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EXTENDED ABSTRACT

SPATIAL IMPACT OF FLASH FLOODS ON THE TOURIST RESILIENCE IN MATEHUALA, SAN LUIS POTOSI, MEXICO

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INTRODUCTION

In the analysis of tourism-climate change, resilience, a component of integrated risk management, has little methodological background to reveal the resilience of tourism sites when a hazard occurs (Mayunga, 2007). In Mexico, the practice of tourism has grown rapidly in recent years, to the extent that numerous inland sites offer numerous alternatives, among which the state of San Luis Potosí stands out (Vázquez, *et al*. 2010). Although there are many studies on the effects produced by floods in the humid tropics of the country, those caused in the dry portion of the northern Altiplano of San Luis Potosí are less treated. The last of these occurred in Matehuala, during 2019, where these events are assumed to be random and natural for the inhabitants and the government, so they do not receive priority attention.

Therefore, the study assumes that, in Matehuala, a place with a tourist presence, the impact of torrential rains during the summer, accentuated by climate change, is conditioned by physical, economic, social and human factors that explain different resilience capacities. Since there are few methodological references for zoning a locality by its resilience capacities, this research relies on the capital-theoretic approach and the probabilistic typification method to reveal them.

1. OBJECTIVE

The work reveals levels of tourism resilience that existing in Matehuala, San Luis Potosi, under the physical, economic, human and social capital approach with the probabilistic typing method.

2. CONCEPTUAL THEORETICAL ASPECTS OF TOURISM RESILIENCE

With an emphasis on tourism, resilience has gained ground in research aimed at examining the economic impacts that crises generated in this sector during the 1990s (Cellini and Cuccia, 2015); at the beginning of the 21st century this approach became interested

in incorporating criteria to identify environmental impacts that are gaining increasing strength (Calgaro, Lloyd, Dominey-Howes 2014), as well as those occurring due to an increase in the displacement of travellers in Europe (Ibanescu, Eva, Gheorghiu, 2020). In addition, global events such as 9/11, or those linked to climate change have privileged resilience as a cognitive positioning (Fabry and Zeghni, 2019; Lew *et al*. 2016).

Thus, this process is seen as part of a natural subsystem that is attached to others of similar or greater scope as explained by Cochrane (2010) with the sphere of "tourism resilience", a systemic approach that will allow tourism destinations to operate more efficiently, so that the best prepared and with the necessary resources will cope with the impacts of climate change, economic crises and other threats in the face of the most vulnerable (Holladay, 2018; Jones and Comfort, 2020; Dogru *et al*. 2019). Three trends emerge from these reflections: 1) Tourism resilience and governance; 2) The impact of the tourism destination life cycle on resilience capacities; and 3) Resilience, adaptive capacities and risk management in the face of climate change, to which this paper belongs. With the support of Farrell and Twinin-Ward's (2004), Becken (2013), Tyrrell and Johnston (2008), Fabry and Zeghni (2019), Holladay (2018) and Lew (2014), tourism resilience is assumed as the way to improve sustainability after a disaster caused by ecological or environmental factors, as its primary objective will be the restoration of the complex functions of the tourism system, taking it to a more robust condition than the one existing prior to the event.

3. METHODOLOGY

3.1. Main attributes of the physical-geographical environment of Matehuala

The town of Matehuala and its surrounding tourist attractions lie in the southeastern portion of the Chihuahuan Desert (Rzedowski, 1978), and the Sierras y Llanuras Occidentales subprovince, in the Mexican Altiplano (Brender, 1982), at an altitude of 1577 metres (INEGI, 2017). The topography is a plain surrounded by anticlines, most notably Cerro Grande (3180 masl) and Sierra de Catorce (3110 masl) (INEGI, 2017), from whose slopes intense runoff occurs during the summer. The climate in the area is BSh, dry semi-warm (García, 2004). It has a rainfall regime during spring and summer. Precipitation is 438 mm and the mean annual temperature is 18.9 °C, with winters where it drops to 5º C and in the summer it exceeds 30º C. Thus, two factors associated with the flooding caused by rainfall can be detected:

1. The mountain ranges from which the rains that flood Matehuala originate have a temperate sub-humid climate with summer rains in the Sierra de Catorce and a dry temperate climate in the foothills (García, 2004; Vidal, 2007; INEGI, 2017), which produce runoffs that descend the steep slopes towards the urban settlement.
2. Another very important source of moisture comes from hurricanes generated in the Gulf of Mexico, less than 300 kilometres away.

3.2. Temporal dynamics of hydrometeorological phenomena

A list of the events that have occurred over the last three decades was obtained by searching the Internet, local and national newspapers and the specialised sites Desinventar

and EM-DAT. The occurrence of atypical rainfall and hurricanes in the area since 1983 was determined, followed by a baseline with information from climatological stations near Matehuala between 1983 and 2021 and from LANDSAT satellite images to calculate temperature —MODIS satellite— and IMERG —GMP satellite— for precipitation. Both variables were correlated with flood frequency.

For temperature and drought, MODIS images with 0.5° from 2011 to July 2021 from LANDSAT 7 were used. In both cases a normalised annual mean was obtained. When relating rainfall, temperature and flooding, it is observed that the highest intensity occurred in 2019, when the May rains caused the highest flooding recorded in 28 years.

3.3. Methodological procedure

The work used the indicators proposed by Mayunga (2007), modified by Hernández and Vázquez (2019) to assess tourism resilience. The following capitals and indicators were used: a) Physical (Emergency bodies, airstrips, roads and communications); b) Economic (Insurance, income, investment and trade); c) Human (Population with disabilities, 15 years and over illiterate, without rights to health services and 60 years and over with disabilities); and d) Social (Social networks and association pages, collective action and migration).

Data for indicators on physical and human capitals were obtained from the Population and Housing Census, 2020 (INEGI 2020a), while that on economic and social capitals were collected in two field works carried out in 2019. To measure the impact of the threat, 330 semi-structured interviews were conducted with tourism service establishment owners, visitors and local people. The questionnaires addressed strategies employed in the presence of flash floods, prevention measures and recovery strategies from previous events.

Quantitative values were organised by regular intervals, logarithms or geometric progression, according to the behaviour of the data. Five classes were obtained using the multi-point mapping scale (Briguglio, 2003), where number one designates very high resilience; two, high; three, medium; four, low; and five, very low. For the qualitative values, a Likert scale was used with values from one to five. This made it possible to standardise the data. Thus, the values of each indicator were grouped using the probabilistic typification, method applied by Propin (2003) to delimit economic regions and adapted by Hernández and Vázquez (2019) to assess tourism resilience.

4. RESULTS

4.1. Spatial differences in tourism resilience

From the results by capital city and overall tourism resilience, the following is identified:

I. *Spatial units with high and very high tourism resilience*. These are the areas classified in levels I, II and III, and have very high economic, human, physical and social capital. Even when the impact of floods is higher than in other areas, they have an effective resilience because they are more accessible to support centres in case of emergency, their nuclear character distinguishes them with privileged external links,

the support networks between traders and the local population are more efficient than in other areas of the city.

II. *Transitional spatial units with medium to high resilience in some capitals*. This category includes sites located in groups IV, V and VI. They have irregular behaviour, but are distinguished by areas of high economic capital surrounded by areas of low economic capital; however, they are relatively accessible and well-serviced disaster support sites.

III. *Transitional spatial units with medium and low or very low resilience in most capitals*. They surround the areas in the previous categories. They extend along the access roads to the north and south, along Highway 57, the main access to the city (levels VII, VIII and IX). In them, physical and economic capital are relatively acceptable, but social articulation and human capital are deficient, lacking integration among members, and they are areas of high migration of people who come to the city to work in industry and services and others who migrate to other cities in the country and abroad.

IV. *Spatial units with weak resilience capacity*. These are the least resilient in all capitals. They are located in the peripheral zones where, even though flooding is scarcer because they are located in areas slightly higher than the historic centre where runoff flows, they have the lowest values in all items; they belong to the areas of greatest socio-economic marginalisation, are disjointed from the decision-making centres and do not have priority support in the event of disasters.

5. DISCUSSION

5.1. Implications of the patterns detected

The historical centre of the locality constitutes the space where the main tourist attractions, infrastructure, commerce and services related to the sector are located, concentric spatial patterns were identified which show a decrease in capacities as the physical, economic, social and human capitals also decrease.

Additionally, according to Lew (2014), it is the most resilient sector of the city because its inhabitants have developed better adaptive capacities, allowing them to respond more efficiently and quickly than areas with high socio-economic marginalisation. For them, climate change is a variable of increasing manifestation (Becken, 2013), they perceive it as events that they will have to face in the future, so they must prepare themselves with efficient measures (IPCC, 2007; Carpenter *et al*. 2001).

Physical, economic and social capitals have a uniform and directly proportional territorial distribution, so that areas with high resilience in one capital show the same behaviour for the other capitals and vice versa. According to the arguments put forward by Dobie *et al*. (2018); Ibanescu, Eva and Gheorghiu (2020); Luthe and Wyss (2014), and Tyrell and Johnston (2008), better resilience in small areas such as the historic centre of Matehuala is feasible when there is greater cohesion among its inhabitants, which are key aspects to materialise collective support actions.

This situation explains, in part, why even though this section of the city registers the greatest impact from floods, together with the sites classified in resilience levels II and III, it is the one that manages to recover most quickly from these events. Another aspect that

explains this behaviour is that several tourism businesses have the possibility of taking out insurance to face contingencies in case they need it, in a country where there is little culture of acquiring insurance against damages.

In this respect, even though the response times provided by insurers are usually lax, the experience shared by the owners indicates that those who take out insurance rehabilitate their business more quickly than merchants who must also repair the damage with their own means. Among the establishments interviewed that meet this characteristic are hotels and specialised tourism services located in the centre of Matehuala and on the main avenues. They are also the ones with the largest lodging capacity to accommodate visitors.

On the other hand, the average population protects their homes and patrimony from hydrometeorological events with "hard" solutions or structures, which include raising their pavements, building walls to contain floods, repairing damaged walls and floors, as well as replacing furniture. Results from fieldwork show that in peripheral areas, the economic capacity to invest in and repair such damage to homes and businesses is lower.

In particular, human capital is the most unevenly distributed territorially. It is estimated that the population uses more or less efficient mechanisms to make up for the deficiencies resulting from deficient physical capital and precarious economic conditions. In fact, it was detected that the inhabitants of some marginalised areas establish personal and virtual communication networks to address problems through commonly agreed actions, share their knowledge and also undertake actions for common benefit.

However, among the different actors interviewed (population, municipal government and service providers) there is a predominant opinion that there is not enough preparation or clear and informed strategies to act efficiently in the face of threats. In addition, recovery strategies are applied in a reactive rather than preventive manner.

6. CONCLUSIONS

The tourism resilience presented will allow decision-makers to identify areas with lower capacity for response and recovery, thus requiring a concentration of resources and efforts to support a more efficient resilience process. Correspondingly, the analysis of tourism resilience based on the capital approach allows knowing the variables and aspects that should be strengthened in each of them, as well as the areas of the city that should be addressed with greater urgency, in order to improve the adaptation process and resilience conditions, not only in terms of tourism.

Recommended actions to be considered, as regulators to stimulate an effective response to future hazards, include the elaboration of a municipal atlas of hazards and risks, with the coordination of the Municipal Civil Protection, the Secretariat of Tourism and the regional delegations of the sector.

The need to promote research with an applied orientation is based on the fact that, according to the specialised sources referred to in the reference framework and the results of this work, it is expected that hydrometeorological events will intensify in the coming years, which will increase the risk for the communities that will suffer from them if no provision is made.