



Review article

# Conservation, valuation and sustainable development issues of the Argan Tree Biosphere Reserve in Morocco

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## ABSTRACT

The argan tree is a multi-purpose tree (fruit tree, medicinal, cosmetic, and pastoral plant) found in the semi-arid and arid regions of North Africa. It is under strong human pressure such as the impact of population growth, crop expansion, overgrazing, and wood and fruit exploitation that are also the main causes of desertification in the rest of the world. Over the years, interest in this beneficial tree and demand for its products have increased: especially with the increase in the price of argan oil, which is now one of the most expensive and much in demand oils in the world. This increase has led to many socio-political, economic and cultural changes at the national, regional and local levels, especially in farming behaviour and the habits of the local population. This bibliographic research was therefore conducted in order to analyse the various changes and their consequences on the planning, conservation, and management methods implemented in the argan tree area and their effects on the habits of the local population in order to ensure the sustainability of the Argan Tree Biosphere Reserve in Morocco. Indeed, the aims of this study were, firstly, to analyse the change dynamic of argan forest area in the ABR; and secondly, to investigate the impact of various socio-political, economic and cultural changes resulting from increased prices of argan oil on planning, conservation, and management methods of argan tree ecosystem and on the habits of the local population.

KEY WORDS: argan tree, human pressure, mutation, Argan Tree biosphere reserve, sustainable development

ARTICLE HISTORY: received 4 December 2019; received in revised form 15 January 2020; accepted 23 February 2020

## 1. Introduction

The members of the family Sapotaceae are known for their preference for warm climates that characterize tropical regions (EMBERGER, 1925). However, some species in this taxon are exceptions and this is the case with the argan tree (*Argania spinosa* (L.) Skeels), which is found naturally in the Mediterranean region of Africa, especially in the region of Tindouf in Algeria (BOUDY, 1950; KAABÈCHE ET AL., 2010) or in the south-western region of Morocco (EMBERGER, 1925). It is an endemic species of this northern region of Africa (RADI, 2003). This endemism gives it unique ecological specificity

to the argan tree ecosystem because of its great floristic richness (PELTIER, 1982; BENABID, 2000; ZIRI & GMIRA, 2013; FAOUZI ET AL., 2015). In addition, the argan tree has a very important socio-economic value (M'HIRIT ET AL., 1998), especially in Morocco where the Argan Tree Biosphere Reserve (ABR) has more than two million inhabitants, 60% of whom live in rural areas, according to the 2014 census (HCP, 2014). Thus, these people benefit (directly or indirectly) from argan trees which grow there and whose products are used in many fields, such as medicine, food and cosmetics (M'HIRIT ET AL., 1998; CHARROUF, 1998; TARRIER & BENZYANE, 2003; MOUKAL, 2004). In addition, nine tenths of

the 3.55 billion US dollars that are generated from economic activities in the south-western regions of Morocco (Marrakech-Safi and Souss-Massa), where the ABR is located, are directly or indirectly related to argan trees (EL FASSKAOU, 2009).

All parts of the tree are utilised by humans. First, the argan tree influences the soil (KIRCHHOFF ET AL., 2019), its well-developed deep roots protect the soil against erosion, especially in the borders of rivers (watercourses) where they stabilize the banks and regulate the water flow. Its wood is hard, heavy, without sapwood and thus provides excellent charcoal (BOUDY, 1950; ERRAFIA, 1975). In addition, its leaves, fruit pulp and oilcake (residue of oil extraction) are very appealing and provide excellent forage for livestock (ELBAZ, 2016). The total average pastoral production of the argan forest is estimated at 200 Forage Units (per kg as feed) per ha (hectare) per year and contributes up to 40% of the needs of local livestock (FAOUZI & MARTIN, 2014). The dried argan pulp alone has a fodder value estimated at between 70 and 100 per kg as feed (SANDRET, 1957). Finally, the almonds of the argan seeds are used to extract oil whose average yield is estimated at 3 litres per 100 kg of dried fruit (BENCHEKROUNN & BUTTOUD, 1989). This oil is used in cosmetics and has many therapeutic values (CHARROUF, 1998; MOUKAL, 2004).

Because of these multiple uses, argan products are in great demand. This causes strong pressure on the argan tree ecosystem, which is deteriorating due to pressure from human activities such as crop expansion, excessive logging and overgrazing (ACHOUR ET AL., 2011). These pressures lead to desertification, which is the main environmental problem in the argan tree area (MSANDA ET AL., 2005; ACHOUR ET AL., 2011). In addition, the increase in the price of argan products (fruits, almonds, argan oil) on the national and international markets has led to socio-political, economic and cultural changes at the local and national levels resulting in changes in the habits and cultures of the local population (AZIZ ET AL., 2011; YANN & LAMBIN, 2011). The issues are no longer the same so it is important to analyse the different changes that the argan tree area has undergone over the years and it is in this context that this study was carried out by undertaking bibliographic research which brought together the work carried out on argan tree management and its conservation as well as field surveys to see *in situ* the different changes noticed by the authors.

The aims of this study were, firstly, to analyse the change dynamic of argan forest area in the ABR; and secondly, to investigate the impact of various socio-political, economic and cultural changes

resulting from increased prices of argan oil on planning, conservation, and management methods of argan tree ecosystem and on the habits of the local population.

## 2. Vegetation cover change and human pressure in the argan tree area

The argan tree was cut for firewood (charcoal) over thousands of hectares in the early twentieth century, (DE PONTEVES ET AL., 1990). However, in 1925 the argan forest obtained the status of a private domain of the State where only the local population has the right of enjoyment. In 1998 UNESCO declared the argan tree area, the first Biosphere Reserve in Morocco which extended over approximately 2.5 million hectares and covered the district of Agadir Ida Outanane, Inzeguane Ait Melloul, Chtouka Ait Baha, Taroudant, Tiznit, and Essaouira. At that time the wooded area of the ABR was estimated at 1,175,000 ha, with argan forest occupying 821,800 ha (70%); Thuja forest 262,000 ha (22%) and juniper forest covered the rest (M'HIRIT ET AL., 1998). According to the High Commission for Water and Forests and the fight against desertification (HCEFLCD, 2013), the argan tree area currently covers 3 437 004 ha in the districts of: Tiznit, Chtouka-Ait Baha, Inezegane-Ait Melloul, Agadir-Ida or Tanana, Essaouira, South Taroudant, Chchaoua, and Marrakesh (Fig. 1).

In Morocco, there is a general agreement that the argan forest covers approximately 800,000 ha (MSANDA ET AL., 2005). This area extends from the region of Safi in the north to the Sahara around the River Noun in the district of Guelmin in the south and from the Atlantic coast in the west to the Sirroua Massif in Taroudant in the east (NOUAIM, 2005). According to the National Forest Inventory in 1994, the argan forest covered 868 034 ha and according to JOURRANE (2015), the argan forest covers 999 079 ha. In general, the area of the argan forest varies from one study to another but remains between 800,000 and 1,000,000 ha. There are two categories of argan tree area, these are:

1) The plain argan tree area is found mainly in the Souss Valley and is either mixed with cropland, or along the coastline where the argan tree forms plant associations with *Euphorbia* species (*Euphorbia echinus*, *E. regis-jubae*, *E. beaumeriana*), *Senecio anteuphorbium* and members of the *Chenopodiaceae* (TARRIER & BENZYANE, 2003, 2007).

2) The mountain argan tree area consists of more varied plant associations, in the warm and temperate semi-arid bio-climate, along the slopes of the High Atlas and the mountains of the Anti-Atlas in Tafraoute (Ait-Baha) (TARRIER & BENZYANE, 2003; 2007).

For several decades, the argan tree of Morocco has been under great pressure due to population growth, expansion of crop production, excessive logging and overgrazing (ACHOUR ET AL., 2011). Coupled with the arid semi-arid bio-climate in the Moroccan south-west, this human pressure is often the cause of desertification, which leads to degradation and a dramatic and irreversible regression of the argan forest (MSANDA ET AL., 2005). Indeed, the argan tree's natural regeneration is already non-existent across almost all the argan tree area (BELLEFONTAINE, 2010) caused by excessive grazing throughout the year (M'HIRIT ET AL., 1998; NOUAIM, 2005; YANN & LAMBIN, 2011). In fact, the productive capacity of the argan forest has been largely exceeded. The actual needs of the livestock are estimated at 450 million fodder units while the pastoral production of the argan forest is only 166 million fodder units (NAGGAR & M'HIRIT, 2006) thus it would take three ABRs to support the current amount of livestock. In addition, the aridity of the climate exacerbates the pastoral pressure on existing natural resources that are dwindling (M'HIRIT ET AL., 1998; NOUAIM, 2005; STOUR & AGOUMI, 2008). Unfortunately, the situation will not improve because of intensification of the aridity (IPCC, 2018).

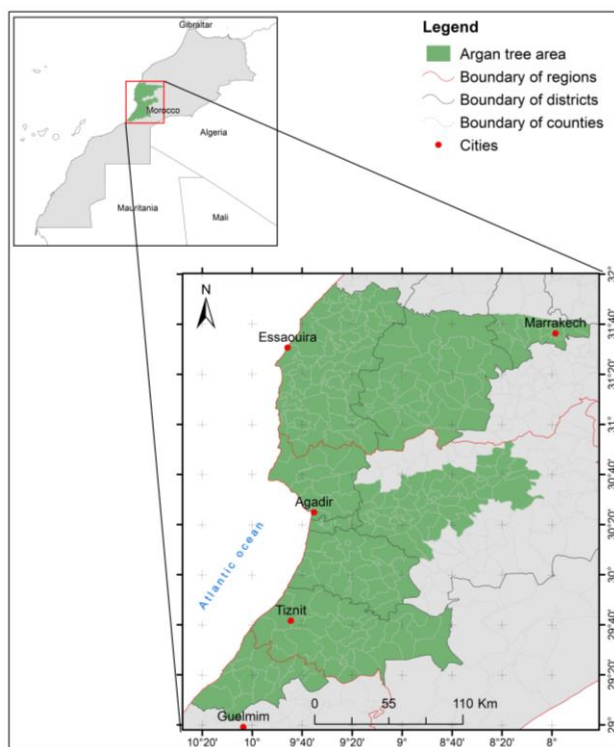


Fig. 1. The geographical and administrative situation of the argan tree area

In addition, it has been shown that argan fruit production varies from 20 to 100 kg per tree depending on age and density, with an average

of 40 kg per tree per year (FAOUZI & MARTIN, 2014). As natural regeneration is almost non-existent (BELLEFONTAINE, 2010) most of the argan tree stands are old. Thus, fruit production per hectare has decreased from 150 kg to 30 kg of almonds (BOUZEMOURI, 2007). In addition, the argan forest has lost a lot of its area per year (BOUZEMOURI, 2007). Indeed, a more recent study noted the decrease in argan forest, indicating that it lost 5% of its area between 1987 and 2014, or 1,911 ha per year (JOURRANE, 2015). Therefore, the situation seems to be getting worse. 87% of the lost area of the argan forest has been transformed into croplands under argan trees or rangelands and 11% has been converted to agricultural land (JOURRANE, 2015; JOURRANE ET AL., 2015).

However, the extent of the degradation is not identical throughout the argan tree area. Under strong agro-pastoral pressures and because of agriculture intensification, the plain argan forest is strongly degraded (FAOUZI ET AL., 2015; VAN DEN EYNDE, 2006). In the district of Taroudant, for example, the argan forest decreased by 44.5% between 1970 and 2007 (YANN & LAMBIN, 2011). This decline was 9% and 5% respectively in favour of agricultural lands and urban areas. The rest of the lost from argan forest (about 86%) has been converted to cropland under argan trees. In addition, there is a decrease in the density of argan trees in the plain of Souss to facilitate cultivation under the argan trees (ZUGMEYER, 2006). In the other area, the mountain argan trees have a denser tree cover and undergrowth, which can increase depending on their remoteness from human activities and the ruggedness of the terrain (SINSIN, 2016). Pastoral pressure is the main cause of degradation of the mountain argan forest (TARRIER & DELACRE, 2007). However, fruiting is more abundant in the plains (especially in the private plots) than in the state forest area in the mountains (DEMOULIN, 2008).

Nevertheless, thanks to the joint efforts of the National Agency for the Development of Oasis Areas and the Argan (ANDZOA), the High Commission for Water and Forests and Combating Desertification (HCEFLCD) and the National Federation of the Arganeraie Users' Rights (FNADUA), the restoration of argan forest has increased. Therefore, the restored lands have increased from 13 027 ha in 2012 to 101 487 ha in 2017. In addition, between 2000 and 2007, 1,294 ha of argan forest were reforested as part of the "Argan tree project" and more than 200 000 ha were restored through the "Green Morocco Plan" (JADAOU, 2012).

However, according to MOUKRIM ET AL. (2019), 32% of the current area suitable for the argan

tree, will be no more by 2050. Fortunately, studies have shown that reforestation with argan trees is possible in northern Morocco (AFILAL ET AL., 2015). This could be a way to preserve the species and contribute to the sustainable development of other regions of Morocco.

### 3. Increase in demand for argan oil and its impact

Argan oil has many culinary, cosmetic and medicinal values which have been especially highlighted since the 1990s (CHARROUF, 1998; M'HIRIT ET AL., 1998; MOUKAL, 2004; FAOUZI & MARTIN, 2014). This recognition has led to an increase in its demand and considerable rise in commercial value. According to the Ministry of Agriculture and Maritime Fisheries, exports of argan oil increased from 36 tons in 2002 to 343 tons in 2009-2010 and then to 1,387 tons in 2016 and the export of this oil to Europe generated nearly 298 million dirham in 2016 compared with 935,000 dirhams in 2002. These data are those reported by the Autonomous Export Control and Coordination Establishment (EACCE). The total annual production of argan oil turns out to be much higher. It can vary between 2,500 and 4,000 tonnes (NOUAIM, 2005) and could generate, on average, 18 million euros per year (EL FASSKAOUI, 2009). The price of fruits and argan almonds almost doubled between 1998 and 2007 (FAOUZI & MARTIN, 2014). Indeed, the price went from about 0.7 dirhams per kg in 2000 (GUYON, 2008) to 2 dirhams per kg in 2010 considering that it takes an average of between 25 and 35 kg of fruit to produce 1 litre of oil (CHAKIB, 2013).

In the face of soaring prices, fraud and fake products flooded the market. Thus in 2008, the Moroccan Association of Geographical Indications for Argan Oil (AMIGHA) was created. It aims to promote and protect the knowledge and interests of producers through the implementation of the Protected Geographical Indication (PGI). The role of the PGI is to identify and certify the origin of the product. It also facilitates the reduction of the anarchic exploitation of the argan tree area by attributing the PGI to some farmers who respect the sustainable management methods (ROMAGNY & BOUJROUF, 2010).

The increase in the value of the oil has also resulted in a rapid increase in the number of cooperatives producing argan oil. Indeed, according to the Office for Development Cooperation (ODECO), the number of cooperatives increased from 2 in 1998 (JADAOU, 2012) to 156 in 2013 (CHAKIB, 2013).

### 4. Change in the habits of the population and in their management methods

The argan tree area is characterized by pastoral agriculture and tree cultivation by ancestral practices (MARIA, 2010). Even today, these ancestral practices persist according to a socio-spatial structure inherited from their tribal past as defined by some authors (GELLNER, 1969; BEN SALEM, 1982). This tribal organization defines the current conformations (spatial structures of the exploitation) in the argan tree area. These conformations include complex agroforestry systems such as fruit tree farming (especially olive and almond trees with some argan trees); private argan orchards (commonly called Melk); crops under argan forest (or cultivated Agdals); argan forest closed to grazing animals (or uncultivated Agdals) and the argan national forest with collective use (BOURBOUZE & EL AÏCH, 2005; MOCTAR, 2009). In the argan national forest, we can see the Mouchaa, which is never closed to (far from) grazing animals contrary to the Agdals. The Mouchaa include all mixed species argan forests or those without Thuja (*Tetraclinis articulata*) far from rural towns or on rugged terrain (BOURBOUZE & EL AÏCH, 2005). On the other hand, the Agdal refers to a management method involving temporarily (or periodically) closing an area in the argan forest to protect and restore the ecosystem (FAOUZI, 2011).

In general, the right of enjoyment is granted to the local population in the argan forest. Given that free access and high demand increase the pressure on ecosystems this leads to over-exploitation of argan trees and leads to degradation of the natural ecosystem (FEENY ET AL., 1990). Yet, in the case of the argan forest, with the advent of the participatory approach, the forest resources were, somehow, managed sustainably (BEURET, 2006; MARIA, 2010). However, with the rise of the "argan business sector", the village associations (for local development) are replacing the traditional, participatory and autonomous institutions, which previously brought together the inhabitants of the same village for conflict and resource management (THIEBA, 1992). According to THIEBA (1992), these associations are oriented mainly towards the setting up of lucrative activities which promote the economic aspect rather than the social character contrary to the traditional institutions. This new dynamic has made participatory approaches dreamlike (BLANC-PAMARD & FAUROS, 2004), even though the various local, regional and international community projects promote sustainable development (MARIA, 2010).



To mitigate this, development projects have integrated a component concerning the valuation of local and traditional knowledge (MARIA, 2010) into their objectives.

In addition, in order to improve farming methods and to increase income, there has been a shift from a totally traditional and artisanal farm to the semi-mechanized production of argan oil, which is more profitable and better adapted to international standards and requirements (CHAKIB, 2013). Even crushing, which was, until a few years ago, totally manual in most argan-oil production systems, is mechanized to increase the profit margin by certain economic businesses (under the guise of their PGI certification) to the detriment of the local workforce, which is unemployed (CHAKIB, 2013).

On the other hand, those involved in the sector have become more numerous because of the soaring prices of argan oil. Since the creation of the ABR in 1998, the integration of these different businesses has been achieved according to a heritage approach which is defined as a form of management of natural resources based on "a state of mind allowing the greatest number of holders of a heritage to have at heart the long-term concern, to become aware of the multiple interdependencies between the actors, and to meet to decide together measures that will, at a fair cost, maintain or increase this heritage while maximizing the benefit" (REVÉRET & WEBSTER, 2002). This heritage management gives rise to the dynamics of conservation, protection and enhancement and is inseparable from traditional practices and tribal organization that has conditioned the management methods in the argan tree area (MARIA, 2010).

In addition, a growing proportion of the population seems to prefer sheep to goat farming (which is better suited to intensive or semi-intensive farming) (EL WAHIDI ET AL., 2014). These changes in the structure and type of livestock breeding increase the pressure on rangelands in argan forests and on the Agdals (EL WAHIDI ET AL., 2014). In the long term, this situation could on the one hand, increase the pressure on the plain argan tree area whose sustainability is already strongly threatened and, on the other hand, reduce the degradation of the mountain argan forest. However, up to now, goat farming remains dominant and concerns 65% of the 1.5 million head of livestock recorded in the argan tree area (FAOUZI & MARTIN, 2014).

It is clear that logging intensity of the argan trees has decreased in the last decade (AZIZ ET AL., 2011). This is due to the increased use of gas,

the availability of wood and charcoal from other species (such as those of the Thuja and Juniperus genera), the preference for modern building materials and the profits from the argan oil market (YANN & LAMBIN, 2011). This desire to make more profit is pushing more and more people to abandon their profession as farmers or breeders to engage in the sale of argan oil on the local market (Souk) thus becoming traders (SIMENEL ET AL., 2009).

In general, argan tree management needs an agricultural, forestry, and pastoral model based on fodder, wood, fruit, and crop production (TARRIER & BENZYANE, 2003). Despite the various socio-political and economic changes in the region in recent decades, argan tree management has remained traditional (SIMENEL ET AL., 2009; MARIA, 2010). This can be explained by the fact that programs funded by the National Initiative for Human Development (INDH) strengthen state stability and control, by providing modest support to rural women so as not to erode the foundation of traditional rural society (PERRY ET AL., 2019). However, techniques for the exploitation of argan oil production have evolved to be more mechanized (CHAKIB, 2013). In addition, knowledge concerning the argan tree exploitation and conservation methods have been considerably improved (AZIZ ET AL., 2011).

## 5. Discussion

A multipurpose tree like the argan tree (EMBERGER, 1925; M'HIRIT ET AL., 1998), plays a very important socio-economic and cultural role in its region (EL FASSKAOUI, 2009) and contributes to the lives of many people (more than two million) (TARRIER & BENZYANE, 2003). Despite this importance, the degradation of argan forest continues mainly because of human pressure (M'HIRIT ET AL., 1998 ; TARRIER & BENZYANE, 2003; NOUAIM, 2005; NAGGAR & M'HIRIT, 2006; BELLE-FONTAINE, 2010; ACHOUR ET AL., 2011).

During the second half of the twentieth century, it was scientifically proven that argan oil has many culinary, cosmetic and medicinal virtues (FAOUZI & MARTIN, 2014). It was also noted, during the same period, that the natural regeneration of the argan tree was non-existent in almost all of the argan tree endemic area (BELLEFONTAINE, 2010). According to many authors, the increase in the value of argan products (fruits, almonds, oil) on the market is one of the causes of argan forest degradation (SIMENEL ET AL., 2009; LYBBERT ET AL., 2011). Indeed, LYBBERT ET AL. (2010; 2011) tried to highlight this causal link by outlining the fact that harvesting techniques have become more aggressive and that

fruit collection has intensified. Nevertheless, they have recognized that the increase in the price of argan oil has improved the living conditions of the local population whose income has increased significantly (LYBBERT ET AL., 2010). It is in this context that CHARROUF (2007) said that the argan tree is a "human development lever". However, AZIZ ET AL. (2011) indicate that the increase in the price of argan oil on the market has had a negative impact on farmer behaviour and subsequently on local biodiversity. Nevertheless, they qualify this by highlighting the improved practices and knowledge of the local population who have begun to protect the germinating argan seedlings against their livestock (AZIZ ET AL., 2011; ELKANDOUSSI & OMARI, 2011).

According to JADAOU (2012), the increase in the price of argan oil is not a direct cause of the argan forest degradation but rather a consequence of the fact that the intermediary players in the "argan sector" monopolize a significant proportion of the revenue, control the prices and dominate the market through some companies and investors. Thus, although the price of argan oil has increased, the benefits to the local population have remained unsatisfactory (MARIA, 2010; FAOUZI & MARTIN, 2014). This reduces the enthusiasm of the local population for the policies for the protection and preservation of argan trees.

Some authors, including MARIA (2010), are concerned that the local knowledge is not sufficiently taken into consideration, even though some efforts have been made in this direction, and even worse, the local population has been dispossessed of its product (argan) and ousted from the decision-making process. The heritage of the argan tree must integrate local knowledge for the sustainable management of forest resources (MARIA, 2010). For the participatory approach, to be effective, it must integrate all the stakeholders (PINTON & GREINAND, 2007). According to JADAOU (2012), the sustainable development of the argan forest can only be achieved by promoting local knowledge and labelling its main derived product (argan oil), in order to be recognized as a PGI product. Unfortunately, the policies behind the PGI are often too focused on economic issues that favour international players and the external market to the detriment of the interests of the local population and the sustainable development of the argan forest (RAIMBEAU, 2009).

## 6. Conclusion

This study presents the issues related to the sustainable management of a Biosphere Reserve.

The ABR is a typical case where the challenges of biodiversity conservation and the valuation of a natural product (such as argan oil) are confronted (SIMENEL ET AL., 2009). The ABR has a specific richness that is conferred not only by the argan trees (a native species of the region) but also by its ancestral management methods. The ABR is under strong pressures from the local climate and human activities (M'HIRIT ET AL., 1998; TARRIER & BENZYANE, 2003; NOUAIM, 2005; NAGGAR & M'HIRIT, 2006; BELLEFONTAINE, 2010; ACHOUR ET AL., 2011). These pressures cause the strong degradation of the argan forest despite the many (admirable) efforts of the various participants from the development sector for the rehabilitation of the ecosystem.

In addition, renewed interest in the argan sector over the last few decades has led to the establishment of numerous programs for the management and conservation of the argan trees. However, it has also accentuated the anthropogenic pressure on the argan forest. The direct link between the rise in prices of argan oil and the degradation of argan forest has not yet been clearly established by the authors, who avoid having a categorical opinion on the subject. However, although the management methods in the argan tree area regarding its various traditions have not changed enormously over time, the exploitation techniques themselves, have evolved; as well as the habits of some households.

In general, the sustainable development of the ABR must be done through a participation and heritage approach that promotes local knowledge and integrates all stakeholders in the management and decision-making processes.

## Acknowledgments

*Our sincerest thanks go to the German International Development Cooperation Agency (GIZ) for financially supporting this work. I also thank the National Agency for the Development of the Oasis and Argan Tree Areas (ANDZOA) and the National Forestry School of Engineers (ENFI) for their support.*

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