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EXTENDED ABSTRACT

ASSESSMENT OF SUSTAINABILITY IN THE SOCIO-TOURIST SECTOR OF FUERTEVENTURA (THE CANARY ISLANDS)

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1. INTRODUCTION

Socio-ecological systems (SES) can be defined as integrated systems of ecosystems and human society with reciprocal feedback and interdependence (Halliday and Glaser, 2011). In complex systems, a change in the socio-tourist dynamic may be considered as a systemic change, since it might lead to a shift in the state of the entire system (Filatova and Polhill, 2012) and, therefore, threaten its sustainability.

The unsustainable trends in the evolution of SES have stimulated a search for new approaches to understand complex problems of environment and development (UNEP 2002). Despite of the existence of an increasing awareness about the need of the implementation of more sustainable policies, the real application of sustainable policies in socio-ecological systems is quite far from required.

The analysis of barriers and difficulties which explain the gap between knowledge and action, points the need to develop and apply quantitative tools that allow an integral analysis of the sustainability of real socio-ecological systems. Likewise, it can show how certain management measures and scenarios can affect these systems and analyse quantitatively its change in terms of sustainability.

In this paper we address the usefulness of the application of dynamic models, in combination with other tools (GIS, statistical packages, sustainability indicators) for the sustainable management of tourism on island socio-ecological systems. Thus, the specific aims of this work are: i) to develop and validate an integral model which incorporates the factors and key processes of a socio-ecological system, in this case, the Fuerteventura sustainability dynamic model (MSF) and which includes the most relevant sustainability indicators in the model; ii) to use the model to analyse the vulnerability of this island to external changes, such as economic scenarios and those of climate change; iii) to apply the model to assess how some of these sustainability indicators behave under a set of management measures.

2. AREA OF STUDY

Fuerteventura is the most arid island of the Canarian Archipielago. Its hyperarid climate maintains a weak vegetation cover dominated by xerophytic scrub and annual grassland vegetation (Schuster et al., 2012). In recent decades, the traditional productive activities have been mainly substituted by tourism and related activities; and it has experienced a spectacular demographic growth, with a rate of 282% from 1990 to 2010, reaching more than one hundred thousand inhabitants in 2010 and receiving around 1.5 million foreign tourists (ISTAC, 2012). This quick and disorganized growth can be affect the image of the wild and peaceful island, which is its distinguishing feature compared to other coastal destinations with similar climatic conditions (Santana-Jiménez and Hernández, 2011; Hernández-Luis et al., 2017).

3. METODOLOGICAL APPROACH

3.1. Model description

The Fuerteventura sustainability dynamic model (MSF), developed under the system dynamics approach (Forrester, 1961) is structured in five sectors (Land Uses, Biodiversity, Socio-tourist, Environmental Quality and Water Resources) and integrates 37 sustainability indicators. In this work, we focus on the latter three sectors of the model, directly related to the socio-tourist dynamics, which are detailed below.

3.2. Assessment of the behaviour of the sustainability indicators under different scenarios and management options

In order to perform a quantitative evaluation of the sustainability, the behaviour of 6 indicators under different scenarios and management measures for the period 2012-2025 was assessed (Table 1). The identification of these thresholds is essential when controlling trends in terms of sustainability in future scenarios, and may increase the real influence of the indicators in the adoption of sustainable policies.

3.3. Description of scenarios

In order to address a preliminary assessment of the sustainability of this socio-ecological system for the 2012-2025 period, two climate scenarios (A2 and B2, according to IPCC, 2014), two economic scenarios (growth and recession) and two policy management measures were explored. Measure I (M.I) would cover 100% of the electricity demand for the supply of desalinated water of the island with renewable energy; and this represents one of the goals of the Action Plan of Fuerteventura Biosphere Reserve. Measure II (M.II), would consist of limiting the construction of new tourist accommodation, in line with the carrying capacity in tourist areas (Gobierno de Canarias, 2008).

Table 1
SELECTED SUSTAINABILITY INDICATORS INCLUDED IN THE MSF AND THEIR THRESHOLDS

Indicators	Units	Meaning of the threshold
Ratio between tourist accommodation and resident population (RATPR)	Touristic bed/inhabitant	The ratio between tourist accommodation and resident population should be lower than 0.97 (Government of the Canary Islands, 2008)
Ratio between tourist and resident population (TURES)	dimensionless	The ratio between tourist and resident population should be lower than 0.3152 (Government of the Canary Islands, 2008)
Artificial land proportion (PSA)	%	Percentage of land modified should be lower than 20% (Graymore et al., 2010)
Per capita primary energy consumption (EPpc)	GJ/ Year*pc	42 GJ/ Year*pc is the minimum energy use required to reach a Human Development Index of at least 0.8, as recommended by UNDP (Johansson Goldemberg, 2008)
Per capita CO2 emissions (CO2pc)	metric tonnes CO2/ Year*pc	9.52 metric tonnes CO2/ Year*pc represents a 20% reduction in the per capita CO2 emissions from 1990 levels (EC, 2008)
Share of renewable energy (SER)	%	A share of renewable energy of at least 20% in 2020 and 27% in 2030 (EC, 2008).

4. RESULTS AND DISCUSSION

The model successfully passed a set of testing procedures, including: dimensional consistency test, sensitivity analysis, extreme conditions test and goodness of fit test for the 20 variables with available observed data series (See Banos-González et al. 2015 and 2016 for details). Therefore, these results point to a high degree of fit between simulation results and observed series, which supports the ability of the model to track the behaviour of the

SES of Fuerteventura for the calibration period (1996-2011), as well as to explore the potential system's response under a set of scenarios and measures for 2012-2025 period.

Under the base trend simulation (ESC), in which no changes would be expected and observed trends in model parameters would be maintained, all the analysed indicators would worsen between 2012-2025, and only two, RATPR and PSA, would not exceed their sustainability thresholds.

The increase in tourist and resident population and, thus, the demand of new infrastructures expected under the economic growth scenario, would give raise to an improvement of the TURES and RATPR around 5.4% and 7.8% respectively, compared to ESC, whereas PSA would worsen around 7.5% under this scenario. Both EPpc and CO2pc would tend to worsen since, under an economic growth circunstances, the consumption of natural resources, such as water and energy, tend to increase. When the economic conditions tend to get worse, these two indicators would tend to improve, whereas TURES and RATPR would worsen comparing to ESC, since the resident population would decrease.

In light of the simulation results for 2025, it seems that the impact of climate change on the studied indicators would still be limited. In comparison with ESC, slight increases in EPpc and CO2pc would be expected, being 0.8% and 1.1% under A2 and B2, respectively; although they do point to a downward trend, which would increas its distance to their sustainability threshold.

In terms of management measures, measure I would improve the results of the three energy indicators, although still far from their sustainability thresholds.

Regarding the implementation of measure II, two indicators would improve compared to ESC (RATPR and PSA); SER would not change; while the other three (TURES, EPpc and CO2pc) would worsen. It should be notice that the behaviour of these last three indicators has reflected that some 'per capita' or relative indicators do not always provide solid information on sustainability when considered isolated, or with a discrete, static value. Therefore, its evolution and interactions with other variables must be evaluated (Hanley et al., 2009) to avoid errors in the diagnosis.

It is observed in all the analysed simulations that, both RATPR and PSA, would remain far from their thresholds, which could mean a good result in terms of sustainability. This could be interpreted as a possibility to respond to an increasing demand for tourist and residential infrastructures on the island. However, it is difficult to maintain a moderate increase in the arrival of tourists, to favour the conservation of some of its natural attractions and, at the same time, to sustain a balance between the local population and other stakeholders (Dodds, 2007; Santana-Jiménez and Hernández, 2011). Therefore, in line with the objectives of the Action Plan of Fuerteventura Biosphere Reserve, it would be appropriate to avoid uncontrolled growth, already incipient in Fuerteventura, and experienced by other islands of the archipelago. In relation to these effects, the results of the model in the period 2012-2025 support the maintenance of certain restrictions in the construction of new tourist establishments, betting on a greater use and rehabilitation of existing ones.

These preliminary results also suggest that the socio-ecological system of Fuerteventura could be more reactive to certain management measures such as M.II, as also suggested by other authors (Oreja-Rodríguez et al., 2008, Santana Jiménez and Hernández, 2011), than to external factors, both climatic and economic. For example, while under the recession scenario, indicators such as PSA would improve around 3%; under the management measure M. II, this improvement would reach almost 24%. This reflects the impact of the actions (and inactions) of the policies in the management of this SES and underlines the responsibility of those who take decisions when addressing measures and policies to contribute to a more balanced and sustainable development of the socio-ecological system of Fuerteventura.

On the other hand, it has also been identified that the Action Plan lacks more ambitious measures to achieve the sustainability objectives with respect to the problems of the water-energy binomial in this island.

In conclusion, this paper shows the usefulness of these tools (the dynamic simulation combined with sustainability indicators and their thresholds, as well as the modelling of scenarios and measures) for the diagnosis of sustainability in tourist destinations such as Fuerteventura and for informed decision-making processes involved.