



## A review analysis of the degradation of cork oak forests in North Atlantic, Morocco

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### Abstract

Like Mediterranean forests, Morocco's forest formations are highly diverse and comprise many species. Among the noble species, the cork oak (*Quercus suber* L.) is important in the Moroccan forest landscape. However, anthropogenic and natural pressures have almost completely degraded cork oak ecosystems. This study was conducted on the Maamora cork oak forest in north-west Morocco. The methodology adopted was based on a bibliographic review, GIS cartographic and teledetection analysis of the forest area, in order to assess the state of degradation of the forest areas and their evolution and to investigate the causes about anthropic pressure and the climate change factor. Progressive degradation results from a combination of climatic and anthropogenic factors that continue to intensify. The lack of natural regeneration is one of the most worrying problems, requiring advanced reforestation and sustainable development.

**Keywords:** Anthropogenic pressure, Maamora, Morocco, *Quercus suber*, Regeneration

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## 1. Introduction

Cork oak (*Quercus suber* L.) is an endemic species in the Mediterranean bioclimatic zone, especially on the Atlantic coasts of Morocco, Portugal, Spain, southwestern France, and the Bay of Biscay. Its distribution has been greatly reduced primarily due to human activities but also because of significant historical variations in climatic conditions (De Sousa et al., 2008).

In Morocco, cork oak forests extend across the North-Western part of the country, from the coastal plains to the Central Rif and the Middle Atlas region. Cork oak, which covers an area of almost 384200 ha, is a remarkable species, given its ecological and socio-economic roles. Unfortunately, the area covered by cork oak continues to decline under the influence of anthropogenic degradation, as well as damage caused by several insect pests, including Lepidoptera, and climate change. All these factors essentially threaten the world's most extensive lowland Cork oak forest (Maamora forest) with inevitable disappearance in the near future (Laaribya et al., 2021).

The study area was carried out in the Maamora cork oak forest, the largest lowland cork oak forest in the world, covering an area of 133000 ha, including 64000 ha of pure cork oak. On the one hand, it is a major recreational area for the population of the major urban agglomerations (Rabat, Salé, Khémisset, and Kénitra), and on the other, the primary source of income for a user population of around 300000 (Laaribya et al., 2014). This forest has been the subject of several development plans and research and development programs, but it does not enjoy its rightful place in the national forestry plan. Despite the efforts made by the public authorities to safeguard and conserve this forest, its degradation continues to cause concern.

## 2. Material and Methods

### 2.1. General characteristics of the study area

The roles played by this forest go beyond the tripolar framework recognized for other Moroccan forest areas. We are witnessing a significant heterogeneity in the demand for forest products, with intra- and extra-forest



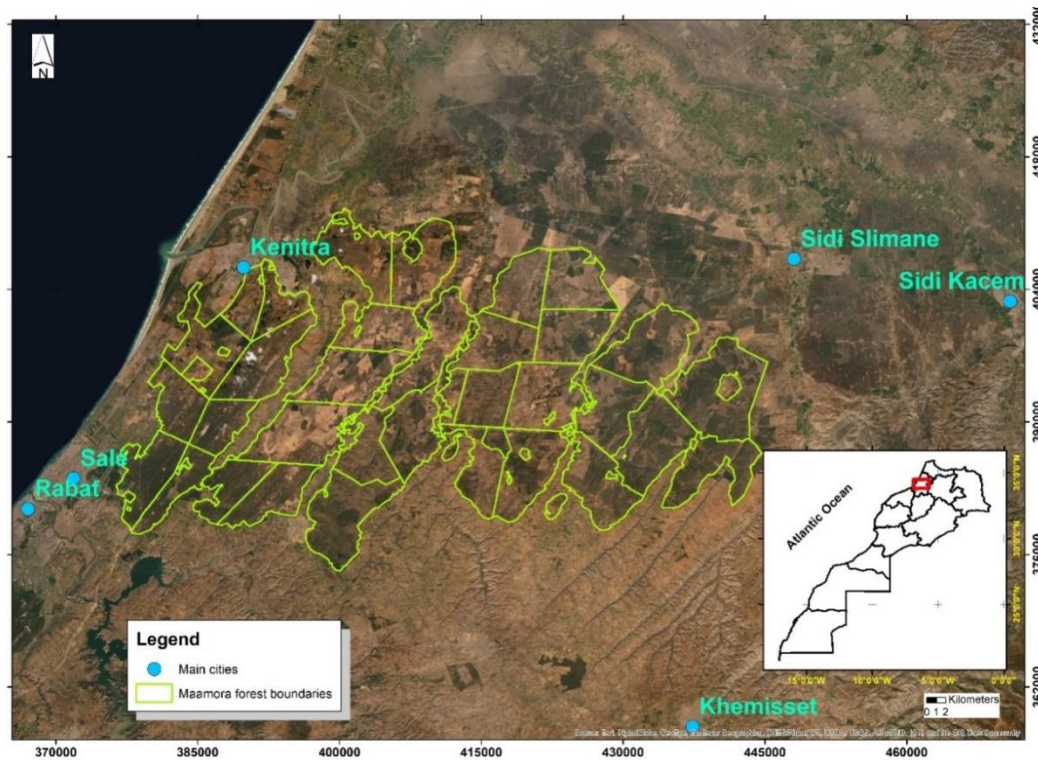


Figure 1. Cork oak forest study area

pressure suffocating this important cork oak area. Figure 1 shows the study area (Maamora forest in Morocco).

The Maamora Forest is situated in the northwest of Morocco close to the Atlantic Ocean, between  $6^{\circ}$  and  $6^{\circ}45'$  W, and  $34^{\circ}$  and  $34^{\circ}20'$  N. The forest occupies a sub-humid bioclimatic zone in its western part and a semi-arid zone in its central and eastern part (Figure 1). In terms of its social role, the Maamora forest is a source of income for the local population, which raises extensive livestock and harvests firewood, acorns and mushrooms. The forest's economic role is illustrated by the revenue it generates from selling forest products (wood and cork), estimated at several hundred million Dirhams per year, which is paid into the coffers of the user rural communities. In addition to its contribution to maintaining the region's ecological and biological balance, the Maamora represents a recreational area for an urban population of over two million. The distribution of the studied cork forests among provinces is given in Table 1.

Table 1. Distribution of the study area forests

Provinces	Number of rural communes	Forest area (ha)	%
Kénitra	5	35 704	27
Sidi Slimane	3	28 006	21
Kémisset	7	54 516	42
Salé	3	13 533	10

The local population highly values the Maamora cork oak for the diversity of its products. In addition to cork and wood, the cork oak produces non-timber forest products (NTFPs), including acorns, and has abundant foliage, much appreciated by livestock, particularly during famine (Laaribya, 2023). The shrub-based undergrowth provides a haven for wildlife. For forage production, the undergrowth of the Maamora cork oak is renowned for its wealth of pastoral plants (grasses and legumes). Fodder production is enriched by acorns, consumed by humans, livestock and game, and branches harvested directly by herders during periods of drought and dearth.

In addition, the forest area produces quality mushrooms, in particular truffles, sweet acorns for human consumption, lichens, honey, aromatic and medicinal plants (Laaribya et al., 2022), and attract many small and big game hunters.

Estimates of non-timber forest products in the Maamora forest:

- Truffles: 85 tons/year,
- Other mushrooms, lichens: 30 tons/year,
- Medicinal plants and tannin: 5000 tons/year,
- Honey: 1000 tons/year,
- Forage production: 24 million forage units/year for 250000 head of sheep and cattle (75% of the area's livestock needs),
- Cork oak acorns: 3000 tons of sweet acorns,
- Cork: 6000 tons (47% of national production),
- Acacia flowers: 400000 tons/year.

Indicators for wood-based forest products are as follows:

- Industrial wood: 300000 m<sup>3</sup> (85% of national production), mainly eucalyptus for pulp,
- Fuelwood: 600000 m<sup>3</sup>/year (87% of the area's needs),
- The jobs generated in rural areas for both non-timber and timber forest products amount to 300000 working days per year.

These products are mobilized mainly by (1) forestry companies, (2) timber harvesters, and (3) forestry cooperatives.

## 2.2. Approach and data used

The approach adopted was based on a bibliographic review, GIS cartographic and teledetection to analyse and estimate cork oak forest area for a period from 1986 to 2016 from a comparison of the state of the most recent forest cover and its reference state. The method used is based on the comparison of two digital forest map files from the National Forest Inventory and that compiled in this study from the most recent aerial photography (IFN, 2005, 2020). A detailed diagnosis was carried out with all the stakeholders concerned by the problem of degradation in the area. These stakeholders are as follows: Foresters, local populations, associations and cooperatives, NGOs, local management administrations, and scientific researchers. The results of my work in the study area were also used as a basis for the diagnosis (Laaribya, 2006; Laaribya et al., 2014; Alaoui et al., 2020; Laaribya et al., 2021; Laaribya et al., 2022).

## 3. Results and Discussion

The main factors of degradation of this forest are linked to chronic human pressure in Maamora. This pressure has resulted in deterioration and increasing degradation of the cork oak forest, including:

**- Recurrent droughts:** The droughts of recent decades have had a negative impact on Maamora's forest stands, which have become fragile. Indeed, the drought of recent years, the irregularity of rainfall, and its chronic deficit, combined with their effects and those of the nature of the Maamora's sandy soil, further aggravate the situation. Most areas with currently suitable conditions for *Quercus suber* were located in the western and central Maamora Forest regions, which enjoy a humid bioclimate and receive significant sea-spray from the Atlantic Ocean. Moving away from the ocean, the humidity decreases, and the temperature increases, so cork oak has difficulty adapting and regenerating (Laaribya et al., 2021). The maximum-entropy algorithm (MaxEnt) was applied to predict the current and potential distribution of cork oak in the Maamora Forest (Figure 2). Indeed, it was used field-based spatial records of cork oak locations, altitude, and bioclimatic environmental variables to model this potential distribution of the cork oak under climate change. Figure 2 shows the MaxEnt model's representation of suitable/unsuitable potential future areas for cork oak distribution. Green colours show areas with predicted moderate- and good- conditions.

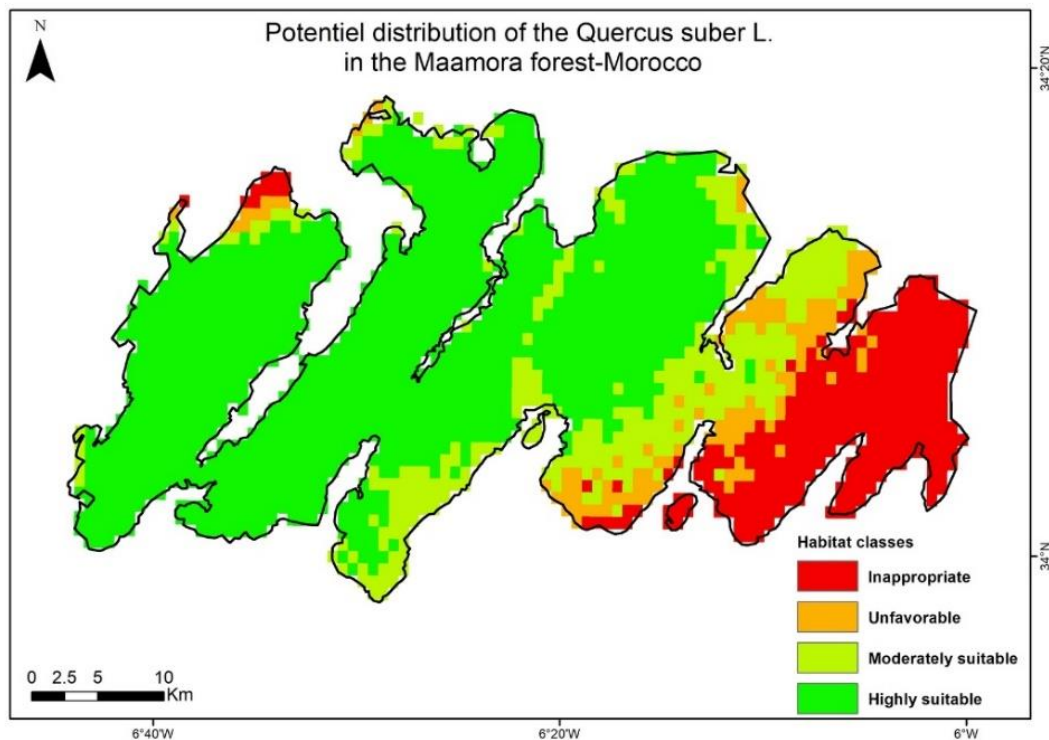


Figure 2. Potential distribution of the cork oak in the study area (Laaribya et al., 2021)



- **The regression of the cork oak area:** The history of this forest reminds us that the problem of its reconstitution and the regeneration of the cork oak is not new. It goes back to the beginning of the century. Indeed, the absence of natural regeneration led the Forestry Administration between 1920 and 1951 to undertake a vast cork oak rejuvenation program by recutting a large part of the forest. Faced with this situation, the Administration paid particular attention to this cork oak forest, implementing three management plans in 1952, 1972, and 1992. The inventory carried out in the Maamora forest showed that the area under cork oak decreased by around 35% between 1952 and 2016 (Figure 3).

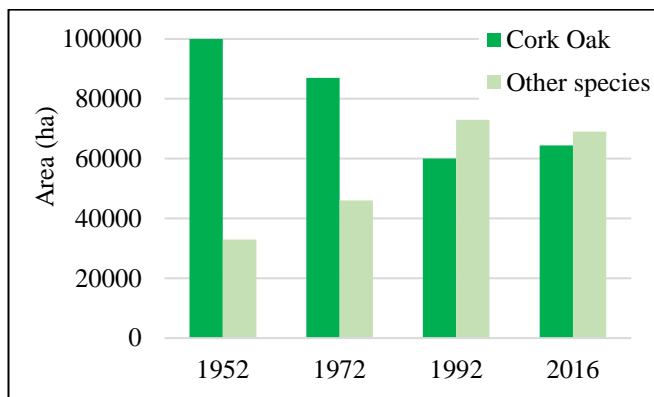


Figure 3. Evolution of cork oak forest area

- **Age class imbalance:** In addition to the damage caused by dieback, age class imbalance is very apparent, giving the cork oak forest the appearance of aged trees. Over and above the ecological and densitometric imbalance associated with this condition, the economic consequences are likely to be disastrous in the medium term. In the concise term, considerable areas of cork oak will have to be regenerated (over 2000 hectares/year) (Laaribya, 2006). Attempts have been made to regenerate the cork oak forest (Figure 4). Several studies have shown that climate change and reduced germination capacity affect the preservation and regeneration of cork oak (Laaribya 2006; Alaoui et al., 2020). The current challenge is to restore this cork oak ecosystem and confront the problems of tree mortality, lack of regeneration, and the effects of climate change (Laaribya et al., 2014; Oubrahim et al., 2015; Alaoui et al., 2020).

- **Demographic growth:** which has increased the number of users and thus the pressure on the forest. In fact, since 1971, the number of local residents has risen from 212000 to over 470000. This is one of the reasons for the explosion in forest harvesting. In addition, population growth, the accelerated settlement of populations in the enclaves and on the edge of the forest, and the transformation of the modes of exploitation of the spaces of pastoral societies to sedentary human groups have accelerated the phenomenon of degradation through clearing of land, fire, grazing and cutting of trees.



Figure 4. Cork oak regeneration patch (by Laaribya, April 2021)

- **Deliberate harvesting of forest products:** This is almost universal and is practiced by most households. All of the population's needs for forest products are met from this forest, which is a significant drain on existing capital. Other illegal harvests are intended for sale to meet the needs of local households.

- **Acorn harvesting:** Most households harvest acorns for livestock feed or for sale for human consumption, as the Maamora acorns are of the sweet "balata" variety (Figure 5). This harvest, which is close to the forest's total production, is often sold along main roads, towns, and souks. Local residents and their livestock consume the rest. The early harvesting of acorns causes injuries and promotes decay.



Figure 5. Acorns (sweet fruit) of cork oak (by Laaribya, October 2021)

- **Overgrazing:** The livestock grazing in the forest, made up of sheep (200000 head) and cattle (50000 head), stays in the forest all year round (Table 2). The pastoral load likely to be borne by the forest is excessive. The presence of these livestock, often in association with non-users, prevents any possibility of natural regeneration by compacting the soil, consuming acorns, and browsing the few seedlings that have managed to germinate. The overgrazing coefficient for the cork oak species was

calculated at 78% in the Maamora forest (Laaribya et al., 2014). There is a worrying disproportion between the

pastoral possibilities under cork oak forest and the actual load to which it is subjected.

Table 2. Herd forage calendar in the Maamora forest

Livestock	September	October	November	December	January	February	March	April	May	June	July	August
Cattle	FP	F	FP	FS	FS	FSP	FP	F	F	FSt	StP	PS
Sheep	F	F	F	FS	FS	FP	FP	FP	F	FSt	FSt	FSt
Goats	St	F	FP	FP	FP	FP	FP	P	FStP	St	St	St

F: Forest, P: Pasture, S: Supplementation, St: Stubble

- **Deadheading and delimbing:** The practice of deadheading and delimbing to feed livestock during periods of hunger and famine affects more than 1/3 of the trees. In times of drought, this practice is widespread throughout the forest. These anarchic practices cause injury, physiological stress, and predispose stands to parasitic attack, leading inevitably to dieback and death (Figure 6).



Figure 6. Collecting wood in cork oak forest (by Laaribya, March 2021)

- **Cork harvesting:** The harvesting of cork by unskilled workers leads to injuries that weaken the trees and cause them to wither.

- **Public infrastructures and urbanization:** Due to its proximity to major urban areas, the Maamora forest is considered a land reserve, quickly mobilized to meet the expansion needs of these towns and villages. For example, the Rabat-Tangier freeway cut through much of the forest.

- **Lack of supervision of users:** Cattle grazing in the Maamora is carried out without any load limitation. Safeguarding this subalpine forest requires the management and organization of users, as stipulated by law.

#### 4. Conclusion

Let's look at the history of this forest. We can see that the problem of degradation of the cork oak goes back a long way, particularly in terms of regeneration, reconstitution. Over the decades, the forest has undergone a regressive

evolution due to constraints that have constantly evolved in line with the socio-economic development of neighbouring regions and the evolution of local practices in the forest area.

Although the cork oak species is a source of income for rural people and an essential role in ecological processes, there is population fragmentation and a reduction in its natural distribution areas due to long-term overgrazing and utilization, fire, low germination-regeneration problems, and climate change.

The development of the cork oak forests in the North Atlantic cannot be considered in isolation from its socio-economic environment, which is a fundamental support for local development and biodiversity in the region. Moreover, man is a crucial factor in any development program.

#### Acknowledgement

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#### Conflict of interest

The author declares that there is no conflict of interest.

#### Ethical Approval

For this type of study, formal consent is not required.

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