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MULTIPLE SPATIAL CHANGES IN THE ARGAN ECOSYSTEM- *(Argania spinosa (*L.*)* Skeels*)* - CASE STUDY (MOROCCO)

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Abstract

Argania spinosa L. endemic to Morocco, is a multipurpose tree with an important socio-economic and ecological interest. The study was carried out in an Argan forest Laqliaa municipality, South West Morocco, which is located in semi-arid bioclimatic region. The objective is to present a diagnosis for the state and dynamics of forest degradation through cartography, GIS and socioeconomic analyses between two periods (1986-2018). For this purpose, we analyzed and estimated all multiple change in the forest area surfaces. The method used is based on the comparison of two digital forest map files from the National Forest Inventory (1986 mission) and from the most recent aerial photography (2018).

The cartographic analysis of the spatial forest area and socio-economic dynamics revealed a regressive dynamic of change resulting from agriculture under Argan forest, urbanization, human and pastoral pressure.

The rescue and restoration of the Argan forest remains conditional on vigorous actions in time and space and especially in the duration of sustainable development.

Keywords: *Argania spinosa L.; GIS; spatial changes; degradation; urbanization; Morocco.*

1.Introduction

The geographical position of encounter between the European, Saharan and Macaronesian flora make Morocco a true floristic crossroads of a diversity and an undeniable complexity. This diversity results in a great floristic and faunal wealth of forest areas covering nearly 9 million hectares, a cover rate of 12.7% of the national territory and an average afforestation rate of 8% (IFN, 1994).

Among the noble and endemic forest species of Morocco, the Argan species (Argania spinosa L.) Skeels) is a wild tree native to southwestern Morocco.It'is an open

and multifunctional ecosystem that has assets in relation to its great biodiversity and the support it represents for the environment. Nevertheless, it is undergoing profound changes that have led to the emergence of conflicting issues and interests (Alaoui, A., Laaribya, S., & Ayan, S., 2020).

The Argan forest of Morocco (Fig. 1) occupies approximately 800,000 ha, is recognised by the United Nations Educational, Scientific and Cultural Organization (UNESCO) as a Biosphere Reserve with a rich biodiversity. The forest is also threatened by the impact of climate change upon its regeneration.

The Argan forest suffers from the lack of a forest practice appropriate to ecological and socio-economic conditions (Benchekroun F & Buttoud G., 1989). Argan tree is widely distributed from Safi in the north to Draa River in the south, and both in the Souss plain and the High and Anti-Atlas piedmont (Peltier 1982). The tree growth extends from sea level up to 1300–1500 m. Despite their biogeographical, historical, and socioeconomic value, vegetation structures are vulnerable and threatened by human activities (Msanda et al, 2021). But, it is clear that despite the effort made for its restoration, the overriding objective on which they have emphasized namely, regeneration and sustainability not only has not been achieved, but the degradation continues with an alarming pace in terms of degradation and clearing. Argan woodlands provide various economic opportunities in relationship with ecotourism and local products which can contribute to socioeconomic development of rural communities (Laaribya et al. 2017). The Argan oil is highly prized as an edible and cooking oil by the local people.

The advance of desertification into the Argan orchard areas increasingly threatens the livelihoods of local communities. Argan trees are a true bastion against desertification. At maturity, Argan trees (*Argania spinose* L.), may reach 10 meters in height and individuals may live for 200 years. By boring deep into the ground, they play a key role in halting soil erosion. The tree also has an amazing ability to adapt to severe droughts by simply going dormant until it can sense moisture once again (Laaribya et al., 2021). To decrease the pressure on the species and to satisfy the growing demand for its oil, the preservation and characterization of the high diversity of endangered populations of Argan trees and its cultivation, constitute a crucial step toward their preservation (Mouhaddab et al, 2017 Ait Aabd et al, 2019). Argan forest degradation has become a serious problem, especially in Morocco. Among other impacts, it was an urgent need to measure and analyse it, in order to design action to reverse the process (Laaribya et al, 2021). The sustainability of the Argan agro-forestry system is now threatened by overgrazing and over-exploitation leading to an alarming decline in the number of trees (Yatrib et al, 2015).

This study contributes to a better understanding of dryland Argan forest degradation as a basis for conservation policies. In order to present a diagnosis of the situation in the Argan forest, our investigations aim to:

- Present an in-depth inventory through a case study (Laqliaa municipality)
- Participatory socio-economic analysis and spatial dynamics through cartographic analysis (1986-2018)

• Propose participative solutions with a view to reversing degradation trends.

(*Argania spinosa (L.) Skeels*)

The Argan tree (*Argania spinosa*) is a member of the tropical family Sapotaceae, endemic to Morocco from the arid regions of south-western Morocco (Emberger 1925), where it has been traditionally cultivated for centuries. It's is a thorny tree from the arid and semi-arid regions of Morocco. It is mainly cultivated for its oil and it is an important fodder tree in Morocco, particularly for goats. The fruit pulp and the oil extraction by-products are also fed to livestock. The nutritional quality of the oil is due to the presence of a high percentage of unsaturated fatty acids especially oleic and linoleic acids (Yaghmur et al. 1999; Khallouki et al. 2003).

The Argan tree is a major source of forage for sheep, goats, camels and cattle in Morocco

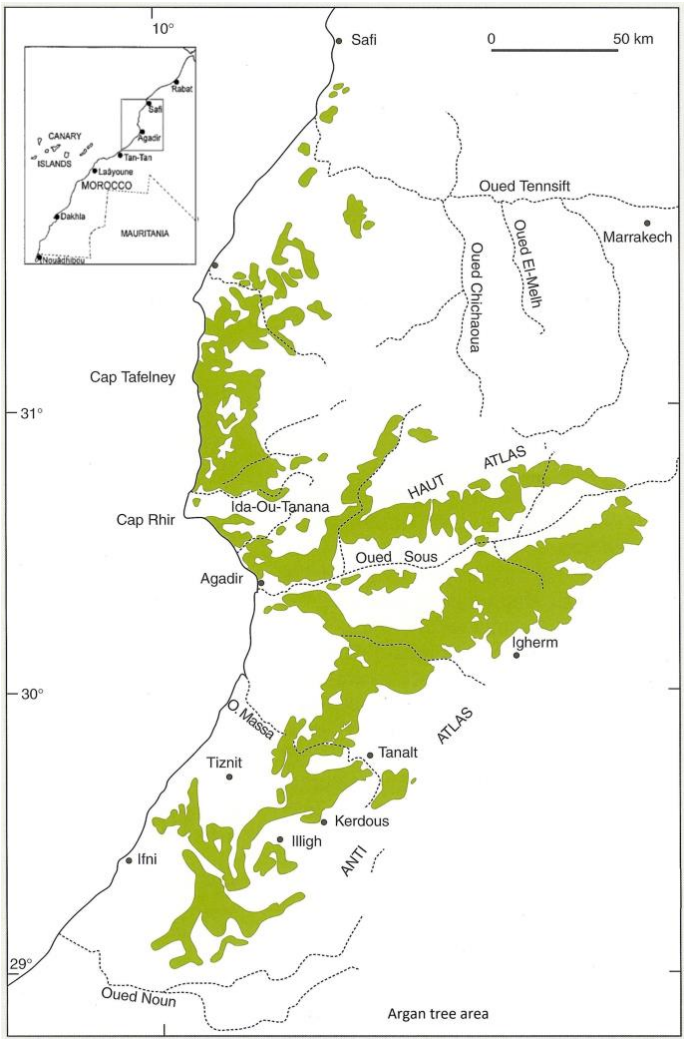

Fig. 1. Geographic location of the Argan forest in Morocco

2. Materials and methods of research The present work aims to make a diagnosis of the socioeconomic and spatial changes of the situation through a detailed analysis of the dynamics of space for the case of Laqliaa municipality (Fig.2) located in the Argan forest. To do this, we used several approaches.

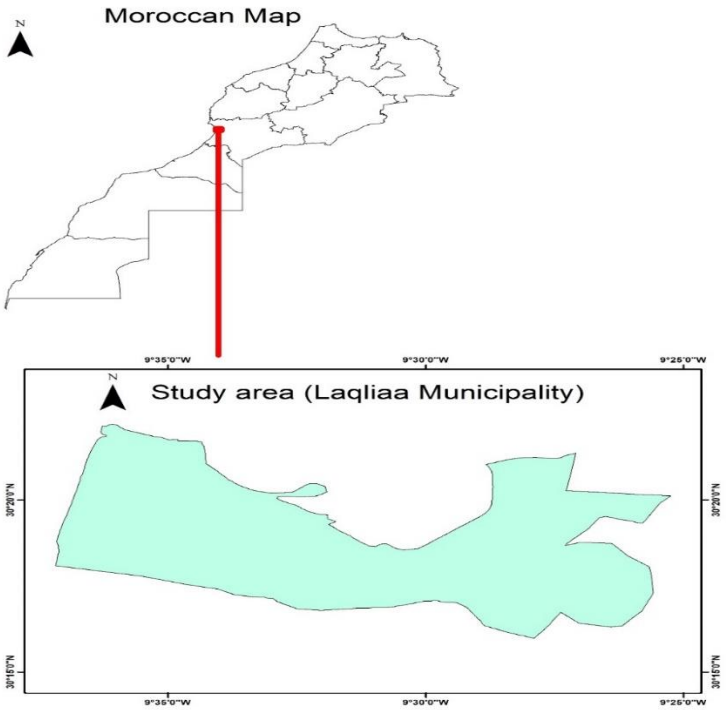

Fig. 2: Study area

Workshops and consultations with stakeholders and local population

Participatory and concerted workshops with all stakeholders took place. The main problems related to the definition and development of the concerted development plan and restoration of the Argan tree have been synthesized. Six rural locality (douars in Moroccan language) involved in the investigations in question are: Laazib, Benaanfar, Lakhmaiss, Lajnan, Jnanate, Hay Qliaa

At these workshops took part various actors related from near or far to this problematic. The recommended development principles are:

• The interest of preserving the Argan tree and promoting local development for sustainable local development;

• The development of inter-communal infrastructures;

• Special attention to gender for the promotion of ancillary activities;

• The integration of the various actions with a view to a harmonious change of the agro-silvo-pastoral area and the promotion of the production sectors;

• Measures to restore the forest environment.

We used the SWOT method, which is a tool for strategic analysis of our space. This tool has been very useful to help us define our plan and strategy for development and restoration.

The participatory diagnosis of the situation highlights the dynamics, strengths and weaknesses within the area. This analysis of the situation was realized with the implication of the various stakeholders acting on the territory of the study area.

Cartography and Development of spatial dynamic Maps

The classification of forest formations to form homogeneous strata has led directly to the mapping of stand types. It consists in interpreting the aerial photography that is to say to carry out an examination of the photographs aiming to determine the characters of the vegetal formations which it represents. The purpose of the study is to analyze and estimate forest area surfaces for a period from 1986 to 2018 from a comparison of the state of the most recent forest cover and its reference state in 1986. The method used is based on the comparison of two digital forest map files from the National Forest Inventory (IFN 1986 mission) and that compiled in this study from the most recent aerial photography. To do this, three major classes were selected for the development of the evolution map. We cite:

• Areas that have evolved positively (progressive evolution): these are non-forested lands that have evolved in the forest. This is the case of reforestation or restocking;

• Areas that have evolved negatively (regressive evolution): this is the degradation of the forest in non-forested lands. This is the case of deforestation, cutting, etc. ;

• Stable areas.

The results of the treatments made it possible to draw up matrices of confusion that is to say the tables, which show the changes in the surfaces and in the densities of the different strata of the maps resulting from the most recent aerial shots compared to the reference state (1986 mission). We proceeded to the verification of the evolution polygons (closure, codification, etc.) while paying particular attention to the analysis of the results in order to make a real interpretation of the various changes that took place in the space studied.

3. Results

3.1 Sociodemographic and urbanization dynamics

In 2008 the municipality moved to the rank of urban municipality, which triggered a dynamic urban and demographic very marked. Indeed, between the two censuses 2004 and 2014, we see that the average annual growth rate is high at the commune level (+5.54). The number of households has increased at a much higher rate

as well. According to the results of the participatory diagnosis with the actors of the municipality, this rampant trend is mainly the result of urbanization and the rural exodus towards the urban center Lqliaa Municipality. Indeed, the rate of urbanization recorded is of the order of 108% between 2004 and 2014.

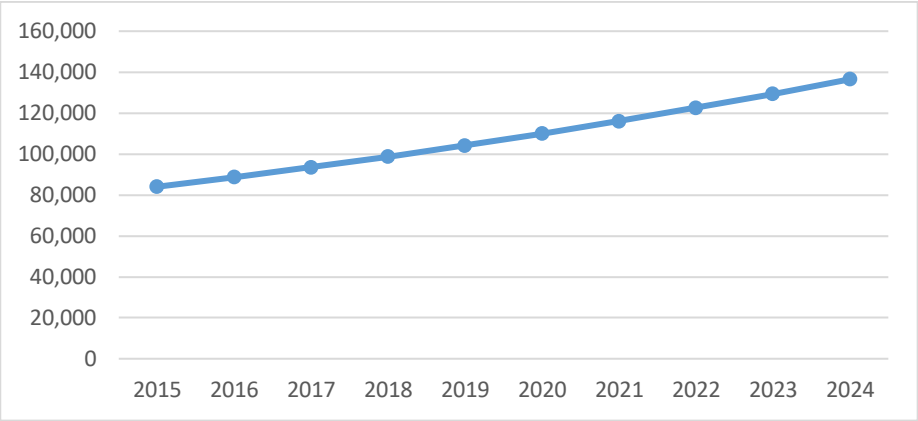

Fig 3: projection of the population of Lqliaa Municipality (2004-2014)

3.2 Dynamics of socio-economic development

According to the results of the participatory diagnosis, in addition to the urbanization of the environment by the proliferation of anarchic habitat, the poverty and the degradation of the Lqliaa Argan forest often go hand in hand in the environment, by various mechanisms of articulation and in various forms. This situation has resulted in the loss of biodiversity, land degradation, and water resources in the environment (Laaribya, S., Alaoui, A., Gmira, N, 2017).

For most users of Lqliaa, forest areas and their resources are one of the main sources of life and the exploitation of which must not be restricted. The notion of poverty in the commune is first understood as a lack of purchasing power and living conditions of local populations; but it also translates into precarious living conditions and the risk of social exclusion. This may be due to the "subjective" feeling of confiscation, dispossession and powerlessness in the face of life's demands and the search for access to health care, education and basic support infrastructure, in terms of roads, electrification, drinking water ... services that can eventually lead to the renunciation and abandonment of any form of struggle to change a situation deemed unacceptable. The evolution of the Gini index shows income inequality in the municipality of around 36%. This dispersion of income has been evoked by local populations and is reflected in an inequality between the masculine and feminine gender. In fact, poverty in the commune has a feminine face. All the time, the women who practice the exploitation of the Argan tree contribute to the income of the family household. We note the presence of a single cooperative called Lakhmaiss production of Argan oil. Indeed, Argan oil is a plant oil produced from the kernels of the Argan tree (*Argania spinosa* L.) that is endemic to Morocco. The Argan oil is used to dip

bread in at breakfast or to drizzle on couscous or pasta. It is also used for cosmetic purposes.

There has been a “market boom” in Argan oil, and its rising demand has improved household income for local communities but generated serious pressure on the natural forest, threatening its sustainability.

In our study area, the dependency ratio is 0.8, which reflects that almost two-thirds of local populations depend on the activity of other active people. Indeed, this obtained report means that each active person supports about two people. It is important to note that this report does not accurately reflect the reality, as long as even if some people are of working age, they are economically dependent. This is the case, in particular, of active unemployed, schooling of more than 15 years, women in homes, ... etc.

3.3 Spatial dynamics and degradation factors

One of the characteristics of the Argan ecosystems in the study area is their rapid evolution due to the ecological, social and economic constraints that lead to different forms of degradation following the gradual opening of the forest cover. It is in fact the social function and its socio-economic interest that make it vulnerable to human degradation.

To the degradation of the climate-related environment (droughts, erosion) are added the effects of rapid urbanization and the development of economic sectors that have great needs for natural resources. The overexploitation of these resources contributes to accentuate the dysfunction of the physiological, biological and socio-economic mechanisms specific to the Argan tree.

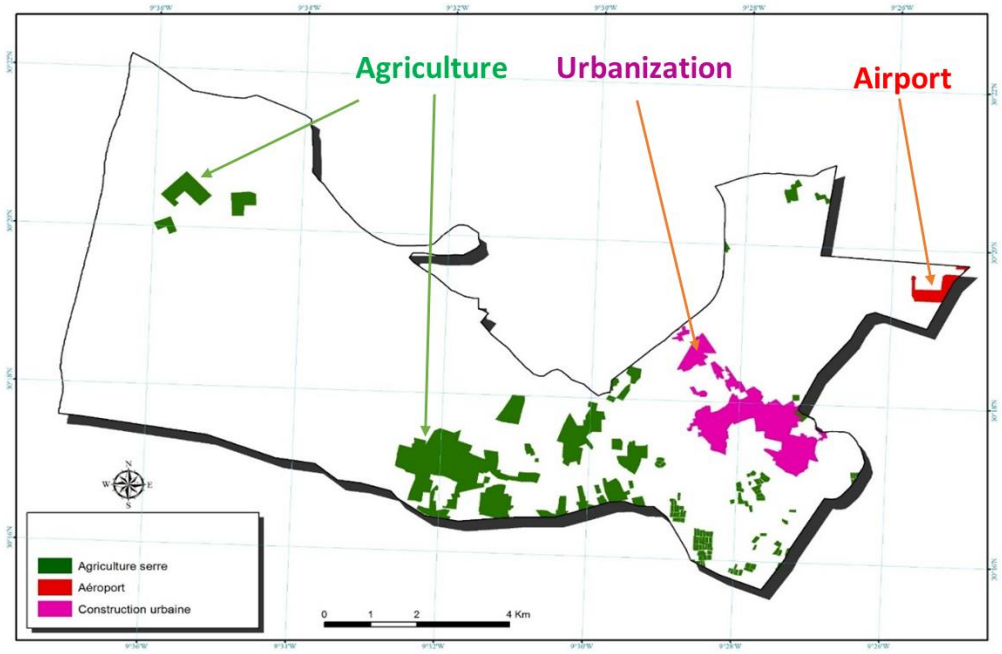

Fig 4 : Urban and agricultural areas in the Municipality of Lqliaa

The components of the Argan tree are exploited in a systemic framework giving rise to a production system dominated by livestock farming associated with agriculture mostly subsistence because of the very limited areas aggravated by the continuous fragmentation of plots (Fig 4). The overgrazing coefficient is evaluated at 40%. Goats and sheep graze in the Argan forest. The cattle benefit from these spaces during the year.

The main characteristic that emerges from the map analysis and the forest composition of the municipality of Laqliaa (Fig 5 and Table 1) is the abundance of reforestation which occupies 3.788 ha, or 70% of the forest cover and 35% of the total surface area of the municipality in question. . They are present particularly in the western half of this commune. The Argan tree totaled only 1 608 ha with 15% of the total area of the town currently and is coveted by everyone. Indeed, in the absence of sources of income, the local populations fall back on this space and this to draw the means of subsistence.

In order to be able to realize the evolution of the forest areas in our study area, we proceeded to the superposition of the recent data made in the framework of this study to those of the first edition of the National Forest Inventory maps that were carried out in 1990 (based on the photo-air missions of 1986). This allows us to compare the data of the two dates by crossing them in order to elucidate the dynamics of the spaces and the changes that affected the plant cover during this period. Evolution statistics are based on matrices of confusion resulting from spatial cross-tabulations between the cartographic themes of the two aerial photography dates (Table 1).

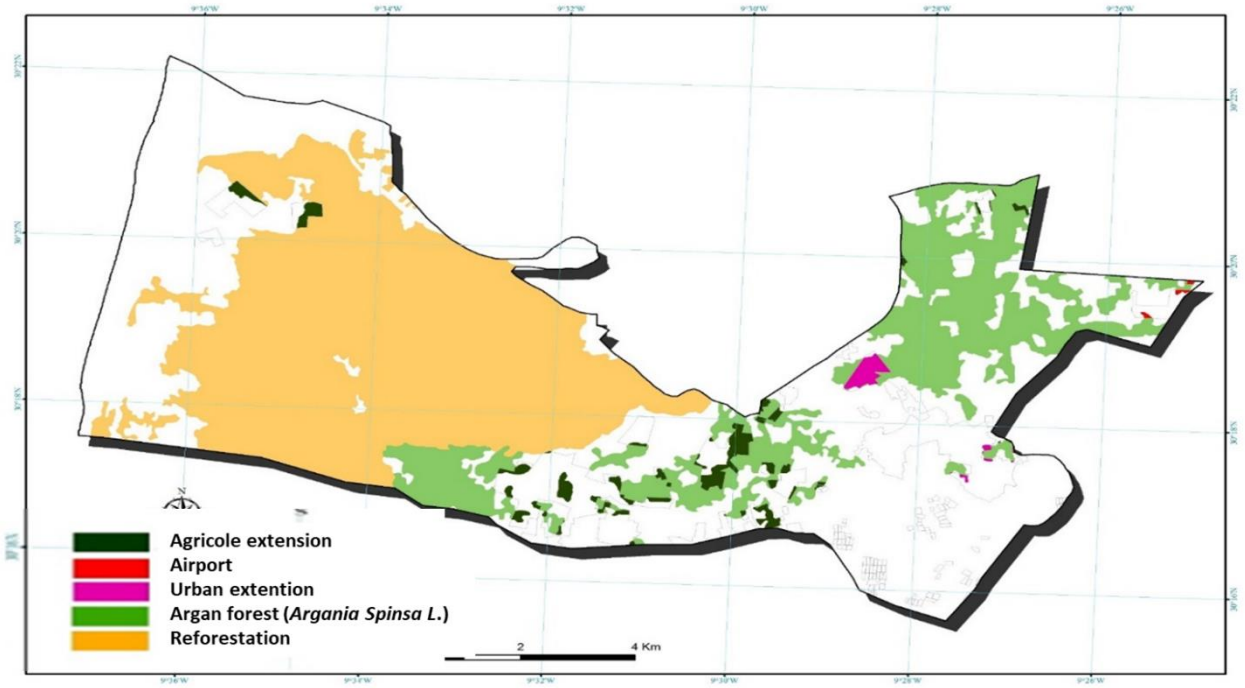

Fig 5 : Spatio temporal space dynamics

Table 1. Confusion matrix of Laqliaa municipality

	Recent occupation (Hecatre)								
Old occupation 1986 (Hecatre)		Airport	Agriculture	*Argania spinosa*	Others species	Reforestation	Empty	Urbanisation	Total
	Argania spinosa	4	143	1 608				36	1 791
	Others species				34				34
	Reforestation		25	-	-	3 788	-	-	3 813
	Vide	30	519				4 220	270	5 039
	Total	34	687	1 608	34	3 788	4 220	306	10 676

The results of the above cartographic analysis (Table 1) show that the study area has undergone a regressive dynamic in its vegetation cover and in particular the Argan tree which has experienced a negative regression evaluated at 183 ha with an average annual loss of 13 ha. year. In fact, the Argan spaces of this town have given way to 40 ha for urbanization, and 143 ha for agriculture. The commune experienced 306 ha of urbanization between 1990 and 2014. Reforestation also experienced a slight decrease, from 3,813 ha in 1990 to 3 788 ha in 2014. The analysis shows that in this area, forest areas are in decline and the state of the Argan stands is marked by hyperbole and excessive degradation. Thus, many of the towns in the Argan forest region have had their urban extension, although necessary, to be in the forest domain, given its proximity and ease of occupation. This situation has generated a large number of distractions dedicated to the urbanization of these centers which have become invasive cities:

For example, for the Admine forest, which includes the forest areas of our studied municipality, the distractions total nearly 1901 ha, intended for the urbanization of the city of Ait Melloul; and the establishment of a new airport for the Agadir city. Investment in the various activities requires land, so the forest estate in the region is highly sought after and even coveted.

- Intensive agriculture: The area has acquired a great deal of experience in intensive agricultural production and has imported new technologies to comply with and meet the requirements of importing countries. The total area under cultivation varies constantly;

- Tourism development: the area is known for its diversified tourism products, and has managed to make an image among the various players in the field.

- Urbanization: the growth rate is among the highest in Morocco. To respond to this growth, demands for occupation of forestland are increasing.

Measures of restoration and reversal of degradation trends

The fragility and sensitivity of Argan ecosystems and their current evolution require a profound thought on the vectors of change, a set of dynamic factors that can influence the problem of degradation and lead to the maintenance of the balance between conservation and development of its resources.

Development and reconstruction projects must involve the local population more in a concerted planning approach.

The Argan tree sector cannot be considered in isolation from the social reality. The majority of usufructuaries live in areas that are poor and deprived of basic social services. It is important to set up local development projects, ranging from infrastructure to income-generating actions, without forgetting the capacity building of the operators' structures, particularly the cooperatives and their unions. The involvement of the private sector in the area will further support the restoration of the Argan forest.

The regulation of the Argan forest gives wide rights of enjoyment to the inhabitants. These rights, which include, among other things, deadwood collection,

fruit picking and land use, should be reviewed so that they can be reconciled with a good agro-forestry balance.

4. Discussion of the results and conclusion

The analysis of the dynamics of Argan ecosystem reveals several indicators of degradation. In addition to the dedensification of stands and the reduction of cover, the Argan tree provides only a limited quantity of goods and services and retains only limited biological diversity. She lost structure, function, and productivity. The Argan tree develops in difficult conditions that constitute its ecological limit. The absence of natural regeneration and the presence of voids are the good indicators of this regression.

The complexity of Argan tree management, stemming from a number of factors including: expanded user rights, high levels of urbanization and resource pressure, intensive agriculture and high demand for water resources, demonstrate the importance of interactions between this ecosystem and its human environment and constitutes both challenges and assets for its preservation.

In order to no longer be content to accompany the current dynamic toward a situation of decline by limiting itself to preserving what already exists, it is considered imperative to focus the bulk of the interventions on the overhaul of the existing regulations, and renewal of forest resources. The formulation of the projects should be based on the consideration of regeneration as the main nucleus around which other accompanying actions will be carried out making it possible to facilitate the adhesion of the populations concerned.

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