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Research Paper

Evaluation of sustainable tourism via GIS: Tangier case study

Samir Haloui[1*], Mustapha Ait Rami[2] and Jamal Chao[1]
[1]Natural Resources Geosciences Laboratory, Faculty of Sciences, B.P 242, Kénitra - Morocco
[2]Laboratory Systems, Control & Decision. Quartier Souriyenne Tangier - Morocco
*Corresponding author Email: s.haloui@uae.ac.ma

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Abstract: Assessing the sustainability of a tourist destination becomes more and more complex, because the involved actors must cooperate with the economic, social and environmental requirements that represent the pillars of sustainable development. Geographic Information Systems (GIS) can be seen as a toolbox of techniques and technologies widely applied to achieving sustainable tourism development. Spatial data can be used to track, control the state of sustainability and aid in decision making. Assessment is increasingly important in tourism development, based upon GIS that can play an important role in auditing environmental, economic and social conditions. Systematic evaluation of the environmental impact is often hampered by gaps in information but also in tools for integrating, manipulating, visualizing and analyzing data.GIS seems particularly suitable to this task. This article provides a systematic model evaluation for sustainable tourism. Moreover, a geoportalsoftware is designed towards the use of GIS and its implementation for a case study on sustainable tourism in Morocco at Tangier.

Keywords: Sustainable tourism, Sustainable development, Geographic information systems, Geoportal, Indicators, Evaluation model.

Introduction:

From the early 1990s, the amount of research articles, report documents and books relating to sustainable tourism has importantly increased. By now, the term sustainable tourism has established itself among academics and practitioners. It emerged as part of a larger discourse on the notion of "sustainable development" which, according to Bramwell and Lane (1993) has gained momentum with World Conservation Strategy (UICN, PNUE, WWF) in 1980.
Sustainable tourism can be seen as the application of the idea of sustainable development to the tourism sector, i.e. tourism development that meets the needs of the present without compromising the ability of future generations to meet their own needs. In accordance with Budowski's (1976) such tourism uses and conserves resources wisely in a sustainable development manner in order to maintain

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their long-term viability. However, the implementation of sustainable development in tourism requires a reliable and accessible assessment. According to Clift (2000), sustainability in general, can be seen as the goal, and sustainable development as the process to achieve it. The evaluation of such sustainability in tourism has been the subject of several studies, by relying on composite indicators that have become increasingly important in the discourse on benchmarking performance indicators of countries, specific destinations and institutions. Indeed, their wide variety reveals their recognition as toolsfor policy evaluation and communication. According to Nardo et al. (2008), the used number of composite indicators in real-life is increasing year by year. This is due in particular to their key role to summarize, focus and condense the complexity of our dynamic environment. By following Singh et al. (2009) and Paruolo et al. (2013), we mention that composite indicators are much easier to interpret than trying to find a common trend in many single indicators. In practice, they have been used in relevant real-world situations such as in country's competitiveness (World Economic Forum 2017), quality of governance (World Justice Project 2016), freedom of press (Freedom House 2017), national human development (United Nations Development Program 2016), global measure of world peace (Institute For Economics & Peace 2017), competitiveness of travel and tourism (World Economic Forum 2017), measurement of the country's economy (World Development Indicators: The World Bank 2017), efficiency of the universities (the Academic Ranking of World Universities, the Times Higher Education, World University Ranking or the QS World University Ranking), etc.

Information and communication technologies (ICT) are tools that are revolutionizing the way the different actors communicate and interact. Note that Geographic information technologies are also of paramount importance for the deployment and implementation of ICT in the dynamic of smart tourist destinations,

because of the central role they can play as decision-making tools. Indeed, they allow quick access to different layers of information that can be combined and integrated to facilitate the analysis and make the best decisions.

The information society constitutes an efficient means of managing territorial resources, as well as a mechanism of transparency and control available to society for the formulation of policies focused on sustainable development (Omer, 2017; Pérez et al. , 2018; Gamez et al., 2017).

The rise of GIS technologies is now paving the way for designing solutions that meet the needs of multiple businesses. This is particularly with regard to acquisition, management, analysis and presentation methods that exploit efficient tools to locate on the surface of the earth, analyze spatial dimensions, collect and process information in a minimum of time and with enormous flexibility. Geomatics is therefore necessary to give the best geo-spatial representation of the studied processes.

In this article, GISs are fundamental to the proposed methodology in studying the sustainability of a tourist destination. The importance implication of geomatics for a tourist destination regarding its sustainable development is demonstrated trough a geoportal platform that integrate the concept of sustainable destination and some of its distinctive features that it should have to support and maintain its sustainability.

The proposed geoportalis based on an evaluation model for conceiving and calculating indicators by the involvined stakeholders at the local level, with relevant

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information related to the availability of endogenous resources that can be used to promote sustainable development at the local level. The proposed application will allow access to involved parties and stakeholders, to relevant data related to endogenous resources for sustainable tourism at the city of Tangier in Morocco.

Problem statement

This section is dedicated to positioning the context of this work in order to clarify the problematic of sustainable tourism through GIS. In addition, the targeted objectives and the proposed specifications are discussed with connection to the methodology, the planning and the design.

Sustainability assessment

Our first aim is to construct an evaluation modelin order to ensure continuous monitoring of a tourist site and guarantee the interaction of stakeholders with respect to the sustainability of the considered destination in means of the economic, social and environmental performance at each scheduled time-period. For this purpose, we propose an evaluation model by establishing an adequate set of elementary indicators from which one can construct combined indicators that are relevant for analyzing and assessing sustainability.

Geoportal application

Our mainapplication objectiveis the conception and the realization of a geo-portalsoftware based on webmapping(see Fig. 1). Such toolimplements the proposed methodology for evaluating and managing the sustainability of a touristic destination. Thisvisualizesthe involvement of stakeholders in planning, decision-making and their interactivity with the sustainability monitoring model of the tourist destination

This geo-portal consistsof static and dynamic interfaces. The first static interface permits:

- Localization of the studied tourist destination on a geographic map.
- Visualization of the site with its corresponding parameters, indicatorsand its sustainability state.

The second dynamicinterface allows:

- Registration of stakeholders in the geoportal platform.
- Determination of the stakeholders consensus for the parameters and indicators in order to reach the evaluation and control period of the tourist destination.
- Determination of the tolerance for each indicator and their impact factors.

Tangier case study

The proposed application for evaluating and monitoring,sustainable development of local tourist destinations, consists of the case study of the city of Tangier which is a maritime city in Morocco located between the Atlantic Ocean and the Mediterranean Sea.

This study is performed on two touristic sites at Tangier. The first one represents historical destination know as Kasbah; and the second one represents a well-known ecological destination named Perdicaris. The geoportal platformcan be apply to these destinations for analyzing and assessing the output results of the proposed sustainabilityevaluation model.

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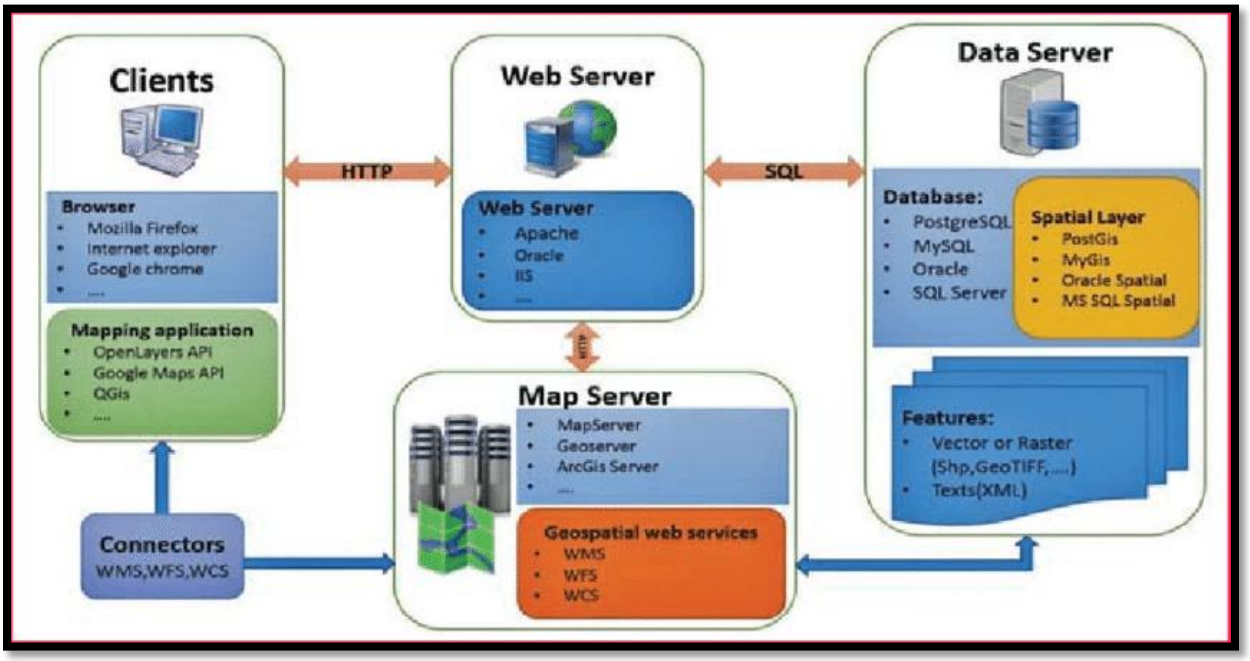

Figure 1: Structure of web mapping

Sustainability model evaluation

In this part, an evaluation systemis proposed along with its implementation via geoportal plate-form

Materials and method

In order to deal with the sustainability of a destination site, in accordance to a pre-agreed reference between stakeholders, we define a sustainability evaluation system, which consists of a set of layers, and their settings evaluated by stakeholders through some key indicators as depicted in Table 1.
In the sequel, we discuss how such model has been developed based upon a proposed method.

1. Locate a tourist destination and determine its characteristics, for example

- An ecological site (natural resources, landscape, endemic species, beach, forests, etc.)
- A cultural site (historical site, museum, etc.)

2. Determine the stakeholders involved in the site

- The State and its institutions (region, municipality, province, ministry etc.)
- Tourism professionals (hotel institutions, restaurants, cafes, transport, etc.)
- The local community in relation to the tourist activity (artisans, itinerant trade etc ...)
- Associations and unions in relation to the tourism sector
- Tourists and site visitors (locals, foreigners, etc.)
- Academic researchers

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3. Based upon stockholders decisions, define the layers of the touristic destination, their settings and key indicators

4. For the performance evaluation of the touristic destination, define indicators and their composite performance index for a given periods. For this purpose, we first introduce a useful parameter**s** that represents a predefined tolerance factor for the indicators evaluation with their corresponding norms. Also, we define the sign function by

Sign (x) = -1 if x<0

Sign (x) = 1 if x≥ 0,

the role of this sign function is that it is used to detect that an indicator plus a given tolerance factor **ρ** is less than its corresponding standard norm, which by conception leads to a negative contribution into the whole constructed composed indicator, otherwise it leads to a positive contribution.

Now, based on this sign function, we introduce the following conceptual composed indicators depending on the time periods$t_{k\ ,k=\ 1,2,\ldots}$

- Composed Economy Indicator

$$CCI(\boldsymbol{tk}) \coloneqq \left(\frac{1}{\sum_i^l \alpha i}\right) \sum_{\boldsymbol{i=1}}^{\boldsymbol{l}} \boldsymbol{\alpha i\ sign}\left(\frac{ci}{Nci} - 1 + \boldsymbol{\rho}\right) ciNci$$

where ci are the chosen economy indicators, Nci are their norms. The positivescalars αi> 0 are thecorresponding ponderations

- Composed Environment Indicator

$$CVI(\boldsymbol{tk}) \coloneqq \left(\frac{1}{\sum_i^l \beta i}\right) \sum_{\boldsymbol{i=1}}^{\boldsymbol{l}} \boldsymbol{\beta i\ sign}\left(\frac{\boldsymbol{vi}}{\boldsymbol{Nvi}} - \boldsymbol{1} + \boldsymbol{\rho}\right) viNvi$$

where vi are the chosen environment indicators, Nvi are their norms.. The positive scalars βi> 0 are the corresponding ponderations

- Composed Social Indicator

$$CSI(\boldsymbol{tk}) \coloneqq \left(\frac{1}{\sum_i^l \gamma i}\right) \sum_{\boldsymbol{i=1}}^{\boldsymbol{l}} \boldsymbol{\gamma i sign}\left(\frac{si}{Nsi} - 1 + \boldsymbol{\rho}\right) siNsi$$

wherevi are the chosen social indicators, Nsi are their norms. The positive scalars γi> 0 are the corresponding ponderations

In the sequel, we refer to these ponderations as **impact factors**of the introduced composed indicators of sustainability.

Once these composed indicators are defined, we are in position to introduce the Sustainability Index (SI) that provides a clear evaluation on the state of the sustainability of the whole tourism destination. Such evaluation index is defined by

$$SI(\boldsymbol{tk}) \coloneqq \left(\frac{\boldsymbol{1}}{p1+p2+p3}\right)(p_1 CCI(tk) + p_2 CVI(tk) + p_3 CSI(tk))$$

where p_1,p_2 and p_3 are the sustainability ponderationssuch that p_i>0, $p_1+p_2+p_3= 1$.

5. Visualize on the geoportal the sustainability of the touristic destination based upon the computed indicators and their composite performance index.

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Table 1*: Partition model of layers with indicators and their output values

Layers	Settings	Indicators	**Values** (to be measured)	**Standars** (to be determined)	**Evaluation** (to be defined)
Economic	Turnover	Tourism turnover(average Dhs)			
	Infrastructure	Number of hotel establishments			
	Number of tourists	Number of nights / month			
	Local products, crafts	Number of units per business			
Evaluation of the economic component (to be calculated)					
Environmental	Pollution	Air pollution, tourist waste(AQI)			
	Green area	m^2 of green space per inhabitant.			
	Tourist transport	Carbon emissions from tourist transport			
	Tourist density	Number of visitors compared to the local population(%)			
Evaluation of the environement component (to be calculated)					
Social	Security	Frequency of prevention and control			
	Employability	Employability of indigenous people (%)			
	Costume,Traditions	Number of cultural and artistic activities of the native people			
	Unemployment rate	Number of active women per 100 active men(%)			
Evaluation of the social component (to be calculated)					
Sutainability Evaluation (to be calculated)					

*The settings and indicators correspond to the Kasbah destination

Geoportal implementation

In order to develop the architecture of the proposed geoportal a client-server web-mapping model was used as depicted in Figure 1. This is a distributed model in which the tasks are distributed between the providers of resources or services, called servers, and requesters called clients. Also, to make each component of the geoportal application operational, some technologies have been used as Prado, Extjs, Geoext, OpenLayersand PHP framework.

Case study: Tangier destinations

Tangier is a maritime city in Morocco located on the northern tip of the country, facing theStrait of Gibraltar, separating the Atlantic Ocean from the Mediterranean Sea.
In what follows, we perform our studyon two touristic sites at Tangier. The first one represents historical destination know as Kasbah; and the second one represents a well-known ecological destination named Perdicaris.We show how one can apply the proposed geoportal model to these destinations and analyze the outputs results of the proposed evaluation model.

Considered touristic sites

- **Historicaldestination: Kasbah**

The Kasbah (depicted in Fig 2) is among the most important historical and most visited tourist destinations in the city of Tangier. This monument indeed bears traces of the Roman period, an Umayyad construction technique dating from the 12th century identical to that which is still visible today at the mosque of Cordoba in Spain.
The Kasbah was built on the highest land in the city of Tangier, above the medina. It has ramparts dating from the 13th century. It has the distinction of having retained its original and unique architecture, marking a rich period in Moroccan history. This monument is highly visitedand can suffer from deterioration.Yet several of its dilapidated spaces require urgent restoration.

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Fig 2: The tourist destination Kasbah

- **Ecological destination:Perdicaris**

This destination (depicted in Fig 3) represents a large park. with a large area of nearly 70 ha, also known as the Rmilat forest, is a veritable botanical park containing hundreds of indigenous and exotic species such as eucalyptus, dragon trees, crown trees, oak-cork and Parasol pine, pinion pine ... etc. Thus, this area was declared in 1993 as a Site of Biological and Ecological Interest (SIBE). This detination also offers a breathtaking view of the Strait of Gibraltar and intersects with the Mediterranean Sea and the Atlantic Ocean.As this site is located at 4 km from the town of Tangier, it experiences a large number of visitors.This has increased the risk of degradation of this rich but fragile space.

Fig3 :Perdicaris destination

Model determination

The features of the two destinations are mainly based on the ecological potentials, historical potentials, the services offered and the relationship with the local community.

Data implementation for the evaluation model was carried out by the involved stakeholders. The agreed

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data have been transferred into the geoportal platform for obtaining results in the form of maps depicted in Fig. 4 and Fig. 5.

In the sequel, the details on the involved parameters of the model are provided; see Table 2, 3, 4, 5, and 6.The performance studyhas been done for two specific time periods t1, t2.
The pre-agreed values by the stakeholders: standards,norms, tolerances, impact factors and other parameters, are provided in details in the demonstration Tables 2, 3, 4, 5, and 6. Table 2 below represents theadopted tolerances and impact factors.Note that since the studied destinations are not of the same category, thecorresponding impact factors of the three components of sustainability can differ. Since the first destination site(Kasbah) is rather historical, therefore its impact factor is strong on the social component (p3 = 5) and the other two componentstake thesame impact value 2.5 each (p1 = p2 = 2.5). On the other hand for the second destination (Perdicaris), its impact factor is stronger on the environmental component (p2 = 5) and the otherscomponents have equal impact factors (p1=p3=2.5).

Table2 : Tolerances and impact factor

Tolerance **ρ =5%**			
	ci = *ci* + ρ	vi= *vi* + ρ	si = *si* + ρ
Impact Factors(Kasbah)	p_1=2,5	p_2=2,5	p_3= 5
Impact Factors(Perdicaris)	p1=2,5	p_2=5	p_3= 2,5
The standards of each indicator are mentioned directly in the calculation tables			
Evaluation with sustainability degree			
Perfect sustainability= 100%	Sustainable= 75%	Unsutainable = 50%	Regressed = 0,25

Table 3 : Measuring sustainability in Kasbah at t_1

Layers	Settings	Indicators	Values	Standars	Evaluation	V/S	FI(p1,p2,p3)	ρ
Economic	Turnover	Tourism turnover(average Dhs)	900045	1200000	Deficit	0,75	2,5	0,05
	Infrastructure	Number of hotel establishments	20	20	Normal	1	2,5	0,05
	Number of tourists	Number of nights / month	3400	3500	Normal	0,971	2,5	0,05
	Local products, crafts	Number of units per business	500	520	Normal	0,962	2,5	0,05
Evaluation of the economic component			-0,02					
Environmental	Pollution	Air pollution, tourist waste(AQI)	38	30	Normal	1,27	2,5	0,05
	Green area	m^2 of green space per inhabitant.	7	10	Deficit	0,7	2,5	0,05
	Tourist transport	Carbon emissions from tourist transport	0,11	0,1	Normal	1,1	2,5	0,05
	Tourist density	Number of visitors compared to the local population(%)	20	25	Normal	0,8	2,5	0,05
Evaluation of the environement component			0,07					
Social	Security	Frequency of prevention and control	30	32	Normal	0,938	5	0,05
	Employability	Employability of indigenous people (%)	25	43	Deficit	0,581	5	0,05
	Costume,Traditions	Number of cultural and artistic activities of the native people	30	30	Normal	1	5	0,05
	Unemployment rate	Number of active women per 100 active men(%)	48	50	Normal	0,96	5	0,05
Evaluation of the social component			-0,04					
Sutainability Evaluation			-0,0078					

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Table 4: Measuring sustainability in Kasbah at t_2

Layers	Settings	Indicators	Values	Standars	Evaluation	V/S	FI(p1,p2,p3)	ρ
Economic	Turnover	Tourism turnover(average)	11995045	12000000	Normal	1	2,5	0,05
	Infrastructure	Number of hotel establishments	20	20	Normal	1	2,5	0,05
	Number of tourists	Number of nights / month	3400	3500	Normal	0,971	2,5	0,05
	Local products, crafts	Number of units per business	500	520	Normal	0,962	2,5	0,05
Evaluation of the economic component			0,03					
Environmental	Pollution	Air pollution, tourist waste	38(AQI)	30	Normal	1,27	2,5	0,05
	Green area	m^2 of green space per inhabitant.	9	10	Normal	0,9	2,5	0,05
	Tourist transport	Carbon emissions from tourist transport	0,11	0,1	Normal	1,1	2,5	0,05
	Tourist density	Number of visitors compared to the local population	24%	25%	Normal	0,96	2,5	0,05
Evaluation of the environement component			0,134					
Social	Security	Frequency of prevention and control	30	32	Normal	0,938	5	0,05
	Employability	Employability of indigenous people	44%	43%	Normal	1,023	5	0,05
	Costume,Traditions	Number of cultural and artistic activities of the native people	30	30	Normal	1	5	0,05
	Unemployment rate	Number of active women per 100 active men	48%	50%	Normal	0,96	5	0,05
Evaluation of the social component			0,03					
Sutainability Evaluation			0,06					

Table 5: Measuring sustainability in Pedicaris at t_1

Layers	Settings	Indicators	Values	Standards	Evaluation	V/S	FI(p1,p2,p3)	ρ
Economic	Turnover	Tourism turnover	200000	250567	Defecit	0,80	2,5	0,05
	Infrastructure	Number of Touristit establishments	5	10	Defecit	0,50	2,5	0,05
	Number of tourists	Number of clients	50000	45000	Normal	1,11	2,5	0,05
	Local products, crafts	Number of units per business	10	10	Normal	1,00	2,5	0,05
Evaluation of the economic component			-0,03					
Environmental	Pollution	Air pollution CO2(AQI*)	24	30	Normal	1,27	5	0,05
	Tourist waste	Quantity of waste collected per inhabitant,(Tones)	50	25	Excess	0,50	5	0,05
	Biodiversity	Number of species fauna, flora	120	220	DEFICIT	0,55	5	0,05
	Natural resources	Total forest area(Ha)	67	70	Normal	0,96	5	0,05
Evaluation of the environement component			-0,01					
Social	Security	Frequency of prevention and control	25	23	Normal	1,09	2,5	0,05
	Employability	Employability of indigenous people (%)	50	56	Normal	0,89	2,5	0,05
	Costume,Traditions	Number of cultural and artistic activities of the native people(%)	15	15	Normal	1,00	2,5	0,05
	Unemployment rate	Number of active women per 100 active men	20	50	DEFICIT	0,40	2,5	0,05
Evaluation of the social component			-0,02					
Evaluation of the sutainability			-0,02					

Table 6: Measuring sustainability in Kasbah at t_2

Layers	Settings	Indicators	Values	Standards	Evaluation	V/S	FI(p1,p2,p3)	ρ
Economic	Turnover	Tourism turnover	244000	250567	Normal	0,97	2,50	0,05
	Infrastructure	Number of Touristit establishments	9	10	Normal	0,90	2,50	0,05
	Number of tourists	Number of clients	50000	45000	Normal	1,11	2,50	0,05
	Local products, crafts	Number of units per business	10	10	Normal	1,00	2,50	0,05
Evaluation of the economic component			0,05					
Environmental	Pollution	Air pollution CO2	38 (AQI*)	30	Normal	1,27	5,00	0,05
	Tourist waste	Quantity of waste collected per inhabitant,	27 Tones	25	Normal	1,08	5,00	0,05
	Biodiversity	Number of species fauna, flora	200	220	Normal	0,91	5,00	0,05
	Natural resources	Total forest area	67 Ha	70	Normal	0,96	5,00	0,05
Evaluation of the environement component			0,13					
Social	Security	Frequency of prevention and control	25	23	Normal	1,09	2,50	0,05
	Employability	Employability of indigenous people	50%	56%	Normal	0,89	2,50	0,05
	Costume,Traditions	Number of cultural and artistic activities of the native people	15	15	Normal	1,00	2,50	0,05
	Unemployment rate	Number of active women per 100 active men	47	50	Normal	0,94	2,50	0,05
Evaluation of the social component			0,03					
Evaluation of the sutainability			0,0865					

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Output results via geoportal application

The first version of the geoportal application has been realized in French. That is way the making of the maps is in French.

The first step made by using our clear and simple interface ischoosing the two tourist destinations Kasbah and Perdicaris and generatingtheir corresponding maps.In this way, we have obtained Kasbah map depicted in Fig 4 and Perdicaris map depicted in Fig 5.Also, both destinations can be put into a single map as depicted in Fig 6.

Note that the generated Kasbah map and Perdicaris map are full of details with usefulinformation about the location of these tourist destination, their points of interest, the services provided and the local places to be visited with their Paths to be traveled.
The second step made by using our interface consisted of the determination of the "sustainability index" which allowed us to assess the state of sustainability of the two tourist destination Kasbah and Perdicaris at the time-periods t1 and t2. This index reflects the result of interactions between the various components of sustainability through indicators. Note that those indicators responsible for "unsustainability" according to their assessed values can be easily identified. Fig 7 and Fig 8 illustrate this facts by providing a zoomed maps that show the visual output results at time-periods t1 and t2, resulting from the implementation of Tables 3, 4, 5, and 6.
As depicted in Fig 7 and Fig 8, for both sites at the time-period t1, we have found that several indicators are out of step with their standard norms. Hence, by this fact,the proposed evaluation model automatically qualifies these sites as unsustainable.

In contrast, at time-period t2, after readjustments by the responsible stakeholders, there was a recovery of the deficit indicators while keeping and maintening improvement of the previous successful indicators. Despite this fact, there is still a risk of a decline into an unsustainability if indeed some key indicators turn to take negative values. Of course, this was not the case at the time-period t2 because both sites are far from non-sustainability since their indicators have increased,

Hence, the challenge of good monitoring is to maintain the best indicators values while improving the others, and more importntly to defend and protect these sites against possible internal deteriorations and external disturbances in order to achieve higher sustainability index.

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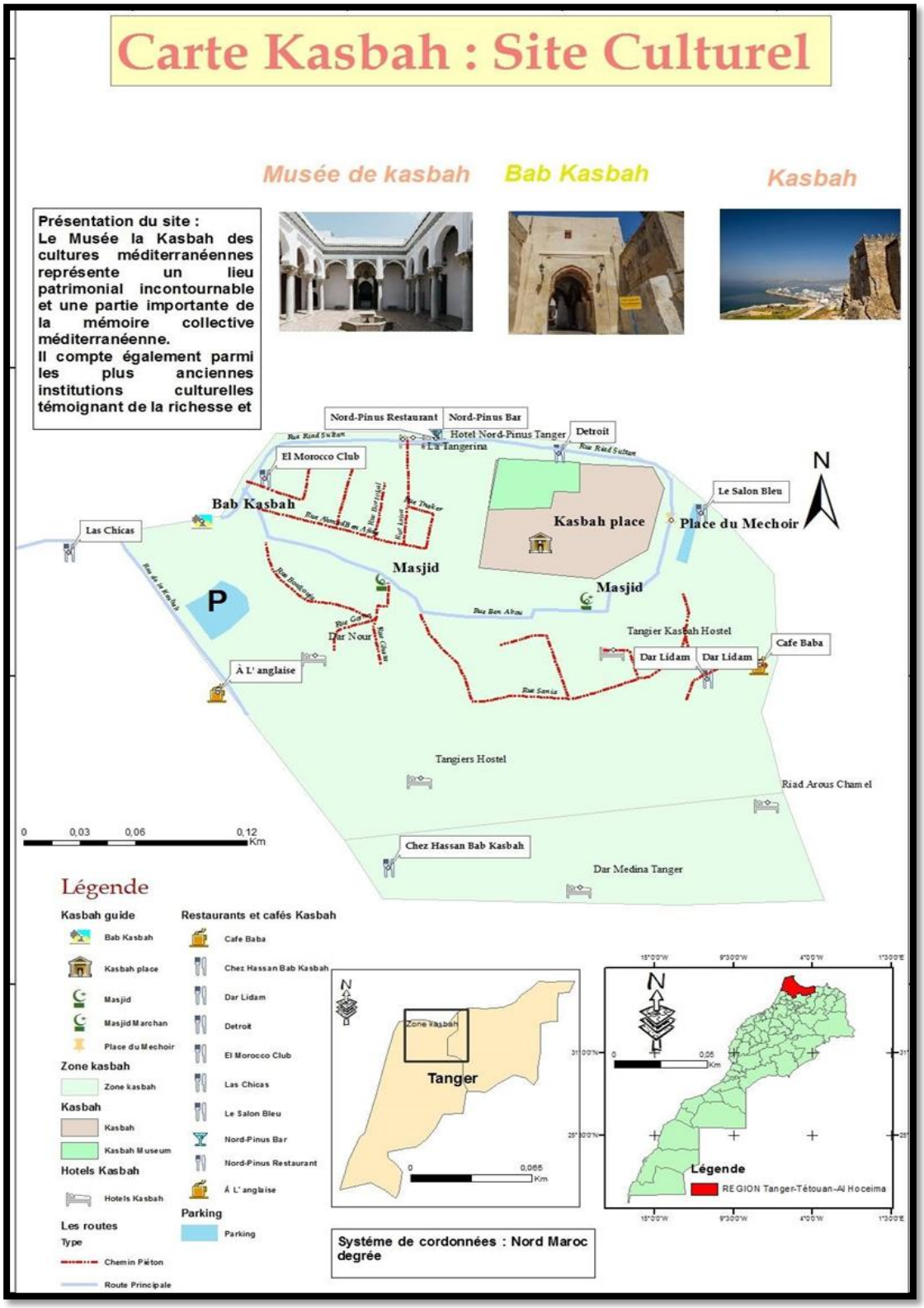

Fig 4: Tangier Kasbahmap

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Fig 5: Perdicaris map

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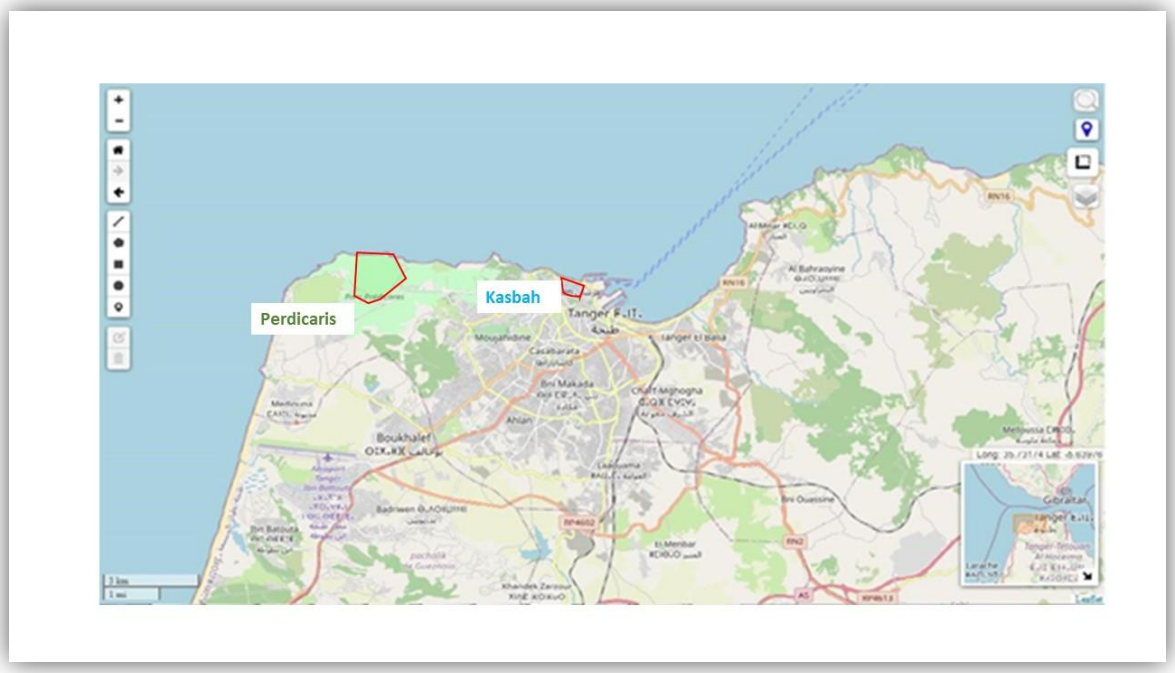

Fig6:Perdicaris and Kasbah in Tangier city map

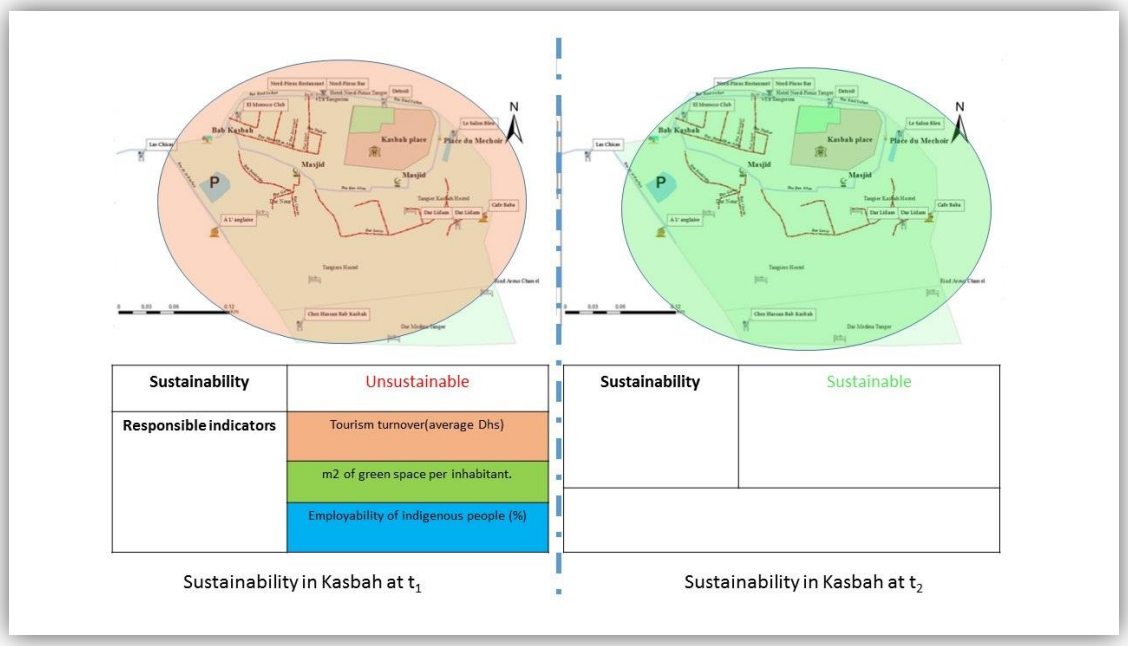

Fig 7: Sustainability of Kasbah at time-period t_1 and t_2

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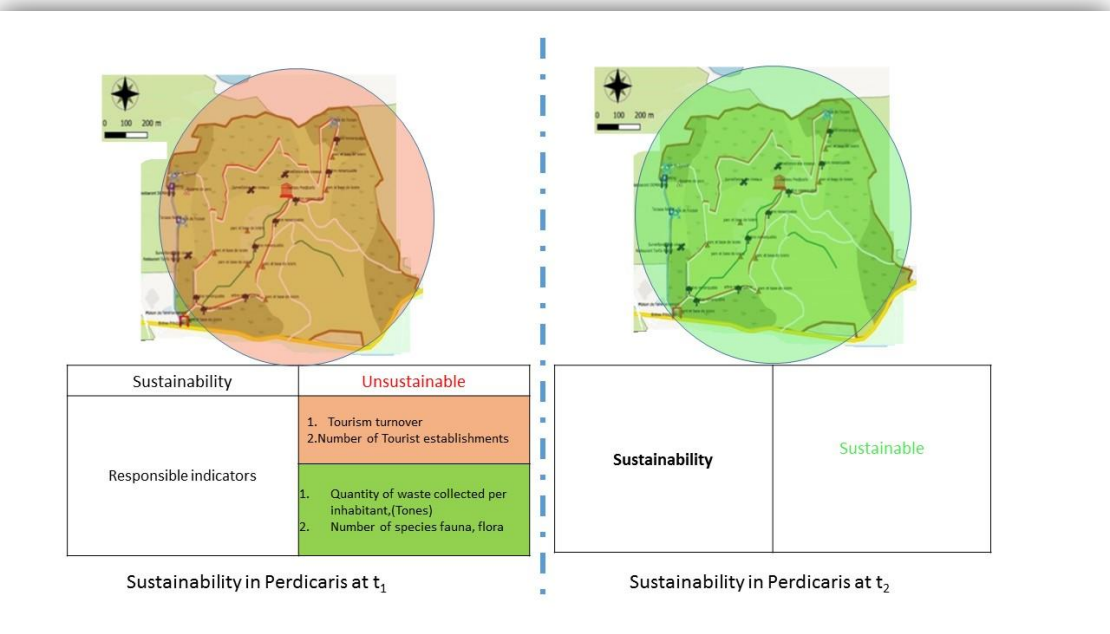

Fig 8: Sustainability of Perdicarisat time-periods t_1 and t_2

Concluding Remarks

This study was concerned with the assessement of the sustainability of a tourist destination in the context of the economic, social and environmental requirements that are the pillars of sustainable tourism development. We have used Geographic Information Systems (GIS) as a toolbox of technologies in order to design a geoportal platform that exploit spatial data to be used to track and assess the state of sustainability and as well to aid in decision making. Moreover, for integrating, manipulating, visualizing and analyzing data, the proposed geoportal platform has been used efficientlyfor this purpose. In addition, a systematic evaluation model is providedfor sustainability along with its implementation byour geoportal software for a case study on sustainable tourism in Morocco at the city of Tangier.

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