



Evaluating GIS as a Tool to Support Sustainable Coastal Planning: Climate Change Awareness as a Moderator

تقييم نظم المعلومات الجغرافية كأداة لدعم التخطيط الساحلي المستدام: الوعي بتغير المناخ كمتغير معدل

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Abstract

المستخلص

In light of the increasing interest in climate change issues and their impacts on the tourism sector, especially in coastal cities that have become at risk of drowning as a result of sea level rise, one of those cities was Alexandria in Egypt. Therefore, officials of the local authorities have recently begun to search for supportive tools that contribute to activating sustainable coastal planning. among these tools, GIS got the most attention in previous studies related to tourism planning and sustainable planning. Hence, the main purpose of this study is to assess the availability of geographic information system (GIS) in local authorities for supporting sustainable coastal planning. This study also aims to evaluate the awareness of technicians and application experts in tourism authorities on climate change issues as a moderator variable and its effects on sustainable coastal planning. This study relied on a quantitative approach through the use of a survey method for collecting data. The questionnaire has been distributed to administrators, technicians, and application experts of GIS at local authorities. Results have shown that hardware, software, and people have significant positive effects on sustainable coastal planning. By contrast, there was a lack of data and procedures, which had negative effects. Additionally, a lack of awareness among administrators, technicians, and application experts about climate change issues has a negative effect on sustainable coastal planning. The results of the current study provide significant recommendations for local tourism authorities in coastal areas for mitigating and adapting to the impacts of climate change.

في ظل الاهتمام المتزايد بقضايا تغير المناخ وتأثيرها على قطاع السياحة، خاصة في المدن الساحلية التي أصبحت معرضة لخطر الغرق نتيجة ارتفاع مستوى سطح البحر، كانت الإسكندرية في مصر من بين تلك المدن الساحلية. لذلك بدأ مسؤولو الهيئات المحلية مؤخرًا، بالبحث عن أدوات داعمة تساهم في تفعيل التخطيط الساحلي المستدام. من بين هذه الأدوات، حظيت نظم المعلومات الجغرافية بأكبر قدر من الاهتمام في الدراسات السابقة المتعلقة بالتخطيط السياحي والتخطيط المستدام. ومن ثم، فإن الغرض الرئيسي من هذه الدراسة هو تقييم مدى توافر نظم المعلومات الجغرافية (GIS) في الهيئات المحلية لدعم التخطيط الساحلي المستدام. تهدف هذه الدراسة أيضًا إلى تقييم وعي العاملين وخبراء التطبيق في الهيئات السياحية المحلية بقضايا تغير المناخ كمتغير معدل وتأثيراته على التخطيط الساحلي المستدام. لذا اعتمدت هذه الدراسة على النهج الكمي من خلال استخدام طريقة المسح لجمع البيانات. تم توزيع الاستبيان على الإداريين وخبراء تطبيق (GIS) في الهيئات المحلية بالإسكندرية. أظهرت النتائج أن الأجهزة والبرامج والأشخاص لها تأثيرات إيجابية كبيرة على التخطيط الساحلي المستدام. على النقيض من ذلك، كان هناك نقص في البيانات والإجراءات، مما كان له آثار سلبية. بالإضافة إلى ذلك، فإن قلة الوعي بين الإداريين والفنيين وخبراء التطبيق حول قضايا تغير المناخ كان له تأثير سلبي على التخطيط الساحلي المستدام. تقدم نتائج الدراسة الحالية توصيات مهمة لسلطات السياحة المحلية في المناطق الساحلية للتخفيف من آثار تغير المناخ والتكيف معها.

Keywords: Geographic Information System (GIS); Sustainable Coastal Planning; Climate Change Awareness; Coastal Tourism.

الكلمات الدالة: نظام المعلومات الجغرافية (GIS)؛ التخطيط الساحلي

المستدام؛ الوعي بتغير المناخ؛ السياحة الساحلية.

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Introduction

Globally, coastal tourism is the most popular and profitable pattern of tourism in the majority of nations (Hall, 2001; Ghosh, 2011; Silvestri, 2018). Some scholars refer to it as "popular tourism" or "mass tourism" (Rutty & Scott, 2014). This type of tourism is frequently paired with other tourist activities such as diving, surfing, and leisure (Miller et al., 2002; Rutty & Scott, 2014). Nationally, Egypt has some of the best beaches in the world; it overlooks the Mediterranean Sea and the Red Sea, which extend for about 3000 km (El-Raey, 2010), as well as a mild summer and winter climate, making it a popular coastal destination (Abul-Azm, 2003). Locally, Alexandria is distinguished by its unique geographical location along the Mediterranean coast, stretching from the Gulf of Abu Qir in the east to Sidi Kerir in the west, which has earned it a variety of beaches (El Menshawy et al., 2012; Salem et al., 2013; Orabi, 2022). Furthermore, its moderate temperature and closeness to the tourism market make it a favorite coastal destination for local vacationers during the summer (Eiweida, 2004; El-Raey et al., 2006; Salem et al., 2013; Abd elnaby, 2017; Orabi, 2022).

Notably, coastal tourism is one of the activities most influenced by the climate since it is directly affected by both temperature, solar radiation, coastal erosion, and flooding (Moreno & Becken, 2009; Andersen et al., 2018; Arabadzhyan et al., 2021). When temperatures and the number of sunshine hours increase, beach activities halt in part because they expose visitors to sunstroke and some skin and eye illnesses (Andersen et al., 2018; Drius et al., 2019; Lithgow et al., 2019). Moreover, studies show that increasing temperatures cause sea levels to increase by 18 to 59 cm, causing coastal cities to drown, such as Alexandria in Egypt, Dhaka in Bangladesh, and Bangkok in Thailand (Andersen et al., 2018; Lithgow et al., 2019).

The majority of coastal destinations lose most of their sandy beaches unless they are preserved by technical methods and appropriate solutions (Ricketts, 1992; Thumerer et al., 2000; Bartlett & Smith, 2004). If coastal destinations lose their sandy beaches, this means a drop in tourism movements worldwide (Nwilo, 2004; Bendell & Wan, 2011). because coastal tourism still represents about 60% of overall tourism (UNWTO, 2020). Therefore, decision-makers and planners in coastal regions have begun looking for an effective and comprehensive tool like the geographic information system (GIS) that helps in selecting the optimal decision, the management of coastal hazards, and integrating different coastal managements in order to support sustainable coastal planning (Boateng, 2012; Ahmed et al., 2018).

Literature Review

Geographic Information System (GIS)

There is no doubt that traditional methods that are used in tourism planning suffer from limited processing and analysis, as they depend on the manual formation of paper maps (hard copies) (Inskeep, 1991; Bartlett & Smith, 2004; Dredge & Jenkins, 2007). It also requires a lot of effort and time, doesn't enable the planner to consider all the natural determinants, and doesn't provide sufficient alternatives and planning options that can be implemented (Inskeep, 1991; Dredge, & Jenkins, 2007). While the GIS contributes to enhancing spatial and geographical studies that are based on analysis, interpretation, and measurement, this plays a significant role in predicting the future of all natural geographical phenomena as well as drawing conclusions that support future development plans in various economic fields (Fedra & Feoli, 1998; Boateng, 2012; Ahmed et al., 2018). As a result, tourism destinations have lately begun to use GIS in their tourism development plans to manage, organize, and integrate spatial data and then analyze and process them in order to draw and design tourist maps that represent the main part in determining the tourism potential (Nwilo, 2004).

A GIS is a database system that contains organized spatial information as well as a set of operations that answer inquiries about certain phenomena (Hasse, & Milne, 2005; Pareta, 2013; Jovanović, 2016). Rhind (1989) has defined GIS as "a system of hardware, software, and procedures designed to support the capture, management, manipulation, analysis, modeling, and display of spatially referenced data for solving complex planning and management problems" (p.28). While Kumar (1995) has mentioned that GIS is "a computerized system for capture, storage, retrieval, analysis, and display of spatial data describing the land attributes and environmental features for a given geographic region, by using modem information technology" (p.15). Others have mentioned that GIS is a set of programmes and devices that assist in entering various types of data and then processing this data in order to produce accurate results that allow decision makers to make the appropriate decision (Wei, 2012; Masron et al., 2015).

According to most researchers, GIS has been described as a container for storing map data in digital form, and information systems can be considered as just a tool for transforming paper maps into data-driven, interactive spatial applications (Stankov et al., 2012; Shyti & Kushi, 2012; Jovanovic & Njegus, 2013; Kyriakou et al., 2017). GIS is a system consisting of hardware, software, data, methods and procedures, and people for storing, analyzing, and distributing geographic information about a certain region (Shyti & Kushi, 2012; Lee et al., 2013). As shown in the following Figure (1).

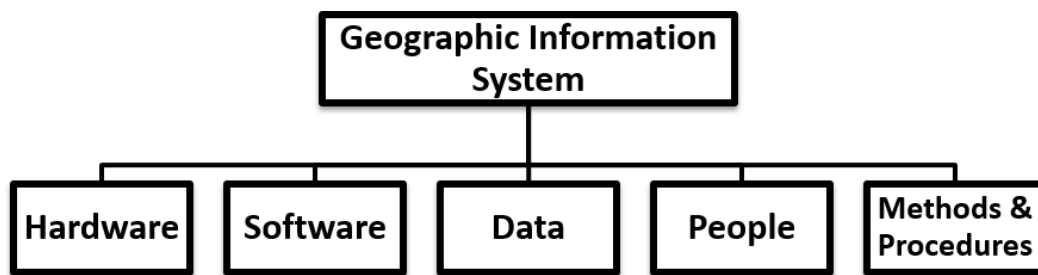


Figure .1 GIS Components

- **Hardware:** It comprises the computer's physical components, which are divided into input units (mouse, keyboard, camera, GPS, satellite, and scanner) and output units (printer, plotter, and screen).
- **Software:** It refers to the programmes that operate geographic information systems, such as GIS software, database software, operating system software, networking software, and image processing software.
- **Data:** It is one of the most important components. The data entered into the systems varies (vector data, raster data, image data, tabular information) because it includes types like regions, population, urbanization, transportation, disasters, and problems.
- **People:** They are specialized individuals (administrators, technicians, and application experts) who work on designing and operating the systems, as the people operating the systems must have sufficient experience and knowledge.
- **Procedures:** The rules and regulations ensure that the database is working properly.

The Advantages of GIS:

1. **Reducing transportation and time costs:** GIS provides alternatives that assist decision-makers in shortening methods and identifying alternatives and solutions.
2. **Concurrency in service:** Organizations can follow a set of instructions at the same time if they use GIS.
3. **Accuracy and integration with other organizations:** GIS is one of the most modern and sophisticated systems that is characterized by the accuracy of spatial information as well as providing networked collaboration environments with many organizations.

The important role of GIS in sustainable tourism planning:

1. Determining the region that needs to be developed and planned: In the first phase, the geographical scope must be determined. The boundaries of the target region should be identified, and then the appropriate proposed systems should be applied to it (Farsari & Prastacos, 2004; Jovanović, 2016). This enables us to recognize land units and their characteristics, as well as knowledge of geomorphological processes such as erosion factors, environmental hazards, torrents, and fault areas that affect tourist services and facilities (Jovanović, 2016).
2. Laying the planning criteria: identifying the natural determinants of the region to be planned and how to deal with them, such as: studying the soil and vegetation cover, the rise or fall of the land surface, and the sea level altitude (Farsari & Prastacos, 2004; Jovanović, 2016). In addition to being away from rocky fissures, earth folds, and torrents, these regions are perilous and susceptible to overflowing. Then select the most appropriate geological formations that are appropriate for the establishment of tourist facilities and services (Jovanović, 2016).
3. Collection and classification of data: After defining the study area, the data that will be entered into the database is collected. This system is characterized by its ability to deal with many types of qualitative and spatial data (Jovanović, 2016).
4. Analysis and design of GIS: The analysis and design phase includes determining the needs of system users, the types of available data, and defining the workflow (Farsari & Prastacos, 2004). Based on the results that are obtained in the systems analysis phase, new systems will be proposed (Farsari & Prastacos, 2004; Jovanović, 2016).
5. Follow-up and evaluation phase: In this phase, the results of the systems are evaluated (Jovanović, 2016).

As mentioned previously, coastal destinations are the most affected by climate change. These prompted officials to use new techniques, such as GIS, to enhance sustainable coastal planning. The coastal development process needs to inventory and assess natural and human resources to develop plans that fit with the rising consequences of climate change (Neumann et al., 2010; Irwansyah, 2012). Thus, to enhance our understanding of the role of the GIS in supporting sustainable coastal planning, the current study suggests the following hypotheses:

Hypothesis 1 (H1): *Hardware has a positive influence on sustainable coastal planning.*

Hypothesis 2 (H2): *Software has a positive influence on sustainable coastal planning.*

Hypothesis 3 (H3): *Data has a positive influence on sustainable coastal planning.*

Hypothesis 4 (H4): *People have a positive influence on sustainable coastal planning.*

Hypothesis 5 (H5): *Procedures have a positive influence on sustainable coastal planning.*

Sustainable Coastal Planning

Although coastal cities are among the most beautiful, important, profitable, and popular, they are also inequitable and dangerous locations to live and work (Papageorgiou, 2016; Jarratt & Davies, 2020; Kim et al., 2021). Due to their diverse and intense usage in different economic fields, coupled with climate change-related consequences, they are increasingly threatened by coastal hazards, suffer ecological degradation, and face several obstacles in planning for and managing beaches (Irazábal, 2018; Hjalager, 2020; Kim et al., 2021). Urban planning for disaster prevention has become a critical concern for the socioeconomic development of coastal cities (Birkic et al., 2014; Papageorgiou, 2016).

In coastal destinations, comprehensive coastal planning was handled by line ministries and the governorate with minimal coordination, resulting in unsustainable growth (Olsen, 2003; Cicin-Sain & Belfiore, 2005; Norman, 2009). For instance, building massive beach resorts, holiday homes, and apartment towers, along with significant coastal erosion, would degrade the environment and put

ecosystems in danger. This has contributed to the emergence of the term "Integrated Coastal Zone Management" (ICZM) (Norman, 2009; Portman et al., 2012).

Integrated Coastal Zone Management (ICZM) provides a framework for sustainable management of the coastal zone by enhancing spatial and sectoral integration and coordination of coastal activities in the region. The Intergovernmental Panel on Climate Change (1994) has defined ICZM as "*an adaptative process of resource management for environmentally sustainable development in coastal areas. It is not a substitute for sectoral planning but focuses on the linkages between sectoral activities to achieve more comprehensive goals*" (p. 97). Therefore, the worldwide interest in incorporating the notion of sustainability into coastal planning grew throughout this time period (Irazábal, 2018; Hjalager, 2020). Norman has relied on the concept of integrated coastal zone management when determining the concept of sustainable coastal planning. Norman (2009) has defined sustainable coastal planning as "*an integrated and adaptive systems approach to coastal planning that leads to long term improved environmental outcomes for the coastal zone*" (p. 171). This concept depends on a set of main elements that represent integration, adaptation, systems, long-term, outcome-oriented communities, and a broadly defined inclusive coastal zone (Norman, 2009).

The importance of tourism planning for coastal regions appears in its ability to meet the needs of tourism development on beaches while preserving the environment (Hjalager, 2020; Singh et al., 2021). This is achieved through development plans and decisions that are generated from planning and implementing policies that seek to enhance the coastal environment, taking into consideration the enormous challenges that the world has recently experienced due to climate change, such as coastal erosion and flooding (Irazábal, 2018; Kim et al., 2021).

Sustainable coastal planning involves a new orientation toward the future through the adoption of a long-term timeframe to ensure the resource's sustainability in coastal regions (Norman, 2009). In other words, sustainable coastal planning includes promoting the concept of an equitable use of resources and opportunities in coastal cities (Norman, 2009). As tourism is vital to the majority of coastal regions, it must be modified and reconsidered, its potential must be uncovered, and its alternatives must be developed through sustainable planning (Birkic et al., 2014; Papageorgiou, 2016).

To ensure the flourishing of coastal regions, there must be a framework that helps to strike a balance between environmental conservation and economic growth, both of which may be fostered through sustainable coastal planning (Hjalager, 2020; Singh et al., 2021; Ghafourian & Sadeghzadeh, 2022). The following points summarize the most influential factors on the efficacy of sustainable coastal planning (Norman, 2009):

- cooperating between all local authorities and related ministries when planning for sustainable development and identifying beach uses.
- involving the local community in coastal development plans.
- coordinating between laws and regulations regulating beach management and environmental protection.
- reviewing and monitoring the coastal development plans periodically to face climate change challenges.

Tourism planning for coastal regions includes a set of plans and strategies according to three levels: the national, the regional, and the local level (Prasetyo et al., 2018; Singh et al., 2021). Each level has a series of interconnected and complementary activities that aim to achieve the intended objectives of sustainable coastal planning (Norman, 2009; Irazábal, 2018; Hjalager, 2020; Kim et al., 2021). as demonstrated in the following table (1).

Table 1. Shows The Levels and Tasks of Sustainable Coastal Planning

Level	Main Tasks
National Level	<ul style="list-style-type: none"> • establishing environmental guidelines for coastal regions. • determining the legal and financial processes associated with coastal tourism. • creating an atmosphere conducive for coastal tourism.
Regional Level	<ul style="list-style-type: none"> • developing strategies and plans for sustainable coastal development. • developing regional and comprehensive plans for coastal tourism. • providing transportation and road links between bordering cities and within the cities.
Local Level	<ul style="list-style-type: none"> • coordinating and carrying out tourism policies and plans for coastal areas. • laying out plans for coastal tourism development at the local level. • controlling coastal city densities and the distribution of tourist land uses.

Source: Norman (2009).

Climate Change Awareness

Over the past decade, the coastal erosion phenomenon has become a global disaster for coastal communities; approximately 86% of islands and beaches all over the world have suffered erosion during the 20th century (Scott et al., 2008; Pang et al., 2013; Fang et al., 2018). According to previous studies, coastal regions have witnessed an increase in the number of severe occurrences as a result of climate change (Jones & Phillips, 2009; Arabadzhyan et al., 2021). Changes in the sea level rise, the rate of erosion, sea-ice cover, and wave height are all examples of changes that have occurred due to climate change (Arabadzhyan et al., 2021; Pathmanandakumar et al., 2021).

Since then, climate change has become a constraint on tourism growth and development in coastal destinations whose economies have grown as a result of development and tourism demand growth (Fang et al., 2018; Arabadzhyan et al., 2021). In this respect, some coastal destinations will become permanently off-limits to visitors by the middle of the 21st century, or at the very least be subject to severe limitations on visitor numbers (Jarratt & Davies, 2020; Arabadzhyan et al., 2021). The primary impacts of climate change on the tourism industry in coastal destinations are as follows (Hall, 2018):

- Tourism infrastructure is destroyed as a result of coastal erosion and flooding.
- The value of coastal tourism products has decreased due to changes that have happened to the beaches as a result of the increase in sea level and wave action.
- Impacts on marine diving sites owing to reef damage as a consequence of increasing sea surface temperature.
- The image of some coastal destinations has been destroyed as a result of climate change and weather patterns.

Coastal environmental concerns have a direct influence and provide a significant challenge to coastal regions (Hall, 2018; Seekamp et al., 2019; Pathmanandakumar et al., 2021). The erosion of coasts and beaches will definitely continue to represent a substantial danger to both the environment and tourism in the future, as well as the tourism economy of many coastal destinations (Hall, 2018; Jarratt & Davies, 2020; Arabadzhyan et al., 2021). Decision-makers in coastal destinations have problems addressing the consequences of global climate change (Seekamp et al., 2019; Pathmanandakumar et al., 2021). In addition, it is impossible to activate the concept of sustainable coastal planning if decision-makers in local authorities are not fully aware of climate change challenges (Santos-Lacueva et al., 2017; Norton, 2022).

Hypothesis 6 (H6): *climate change awareness moderates the relation between Geographic Information System and sustainable coastal planning.*

Hence, officials must take the appropriate actions and measures to solve the crisis, which include (Jones & Phillips, 2009a; Jones & Phillips, 2017b):

- Identifying the problems and threats, hazards are predicted and recognized.
- The influence of the media on the interpretation of significant challenges and risks posed by climate change on coastal destinations.
- The role of local government and public policy-making in mitigating perceived and actual dangers through formulating a long-term planning strategy.
- Predicting climate change threats entails making intelligent decisions and options between mitigation and/or adaptive actions.
- Recognizing legal frameworks, insurance risks, and risk-averse management techniques.
- Accountability of alternative financing choices, as well as the roles and obligations of public and private funding sources.
- Keeping coastal destinations' economic, social, and environmental well-being.

Study Area

Alexandria is one of the Mediterranean coastal cities threatened by coastal flooding and erosion as rising sea levels and heavy waves have exceeded 7.50 metres between 2010 and 2020 (Frihy & El-Sayed, 2013). The Intergovernmental Panel on Climate Change (IPCC) report has shown that climate change will raise sea levels by 0.28 to 0.98 m (1–3 feet) by 2100 (Hemeda, 2021), as clarified in the Figure 2.

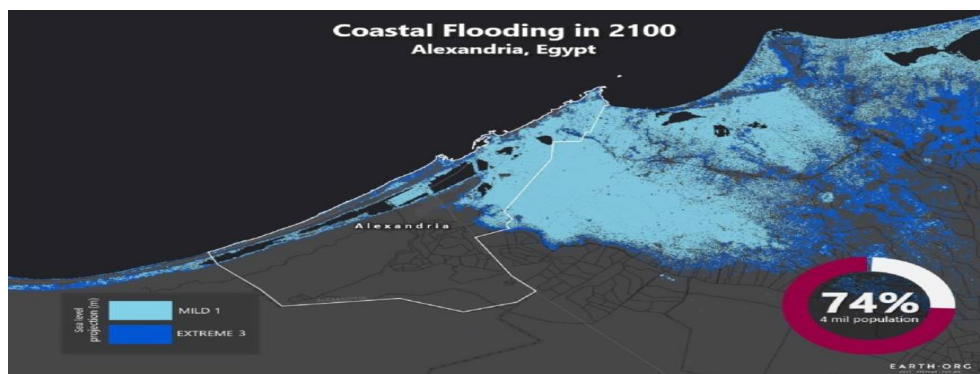


Figure2. Coastal Flooding in 2100 Alexandria

Source: Hemeda (2021).

Notes: Sea level rise projections by 2100 for two scenarios with the amount of rise in meters indicated (mild=1 m; extreme=3 m).

Over the last two decades, Alexandria has seen many economic losses and problems resulting from increasing sea levels and coastal erosion. These problems are divided into two sections: First section: Economic losses for Alexandria as a coastal city in general that include destruction of the beach wall (Sidi Beshr), drowning of some clubs (El Mohandeseen Club) that stretch along the beaches, damage to personal property, and suspension of work at government institutions and schools, especially during Nawa Qassem, as shown in the following Figure 3 (Frihy & El-Sayed, 2013; SPA, 2019; Hemeda, 2021).



Figure .3 Economic losses for Alexandria as a Coastal City (2010-2021)

Source: SPA (2019), Hemeda (2021).

Second section: Economic losses for Alexandria as a coastal destination that include the disappearance of a large number of Alexandria's beaches until they have reached 61 sand beaches only in 2022 and the remaining coastline has been turned into an offshore breakwater barrier, notably El Shatby beach, Camp Caesar, Cleopatra, Ibrahimya, Sporting, and others, which have contributed to an increase in economic losses for the governorate (SPA, n.d.). In addition, rising temperatures contributed to an increase in phytoplankton at Miami Beach in 2021, which changed the color of the sea from blue to green (Orabi, 2022). as clarified in the following Figure (4).



Figure.4 Economic Losses for Alexandria as A Coastal Destination

Source: SPA (n.d.), Orabi (2022).

It should be noted that economic losses in the tourism industry were not restricted to the public sector only, but also extended to the private sector. In fact, most of the beaches that are managed by the governorate (the central administration in tourism and resorts) are leased to the private sector through a contract or agreement concluded between two parties for a period of three years for a sum of money with an annual increase of 10% (Orabi, 2017). as shown in Figure 5, "Edward Al-Kharrat" beach is one of the beaches that have been leased from the governorate at a public auction in August 2021 for three years at a cost of E£ 2 million and fifty thousand (CATR, 2021). However, by the winter season (December), the beach had vanished totally, which led to significant financial losses for the renter (even after getting monetary compensation) (Youns, 2021). as a consequence of sea level rise in Alexandria, one of the tourism restaurants overlooking the beachfront was drowned in 2010. as demonstrated by Figure 6.



Figure .5 Illustrates Beach Erosion in Alexandria

Source: (a) Orabi (2017), (b) CATR (2021).



Figure .6 Shows Sea Level Rise in Alexandria

Source: Orabi (2017).

Coastal destinations with a high number of vulnerable beaches should implement adaptation strategies at the national level (Hemeda, 2021). Therefore, the Shores Protection Authority is working to develop plans for adaptation to climate change that include shore protection projects that involve the implementation of a set of submersible barriers on vulnerable beaches in Alexandria, starting from Bir Massoud to Al-Silsila area at the eastern harbor. This project was divided into three phases, as illustrated in Figure 7 (SPA, n.d.).

Phase 1: From Bir Massoud to Mahrousa Hotel.

Phase 2: From Mahrousa Hotel to San Stefano Area

Phase 3: From Sidi Gaber to Al-Silsila area at the eastern harbor.



Figure .7 Submersible Barriers Project in Alexandria

Source: (SPA, n.d.).

Therefore, decision-makers and planners in coastal regions have begun looking for an effective and comprehensive tool like the geographic information system (GIS) that helps them in selecting the optimal decision, the management of coastal hazards, and integrating different coastal managements in order to face up to the losses and damages mentioned above, as well as activate sustainable coastal planning. So, this study aims to assess the availability of GIS tools that have been mentioned previously in local authorities to support sustainable coastal planning. Furthermore, this study constructed a structural model by using climate change awareness as a moderator variable, which is expected to enhance or weaken the interaction between people (administrators, technicians, and application experts of GIS) and sustainable coastal planning, as shown in the following Figure (8).

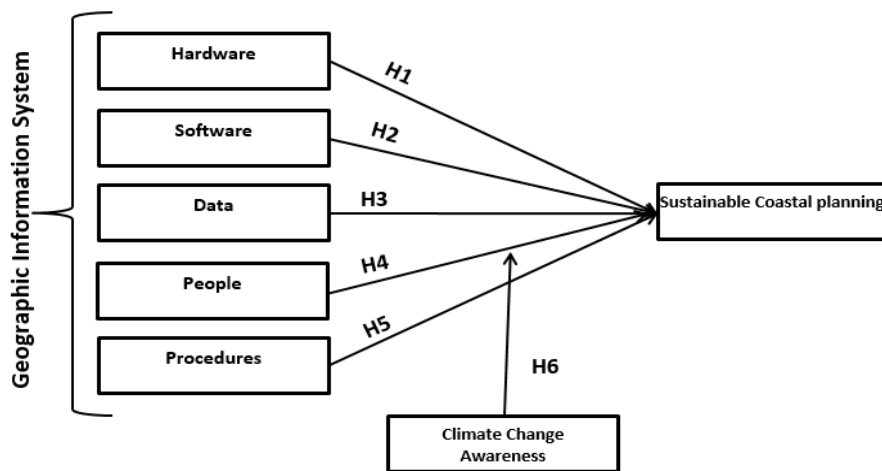


Figure .8 Structural Model

Research Methodology

Sampling and Data Collection

This study has been conducted to analyze the theoretical framework that has been mentioned above and test the hypotheses of the study (H1, H2, H3, H4, H5, and H6) to examine the relationships among variables that have been illustrated in the previous figure. Therefore, this study relied on a quantitative approach through the use of a survey method for collecting data. In order to implement the research objectives, the study has been based on the purposive sampling method to select the research target sample. So, the questionnaire has been distributed to administrators, technicians, and application experts at local authorities in Alexandria, which represent the central administration for tourism and resorts (CATR) as an authority responsible for managing the beaches and the shore protection authority (SPA) as an authority responsible for protecting the beaches.

The target sample size is 60 questionnaires that were personally distributed to employees (technicians and application experts) who are using GIS in their tasks. However, only 11 questionnaires were returned, of which only 49 were valid. In this study, inferential statistics were used to examine sample data on the effect of people's awareness (technicians and application experts) of climate change on sustainable coastal planning. To assess the available data, version 3.3 of partial least squares structural equation modelling (PLS-SEM) has been used. Henseler et al. (2009) have mentioned that the PLS is a strong statistical method for estimating structural models, especially when those models are very complicated.

Measurement items

This research relied on a multi-item questionnaire to collect the required data and achieve the objectives of the study. All items in this questionnaire were derived from previous studies to ensure the validity of the content of the data collected. In this study, all items were measured using a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). The questionnaire was divided into seven constructs. The first five constructs represent the components of GIS (hardware, software, data, methods and procedures, and people) that have been mentioned previously in the theoretical side of the study, as well as the construct of sustainable coastal planning as a dependent variable, and finally, the construct of climate change awareness as a moderating variable. The GIS constructs consist of nineteen items to assess the availability of GIS tools at the local authorities, which were modified from Shyti and Kushi (2012) and Lee et al. (2013). The sustainable coastal planning construct has been examined by using twelve items that were obtained from Irazábal (2018), Hjalager (2020), and Kim et al. (2021). The last construct is "Climate Change Awareness" as a moderating variable, which comprises five items that were adapted from Fang et al. (2018) and Arabadzhyan et al. (2021), as illustrated in Table 2.

Analysis of Results and Discussion

According to PLS-SEM, the first criterion for evaluating a reflective measurement model is to investigate the internal consistency of reliability and validity of measures (Hair et al., 2017). Table 2 demonstrates the measurement model evaluation findings, where the factor loading for each item was greater than the suggested threshold of 0.70 according to Henseler et al. (2009).

Table 2. Illustrates Standardized Loadings for Each Items

Variables	Indicators	Items	Factors loading	Results	Sources
Hardware	GISH1	The organization has a sufficient number of devices operating geographic information systems.	0.892	Accepted	(Shyti & Kushi, 2012; Lee et al., 2013)
	GISH2	The devices operating the GIS contribute to reducing the time taken to implement the tourism plan.	0.865	Accepted	
	GISH3	The devices operating the GIS have the advantage of reducing the costs required to implement the tourism plan.	0.912	Accepted	
	GISH4	The devices operating the GIS contribute to saving time and effort in preparing the tourism plan.	0.787	Accepted	
Software	GISS5	The system allows for adding new software and tools that facilitate the required work.	0.876	Accepted	
	GISS6	The system features high-quality application software.	0.871	Accepted	

Data	GISS7	The system allows the integration of other programmes according to the requirements of the work.	0.849	Accepted
	GISS8	The programmes are easy to use for all employees of the organization.	0.675	Accepted
	GISD9	The organization has a database to help implement the plan.	0.774	Accepted
	GISD10	The system is characterized by the availability of a database that is available to everyone.	0.897	Accepted
	GISD11	The data available in the system includes all types of data required to implement the plan.	0.839	Accepted
	GISD12	The data used to implement the plan is constantly updated.	0.838	Accepted
	GISD13	The available data is comprehensive and facilitates the forecasting process for the future.	0.873	Accepted
People	GISP14	Within the organization, there are highly experienced and efficient workers operating the system.	0.948	Accepted
	GISP15	Training the organization's employees on an ongoing basis is necessary to keep pace with the latest developments in geographic information systems.	0.932	Accepted
	GISP16	GIS operators are sufficient for the implementation of the tourism plan.	0.929	Accepted
Methods and procedures	GISM17	The operating procedures for GIS are characterized by modernity.	0.932	Accepted
	GISM18	The operating procedures of a GIS help in analyzing and processing data to make the appropriate decision.	0.955	Accepted
	GISM19	The operating procedures for GIS contribute to the implementation of the plan's objectives.	0.926	Accepted
Sustainable Coastal planning	SCP20	The tourism plan is characterized by clarity and accuracy.	0.840	Accepted
	SCP21	The tourism plan is characterized by an accurate prediction of the future.	0.846	Accepted
	SCP22	There is great support from the senior management in implementing the tourism plan.	0.761	Accepted
	SCP23	The higher authorities provide continuous financial support to implement the tourism plan.	0.822	Accepted
	SCP24	Senior management provides highly experienced human cadres to implement the tourism plan.	0.806	Accepted
	SCP25	The tourism plan is flexible and can be modified according to business requirements.	0.835	Accepted
	SCP26	There is a constant follow-up and review of the tourism plan.	0.765	Accepted
	SCP27	There is cooperation and coordination between the institutions involved in the implementation of the plan.	0.842	Accepted
	SCP28	The organization provides all the services and capabilities required for the implementation of the plan.	0.872	Accepted

(Norman, 2009)

	SCP29	The necessary infrastructure is being developed to implement the tourism plan.	0.833	Accepted	
	SCP30	The tourism plan is objective and appropriate to current and future conditions.	0.745	Accepted	
	SCP31	The plan has been developed based on available resources.	0.657	Accepted	
	SCP32	There is a sound administrative organization among all the bodies responsible for drawing up the tourism plan.	0.792	Accepted	
Climate Change Awareness	CCA33	I plan to support climate change initiatives in the future.	0.834	Accepted	(Fang et al., 2018; Arabadzhyan et al., 2021)
	CCA34	I seek to implement smart beaches in order to support sustainable activities (e.g., energy conservation, recycling).	0.917	Accepted	
	CCA35	I intend to seek out ways to support and promote sustainable approaches to facing climate change.	0.893	Accepted	
	CCA36	I don't pay attention to the impacts of climate change on beach tourism.	0.818	Accepted	
	CCA37	I seek to mitigate the effects of climate change on coastal destinations.	0.775	Accepted	

Table 3 reveals that all the average variance extracted (AVE) values for each construct have varied between 0.645 and 0.879. Thus, all constructs have exceeded the suggested threshold of 0.5 (Fornell & Larcker, 1981). Also, Cronbach's alpha (α) and composite reliability (CR) values for all constructs were well above the 0.70 threshold, which shows that all measures of the constructs are reliable (Hair et al., 2017).

Table 3. Reliability and Validity of Measurement Scales

Constructs	Alpha (α)	Rho	CR	AVE
Hardware	0.887	0.899	0.922	0.748
Software	0.838	0.862	0.892	0.676
Data	0.900	0.906	0.926	0.714
People	0.930	0.930	0.955	0.877
Methods and Procedures	0.932	0.935	0.956	0.879
Climate Change Awareness	0.902	0.909	0.928	0.721
Sustainable Coastal Planning	0.954	0.956	0.959	0.645

The Heterotrait-Monotrait ratio (HTMT) criteria were used to test discriminant validity, which reflects the ratio of between-trait correlations to within-trait correlations (Hair et al., 2017). Table 4 reveals that all HTMT values of latent constructs are between 0.227 and 0.855, which are obviously lower than the threshold value of 0.90. (Henseler et al., 2015). As a result, the conceptions do not have any discriminant validity issues according to the Fornell–Larcker and HTMT criteria.

Table 4. Discriminant Validity Fornell–Larcker Criterion

	(DA)	(CCA)	(HW)	(PP)	(MP)	(SW)	(SCP)
Data (DA)	0.845						
Climate Change Awareness (CCA)	0.657	0.849					
Hardware (HW)	0.727	0.744	0.865				
People (PP)	0.841	0.790	0.839	0.936			
Methods and procedures (MP)	0.281	0.227	0.452	0.446	0.938		
Software (SW)	0.751	0.749	0.815	0.851	0.530	0.822	
Sustainable Coastal Planning (SCP)	0.783	0.811	0.855	0.817	0.342	0.812	0.803

Note: Bold values are the square root of AVE

According to the above table (4), the findings have emphasized that the discriminant validity is acceptable because the square root of each construct's AVE was greater than any other construct. For instance, the square root of the AVE for the data construct was 0.845, which is higher than the correlations of other constructs (see Table 4).

The coefficient of determination (R^2) was used to assess the structural model's prediction accuracy. The R^2 value is the percentage of variance that has occurred in the dependent variable that has been explained by the independent variables. According to Shanka et al. (2010), the R^2 value has been categorized as considerable (0.75), moderate (0.50), and weak (0.25). In this structural model, the R^2 of sustainable coastal planning is 0.96, indicating that the model has substantial predictive accuracy. The hardware, software, data, methods, procedures, and people can explain 96% of the variance in sustainable coastal planning. As a result, the model's goodness-of-fit metric is larger than the global PLS model's sufficient validity.

Hypothesis Testing

The Smart PLS analysis was performed to examine the correlations between all of the study variables: data, hardware, software, methods and procedures, and people, to predict their influence on sustainable coastal planning as clarified in Figure 9.

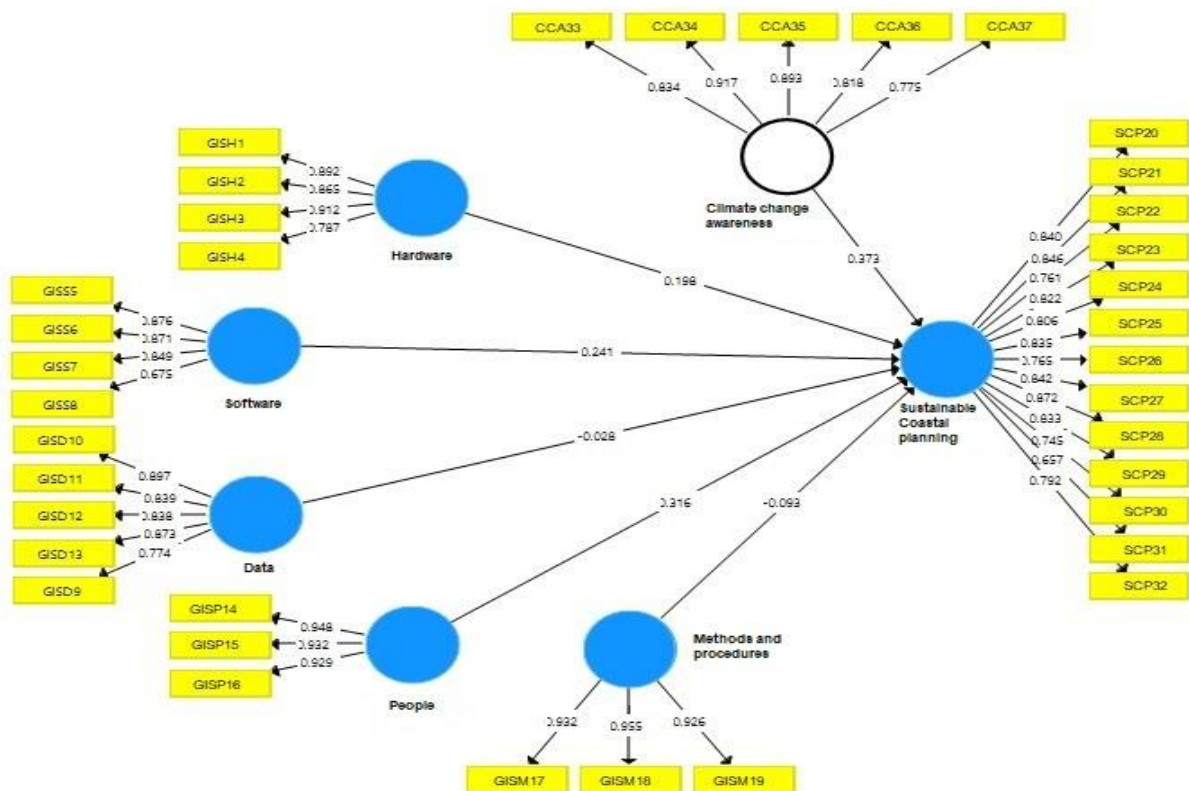


Figure 9. PLS Path Coefficient Algorithm

The findings of the hypothesis analysis are summarized in Table 5, which includes the β coefficient, P-values, t-values, and the decisions that have been taken to accept or reject the hypothesis of the current study. After testing the algorithm for the current structural model, the hypothesis was tested by conducting bootstrapping in the Smart PLS tool. Most of the suggested hypotheses in the current structural model have been accepted except for H3 (data on sustainable coastal planning) and H5 (procedures on sustainable coastal planning), as indicated in the following table.

Table .5 Path Coefficient and Hypotheses Testing

No.	Relationship	β values	P values	t-Values	Decision
H1	Hardware → Sustainable Coastal planning	0.210	0.002	3.076	Accepted
H2	Software → Sustainable Coastal planning	0.216	0.007	2.694	Accepted
H3	Data → Sustainable Coastal planning	-0.042	0.534	0.622	Rejected
H4	People → Sustainable Coastal planning	0.302	0.002	3.051	Accepted
H5	Procedures → Sustainable Coastal planning	-0.093	0.066	1.838	Rejected
H6	People → Climate Change Awareness → Sustainable Coastal planning	-0.051	0.353	0.929	Rejected

The direct impact of hardware on the sustainable coastal planning was examined and found to be significant and positive ($\beta=0.210$, t-value=3.076, p-value <0.05). This result supports H1, indicating that hardware as one of the most important components of GIS positively influences sustainable coastal planning. The findings also showed that the availability of software in local tourism authorities has a significant and positive impact on sustainable coastal planning ($\beta=0.216$, t-value=2.694, p-value <0.05). This finding confirms H2, demonstrating that software has a positive influence on sustainable coastal planning. People construct has found to positively and significantly affect sustainable coastal planning ($\beta= 0.302$, t-value= 3.051, p-value <0.05). People construct was also found to be the strongest factor that affects sustainable coastal planning beside hardware construct. Thus, the results support H4, signifying that people construct has a positive influence on sustainable coastal planning. The results also showed that data, H3 ($\beta= -0.042$, t-value=0.622, p >.05), and procedures, H5 ($\beta -0.093$, t-value=1.838, p >.05), do not significantly influence on sustainable coastal planning. Thus, results do not support H3 and H5, indicating that data and procedures do not positively influence sustainable coastal planning. The Shores Protection Authority relies for most of their implementation projects on the digital maps that it receives from the Egyptian General Survey Authority (Ministry of Water Resources and Irrigation). while the central administration for tourism and resorts depends on the digital maps that it receives from the General Authority for Urban Planning (the ministry of housing, utilities, and urban communities).

Exploration of Moderating Effects of Climate Change Awareness

The main objective of this part is to determine if climate change awareness influences the relationship between people (administrators, technicians, and application experts of GIS) and sustainable coastal planning. H6 suggests that climate change awareness has a moderating effect on the relationship between people and sustainable coastal planning.

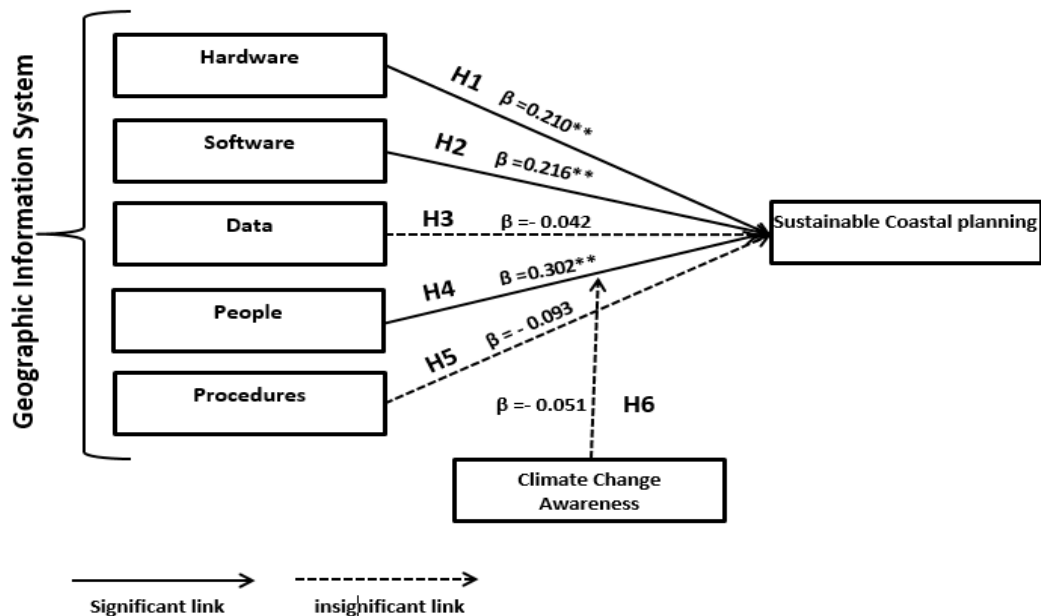


Figure 10. Empirical Framework

The moderating effects of climate change awareness were tested using the Smart PLS (Table 5 and Figures 10–11). The results showed that lack of awareness of climate change by people in local authorities has a negative effect on sustainable coastal planning ($\beta = -0.051$, $t\text{-value} = 0.929$, $p > 0.05$). The t -value of 0.929 is below the accepted level ($t\text{-value} = 1.65$). Hence, H6 is not supported by the results, indicating that administrators, technicians, and application experts in local authorities do not have enough awareness of climate change issues and do not take them into consideration when they are laying the tourism plan for coastal beaches.

Discussion

This research aims to examine the availability of GIS at local tourism authorities in order to support sustainable coastal planning, with a focus on the moderating effect of climate change awareness. To achieve this objective, the current study has constructed a structural model by using climate change awareness as a moderator variable, which is expected to enhance or weaken the interaction between people (administrators, technicians, and application experts of GIS) and sustainable coastal planning.

This research found that hardware, software, and people can positively influence sustainable coastal planning. Hardware and people have shown the strongest influence on sustainable coastal planning. The results also found that data and procedures negatively affect sustainable coastal planning.

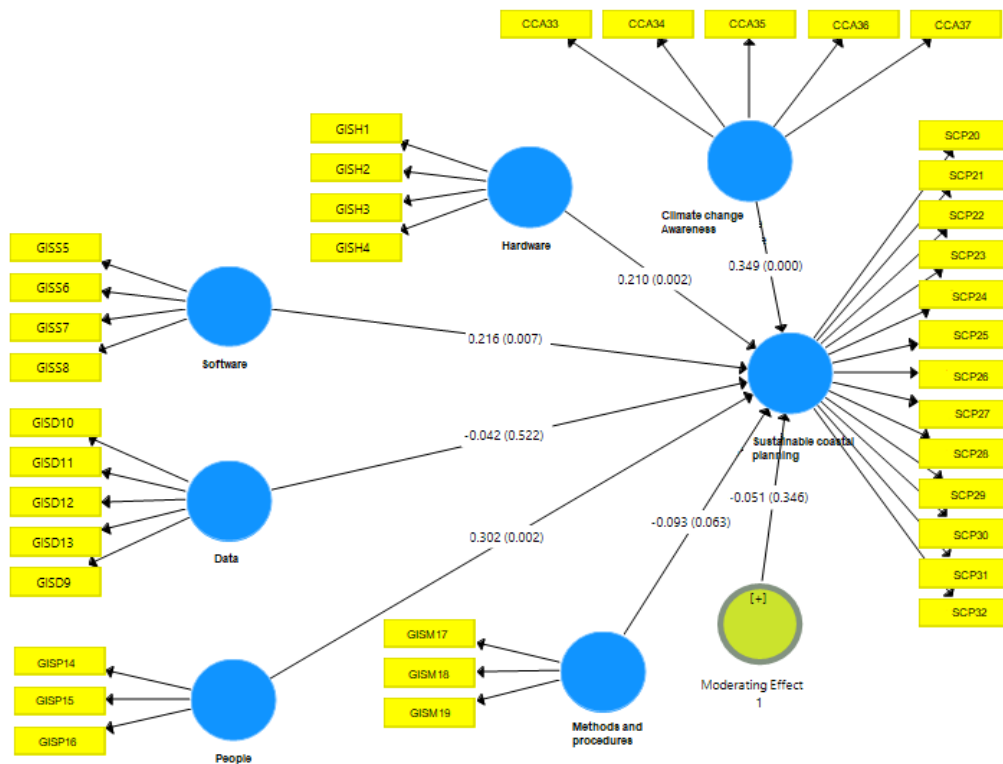


Figure 11. PLS path t-values of the moderator

Interestingly, the results of this study have revealed that climate change awareness among administrators, technicians, and application experts of GIS has no moderating impact on sustainable coastal planning. Local tourism authorities (administrators, technicians, and application experts of GIS) were asked to rate their climate change awareness when planning the beach "I plan to support climate change initiatives in the future", "I seek to implement smart beaches in order to support sustainable activities (e.g., energy conservation, recycling)", "I intend to seek out ways to support and promote sustainable approaches to face climate change", "I don't pay attention to the impacts of climate change on beach tourism", and "I seek to mitigate the effects of climate change on coastal destinations". This suggests that climate change awareness related to sustainable coastal planning is

still low among the local tourism authorities in Alexandria. Despite the fact that 68% of participants were aware of climate change, this is not reflected in tourist plans and decisions. On the other hand, 32% were unaware of the issue, which explains the insignificant moderating effect of climate change awareness.

Conclusion

This study concludes that the GIS is crucial for sustainable coastal planning, particularly in coastal cities like Alexandria that depend totally on beach tourism. According to the Intergovernmental Panel on Climate Change (IPCC) report, Alexandria is one of the Mediterranean coastal cities threatened by coastal flooding as a result of the effects of climate change. Therefore, the current study has sought to assess climate change awareness as a moderating variable among administrators, technicians, and application experts of GIS in local tourism authorities. This study posits that climate change awareness among administrators, technicians, and application experts can influence the relationship between the components of GIS and sustainable coastal planning. This study has shown that hardware, software, and people could influence sustainable coastal planning. However, data and procedures were shown to have an insignificant effect on sustainable coastal planning. Hardware and people have shown the strongest effects on sustainable coastal planning. Thus, it should be considered a crucial factor in the planning process for coastal tourism. Climate change awareness was found to have no moderating effect on the relationship between administrators, technicians, and application experts that are working in local tourism authorities and sustainable coastal planning. This research is expected to spark interest in future studies on sustainable coastal planning and climate change.

Recommendations

1. supporting GIS in the local authorities in coastal regions due to their comprehensiveness and accuracy in predicting the future.
2. encouraging collaboration and coordination among all local governments and related ministries when planning for sustainable development and identifying beach uses.
3. increasing awareness of climate change and its ramifications on coastal tourism in Alexandria among employees at the local authorities and the local community.
4. Flowing the data and simplifying the procedures between local authorities is necessary to guarantee the efficacy of GIS in sustainable coastal planning.
5. providing GIS training courses because most employees lack expertise and knowledge about how to effectively use these systems.
6. involving the local community in coastal development plans.
7. coordinating laws and regulations that regulate beach management and environmental protection.
8. reviewing and monitoring the coastal development plans periodically to face climate change challenges.

Limitations and future research

When evaluating the findings of this research, there are various limitations to consider. First, this research was limited to one coastal city (Alexandria). As a consequence, these findings may not provide a comprehensive view. Consequently, the scope of future studies may be expanded to include a sample of participants from other coastal cities.

Second, regarding the moderating variable, this study only relied on climate change awareness to examine its effect on sustainable coastal planning among administrators, technicians, and application experts of GIS at local authorities in Alexandria. One of them is represented in the central administration for tourism and resorts (CATR) as an authority responsible for managing the beaches and the shore protection authority (SPA), the body responsible for protecting the beaches. But the

study ignored the evaluation of tourism awareness as a moderating variable. Hence, future studies should strive to increase moderating factors in order to better understand their different impacts on sustainable coastal planning. Finally, future studies can carry out a comparative study between an authority that is responsible for managing the beaches and an authority that is responsible for protecting the beaches due to the different nature of their tasks and their goals on the beaches.

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