The cutaneous leishmaniasis vulnerability index (CLVI)

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A B S T R A C T

South east of Morocco is one of the biggest cutaneous leishmaniasis disease foci. Despite its non-lethality, this disease causes several socioeconomic and psychological impacts. This disease has lots of risk factors. Some of these are related to the environmental change, and others are linked to the demographic and socio-economical system. The interactions between these risk factors create the need for a multidisciplinary approach to estimate the vulnerability risk to the cutaneous leishmaniasis. In this context, a new index was proposed and six provinces were selected, which are Zagora, Ouarzazate, Tinghir, Errachidia, Figuig, and Tata. The findings depict that in term of anthropogenic vulnerability, Tinghir is the most vulnerable to leishmaniasis followed by Errachidia and Ouarzazate. Geographically, Errachidia has the very high vulnerability score and Figuig have the high vulnerability. The results show also an important risk to leishmaniasis in all provinces regarding the socio-economical component, except for Tata. Regarding services category, Zagora is the most vulnerable. However, for the hygiene, Figuig, Ouarzazate, and Errachidia present the high scores of vulnerability, then the rest provinces. The total score of cutaneous leishmaniasis vulnerability of the selected provinces indicates that Tinghir is the most vulnerable regarding this disease followed respectively by Errachidia, Ouarzazate, Zagora, Figuig, and Tata.

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1. Introduction

The vector-borne diseases are all diseases transmitted by vectors like insects and other vectors. According to the World Health Organization [1], more than half of the world's population is at risk of these diseases. Among these diseases, we can cite by way of example malaria, yellow fever, schistosomiasis, leishmaniasis … etc. The incidence of these diseases is frequent mainly in the poorest countries. In Morocco, the leishmaniasis constitutes the first parasitic disease followed by the Malaria and Bilharziasis. In fact, the leishmaniasis represents 84% of the recorded cases at the national scale [2].Talking about leishmaniasis in Morocco, there are three species of *Leishmania*, *L. major* (ZCL), *L. tropica* (CL) and *L. infantum* (ZVL, CL). In pre-Sahara, ZCL has been identified for the first time in 1914 [3], and the main vector, *Phlebotomus papatasi* in 1916 [4]. In this paper, special attention was given to the first type of leishmaniasis, the *L. major* (ZCL). The causative agent or vector is the *Phlebotomus papatasi* and the reservoirs are *Meriones shawi*, and *Psammomys obesus* [5]. The leishmaniasis is confined to Moroccan Sahara and pre-Saharan region because this region creates favorable conditions for the sand fly vectors. These poorest provinces are the most affected by this disease.

The Sahara and pre-Saharan region is characterized mainly by an arid climate and the vegetation is concentrated mainly in oases system [6–9].

Obviously, there are several variables that promote the expansion of cutaneous leishmaniasis, hence the need for an integrated approach. This can take into account the most important variables that are helpful in predicting the expansion. In this paper, a multidisciplinary approach to measure the vulnerability to cutaneous leishmaniasis is needed. In this context, we propose a new index that uses 22 variables or indicators. The data of used indicators of the seven components were prepared and compiled for the six selected provinces. In order to estimate the cutaneous leishmaniasis vulnerability for these provinces, the missing data for the 22 indicators was 0%. All the used data were provided by official sources as provided in material and methods section.

The used indicators show all possible aspects of the biophysical and social system related to the cutaneous leishmaniasis disease. This paper gives a new tool to understand the expansion of this disease toward the associated risk factors. Dry land including, the oases of Morocco is the most threatened by this phenomenon. The desert biome is the suitable habitat of sand fly, the vector of leishmaniasis. Water and vegetation are concentrated in biome called oasis with its arid conditions favors the existence of both the vector and the reservoirs. We used different spatio-temporal information in the Moroccan dry land, following the availability of official data. In this area, the environment and aquatic ecosystems are at risk and vulnerable to climate change and anthropogenic factors [10]. The index integrates several aspects related to the leishmaniasis disease in this region. The purposes of this paper were to:

- give an overview of the leishmaniasis situation in Morocco and in pre-Sahara region by the illustration of the leishmaniasis

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distribution;

- to validate the applicability of the proposed index regarding the cutaneous leishmaniasis transmission;
- to compare the vulnerability of cutaneous leishmaniasis for the six selected provinces.

2. Material and methods

2.1. Study area

At national scale ten provinces know the distribution of Zoonotic cutaneous leishmaniasis (ZCL), Boulemane, Errachidia, Figuig, Jrada, Midelt, Ouarzazate, Taourirte, Tata, Tinghir, and Zagora. The six most important provinces are Zagora, Ouarzazate, Tinghir, Errachidia, Figuig, and Tata were selected (representativeness). These later provinces recorded 70.4% of cases of leishmaniasis in 2009 and 87% in 2014 compared to the total cases at national scale [2]. These provinces are situated in the south east of Morocco (Fig. 1), where the climate is a semi-arid to arid. These provinces are the endemic focus of cutaneous leishmaniasis [11]. The aridity, the frequent drought, and the social vulnerability make the region vulnerable to the parasitic diseases.

Both at Moroccan and pre-Saharan scales, the leishmaniasis constitute the first parasitic disease followed by the Malaria and Bilharziasis (Fig. 2a and b).

The main characteristics of the study area regarding the leishmaniasis transmission (cutaneous and visceral) are illustrated in Fig. 2 c and d. The important number of leishmaniasis cases affects individuals with the age above 9 years followed by the age between 10 and 19 (Fig. 2c). The above 19 age group is particularly at risk for leishmaniasis,

which influences school attendance. This has repercussions on the human development and, subsequently, economic growth because the good health plays an important role in economic productivity. An increase of threat (the trends) can be seen in the period 2004–2010 and a rapid decrease from 2010 to 2014 (Fig. 2d) because of the government intervention after the epidemic year, 2010. This intervention was in form of rodent control and hygiene or waste management and through the free treatment and care of leishmaniasis cases.

The oasean ecosystems are located in the southern provinces of Morocco. These provinces constitute the Pre-Sahara region. The oasis is a wet zone in desert and plays a crucial role in supporting the population by providing the ecosystem services (water, food, and energy) that ensure the well-being. In the oasis, the main economic activity is the agriculture. The climate is arid and the rainfall is very irregular in time and space [8]. The population in the region is mostly rural and socially fragile. The Oasis system is known by a complex hydraulic system and an intense agricultural activity in the palm groves.

The environmental, especially the aquatic ecosystems change are the biggest global concerns that can impact the human health and then the well-being. This later is far from being achieved. This is more alarming in Africa where water vulnerability is a real issue. Among the most important, we can cite the leishmaniasis expansion. The sand fly is the vector that supports this disease. This insect, with a nocturnal and twilight activity, has a holometabolic cycle including the egg, four larval stages, a nymph and the imago [12]. As mentioned below, the presence and the expansion of this vector related to the presence of a reservoir. The *Leishmaniasis major* (*LM*) reservoir is *Psammomys obesus* and *Merioness hawi* [13] that exist in polluted sites.

As reported by several authors [14–16,17], the climate change impacts the repartition of the LM vectors and reservoirs. For the
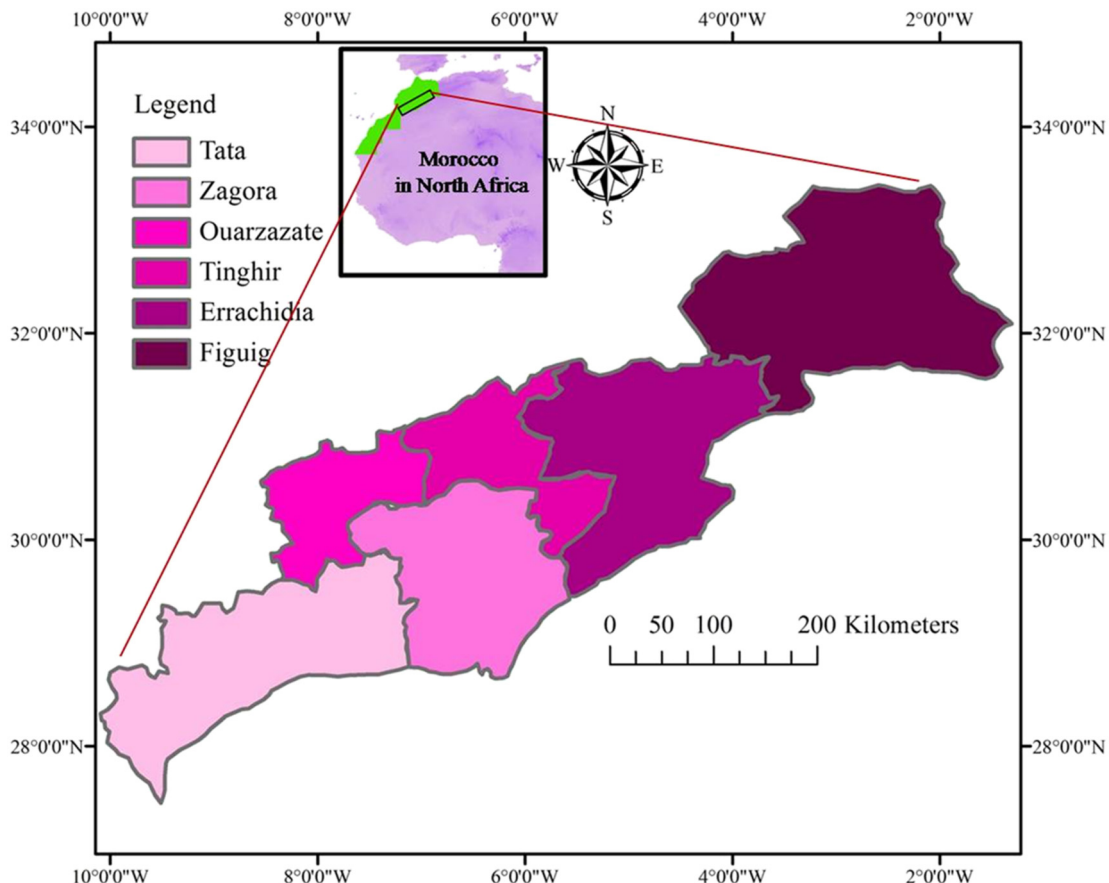

Fig. 1. Localization of the study area, including the six selected provinces, south of Morocco.