EREM 79/3
Journal of Environmental Research, Engineering and Management
Vol. 79 / No. 3 / 2023
pp. 7–23
DOI 10.5755/j01.erem.79.3.33207

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Received 2023/01 | Accepted after revisions 2023/07

https://doi.org/10.5755/j01.erem.79.3.33207

Sustainability Assessment Scale for the Nile Islands (SASNI) as a Guideline to Determine Sustainable Urban Development Policies

Esraa Amin Esmail[1], Ahmed Yousry[1], Seham Mostafa Qutb[2]*, Abdelkhalek Abdelrahman[1]

[1] Urban Planning Department, Faculty of Urban and Regional Planning, Cairo University, Egypt

[2] Environmental Planning Department, Faculty of Urban and Regional Planning, Cairo University, Egypt

***Corresponding author:** seham.mostafa87@gmail.com

Egypt's Nile islands are regarded as a source of biological diversity and natural heritage. Two million people live on 63 of these islands, spread throughout 16 governorates and covering over 155.4 km^2. They are included in the wetlands but treated as a single unit, neglecting their diverse characteristics (environmental, urban, economic, and social). By utilizing a Statistical Package for Social Sciences and a Geographic Information System, this paper aims to develop a method of classifying the Nile islands by designing criteria scales to determine their value. Research is essential in assessing the sustainability of urban and economic development on the Nile islands without conflicting with their protection. The research reached recommendations for protection goals by including uninhabited islands in the national strategic plan. It also prepared an endemic plant and animal species database. It is necessary to conduct a sub-classification process with more detail to make decisions regarding the most suitable sites for various development projects without ignoring the social aspect.

Keywords: ecological, GIS, islands, nature reserves, SPSS, urban, wetland.

Introduction

Throughout history, the Nile River flowed from South Africa to Egypt to its mouth in the Mediterranean Sea, penetrating plains and rocks, and forming valleys and islands in weakened river-strength locations due to erosion and sedimentation (Abdul Qadir, 2020).

It is believed that the Nile islands gained significance from plants, crops, animals, and various birds. If exploited optimally, the Nile islands are powerful national asset (Al-Badawi, 2021). As a result of neglect, most necessities have not been provided to their residents,

resulting in environmental damage (Hamza, 2014). In this context, in 1995, Al-Warraq Island was urbanized on 0.3 km^2, but by 2017, it reached 1.8 km^2 or one-third of its total area. Initially, the island was intended to be primarily agricultural, not urban. Citizens' needs deteriorate, and plants and animals disappear from nature reserves. (Al Khalaly, 2022).

The Nile islands have been subject to several laws over the years. In 1998, the Prime Minister published Legislation No. 1969 declaring the Nile islands' natural reserves (Natural Protected Areas Law, 1983). Through legislation No. 542, the government declared some islands within the Greater Cairo region to be public property in 2001 (Public benefit of the Greater Cairo Islands Law, 2001). From 2007 to 2015, committees were formed to remove unplanned areas to save the Nile. However, residents resisted the decisions, resulting in many clashes (Protecting the Nile River Law, 2021). In 2017, 18 islands were excluded from natural reserves (The islands' exclusion from Natural Reserve Law, 2017,2019). Based on a review of previous geomorphological studies of the Nile Islands in Egypt, four sectors of the valley were identified – according to the folds and slopes of the water – as follows: the High Dam to Qena, Naga Hammadi to Assiut, Minya to Cairo, and the delta sector (Al-Husseini, 1991). As a result, the Nile islands have different shapes and dimensions, including round, striped, and almond-shaped, as well as varying geological formations, including rocky, granite, sedimentary, silt, and sandy (Mahsoub, 2002).

A study of the Nile banks and islands in Greater Cairo has been reviewed (Urban Research and Studies Consultation Center, 2006), as well as several Nile islands' policies and models, including Damietta's branch which monitored the islands' aquatic and swamp habitats, agricultural trees, and bird refuges (ACUES, 2008). Besides, the initial vision of the future of the Nile islands in Cairo and Giza was reached. This vision was to identify the description of the Nile islands in the sector and proposals for development for each island (GOPP, 2017). Previous studies have dealt with each island separately or within a specific scope. There were some for-development planning and others for environmental or geographical reasons. There is a lack of a comprehensive view of the Nile islands as a system of environmental, economic, and social systems. Despite the islands' differences, they have been treated as one without an identified framework for addressing the various elements that contribute to sustainability. Therefore, the different Nile islands require a comprehensive approach.

The research aims to achieve development goals while protecting and balancing the environment. The Nile islands will be categorized into homogeneous groups for evaluation and assessment based on urban, environmental, economic, demographic, social, and legal criteria.

Methods

The research methodology consisted of three phases that were determined by successive steps. In the initial phase, an integrated framework for the classification of the Nile islands was developed, based on the classification criteria listed in order of importance. In the second phase, a ranked scale was designed for the classification criteria, and in the last phase, the most important approaches were identified to deal with the different categories of the Nile islands, leading to the most important results and recommendations.

The Nile islands' overview and environmental classification criteria

According to the International Union for Conservation of Nature (IUCN), natural protection areas can be divided into four categories: marine, wetland, mountain and desert, and geomorphological reserves. The second classification relates to how protected areas are managed and the principles used to define them (Ramsar Convention, 2006). It cooperated with the Ramsar Convention on the designation of Ramsar sites in Egypt. It defined the boundaries of wetlands to be described on the map (Ramsar, 2005) According to Ramsar, there are five wetland systems (marine, estuarine, lacustrine, palustrine, and riverine). The country considers the Nile islands to be wetlands to prevent the destruction of ecosystems. Previous studies have developed environmental criteria for classification, along with a grading of the value of those criteria. This has been done to determine which areas have the highest and lowest environmental values based on shape, size, biodiversity, scarcity, availability, and history (Delsante, 2016). As shown in *Table 1*, a set of appropriate criteria was selected and applied based on this gradation and application to the Nile islands.

Fig. 1. *Research general methodology (Source: authors)*

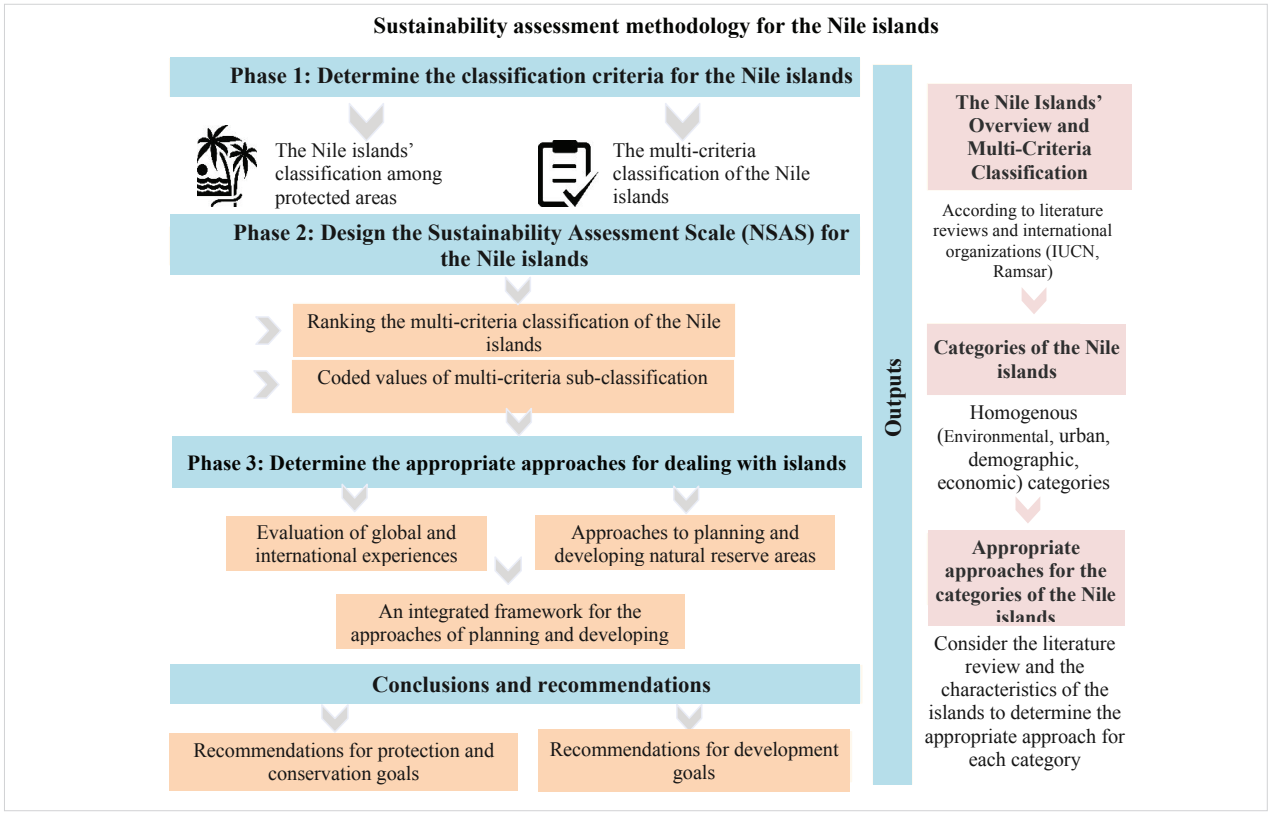


Table 1. *Environmental classification criteria for the Nile islands (Source: authors)*

Value	Shape	Biodiversity			Sensitivity rarity	Size	Productivity	Recorded history
		Species and ecological communities	Waterfowl	Other species				
3	Roundest Rocky soils, the oldest No risk of sinking or docking	Support threatened and diverse ecological communities	Supports at least 20,000 waterfowl	A 1% of species and subspecies rely on it.	Contains a variety of communities or species depending on their unique nature	Large	Globally important commercial, scientific, and cultural species	Historical, scientific, cultural, and artistic values; are listed as a unit of world heritage.
2	A large depth, rectangular, round, or arc Firm rocky or loamy soils Mediates the river course or tends to one side	Supports species and ecosystems	Regularly supports 1% of one type of waterfowl or its subspecies		Rare, sensitive communities, ecological and typological characteristics.	Medium	Vital species to different organisms; local economic, scientific, and cultural importance.	Nationally important sites that have historical or cultural significance
1	Strip-shaped, irregular, and shallow Unstable clay or sandy soils	Supports species diversity within a species and spatial spread			Self-sufficient ecological unit; rare local communities	Small	Locally important commercial, scientific, or cultural species.	Local heritage areas

The Nile islands' urban, demographic, and economic classification criteria

Demographic and social criteria

The criteria are used if the urban form refers to the human appearance of a settlement rather than built-up areas. It represents a group of population variables, the most important of which are population size, population density, and social status. It is based on the characteristics of lifestyles and patterns: urban, semi-urban, rural, and nomadic (Hamdan, 1970). Population size is an indicator for making planning decisions based on the effects on urban agglomeration. The high population density in agricultural islands pushes the removal of the most fertile agricultural land to other uses, especially in construction. The higher the population density, the greater the need for other vital services, and more agricultural land is damaged and degraded; all residential waste, whether it is health, agricultural, industrial, or daily life waste, finds its way to the Nile waters and negatively affects its nature (Amer, 2008).

Economic criteria

Some islands feature unilateral economies in rural communities, while multi-activities are in semi-urban islands. Various economic activities increase the amount of soil, air, and water pollution, affecting the physical and chemical materials and the island environment. The economic activity intensity criterion affects the island's ecology system, unilateral or multi-activity. Most of the island's activity is limited to agricultural activity only, and the activity intensity does not constitute a problem.

Engineering principles

Although many quantitative indicators are used to analyze urban area features, such as land coverage, land area ratio, public and residential use percentages, and the average number of floors in the area (Chrysoulakis et al., 2014), these indicators have limited capabilities in capturing the urban features, which necessitates the use of qualitative indicators that focus on analyzing the urbanization, social, and patterns (spatially) (Agyeman and Evans, 2003). The International Union for Conservation of Nature (IUCN) has developed a set of six urban criteria through which the performance of environmental protection areas can be evaluated: surrounding urbanization, economic returns to the local community, connectivity, the local community, access control, and land use control; grading the values of each criterion from (0) to (4) so that the value (0) represents the lowest value and the value (4) represents the highest value (Hockings et al., 2006). Based on the criteria extracted through past studies, a set and their graded values, which can be used for the urban, socio-economic classification of the islands, were selected in line with the research objective and the association with the environment, and taking into account the unique and distinctive nature of the Nile islands according to what was determined from the studies of the Nile islands in advance. The criteria can be drawn to classify the Nile islands in populations, economic activities, urban density, urban pattern and coverage ratios, accessibility, and the relationship with the surrounding architecture. The following table shows the criteria for the urban classification of the Nile islands.

Table 2. *Urban/socioeconomic classification criteria for the Nile islands (Source: authors)*

Value	Population size	Economic activities	Urban density	Urban pattern and coverage rates	Accessibility	Relationship to the surrounding settlements
3	High population size	The multiplicity of economic activities (tourism, agriculture, craft, fishing, pastoral)	High urban density	Compact urban pattern	Strong accessibility and unsafe transportation methods (roads, bridges, and ferries)	Transit trips to and from the island, as well as nearby urban and semi-urban agglomerations
2	Medium population size	Wasteful economic activities (agriculture, craft, fishing, and pastoral)	Medium urban density	Orthogonal or linear pattern	Moderate accessibility and safe transportation (ferries, pedestrian bridges, ships)	Fewer trips to nearby rural agglomerations
1	Small population size	A mono-economic activity	Low urban density	Point pattern	Safe means of transportation and weak accessibility (Ferries and boats)	Isolation from the surrounding settlements

Table 3. *International experiences and theoretical studies (Source: authors based on the studies shown in the table)*

Study/Experiment	Study/Experiment approach	Study/Experiment pillars
"Towards effective protected area system" An action guide to implementing the convention (Dudley, 2005)	Environmental planning and management approach	• International classification • Planning and managing environmental systems
"Wetland of management planning (A guide for site managers)" (Chatterjee, 2008)	Environmental protection and preservation approach	• Monitoring and evaluating the elements of the wetland system and measuring impacts • The integrated classification of wetlands
"A framework for planning sustainable development in coastal regions: An island pilot project in Croatia" (Frankic, 1998)	Guided sustainable development and land suitability approach	• Monitoring and analyzing data and determining the best locations using ArcGIS
"Spatial planning in small islands: the need to discuss the concept of ecological structure" A case study: Azores islands (Horta, 2016)	An integrated legal approach to nature conservation and socio-economic development	• A legal and legislative environmental development without ignoring the rest sustainability elements
"An environmental overview of the guidelines for the coastal development area of Abu Dhabi islands" (Paleologos, 2018)	Conservation and maintenance approach	• Monitoring and classifying natural habitats, species, and values (traditional, economic aspects...) • Establishing protective and preservation procedures within the legal framework
"Sustainable Urban Design Strategies for island settlements" The Case of Burgazada (Princes' islands, Istanbul) (Kürkcüoglu, 2012)	General urban development approach	• An analysis-based strategy for selecting the optimal site in a small scope

Evaluation of global and international experiences

Through this study, we hope to develop a scientific vision of the various basic principles that govern all aspects of the study so that we can determine the optimal approach in such a way that ensures both biodiversity protection and sustainable development. The following are some previous studies of international and global islands.

Through this step, the most suitable methods of dealing with the Nile islands as natural wetland reserves were extracted based on the objectives and returns of those studies as follows.

Approaches to planning and developing natural reserve areas and islands

A set of long- and short-term solutions were determined, which include recommendations and suggestions to control urbanization in environmental protection areas and specifically islands. These approaches can be summarized as follows.

Environmental protection and preservation

It is recommended to follow this approach in areas with virgin nature that are highly sensitive to the environment, in which grants and ownership are not allowed except after obtaining the approvals. It is forbidden to use the land from agricultural to residential, fencing is not allowed on properties, and all parts of these highly sensitive areas need to be protected and controlled (JICA, 2016).

Guided urban development

This method is divided according to the nature of the region into the following:

- *Guided development for areas of moderate environmental sensitivity.* Ownership is not permitted except after obtaining the approvals. It is forbidden to change the use of the land from agricultural to residential. Building on farms at specific rates, it is not allowed to implement new tourism or recreational development unless it is environmentally friendly (Pirot et al., 2000).
- *Guided development for areas of low environmental sensitivity.* It allows regular ownership and construction on residential property, in which a partial minimum is allowed. It is not allowed to change the use from agricultural to residential. Industrial development or building fencing is not allowed, and about half of the region's area is considered protected lands (Worboys and Trzyna, 2015).

General urban development

Areas dominated by urban aspects are the targets of this method. Ownership is allowed only within existing urban areas, not in newly constructed ones. The proportions of a house can be partially built, as long as they do not exceed the standards. A private farm can be built in a specific ratio. Agricultural and tourism development is permitted. Industrial development serves only tourism. The region's environment allows fences with controls commensurate with its ecology (Makhol and Ghanem, 2009).

Conservation and maintenance

In this approach, environmental protection sites with weak environmental characteristics that do not require intervention are concerned, since it involves areas that can be evaluated and maintained through a group of natural treatments and an attempt to avoid human intervention for fragile environmental systems (Abdel-Rahman, 2005).

The research community and selecting the sample

The researchers selected a sample size and type to analyze a group of islands. Thus, the most appropriate methods can be determined for each type of island. This is to reach homogeneous groups and determine the appropriate approach. The study community is represented by the Nile islands, which were declared natural reserves. According to Law 102 of 1983 and the Prime Minister's Decree 1969 of 1998, the study community consisted of 144 islands. A purposeful sample was selected from a group of islands according to the main objective. A sample of only inhabited islands from the study community was taken, along with 18 islands (13 inhabited, 5 uninhabited) excluded from the nature reserves in 2017 and declared an environmental management area. As shown in *Fig. 2*, there are 63 inhabited islands, of which 5 are uninhabited islands under environmental management. Details about the inhab-

Fig. 2. *Distribution of the Nile islands according to the environmental and legislative framework (Source: authors)*

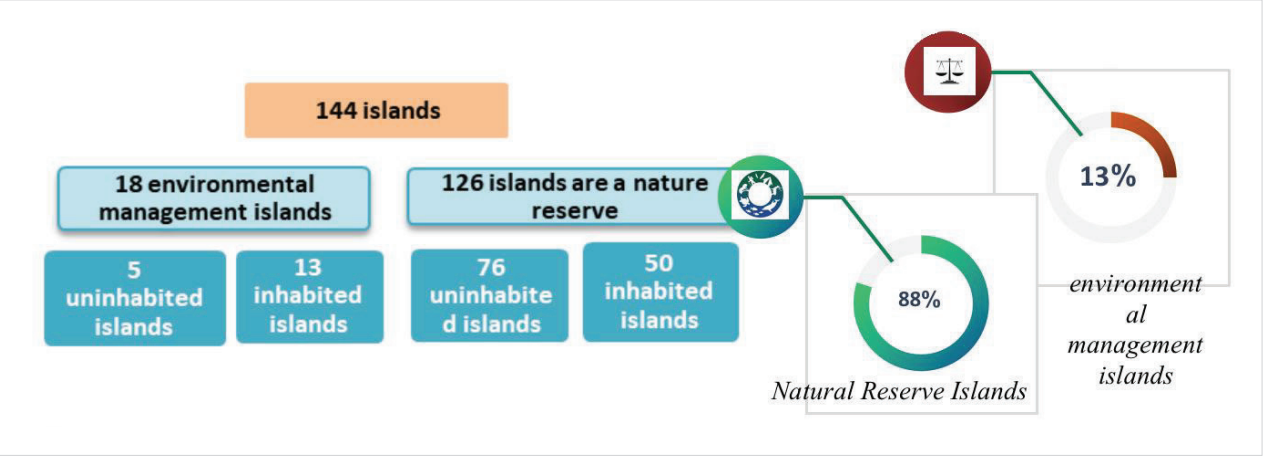


Table 4. *Distribution of inhabited and uninhabited islands according to the legislative framework (Source: authors)*

Classification	Inhabited islands			Uninhabited islands			Total	
	Number	Percentage	Percentage of the total number of islands	Number	Percentage	Percentage of the total number of islands	Number	Percentage
Natural reserve islands	50	79%	35%	76	94%	53%	126	88%
Environmental management islands	13	21%	9%	5	6%	3%	18	13%
Total	63	100%	44%	81	100%	56%	144	100%

Table 5. *Data gathering of study sample islands (Source: authors)*

Island name	Shape	Biodiversity			Sensitivity rarity	Size	Productivity	Recorded history
		Species and ecological communities	Waterfowl	Other species				
Warraq-Giza	An arc-shaped island with strong sedimentary and silty soils	One species with various varieties	A few migratory birds' habitats	Single species	The island's environment supports species of organisms and habitats.	6.5 km^2	A few species of local commercial, scientific, and cultural importance	Nothing
	Population size	Economic activities	Urban density	Urban pattern and coverage rates	Accessibility		Relationship to the surrounding settlements	
	60 000	Agricultural, pastoralism, and fishing	0.45	An urban agglomeration with a compact, striped, or point pattern; coverage rate of 42%.	Connected to major urban and rural communities through ferries, bridges, and motorways		Continuous trips for trade and work between the island and the surrounding urban and rural agglomerations	

ited and uninhabited Nile islands are shown in *Table 3*. Therefore, both inhabited and non-natural islands are included in the study sample. In total, 86 islands were sampled, with *Table 4* giving the numerical distribution regarding inhabited and uninhabited islands.

Collecting the environmental and urban characteristics of the islands

In this step, the necessary data set was collected to monitor the characteristics of the study sample islands, covering the set of criteria that were reached from the results of the theoretical framework, and thus access the integrated data for the study sample of characteristics.

Designing the environmental scale to be applied to the Nile islands' sample

In the first step, the aim was to analyze the data gathered and classify it according to the set of criteria with graded characteristics values. An environmental scale was designed to determine the islands' values. A ranking scale was developed for each criterion starting from the high importance of the island's value, all the way to the less environmental value. These criteria must be analyzed on the ecosystem of the study (the islands) and applied to the Nile islands so that this gradation can be drawn practically.

Shape and geological formation. Southern Egypt's granite islands are more stable and coherent than the rocky ones. The criterion decreases on sedimentary or sandy islands in the north, which are highly susceptible to submersion. However, the islands that separate from the two stream banks are permanently running throughout the year and have old formations. It also refers to the forms of different islands in the sectors of the valley. The criterion is a significant indicator of the stream's movement. The reserves should be regular in shape and deep enough to contain various types of development, geographic features, and aesthetic values. As a result, irregular and rectangular shapes are more vulnerable. Round islands are considered to have more environmental value than rectangular, longitudinal, strip, and triangular islands.

Biodiversity. Studies of natural reserves and wetlands have demonstrated biodiversity and its gradation, as mentioned previously in the theoretical framework. The most diversity is found on the islands with multiple environments and diverse species (flora and fauna). An island with diverse environmental communities containing only plant or animal life has a medium value for biological diversity. A single habitat, plant, or species has the lowest biodiversity value (Dukas, 1998).

Rarity and sensitivity. The Nile islands are graded according to their rare species or uniqueness. Birds, fish, and plants shelter on the Nile islands. There are three types: virgin nature, and islands with ecosystems that rely on a

region partially or totally and are threatened by change. The average value appears on the islands under natural and environmental pressures. The lowest values appear on the islands with endangered organisms.

The area. The Nile islands vary in size, with Shaybah in Minya having the largest area with 9.7 km^2. With a size of just 0.2 km^2, Awad island in Aswan is the smallest island. In principle, the islands can be classified into three categories, depending on their size: the smallest islands with 0.2–2 km^2; the medium-sized islands with 2–4.8 km^2; and the largest islands with 4.8–9.7 km^2.

Productivity. There is a utilitarian relationship between the Nile island species and humans, and there are three categories of productivity. A high-production island contains species of global importance, a medium-production island contains species of commercial or scientific importance, and a low-production island contains species that are only significant locally.

Historical value appears on some islands. The island is also given more importance based on this criterion. There are three grades for the Nile islands. Cultural, scientific, and artistic values at the global and regional levels are highly graded. The average value is for the

Table 6. *Scale of environmental standards for the Nile islands (Source: authors)*

Criteria	Criteria values and definition	
Shape and geological formation	3	Fixed islands with rocky and sedimentary soils with a round shape
	2	A fixed island with strong sedimentary and silty soils with an arc shape
	1	Weak alluvial soils of longitudinal or triangular shape that are submersible and semi-submersible
Area	3	Islands with an area of 4.8–9.7 km^2
	2	Islands with areas from 2–4.8 km^2
	1	Islands with areas from 0.2–2 km^2
Biodiversity	3	Multiple ecosystems and sensitive species (birds, fish, other species) *
	2	The diversity of ecological communities and species multiplicity
	1	Species diversity within one species
Rarity and sensitivity	3	A virgin island has communities or species of organisms that depend on the area, but change affects them and exposes them to danger. **
	2	Unique islands that have organisms or habitats that are sensitive to environmental pressures
	1	Islands with species that are threatened by human activities and uses
Productivity	3	Species of commercial, scientific, and cultural importance at the global level
	2	Species of commercial, scientific, and cultural importance at the regional and national levels
	1	Species of commercial, scientific, and cultural importance at the local level
Historical values	3	Historical, scientific, cultural, and artistic values at the global and regional levels
	2	Historical values at the regional level
	1	Historical values of importance to the local community
	0	No historical values

** The criterion was evaluated by comparing the rare and distinctive breeds observed on the islands with the IUCN red list (IUCN Species Survival Commission, 2000).*

*** The sensitivity and scarcity criterion gradients were measured by comparing the observed communities and species of the islands with the environmental sensitivity index (IUCN, 2023).*

islands with regional historical values. Locally significant historical islands have the lowest value.

In the second step, using the first step criteria scale, the Nile islands were classified. Each island was classified based on the relative importance and gradation of its criteria values. *Table 5* represents environmental criteria in descending importance, so the first column (form and composition) represents the most important and gradually decreases until it reaches the lowest value at the end, as represented by the historical criterion. In *Table 6*, the rows represent the 68 inhabited Nile islands in the applied study, and the inner cells represent their environmental values. In the case of islands with the highest values, they recorded (3), in the case of islands with a low value, they recorded (1), and when not present, they recorded (0).

To categorize and arrange the islands into homogeneous clusters for comparison, statistical analysis was conducted with the Statistical Package for Social Sciences (SPSS) for multivariate data analysis.

In the third step, statistical analysis was conducted by following a set of steps: data entry, data hierarchical cluster analysis, and identifying clusters with homogeneous environmental characteristics and presenting them graphically. Three categories emerged with different environmental characteristics based on the results of the environmental analysis of the Nile islands:

Category (A) is *Fixed islands with virgin nature, multiple habitats, and shelters, and significant historical and economic values.* Despite its small size, the first category has the highest ecological value, due to its granite rock structure that is not submerged, as well as the presence of birds, fish, and ancient civilization artifacts.

Category (B) is a *Fixed island with a wide range of species within one species and a high level of productivity.*

This category consists mainly of alluvial rocky and sedimentary structures with a round, arc, or rectangular shape. It also includes islands with a unique nature, which are sensitive to natural and environmental pressures and productive at the regional level. There are only two historical islands.

Category (C) is *Unfixed islands with a large variety of species within a species and limited productivity and historical values.*

The lowest categories of islands in environmental values are composed of weak, silty, and sandy soils with a longitudinal or triangular shape in which there are many species within the same species, and they are productive and important at the local level, exposed to environmental risks, while they contain historical values at the global and regional levels. The following environmental dashboard of the Nile islands shows the distribution of the islands' categories along the sectors of the Nile in the map display, and the statistical charts in other widgets.

Designing the urban/socioeconomic scale to be applied to the Nile islands' sample

Urban density is the most influential criterion on the environmental aspects of the islands. The islands were divided according to urban densities into urban agglomerations with a density of 0.3 to 0.45, which is the highest category of urban density, followed by the islands of urban agglomerations with a density of 0.15 to 0.3.

Urban coverage and urban patterns take significant importance when making planning decisions. Based on the standard, the Nile islands are divided into point, linear, or compact urban agglomeration islands with coverage rates of 25.1–42%, meaning the highest value, followed by linear or compact islands with coverage rates of 10.1–25%, and the lowest is point islands and coverage rates of 1–10%.

In terms of accessibility and surrounding settlements, three levels of connection refer to the islands connected to major urban or rural communities by ferry, bridge, or motorway. The lowest value (islands relating to village agglomerations and estates through ferryboats only) is islands relating to rural communities through ferries, pedestrian bridges, and ships.

The population size was divided into three graded values, where the highest value is in the islands containing urban communities with a population size of 17 001 to 80 000 people, followed by the islands with a population size of 5001 to 17 000 people. The lowest value is in the islands with a population size of 50 to 5000 people.

Economic activities reflect social patterns, including their surrounding urban communities. A majority, 58 islands (86%), are engaged in unilateral economic activities like agriculture. A high percentage is observed

Table 7. *The scale of urban standards for the Nile islands (Source: authors)*

Criteria values and definition	Criteria	
Urban Density	3	Islands with urban agglomerations and densities of 0.3 to 0.45
	2	Islands with urban agglomerations and densities of 0.15 to 0.3
	1	Islands with urban agglomerations with a density of 0.02 to 0.15
Coverage ratios and urban pattern	3	An urban agglomeration with a compact, striped, or point pattern with a 25.1– 42% coverage rate
	2	An urban agglomeration with a compact or striped pattern has 10.1–25% coverage rates
	1	An urban agglomeration with a point pattern, coverage rates of 1–10%
Accessibility and the relationship with the surrounding settlements	3	Islands connected to major urban or rural communities through ferries, bridges, and motorways
	2	Islands connected to rural communities through ferries, pedestrian bridges, and ships
	1	Islands connected to village agglomerations and estates through ferryboats only
Population size	3	Islands containing urban communities with a population size of 17 001 to 80 000 people
	2	Islands containing urban communities with a population size of 5001 to 17 000 people
	1	Islands containing urban agglomerations with a population size of 50 to 5000 people
Economic activities	3	Tourist, agricultural, and pastoralism
	2	Agricultural, pastoralism, and fishing
	1	Fishing and simple crafts

in the Delta and North Valley. Fishing, simple crafts, and tourism activities are also part of agriculture. *Table 6* shows the scale of urban criteria for the Nile Islands (Chrysoulakis, 2014).

In the second step, there is a table of urban/socio-economic criteria to classify the Nile islands. The rows represent inhabited islands. Criteria values are shown in table cells. Having taken (3) for its highest value, and (1) for its lowest value, (2) is its mean. *Table 7* shows the inhabited Nile islands by urban/socioeconomic criteria. The Nile islands are classified homogeneously. Cluster analysis was conducted with SPSS, as in the environmental analysis step. Urban/socioeconomic categories were identified based on the characteristics of the Nile islands.

Category (I) is *Islands of high urban densities, population size, and accessibility*. Distinguished by high urban values since it shows a higher population size than the other categories, Mansouriya island has the highest population (80,000 people), as well as the highest urban coverage (45% of its area). The accessibility of roads, ferries, and bridges varies, with Al-Warraq representing the islands with the highest densities, ranging from 0.3 to 0.45.

Category (II) is *Islands of medium urban density, population size, and accessibility.* Urban values vary among islands in this category. Although population sizes are mediated, some islands record high densities (0.4–0.45) but have lower than first-category islands. Rahmaniyah island is connected to Disuq, Rahmaniyah, ferries, and vehicles bridge. Urban variables vary between 3500 and 8000 people across the islands.

Category (IV) is *Islands with low urban densities, population sizes, and accessibility.* There are fewer than 800 people on these islands, the lowest in the Nile islands, between 50 and 150. Likewise, urban densities for islands in this category have decreased from 0.1 or less. Urban coverage is the lowest.

The following urban/socioeconomic dashboard of the Nile islands shows the distribution of the islands' categories along the sectors of the Nile in the map display, and the statistical charts in other widgets.

Fig. 3. *Environmental dashboard of the Nile islands (Source: authors based on the data of the Central Agency for Public Mobilization and Statistics and recent satellite images)*

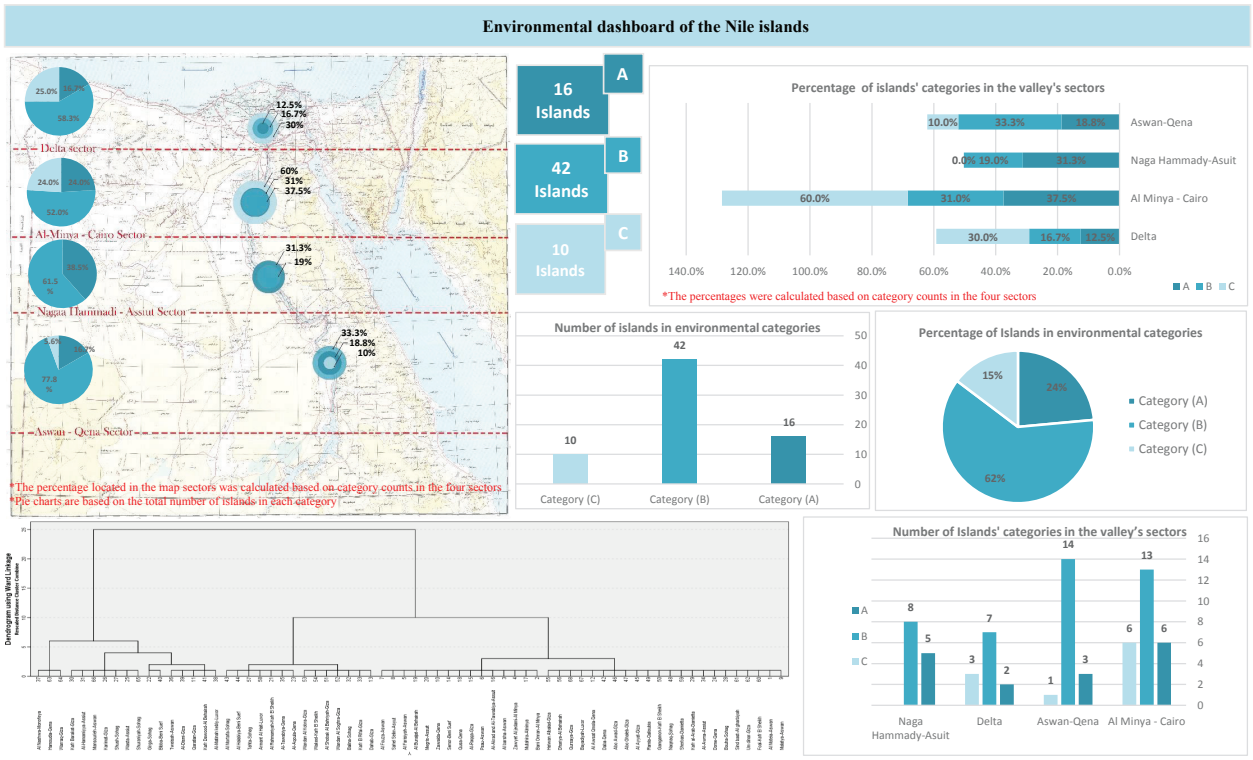
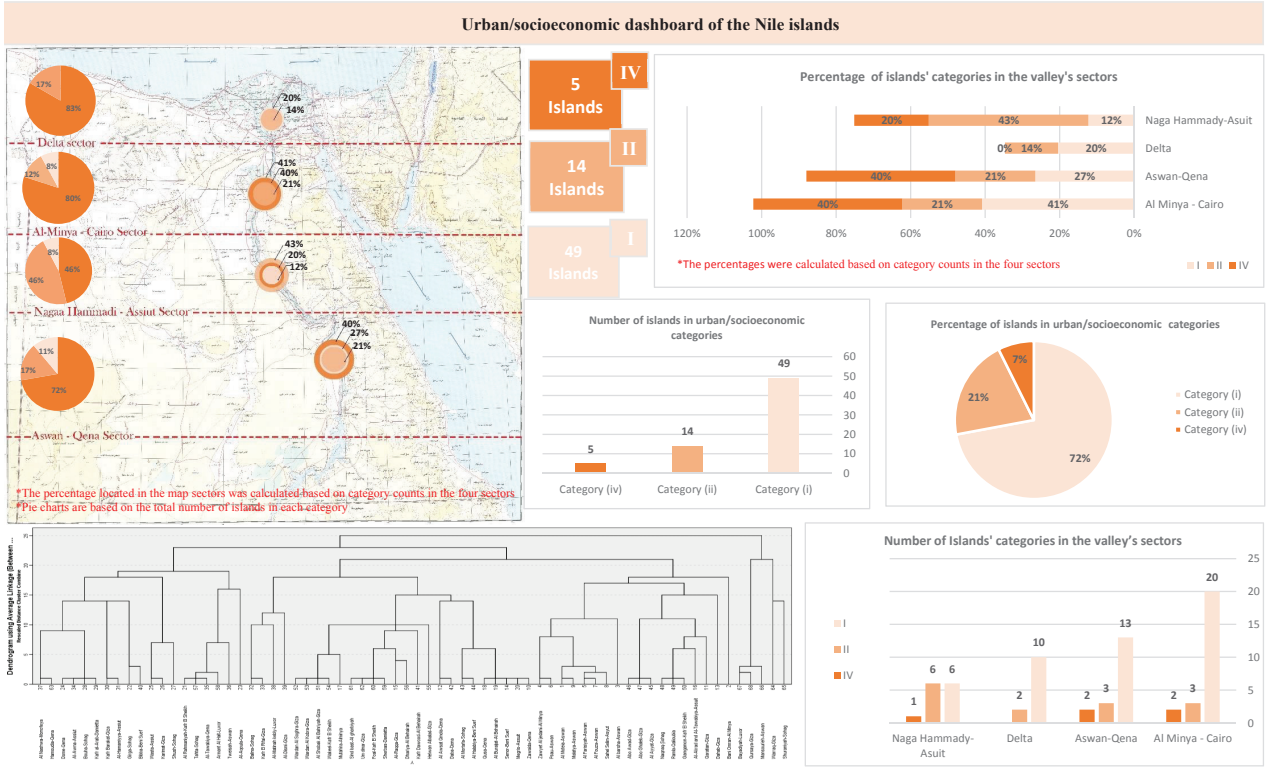


Fig. 4. *Urban/socioeconomic dashboard of the Nile island (Source: authors based on the data of the Central Agency for Public Mobilization and Statistics and recent satellite images)*



Results

Environmental/urban categories of the Nile islands

For the homogeneous categories of urban/socioeconomic characteristics and the environment, we created codes for each environmental classification category from highest to least. In order of sequence, the highest category of environmental characteristics is (A), the middle category is (B), and the lowest category is (C). Similarly, urban/socioeconomic classification categories were designed as (IV), (II), and (I). Each island had its own environmental and socioeconomic codes. The islands with codes were grouped into six categories. Table and Figure show the structure of the environment and urban/socioeconomic classification categories of the Nile Islands.

Development policies for the islands' categories

For environmental and urban/socioeconomic classifications of the Nile Islands, a code was created for each environmental classification category based on its characteristics, starting with the highest and then decreasing in characteristics: the highest category in characteristics Environmental (A); the average category of environmental characteristics (B); and the lowest category in environmental characteristics (C). Similarly, codes were created for the urban/socioeconomic classification categories to be the highest category (IV), the average category (II), and the lowest category (I). These codes were set for each island separately and then grouped islands with similar codes into six groups. Each category had homogeneous environmental and urban/socioeconomic characteristics.

Methods for dealing with each category

Using this framework, we provided the most relevant methods and proposals, based on theoretical studies (natural reserves, wetlands, and urban controls over environmental protection areas). Each category was given a set of general policies based on reference studies. By doing this, environmental and urban goals were achieved.

Discussion

Based on the composition of the environmental and urban categories of the Nile islands, we find:

1 Environmental and urban characteristics of the Nile islands are inversely related. The higher the urban characteristics of the islands, the smaller the environmental characteristics. Environmental values are medium to high, as a result of a decrease in island urbanization.
2 Approximately 35% of all inhabited islands have medium environmental characteristics and the least urban characteristics. Even though most of these islands are fixed or permanent, they lack diversity and multiplicity. Human activity may be causing this.
3 The smallest category contains 5 islands, about 7% of the sample. With medium environmental characteristics and high urbanization characteristics, the islands with high population sizes in the category reached the highest number, for instance on the islands of Mansouriya and Al-Warraq, with populations ranging between 40 000 and 80 000, and the coverage rates varying from 0.4 to 0.45. In addition, accessibility and urban patterns are affected by human activities, as well as being near most urban areas.

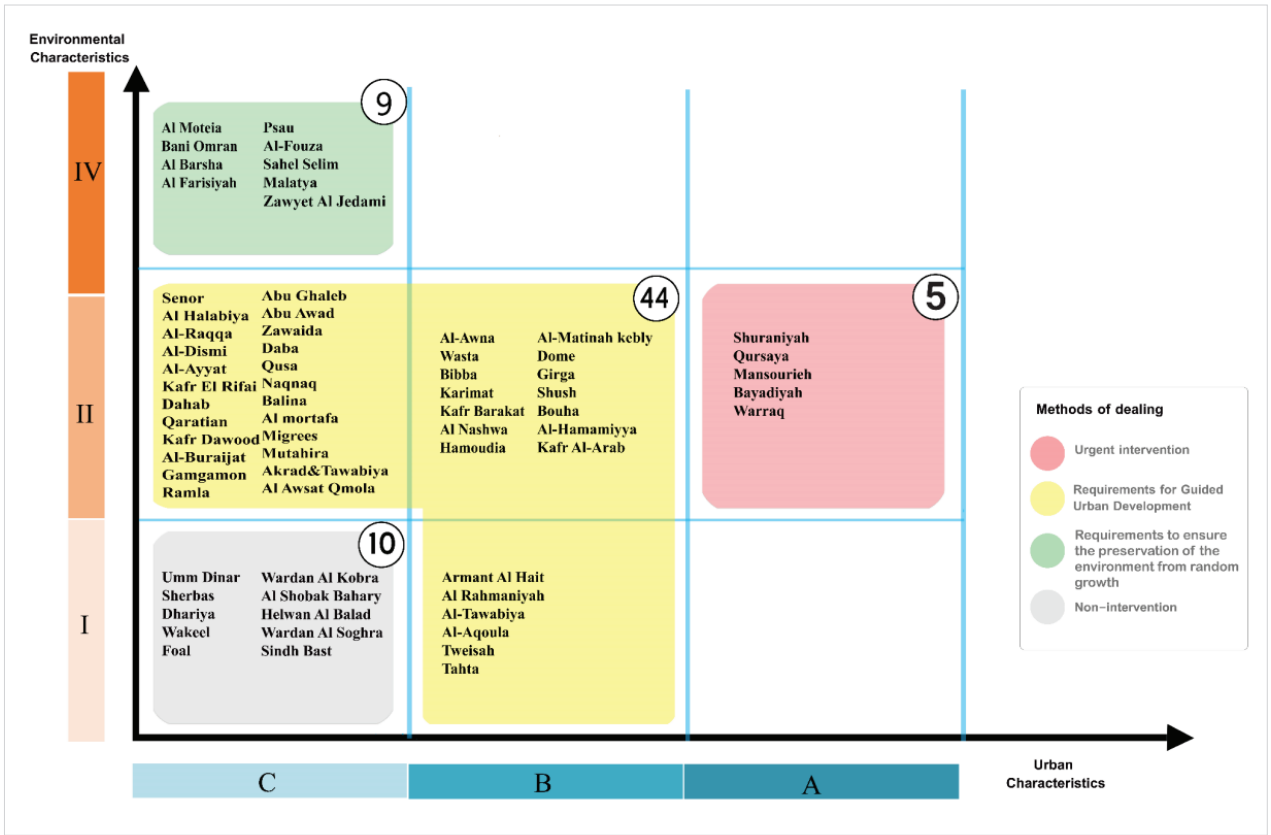
Based on the levels of environmental and urban control, development policies for the Nile islands were proposed. In terms of the methods for each urban agglomeration, the following approaches were recommended:

1 Low-density islands with high environmental values and sensitivity must meet certain requirements to preserve the environment from urbanization random growth. For example, in Bani Omran in Minya, urbanization spreads randomly without considering the most sensitive areas. There are few urban densities and coverage rates on the island, but urbanization may damage the communities' shelters. Therefore, building proportion and activity permits are required for urban management.
2 Islands with medium environmental values and high urban densities are the islands most in need of urgent intervention to restore the environmental balance to them so that urban densities and coverage ratios rise, resulting in damage and destruction of vegetation and agricultural lands with buildings, facilities, and human activity that destroy and damage the island's environmental system.

3 Environmental and urban characteristics of islands subject to submersion or fragmentation are low. They may need environmental treatments or requirements if semi-submersible. The delta sector has most of these islands. The river morphology changes, turning and speeding up, causing islands to disappear or fuse with the floodplain or each other, such as Mit El-Khouli and Darwa island, which fused with the West Bank of the Damietta branch after the Atlas of Egypt Topography emerged in 1929.

4 Island types with medium environmental characteristics, low and medium urban characteristics, and islands with low environmental characteristics and medium urban characteristics are evaluated based on rational development requirements. This way, urban development follows certain criteria and requirements while not damaging the environment. The presence of tourism, entertainment, and investments is especially beneficial. Intervention methods for the inhabited Nile islands are shown in *Fig. 5*.

Fig. 5. *Methods of dealing with each environmental/urban category of the inhabited Nile islands (Source: authors)*



The category of the island	Dealing policy
Islands of pristine nature, environmentally sensitive, and low-density urbanization	Requirements to ensure the preservation of the environment from random growth
Islands of medium environmental sensitivity and urbanization of medium density	Requirements for Guided Urban Development
Islands of medium environmental sensitivity and high-density urbanization	Urgent intervention
Medium-sensitive islands with low-density urbanization	Requirements for Guided Urban Development
Islands with low environmental characteristics and low-density urbanization	No intervention
Islands with low environmental characteristics and medium-density urbanization	Requirements for Guided Urban Development

Conclusion and Recommendations

The Sustainability Assessment Scale for the Nile islands (SASNI) is an effective tool for assessing the sustainability of urban development policies in the Nile islands. It is based on a set of indicators that measure the environmental, social, and economic impacts of urban development. This is to ensure that urban development policies are environmentally sound, socially equitable, economically viable, and well-governed. It will also be a very effective tool in the following ways:

- To make informed decisions on the most effective way to develop the Nile islands;
- To compare the sustainability of different urban development policies;
- To determine the most sustainable policies for the Nile islands;
- To ensure that policies achieve sustainable goals.

Based on the previous set of results, the research reached a set of general recommendations.

Recommendations for protection and conservation goals

1 The 76 uninhabited islands of virgin nature are subject to absolute protection and preservation, considering the entire area of the island as lands required to be protected, and making recommendations for them within the national strategic plan so that they can be considered open green areas to raise the per capita share of green areas at the level of the Republic.

2 It is necessary to prepare a database of endemic and endangered plant and animal species on the Nile islands in general and on virgin nature and environmentally sensitive islands in particular, work on updating and classifying them and determining their economic and social value in coordination with scientific and research institutions and centers.

3 Campaigns are needed to clean up river barriers that arise from sedimentation processes and pose a threat to navigation and movement to and from the islands.

4 It is necessary to remove weeds and harmful plants that grow on the coasts of the islands because these plants deplete the water that can be exploited in agriculture and is a source of insects, which impedes tourism and recreational activities as well as causes narrowing of the riverbed and high sedimentation rates.

5 It is necessary to connect the agricultural mechanization of the islands establish agricultural associations on the large islands, and emphasize the application of a good agricultural cycle that suits the lands of the islands so as not to stress their soil.

6 It is necessary to administratively annex the islands to the villages and the centers closest to them so that there is a merger between the islands and the neighboring villages.

Recommendations for environmental and urban/socioeconomic classification categories

Islands of virgin nature, environmentally sensitive, and low-density urbanization

The islands of this category are subject to the policy of environmental tourism development and urban controls. The research recommends a set of methods to deal with them as follows:

1 About two-thirds of the island's area in this case is considered lands to be protected, and their locations are determined after field surveys and environmental monitoring to determine the areas affected and not affected by urbanization according to some criteria, the most important of which are the volume of development, the density of vegetation cover, building pattern and proximity to tourist attractions such as archaeological sites.

2 Ownership or construction is not allowed except after obtaining the approvals of the concerned authorities and at specific rates. It is considered to transfer the current facilities built on the Nile for non-tourist purposes to other areas far from the Nile, while not allowing any additions to these facilities.

3 Industrial activities are not allowed, except for simple industries that assist tourist and recreational activities, while adhering to the requirements of environmentally sensitive areas that were monitored during the field survey such as:

- Developing a land use plan through the concerned authorities and settling projects by it;
- Commitment to activity intensity requirements according to the capacity that is calculated for the island;
- Commitment to the sanctuary of the coasts of the island, which is determined by the competent authori-

ties, and by the recommendations of the plan of use; these sites are devoid of any fixed facilities, except for the sites where decisions are issued to the contrary by the concerned authorities;

- The proportions of fixed and roofed tourist buildings do not exceed 20% of the site available for development;
- The height of any tourist facility shall not exceed the number of floors determined by the Tourism Development Authority and the concerned agencies and authorities so that it does not obscure the view;
- Providing the necessary places and equipment for recreational activities such as tourist facilities, tourist marinas, various sports activities, green areas, public parks, nurseries, etc.;
- Providing an infrastructure with natural alternatives commensurate with the ecosystem of the island and providing safe disposal systems for waste and solid waste, as well as safe and unpolluted means of communication.

Islands of moderate environmental sensitivity and medium-density urbanization

Islands of moderate environmental sensitivity and high-density urbanization

Islands of moderate environmental sensitivity and low-density urbanization

The islands of these categories are subject to the policy of environmental tourism development, and the research recommends a set of methods to deal with them as follows:

1 About a third of the area of the island is considered land that needs to be protected, and their locations are determined after field surveys and environmental monitoring to determine the affected and unaffected areas;
2 Developing a land use plan through the concerned authorities and settling projects by it;
3 Compliance with the activity intensity requirements according to the capacity that is calculated for the island;
4 Commitment to the sanctuary of the coasts of the island, which is determined by the competent authorities, and by the recommendations of the usage plan; these sites are devoid of any fixed facilities, except for the sites where decisions are issued to the contrary by the concerned authorities;
5 The proportions of fixed and roofed tourist buildings do not exceed 20% of the site available for development;
6 The height of any tourist facility shall not exceed the floors specified by the Tourism Development Authority so that it does not obscure the view;
7 Providing the necessary places and equipment for the practice of leisure activities such as tourist facilities, tourist marinas, various sports activities, green areas, public parks, and nurseries;
8 Providing an infrastructure with natural alternatives commensurate with the ecosystem.

Islands of low environmental characteristics and medium-density urbanization

The islands of this category are subject to the policy of environmental tourism development, and the research recommends a set of methods to deal with them as follows:

1 Less than one-third of the island's area in this case is considered lands where areas are required to be protected. Their areas are diminishing and may even be non-existent in some islands to establish new activity areas. Development sites are determined after field surveys and environmental monitoring to identify areas that are environmentally sensitive and affected or unaffected by the existing construction.
2 It is necessary to make detailed plans for land uses consistent with the developmental goal of the region in accommodating urban expansion providing the deficit of services and activities for the existing urbanization limiting the indiscriminate expansion on agricultural lands and collecting the existing urbanization into urban possessions.
3 It is necessary to extend new road networks in a way that does not affect the stability of the island and its soil, paving the existing ones, and making pedestrian paths with a clear hierarchy to serve the movement of the population within the island and between the island and the surrounding communities.
4 Ownership is permitted according to the possibility and within the existing urban range only and according to the uses and activities proposed in the plan. The building is partially permitted on residential property, provided that the upper limit is not exceeded according to the established building ratios.
5 It allows tourism and agricultural development and encourages the establishment of sustainable investment projects with a tourist attraction near the existing urban communities to ensure the continuity of tourism activity throughout the year.

Limitations and future research

The research has three main limitations:

- Sample selection and sample size. It was difficult to determine the research sample due to the need for the islands to contain the urban system, and it was difficult to determine it because it relied on data from different sides, in addition to sometimes not updating data.
- Availability and reliability of data, access to data. The study involves some organizations and people, and that caused problems with access to these organizations.
- Methods/tools/techniques used to collect data. The research relied on several methods such as observation to identify the inhabited Nile islands based on satellite images, which are considered an inaccurate source because they are not updated, in addition to the available statistical data on the Nile islands that are considered not fixed due to the various changes that occur to the islands.

The significant recommendations for future research:

- The process of classifying the Nile islands is considered at the general level, and it is considered a preliminary stage that should be completed; the classification process should be conducted with more detail separately.
- An approach should be found for the most appropriate environmental management for the Nile islands in terms of dealing methods, dealing mechanisms, tools, and relevant participating parties.
- Inclusion of the environmental impact assessment process within the plan for any development of the Nile Islands is needed.
- In the case of planning islands with urban agglomerations and a large population, the inhabitants should be taken into account.

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