The argan agroecosystem

Local meanings of argan tree and bee diversity within man-made territories

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Introduction

Argan agrosylvopastoral territories in Morocco illustrate the intertwined issues related to climate change and food security in southern Mediterranean semi-arid rural areas. The argan tree (*Argania spinosa* L. Sapotaceae) acts as a shield against desertification and represents the most important southernmost tree formations in Morocco. Its resources have been a pillar of food security in this region at least since medieval times (Ruas et al. 2016). Argan oil is not only a staple food – the tree is a keystone species that supports a large set of food products including domestic animal products (goat: meat, milk), pollinators (honey bees: honey) and other products including almonds, olives, figs cereals, pulses, wild medicinal herbs and animals. The regeneration of the argan tree and transformation of its resources into food products draw on a wide range of empirical knowledge and know-how that should be taken into account if sustainable development goals are to be considered seriously.

The argan tree is endemic to Southwestern Morocco. Its nuts produce an oil that has become a popular cosmetic item over the last decade as a result of national and international development policies and trade (Simenel et al. 2009). Argan forests represent an ecosystem which harbors a rich Mediterranean flora (Alifriqui 2004; M'hirit et al. 1998) but is under threat from desertification, pastoral exploitation and transformation for large scale horticultural productions. Classified as a UNESCO Man and Biosphere Reserve in 1995, the argan area occupies 10% of the national territory and is inhabited by 3.2 million people i.e. 10% of the national population (El Fasskaoui Brahim 2009). Approximately half of this population is rural and is composed of sedentarized berberophone and to a lesser extent arabophone tribes. The argan tree grows in fields (*igran*), horticultural areas (*ourti*), and forests (*tagant*). Forests cumulate pastoral and nut harvesting activities following calendars and rights of access established by customary institutions such as the *agdal*, a system widespread in Morocco (Genin & Simenel 2011, Auclair et al. 2011).

Little attention has been paid by development policies to local knowledge pertaining to trees and forests. Furthermore, development agencies have adopted a marketing approach portraying the oil as "natural" and the tree and forest as "wild". This denies the domestic origin of the product and the important role of humans in the configuration of argan tree populations. The wild collection of argan nuts used by women in oil cooperatives is often emphasized, as well as the folkloric dimensions of its use, whereas integrated arboriculture and pastoral activities requiring specific workloads and social organization are overlooked. This symbolically blurs the role of local social groups which have transformed and domesticated the habitats and the tree over the centuries of human-argan ecosystem mutualism.

Historical forest construction

The soil and infrastructure of argan forests reveal the footprints of intense ancient human activity. Argan forests contain land infrastructures in the form of ruins, such as the ruins of earthen walls, water retention walls and fencing, but also occasionally the ruins of dwellings and stonework which reflect ancient agricultural and horticultural activities. Whether intact or completely dilapidated, these diverse infrastructures of past farms can be mapped in the forests (Simenel, 2011) and bear toponyms which are markers of the territory. These toponyms and ethnohistorical records show that the forests were horticultural and agricultural spaces in the past, which were subsequently abandoned and returned to their natural state.

Past man-made infrastructure is crucial to understanding argan forest development. For example, dense wooded parks – especially in the uplands – are associated

with previous agricultural plots scattered within the forest. Stone removal in rugged land for agriculture resulted in an increase of soil water retention capacities. Shallow terraces reduce the inclination of slopes while the construction of dry stonewalls, earthworks, fencing, or the retention of runoff waters in plots also limit water stress. Finally, walls serve as shade and shelters – humidity sensors that are suitable for argan tree regeneration. Ravine maintenance, stone consolidation in rivulets (*wadi)* beds throughout the plots and small dam constructions all prevent overflow and the erosion of flooded areas. These structures divert water to cultivated terraces through flow channels that circulate along the plots. Although abandoned, this infrastructure still shapes a space conducive to argan tree germination and forest development, as it entails an orderly method for containing rainwater. Past land transformation for agriculture has thus enabled argan forests to take root where they would not have thrived without human endeavour. Water and soil conservation development techniques have changed the landscapes, giving them greater environmental plasticity and enabling the expansion of argan forests and related flora such as the endemic Macronesian flora. We argue that a large part of these argan forests linked to ancient fields and horticultural areas have been favored by human activities and know-how and would not thrive naturally.

Similar situations are found in West African forests, where J. Fairhead and M. Leach (1995) came to the conclusion that "current or previous land use enables the forest to grow in the savannah, even though it would be impossible given the absence of necessary conditions in terms of soil structure, moisture, fire limitation, and types of seeds." Southern Moroccan argan forests represent another important example which highlights the effects of human interactions with the local environment and the development of forests too commonly referred to as "wild".

Argan trees linked to human maintenance have also undergone selection practices which affect tree populations. The fields are a space where we observed on-going argan domestication activities. Practices include maintaining spontaneous sprouts in artificial (walls, benches, ravines) or natural (thalwegs, boulders) microreliefs, protecting and maintaining rootsuckers, seedlings, pruning, thinning (cutting to select a single stem), and selection.

Moreover, animals that graze in the fields after harvest eliminate argan seedlings which are considered the least vigorous, and people recognize that those that are naturally protected – either by spiny plants (e.g. Euphorbia) or as a major stem within coppices protecting each other – are the most vigorous and are therefore simply kept and trained, trimmed and pruned to become a tree. Each argan tree is therefore the expression of the work of several generations of people, from those who protected it from infancy and selected the best strands, to those who have maintained and protected it, and those who sometimes may cut it in order to clear the area for planting other crops or to favor another vigorous tree.

The selection of argan trees according to specific characteristics is based on a kinship terminology between trees. Suckers growing from the roots of original

trees are called daughters (*ilis*), while other suckers that grow at the foot of a tree are named uterine nephews (*ayao*) following similar terms applied to human lineages. The morphological criteria used by women for the selection of trees to be kept are the shape of argan tree shells and kernels, the softness and timing of maturation and in some cases exceptionally large trees associated with historical activities (e.g. the Argan souk – the tree under which people used to rest while travelling to the souk). As specialist preparers of argan oil, women define the typology of nuts. According to their classification, there are long and thin kernels as well as small and thick ones (*tarzift*, *tazdit*, *tdnit*), soft (*tekhlouf*), and easy to break as opposed to hard to break (*tamelhkot*). The trees are thus selected individually. Nuts are harvested once a year in July-August after the fruit has matured. Women first harvest the trees with early fruiting and fruit shells that are easy to break, probably those least resistant while those which are hard can remain on the ground before being collected. Hard nuts can be sold at a higher price before the kernel value falls on the market and once the harvest is finished. They also set aside the hard-to-crack nuts, which they soak in water to soften. If crops are harvested tree by tree, the women will not finish until their handmade wicker baskets are filled with a mixture of kernels of different shapes and sizes, a highly valued diversity that is considered necessary to produce the very best taste for a good argan oil (Photo 1).

Photo 1
A woman shows her basket full of different types of argan kernels. Imi n Tlite Region. Y. Thomas, 2008.

This example of the selection of argan trees by women shows how they interact with the argan tree populations to provide food security through favoring diversity in a context where climate risks are high. Their oil production strategies linked to long-term intergenerational selection processes play a major role in the management and regeneration of the genetic diversity of the argan tree population.

Beekeeping: intimate linkages to the mosaic of argan territories

In Southwest Morocco, beekeeping is closely associated with the mutualist interactions between Berber and Arab groups and this unique agro-forestry system centered on the argan tree over the millennia. The know-how of beekeepers is based on the manipulation of differential agrosylvopastoral spaces. Indeed, although beekeeping in southern Morocco can be qualified as sedentary, bee hives may alternately leave spontaneously and/or be placed in cliffs associated with waterfalls, cereal fields co-existing with argan trees, horticultural spaces, monoculture of prickly pears (*Opuntia indica*), or pastoral areas dominated by *Euphorbia spp*. and argan trees. Each spatial unit of this rural territory supports a different degree of the domestication of yellow Saharan domestic bees, from wild swarms living in autonomy in the cliffs to the most domesticated hives found near houses or in sophisticated collective hives (Photo 2) (Simenel et al. 2015).

Photo 2
A beekeper and his traditional hives, Mesti Region.
R. Simenel, 2016

According to the season and the beekeeper's needs, the latter decides to place his hives in a different space within the landscape mosaic, to favor the collection of new colonies or honey production and/or their health, their rapid division, or their protection in the event of extended drought. Colonies of domestic bees – mostly the endemic Saharan yellow bee – play an essential role in pollinating the argan trees. The mobility of the hives in this agroforestry mosaic is not negligible. Maintaining hives close to homes within prickly pear, or installing them in an arboreal closed area bordering fields encourages bees to pollinate argan trees located in the agricultural zone. From these locations, the bees cover a distance from homes to argan forests, extending over the whole of the cultivated area. The need for pollination is important in the fields where the density of argan trees is high and where some trees may bear fruit twice a year in contrast to argan in forest areas. According to beekeepers, the pollination of argan by bees allows the production of fruit to be doubled. Argan nuts from fields make the most of harvested nuts. Pollination of argan forests is ensured by domestic swarms located in the cereal-argan cultivated areas during droughts, as well as wild bees housed in the cliffs and other pollinating insects or mammals.

Bees do not collect only nectar and pollen from these differentiated spaces; they also collect a significant range of beekeeping materials essential to the good health and reproduction of the swarm. Beekeepers identify all aspects of the bee life cycle, taking into account their uses of plant materials collected. They then evaluate their effects on the development of the hive and the behavior of the bees. The availability of this plant diversity stems from a remarkable spatio-temporal concordance between human practices and bee activities.

According to the knowledge of beekeepers, some plants play an essential role in the development of the various constituent stages of beekeeping, from the evolution of the brood to the swarming (Simenel et al. 2015). The most important plants are those used by the bees to eradicate the Varroa. Varroa is one of the suspected causes of Colony Collapse Disorder. Berber-speaking beekeepers claim that their bees are able to reduce the impact of the disease by using certain plants that are important sources of propolis. In this category are found substances such as the latex of *Euphorbia echinus*, *Euphorbia balsamicus* or the *Ononis sp.* exudate, in addition to the juice of *Senecio anteuphorbium*. According to beekeepers, the degree to which the latex harvested by bees is "peppery" (*harr* in the local language) determines their effectiveness against the Varroa mites. The ethnoecologiocal knowledge of beekeepers may thus contribute to combating Varroa by moving the hives to places where the desired plants are present in higher density.

Across the generations, men and women have shaped an ecosystem and respected the requirements of the nutrition and health of bees through facilitating their access to specific nectar resources and their interactions with plant substances distributed in different spaces with distinct ecologies and following temporal variations relating to the hive development stage and a large diversity of plant flowering phenology within the territory. Bees have thus been fully integrated

into the rural landscape by the beekeepers. The mutualistic relationship between bees and men enables both the pollinating of argan trees and the nurturing of bee colonies. Bees and men here can be considered as the co-constructors of this agrosylvopastoral system and its associated biodiversity.

For ten years, the mutualistic and strongly territorialized relationship between southwestern Moroccan beekeepers and Saharan yellow bees has faced the intrusion of modern beekeeping practices. These industrial practices, whose sole purpose is the production of honey, are based on a standard model of modern hive, carrying with it swarms of black bees from northern Morocco. Today, research fails to measure the impact of such an intrusion on the settlement of the Saharan yellow bees and therefore on the agro-ecosystem pollination process, but preliminary field observations suggest the presence of hybridism and displacement of distribution of the yellow bee further south. Similar to what is proposed by Oldroyd for the American case, one of the likely risks causing the disappearance of bee populations certainly lies in changing cultural practices – and especially in this case, the abandonment of a territorial vision of beekeeping.

Conclusion

Argan territories constitute a mosaic of agro-sylvo-api-pastoral areas whose construction is inextricably linked to practices and know-how such as beekeeping and arboriculture. With the young generation disregarding peasant activities such as the maintenance of terraces, pruning sprouts, and fertilizing fields, there is a risk of the gradual deconstruction of this mosaic. This would lead to the end of the contribution of the rural population to the regeneration process of the argan tree based on multigenerational practices. The loss of knowledge relating to the argan tree is further threatened by marketing activities surrounding the production of argan oil as a cosmetic product which denies the role of local knowledge (Simenel et al. 2009).

The argan forest maintained by humans could possibly decrease in coverage due to lack of care by humans. Subsequently the role of this man-made forest as a shield against desertification may also be weakened. The autonomy in high-quality oil products of local populations also becomes vulnerable in a context where export prices and market structures are within the control of external actors. Climate change may certainly affect the argan territory and its people but social changes here are clearly linked to the resilience of the system. Experts and engineers are increasingly producing new ideas as to how to tame the argan tree, for instance through favoring a few clones that would give a high yield in oil, here also giving little consideration to a millenary system

based on nut diversity that has favored both sexual and clonal reproduction. Moreover, the decline of the Saharan yellow bee and related pollination problems including the reproduction of food resources may be affected not only by climate but more importantly by invasion by modern semi-industrialized apicultural practices.

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The Mediterranean Region under Climate Change

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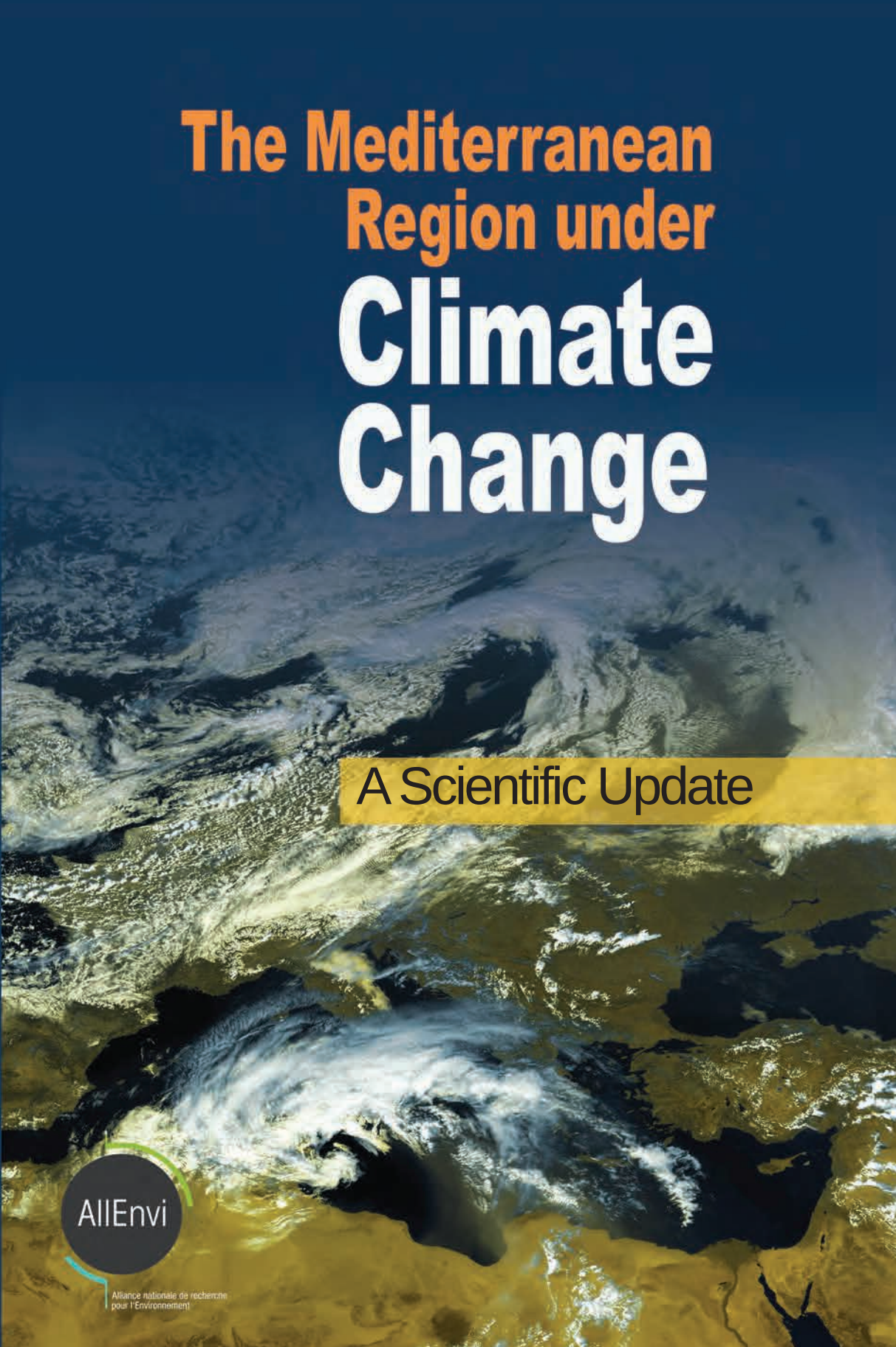

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