A GIS-BASED TOOL FOR ASSESSING CLIMATE CHANGE IMPACTS ON TOURISM

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EXTENDED ABSTRACT

Climate is considered one of the most important drivers of change and, thus, has been the focus of research in terms of impacts on weather dependant activities and systems, such as agriculture and water systems. It became, also, apparent that climate is a key feature of tourism, since it defines the type of activities, as well as the tourism period. In this regard, there is an increased interest for addressing the relationship between climate and tourism, a topic of great importance for the wider Mediterranean region.

Already applied tools for analyzing climate change impacts encompass multi-disciplinary (e.g. scenario analysis) to sectoral (e.g. crop productivity) approaches and are being summarized in the United Nations Framework Convention on Climate Change (UNFCCC) Compendium on methods and tools. Besides direct impacts of climate change (e.g. shift in rainfall pattern), emphasis is also given to indirect impacts, such as economic losses due to shifts in activities and productivity. Therefore, there is a need for practical tools that will (i) enable the analysis in a common framework of climate conditions (current and future), as a driving force of change, and anticipated impacts and (ii) assist decision makers in developing adaptation programs.

This paper presents such a tool developed for assessing climate change impacts on tourism. This GIS-based tool provides a platform for estimating the value of selected impact-related indicators (e.g. tourists' arrivals), and illustrating their spatial distribution. The main advantages of the tool are that it can: (i) examine the impact climate change scenarios may have on tourism, (ii) identify which climate parameter will have the highest influence, and (iii) be used as a reporting mechanism. The tool is illustrated through its implementation for the Syros Island, in Cyclades.

Keywords: climate change, impacts, GIS, tourism

1. INTRODUCTION

Climate change and its impacts have been the focus of research the past years in an effort to better understand and be prepared for the anticipated effects. General provisions on how the climate may evolve and the required actions for improving mitigation efforts are given in the Fourth Intergovernmental Panel on Climate Change (IPPC) report. There it is stated that the efficiency of adaptation is dependent on 'geographical and climate risk factors as well as institutional, political and financial constraints' (IPCC, 2007). Therefore, the development and implementation of a climate change adaptation strategy is highly dependent on specific spatial features (either national or regional).

For the Mediterranean region, climate change is of critical concern, since (i) the most important economic sectors are highly weather-sensitive (agriculture and tourism, Table 1), (ii) ecosystems are already stressed and expected to experience significant losses by 2100 (Klausmeyer and Shaw, 2009), and (iii) water resources are limited (in some regions over-exploited) and vulnerable to climate induced changes (Thivet and Blinda, 2008). Furthermore, water is an asset for economy and a vital component of ecosystems, stressing the need for an integrated assessment of climate change impacts, including indirect impacts, such as economic losses due to shifts in activities.

Table 1: Climate change impacts on tourism (adapted from Simpson et al., 2008)

Category	Focus	Impacts
Direct	Suitability of locations for tourist activities	Sea level rise Loss of recreational value and carrying capacity of beaches Changes in tourist mobility and seasonality
Indirect	Environmental issues that relate to the attractiveness of a destination	Deterioration of landscape and visual appreciation Coastal erosion Cost for beach and property protection
Impact of policies	Policies for reducing GHGs emissions	Changes in tourist mobility and seasonality
Indirect societal	Economic development and employment	Loss of property value resulting from declining amenity value Loss of land value

A series of tools are used for analyzing climate change impacts. The United Nations Framework Convention on Climate Change (UNFCCC) Secretariat issues since 1999 a compendium that reviews existing methods and tools, in an effort to classify and disseminate approaches for impact assessment and the development of adaptation strategies. The latest version was issued in 2008 and reports on approaches according to the sector examined or the method employed (Table 2). The vast number of tools stresses the need for practical tools -of value for decision makers- that will enable the analysis in a common framework of climate conditions, as a driving force of change, and anticipated impacts.

Aim of this paper is to present such a tool for assessing climate change impacts on a strategic economic sector for the Mediterranean region, namely tourism. The tool enables spatial analysis of climate variables and the estimation of impact-related indicators, supporting the development and assessment of adaptation plans. The tool is illustrated through its implementation for the Syros Island, in Cyclades.

Table 2: Classification of tools in the UNFCC Compendium (UNFCC, 2008)

Category	Type of tools
Cross-Cutting Issues and Multisector Approaches	Application of scenario data in Impact and Adaptation Assessment Decision Tools Stakeholder approaches Other multisector tools
Sector Specific Tools	Agriculture Water sector Coastal Resources sector Human Health Sector Terrestrial and vegetation sector

2. THE GIS-BASED TOOL FOR ASSESSING CLIMATE CHANGE IMPACTS

2.1. Theoretical background

Climate is a key feature of tourism, since it defines the type of activities, as well as the tourism period. Amelung et al. (2007) describe climate both as a "pull" and "push" factor for tourism, influencing the choice of destinations and activities. Particularly, topic of tourism climatology is the study of the relationship between climate and tourism in terms of meteorological parameters that define and describe tourist's personal feeling of comfort and satisfaction (Mansfeld et al., 2007). For this purpose tourism-climate indicators are used that combine weather and thermo-physiological parameters to provide an estimate of climate influence on tourism activities.

The most commonly used indicator is the Tourism Climate Index (TCI), developed by Mieczkowski (1985). TCI combines seven climatic parameters (mean monthly values) in five sub-indices, as indicated in Table 3. TCI is calculated on the basis of rates assigned to each sub-index, ranging from -3 to 5. Therefore, using equation 1, the maximum value of TCI is 100, with values over 80 depicting "excellent" conditions for summer tourism.

$$TCI = 8 * CId + 2 * CIa + 4 * R + 4 * S + 2 * W \qquad \text{(eq.1)}$$

Table 3: Climatic parameters used in TCI calculation (Mieczkowski,1985)

Climatic variable	Unit	Sub-index	Unit
Maximum daily temperature	^{o}C	Daytime Comfort Index (CId)	^{o}C
Minimum daily relative humidity	%		
Mean daily temperature	^{o}C	Daily Comfort Index (CIa)	^{o}C
Mean daily humidity	%		
Precipitation	mm	Precipitation (R)	mm
Sunhine	h/day	Sunshine (S)	h/day
Wind speed	Km/hr	Wind speed (W)	Km/hr

Climate change impacts are assessed in this paper through the TCI. Results are obtained through a GIS-based tool, for baseline conditions (historical averages) and climate projections. TCI values are further correlated to key variables describing tourism demand (arrivals, overnight stays and accommodation rates).

2.2. Description of the tool

The GIS-based tool developed aims to serve as a tool for examining climate change impacts on tourism, using TCI as indicator of change. It provides a platform for (i) storing, managing and viewing climate and tourism-related data, (ii) performing TCI calculations,

(iii) building and examining scenarios and (iv) correlating tourism-related indicators to TCI. Particularly, the tool can be used for:

1. Presenting historical climate data and projections (outputs of GCMs or RCMs for different IPCC scenarios), either as maps or time series for each meteorological station;
2. Presenting tourism-related data (e.g. arrivals, overnights) in a graphical or tabular format;
3. Performing TCI calculations and viewing the results. According to the type of data used in the calculations (grid or time series) results can be either in the form of maps or graphs/tables;
4. Defining scenarios of future climate conditions, based on current climate conditions;
5. Correlating historical TCI values to tourism indicators, such as arrivals or overnights;
6. Examining the impact of climate projections and user-defined scenarios on TCI values, and
7. Calculating future values of tourism-related indicators, using the regression equation described in (5).

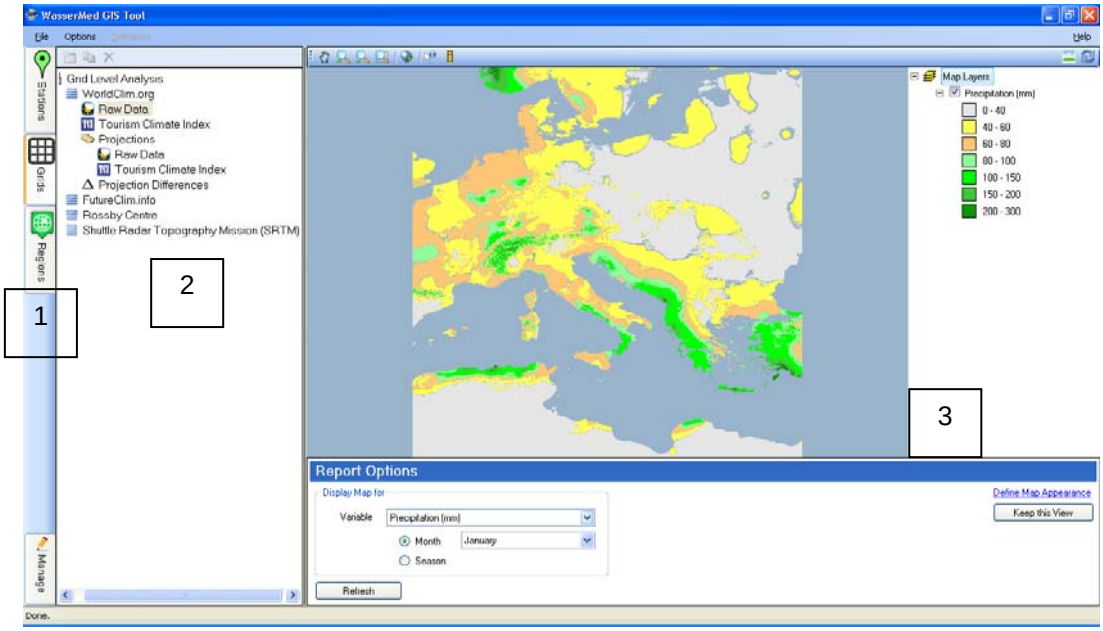

Figure 1: Main application window-Viewing of gridded climate data

The Graphical User Interface is divided into three main areas (Figure 1): 1.Options menu, 2.Tree of tool functions and 3.Display window. Options menu offers the possibility to select the level of analysis (gridded, point or regional data). The Tree offers for each layer three functions: viewing data, performing calculations and examining scenarios. The Display window provides the user with options for viewing data (e.g. selection of parameter, viewing map, graph or table), performing calculations and viewing results (e.g. definition of time period) and setting climate change scenarios (e.g. setting percentage change of parameters).

3. TOOL APPLICATION FOR SYROS ISLAND

The tool functionalities are demonstrated through its application to Syros island, a popular tourism destination. Data stored in the tool refer to: (i) historical climate data for three

meteorological stations located at Syros (Figure 2), (ii) historical tourism data (arrivals and overnights), and (iii) climate projections until 2050.

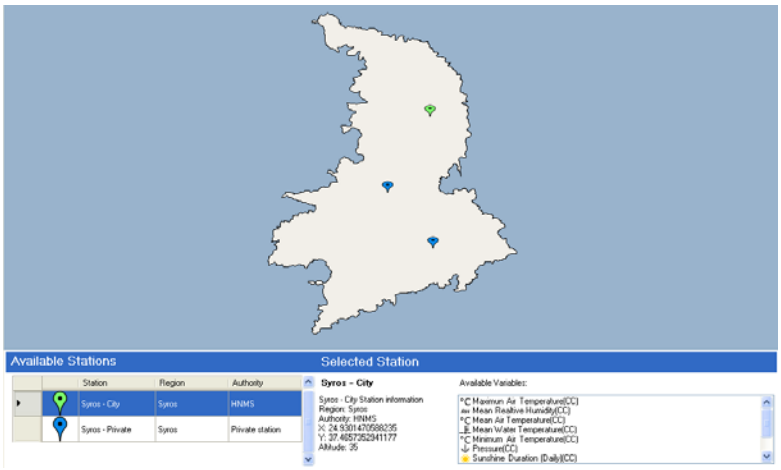

Figure 2: Meteorological stations located at Syros and available historical data

Historical TCI values are calculated on a monthly basis, using the available climate data. As it can be seen from Figure 3 (screenshot from the tool), climate conditions are characterized as excellent during the tourism season, April to October. In order to examine the effect of climate change to tourism mobility, historical TCI values are correlated to the recorded values of arrivals or overnights. The aim is to develop an equation that will estimate future tourism parameters based on projected climate conditions. The results of a linear regression analysis on TCI values and arrivals are presented in Figure 4.

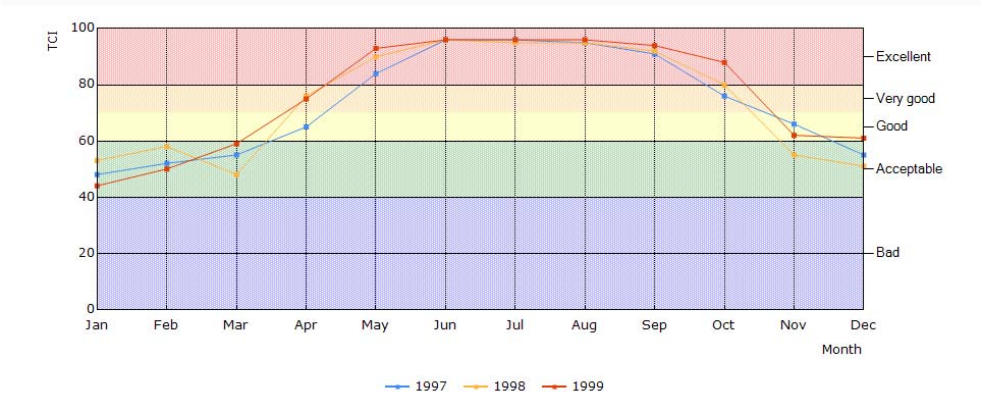

Figure 3: Historical TCI values for Syros island and correlation with parameter “arrivals”

Figure 5 illustrates the estimated TCI values, using climate projections for 2030 from the European ENSEMBLES project (contract number GOCE-CT-2003-505539), as well as the calculated arrivals for the respective year, on the basis of regression analysis Excellent conditions for tourism are estimated for the period May to October, indicating a possible decrease by one month of the tourism season. Regarding the number of arrivals, the projected values are given in Table 4. The results present a more even distribution of arrivals during the tourism season.

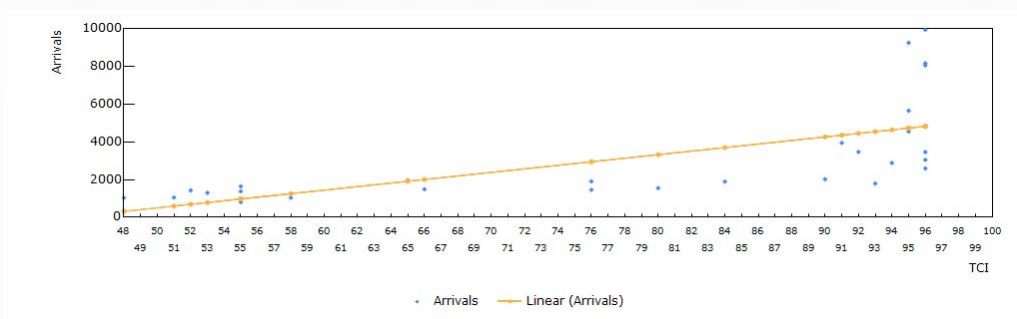

Figure 4: Correlation between TCI values and arrivals

Table 4: Historical and projected arrivals in Syros

	April	May	June	July	August	September	October
Historical data (El.Stat.,2009)	3340	2276	3667	5987	4530	1938	1000
Projected values (2030)	3227	4178	4743	4649	4555	3990	885

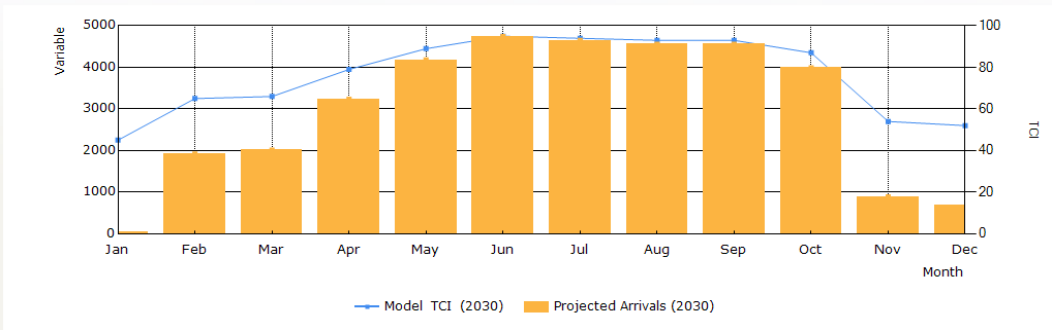

Figure 5: Projected TCI values and arrivals for Syros island

4. CONCLUSIONS

Climate change can be perceived as a challenge from improving existing (unsustainable) development practices in tourism, having in mind the economic output, as well as the use of natural resources. In this regard, tools are needed to assist decision making and the preparation of plans based on easily understood information and the assessment of anticipated impacts.

The GIS-based tool presented in this paper aims to provide such assistance, by: (i) analyzing the impact climate change scenarios may have on tourism in the Mediterranean region, (ii) assessing the influence of climate parameters, and (iii) providing a platform for reporting.

Its application for Syros island illustrates the possibilities of combing spatial and point data for exploring climate induced changes. Particularly for the case study presented, it seems that climate change may influence the most important economic sectors of the island. According to the results tourists' mobility will differentiate from current conditions, indicating a relevant shift in water demand and services provisions.

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