challenging due to observable initial skepticism concerning the research topic. Subsequently, the questionnaires were distributed in print format, and participants were requested individually to complete the questionnaire digitally via the Google Forms platform—a procedure that was successfully followed.

## **Municipality of Eretria: A Venue for Events and Recreation**

The Municipality of Eretria, part of the Central Greece region, is located in central Evia. It was established in 2021 under the Kallikratis Programme by merging the municipalities of Amarynthos and Eretria. The municipality's administrative center is in the town of Eretria and spans an area of 168.5 square kilometers [3].



According to official census data, the population numbers are as follows:

2021: 12,676 residents
2011: 13,423 residents
2001: 12,218 residents

In Eretria, venues for cultural events, festivals, and theatrical performances are available, contributing significantly to the preservation and promotion of local culture. During the summer, events known as "Kanaria" (in honor of the historical hero Kanaris and the "New Fishermen") are organized. These events last for one week, with a different event scheduled every day. All these activities are arranged by local cultural organizations and associations in collaboration with the Municipality. In addition, Eretria boasts beaches and notably the "Island of Dreams," where local cultural groups, in partnership with the Municipality, organize various events and excursions. The hospitality sector in the area is supported by advanced tourism infrastructures, including resorts and rental accommodations—with 13 hotel units and 137 rental apartments or Rbnb options available.

#### Cultural Heritage of Eretria

Eretria possesses a rich cultural heritage that includes Byzantine and post-Byzantine churches featuring noteworthy frescoes and distinctive architecture. The church of "Panagia Paravouniotissa"

stands out as one of the most significant. The church operates normally every Sunday, and aside from the original church building, recent initiatives aim to construct a new structure adjacent to it to host services.



**Source:** Future Leaders [4]. Proposal for Expanding the "Diázoma" Initiative for Sustainable Development through Culture: A Case Study of Eretria, p.86.

Additionally, the city features several neoclassical buildings such as the aqueduct, the house of Kanaris, and the first primary school built in 1900 with the support of banker Andreas Synngrou. The Archaeological Museum of Eretria houses artifacts from excavations—ranging from pottery, statues, and jewelry to everyday objects. Official data indicate that the Archaeological Museum of Eretria is visited by approximately 15,000 people annually; besides the general public, researchers from both national and international institutions also frequent the museum. There are proposals to integrate the archaeological sites into a single route, allowing visitors to experience the entire city along one unified itinerary.

This approach to preservation and respect—recognizing that cultural monuments are not only tangible relics but also carry the memory of those who embodied significant and sacred characteristics—has led to the creation of numerous monuments. These monuments were historically regarded as elements of nature, sites that preserved traces of divine presence, commemorative markers linked to the worship of ancestors (whether mythical or mortal heroes), and locations of historical significance where key historical events and battles unfolded. Furthermore, statues and edifices that memorialize deities and notable individuals serve to reinforce the collective memory.

Even when these ancient monuments lose their original natural context and become embedded within the modern urban fabric, they continue to function as a special type of public space—engaging in a continuous, multifaceted dialogue with the inhabitants of the modern city, thereby maintaining a lasting trace and a unique, cohesive element of the city's historical identity [5].

# **Sustainable Development**

In recent years, the concept of sustainable development has become an integral part of the vocabulary of all developmental cultural programs. It is a notion that seamlessly combines economic and social growth with environmental protection. Within the urban context, sustainable development—or urban sustainability—generally refers to the various approaches of developing and operating a city in ways that render it economically competitive, socially equitable, and more environmentally friendly. Moreover, definitions of sustainable development

and the urban environment are frequently encountered across diverse scientific and non-scientific fields, together with the core principles that underpin sustainable development.



Future Leaders [4]. Proposal of the "Diazoma" Initiative for Sustainable Development through Culture: Case Study: Eretria. Publisher: Unknown, p. 59.

According to sources (dspace.lib.ntua.gr), sustainable development is incorporated into thematic objectives such as: Information and Communication Technologies (ICT), the Competitiveness of Small and Medium Enterprises (SMEs), Low-Emission Economy, Climate Change – Prevention and Environmental Protection, Sustainable Transport, Employment, Social Inclusion, Education and Lifelong Learning, Public Administration Reform, as well as Research – Technology and Innovation [6]. Finally, the concept of sustainable development, as a strategic goal, is also framed by the growing prominence of decision-making discussions related to the environment, culture, and development. The essence of sustainable development lies in the harmonious pursuit of economic, social, environmental, and cultural objectives [7].

# **Linear Regression**

Our simple model is based on linear regression, with the analysis expressed as follows:

 $V(t)=\alpha+\beta t+\gamma X+\epsilon$ 

#### where

- V(t) is the predicted number of visitors to the temple in year
- $\alpha$  is a constant representing the base visitation level.
- β is the coefficient representing the annual change in visitation
- t is the number of years from the start of the measurements.
- $\gamma$  is the coefficient that represents the effect of external factors (e.g., the 2004 restoration).
- X is the indicator variable for external factors (e.g., 0 for years without restoration and 1 for the year with restoration).
- $\varepsilon$  is the error term of the model.

# **Assumptions for the Coefficients:**

- In 2004, a restoration took place; hence, that year might exhibit a different visitation pattern due to the restoration.
- The average number of visitors is approximately 4,000 per year.

# **Model Application:**

Let us use the following example coefficients to forecast visitation:

- $\alpha$ =3500 (base visitation before restoration).
- $\beta$ =50 (an increase of 50 visitors per year).
- $\gamma$ =500 (effect of restoration).
- X=1 for the year 2004 and
- X=0 for all other years.

Assuming we want to forecast visitation for the upcoming years

#### **Visitation Forecasts:**

#### The model is:

V(t)=3500+50t+500X

## For example:

- For the year 2024 (20 years after the restoration):  $V(2024) = 3500+50 \times 20+500 \times 0=4500$  visitors.
- For the year 2004 (the year of restoration):  $V(2004)=3500+50\times0+500\times1=4000$  visitors.

In summary, the model indicates a gradual increase in visitation by 50 visitors per year, taking into account the restoration conducted in 2004. This approach can be utilized for forecasting future visitation trends or for adjusting the model in response to new data.

# Forecasts up to 2044

With regard to the visitation forecasts for the Temple of Apollo Daphnephoros, our model predicts a steady annual increase. The basic trend of an increase by 50 visitors per year is observed starting from 2004, when visitation was 4,000 visitors (reflecting the restoration effect). Some key predictions include:

- In 2004, the restoration year, visitation was 4,000 visitors.
- In 2005, the predicted visitation is 3,550 visitors.
- In 2010, the predicted visitation reached approximately 3,800 visitors.
- In 2020, the predicted visitation is around 4,300 visitors.
- In 2030, the forecast suggests visitation will reach about 4,800 visitors.
- By 2044, at the end of the examined period, the predicted visitation is 5,750 visitors.

Thus, the upward trend in visitation is maintained throughout the period.

# **Exploration of an Extended Model of Sustainable Cultural Development Related to the House of Mosaics**

This section examines a Roman residence—known as the House of Mosaics—which features extraordinary mosaic floors illustrating scenes from mythology and daily life. Attracting approximately 10,000 visitors per year, this site is also a well-known archaeological attraction. Recognizing its significance, it was considered necessary to develop another mathematical model. This model aims to analyze whether the existence of this Roman house with its exceptional mosaics and its high annual visitation can contribute to sustainable cultural development by incorporating various parameters. Our analysis suggests that this model can be adapted and extended to study and evaluate similar scientific fields.

# **Definition of Variables:**

- V: Annual number of visitors (10,000).
- R: Revenue per visitor (e.g., an average ticket price of approximately 10 euros).

- C: Annual maintenance and operational costs of the Roman residence.
- S: Total revenue from all visitors.
- P: Percentage of revenue reinvested in the maintenance and development of the monuments.
- A: Number of other monuments in the area that contribute to cultural development.
- D: Indicator of sustainable cultural development.

## **Calculation of Total Revenue:**

 $S=V\times R$ 

# **Total revenue**

S is determined by multiplying the number of visitors by the average revenue per visitor.

Calculation of Maintenance and Development Cost:  $K=C+(P\times S)$ 

## The total cost

K includes both the fixed maintenance expense and the reinvested portion of the revenue.

D= (further calculations would follow)

# **Model Analysis:**

- If D>0, the model indicates that the Roman residence not only is maintained but also contributes to sustainable cultural development by supporting other monuments.
- If D≤0, it implies that the revenue generated is insufficient to support sustainable cultural development, suggesting that further strategic measures may be necessary.

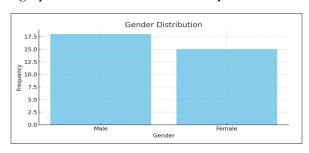
# **Potential Model Extensions:**

- Visitor Increase Projections: Variables predicting increases or decreases in visitor numbers, based on promotional efforts or other factors, can be incorporated.
- Community Involvement: Additional variables accounting for local community participation or supplementary income sources (e.g., donations, sponsorships) may also be considered.

# Statistical Analysis of the Investigated Topic:

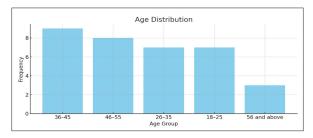
"The Contribution of Culture to the Sustainable Development of the Historic City of Eretria"

# **Demographic Characteristics of the Sample**



The graphical representation illustrates the gender distribution of participants: 18 male participants versus 15 female participants.

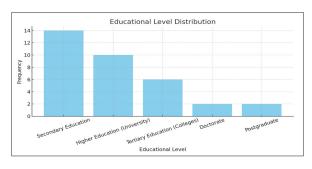
# Age Distribution of the Sample



From the age distribution graph, the following observations can be made:

- Ages 36–45: Largest group with 9 participants, indicating a higher representation in this category.
- Ages 46–55: Second largest group with 8 participants, also showing significant participation.
- Ages 26–35: Comprising 7 participants, reflecting a good representation of younger individuals.
- Ages 18–25: With 6 participants, indicating a smaller yet significant presence.
- Ages 56 and above: The smallest group with 4 participants, suggesting lower representation among older individuals.

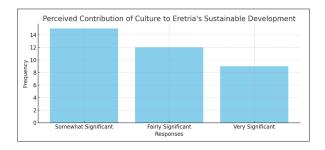
# **Educational Level of the Sample**



## The diagram depicting educational attainment shows:

- Secondary Education (High School): The largest category with 14 participants.
- Higher Education (University): Followed by 10 participants, suggesting a significant number of participants with a university degree.
- Tertiary Education (Technological Institutions/Colleges):
   9 participants, indicating several respondents with this educational background.
- Doctoral Level: 4 participants, a smaller subset holding doctoral qualifications.
- Postgraduate Level: Also 4 participants.

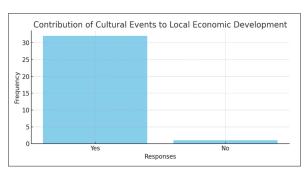
# Perceived Contribution of Culture to Sustainable Development



Regarding how significantly culture is perceived to contribute to the sustainable development of Eretria:

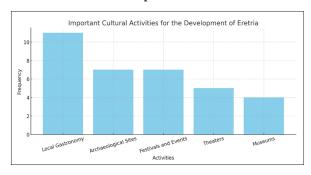
- Somewhat Significant: 15 responses. The majority view indicates that culture plays a moderate role in sustainable development.
- Fairly Significant: 10 responses, suggesting a positive view of culture's contribution, though not overwhelmingly so.
- Very Significant: 9 responses, representing a significant minority that considers culture's contribution to be crucial.

# **Cultural Events and the Local Economy**



The diagram regarding the contribution of cultural events to the local economy shows that a large majority (over 30 respondents) perceive these events as beneficial. Only a minimal number of respondents disagree, indicating widespread support for the positive economic impact of cultural events.

# **Cultural Activities – Development of Eretria**



Analysis of the diagram revealing significant cultural activities for Eretria's development shows:

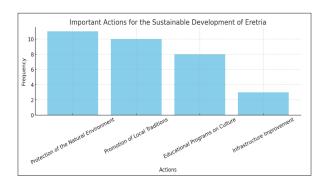
- Local Gastronomy: With 11 responses, this is considered the most important activity for cultural development.
- Archaeological Sites: 7 responses, highlighting the role of cultural resources in sustainable tourism and development.
- Festivals and Events: High support, suggesting these contribute substantially to social cohesion and economic growth.
- Theatrical Performances and Venues: Also valued, indicating that live performances serve as important attractions.
- Museums: Though receiving fewer votes, museums remain important for preserving and showcasing local history.

# **Actions for Sustainable Development in Eretria**

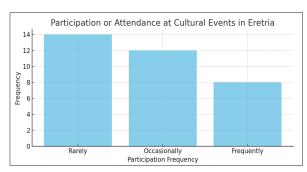
The diagram representing significant actions for sustainable development in Eretria indicates:

 Protection of the Natural Environment: The highest priority, signaling that environmental protection is considered the most critical pillar.

- Showcasing Local Traditions: Also highly valued by participants.
- Educational Programs and Cultural Awareness: Seen as essential to enhancing knowledge and appreciation for cultural heritage.
- Infrastructure Improvements: Though slightly lower in priority, these are still important for supporting other developmental initiatives and overall quality of life.

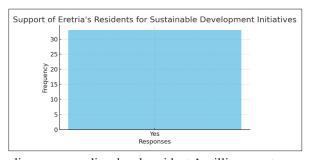


#### Participation in Cultural Events in Eretria



The diagram on participation in cultural events suggests that most respondents attend such events infrequently ("rarely"), with occasional attendance being the next most common response. Only a small fraction of respondents attend cultural activities regularly.

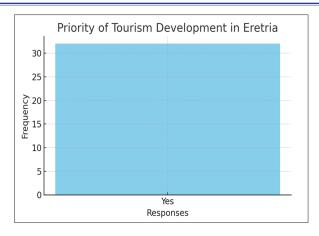
# **Local Contribution to Sustainable Development**



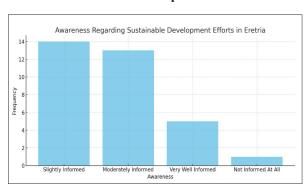
The diagram regarding local residents' willingness to support initiatives for sustainable development shows unanimous positive responses, indicating a strong readiness within the community to support such initiatives.

## Priority of Sustainable Tourism Development in Eretria

According to the survey, the vast majority of respondents believe that tourism development in Eretria should prioritize environmental protection.



## **Awareness of Sustainable Development Initiatives**



The awareness diagram reflects varying levels of information among respondents:

- 14 respondents feel only slightly informed.
- 12 respondents consider themselves moderately informed (the largest group).
- 5 respondents feel very well informed.
- Only 1 respondent indicated no awareness at all.

# Chi-Square Tests of Independence Between Gender and the Degree of Awareness of Sustainable Development Efforts:

Chi-Square Tests				
	Value	df	Asymptotic Significance (2-sided)	
Pearson Chi-Square	10.870	3	0.012	

# Interpretation:

Since the p-value (0.012) is less than the significance level of 0.05, we reject the null hypothesis. This indicates that there is a statistically significant relationship between gender and the degree of awareness regarding sustainable development efforts.

# **Conclusion:**

A statistically significant difference exists between males and females concerning their level of awareness on sustainable development efforts in Eretria—with males tending to report higher levels of awareness than females.

# Between Age and the Perceived Importance of Culture for Sustainable Development:

Chi-Square Tests				
	Value	df	Asymptotic Significance (2-sided)	
Pearson Chi-Square	6.069	8	0.639	

# **Interpretation:**

As the p-value (0.639) exceeds 0.05, we do not reject the null hypothesis. This suggests no statistically significant relationship between age and the perception of culture's importance for sustainable development.

#### **Conclusion:**

There is no significant difference across age groups regarding how crucial they consider the contribution of culture to sustainable development.

# Between Educational Level and the Perception That Cultural Events Contribute to Local Economic Development:

Chi-Square Tests				
	Value	df	Asymptotic Significance (2-sided)	
Pearson Chi-Square	1.472	4	0.832	

# **Interpretation**:

With a p-value (0.832) greater than 0.05, we do not reject the null hypothesis. This implies no statistically significant relationship between educational level and the perception of the economic contribution of cultural events.

#### **Conclusion:**

Different educational levels do not significantly differ in their perception of cultural events' impact on local economic development.

# Pearson Correlation Tests Patryoon "Significance of Culture" and

Between "Significance of Culture" and "Awareness of Sustainable Development":

	Significance of Culture	Awareness of Sustainable Development
Significance of Culture	1.000	0.752
Awareness of Sustainable Development	0.752	1.000

The Pearson correlation coefficient is 0.752, indicating a strong positive correlation. This suggests that participants who perceive culture as important for sustainable development tend to be more knowledgeable about sustainable development efforts in Eretria.

# Between "Significance of Culture" and "Contribution of Cultural Events":

	Significance of Culture	Contribution of Cultural Events
Contribution of Cultural Events	1.000	0.174
Significance of Culture	0.174	1.000

The Pearson correlation coefficient is 0.174, which reveals a weak positive association. Although positive, the low coefficient suggests that the perception of cultural events' contribution to local economic development is not strongly linked to the perceived overall importance of culture in sustainable development.

Interpretation of the Weak Correlation (0.174):

- This slight positive relationship indicates only a minimal association between the two variables.
- It implies that believing in the economic contribution of cultural events does not necessarily equate to attributing high significance to culture for sustainable development.
- Potential explanations include differing personal experiences with cultural events or other factors that were not included in the analysis, as well as the limited sample size affecting the strength of the correlation.

## **Epilogue**

The promotion and protection of culture through a myriad of events in Eretria, under the framework of sustainable development, provides an exceptional opportunity for the long-term prosperity of the region. Furthermore, enhancing sustainable cultural tourism and adopting sustainable practices can safeguard Eretria's cultural heritage while fostering its economic well-being. The city's rich historical legacy significantly benefits the local economy. For instance, the Swiss School of Archaeology-in collaboration with the Ministry of Culture—has contributed extensively through excavations and restoration projects. Today, discussions regarding the prospects of museum tourism often reflect the museum's dynamic role. It is important to recognize that the public sometimes overly focuses on the "monumental" aspect of a site; however, according to Law 3028 on the Protection of Antiquities, monuments—whether movable or immovable—and their surrounding environments, which embody the memory of a past culture, are indispensable for maintaining the city's historical continuity.

# **Conclusions – Proposals**

The visitation patterns of historic and cultural monuments, such as the Temple of Apollo Daphnephoros, can be significantly affected by various factors—both positive and negative—that may alter standard visitation trends. Here are some ways visitation can be positively influenced:

- Restorations and Renovations: As demonstrated by the 2004 restoration, significant improvements can drive an increase in visitors eager to witness the updated site.
- Promotional Campaigns: Advertising initiatives (e.g., tourism programs or cultural initiatives) can heighten awareness and attract more visitors.

- Local Cultural Events: Festivals, exhibitions, and local celebrations can boost visitor numbers, especially when combined with visits to historic sites.
- Major Cultural Festivals: Organizing large-scale cultural events can lead to substantial increases in visitation.
- New Archaeological Discoveries: Groundbreaking findings or ongoing research can generate renewed interest and attract additional visitors.

To optimize these positive influences, targeted communication strategies or programs should be implemented. Based on our field research, although the majority consider culture's contribution to sustainable development as only somewhat significant, a considerable portion views it as quite to very significant. We therefore propose the implementation of informative campaigns and initiatives to clearly demonstrate the impact of culture on sustainable development. Additionally, involving local communities in cultural activities and events can strengthen their perception of culture's value.

Regarding cultural events and the local economy, the vast majority of respondents acknowledge their significant contribution. This strong support suggests that local authorities and event organizers should continue and enhance cultural activities, possibly through programs designed to boost their economic impact while simultaneously promoting sustainable tourism.

Moreover, the survey indicates that local gastronomy is seen as the most important cultural activity for Eretria's sustainable development. Substantial support is also directed towards festivals, theatrical performances, and museum initiatives. These combined efforts can reinforce local economic growth and promote the city's cultural heritage.

A high percentage of respondents also believe that sustainable development in Eretria stems from a robust commitment to environmental protection, the promotion of local traditions, and cultural education. Protecting the natural environment through targeted programs—as well as other similar initiatives—will play a crucial role in preserving Eretria's natural resources. Equally, showcasing local traditions will enhance the city's cultural identity.

The unanimous support for sustainable development among the survey participants is a strong positive signal that can serve as a foundation for further projects. This shared understanding emphasizes the importance of sustainable development and the protection of natural resources in fostering tourism. Accordingly, policies supporting sustainable tourism (e.g., environmental awareness programs that educate both residents and visitors) should be implemented, thereby promoting low-impact tourism forms such as eco-tourism and agri-tourism.

Finally, increasing public awareness regarding sustainable development initiatives is essential. This could be achieved through informative campaigns, seminars, local publications, and the integration of educational programs that enhance residents' understanding of these efforts. Strengthening collaboration with local organizations and stakeholders will further promote community engagement and informed participation.

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