SOURCES OF WATER COMPENSATION OF THE ARGAN GROVE *Argania spinosa* L. IN ALGERIAN WESTERN SAHARA

KECHAIRI Réda
Laboratory of Ecology and Management of Natural Ecosystems LECGEN n°13
Department of Ecology and Environment. Faculty of Nature and Life Sciences
University of Abu Bakr Belkaïd, 13000 Tlemcen, Algeria
E-mail: kechairir79@gmail.com

(Received 03 February 2021 - Accepted 28 July 2021)

Abstract.- *The Argan tree* Argania spinosa *L. is a major sylvopastoral component in the Algerian Western Sahara (Tindouf) in North West Africa. It grows in the rocky plateau "Hamada" of the Saharan desert. It is located in along the wadi beds, on sandy, rocky and gravelly substrates. It turns out that the region of Argan grove is characterized by extreme climatic conditions and a dry period that extends all year round. Under the severe aridity conditions the Argan tree adapts well on the hydrography of Hamada of Tindouf in the presence of underflows, where additional water supply is accumulated below the substrate of dry wadis beds.*

Key words*: Argan tree, hydrography, water sources, water compensation, Tindouf, Algeria.*

SOURCES DE COMPENSATION EN EAU DE L'ARGANERAIE *Argania spinosa* L. AU SAHARA OUEST ALGÉRIEN

Résumé.- *L'arganier* Argania spinosa *L. est un composant sylvopastoral majeur dan le Sahara occidental algérien (Tindouf), au nord-ouest de l'Afrique. Il pousse dans le plateau rocheux "Hamada" du désert saharien. Il est situé le long des lits d'oueds, sur des substrats sableux, rocheux et graveleux. Il s'avère que la région de l'arganeraie est caractérisée par des conditions climatiques extrêmes et une période sèche qui s'étend toute l'année. Dans les conditions d'aridité sévères, l'arganier s'adapte bien au sein de l'hydrographie de la Hamada en présence de sous-écoulements, où un apport d'eau supplémentaire est accumulé sous le substrat des lits d'oueds secs.*

Mots-clés*: Arganier, hydrographie, sources, compensation en eau, Tindouf, Algérie.*

Introduction

The forest plays an important role in the regulation of the hydrological regime [1]. Its disappearance would have unbearable effects. Trees such as the Argan tree are indispensable for stabilising the course of wadis and regulating their flow [2-4]. With its well-developed roots and the herbaceous stratum that it shelters, the Argan tree conserves the soil and protects it from the harmful effects of runoff caused by occasional and heavy rains and also against frequent violent winds [5].

According to Fabre [6], the Hamada appears monotonous, constituting a sandstone-clay complex, generally formed at the base by a conglomerate then one or more limestone or dolomitic slabs in flint beds. It is cut into cliffs and gullies by erosion in a semi-arid climate [6-8]. In general, it is a fairly flat Hamada whose horizontality is rarely disturbed [9] except

for the upper part of the sub-watershed of Wadi El-Ma which is composed of "*Chaabats*" of a disturbed nature. It consists of Tertiary sediment of Paleogenetic age, especially Neogene. These limestones are more or less silicified [10].

Climatic conditions in the area of studies are generally severe. That the maximum temperature reaches 50°C, and the dry period extends throughout the year. However, torrential rains appear every 3 to 4 years [11]. The hydrographic formation on the desert plateau of the Hamada of Draa has a mainly alluvial supply, favorable to the Argan tree. It is explained by the cruel influence of concentrated river flows [6]. According to BOUDAD *et al.* (2003), the hydrographic formation results from the intensity of the humidity of the Upper Pleistocene and Holocene that led to the flow of wadis [12]. At the northern depression which is constituted by the red clay deposits of Upper Carboniferous [6], a few feet of *Argania spinosa* are very scattered. The argan tree crosses the ravines of "*Kreb El-Hamada*" along the cliffs of Merkala and Targant, where it attaches itself on the cracks of hard sandstone and metamorphic and gypsum rocks.

1.- Material and methods

1.1.- Study region

Our study region is located in the northwest of Tindouf Provence. It is constituted in its great part of a plateau of the Hamada, including the Hamada of Draa which contains the natural environment of the Argan tree, covers an area of 56000 ha [13,14]. It is imitated in the south by the Hamada of Tindouf (northern version of Sebkha of Tindouf), in the west by the Hamada El-Hamra (border region) and in the north by the depression of the North and Ouarkziz mountain. The vegetation of the study area is located precisely in the wadi beds (fig. 1).

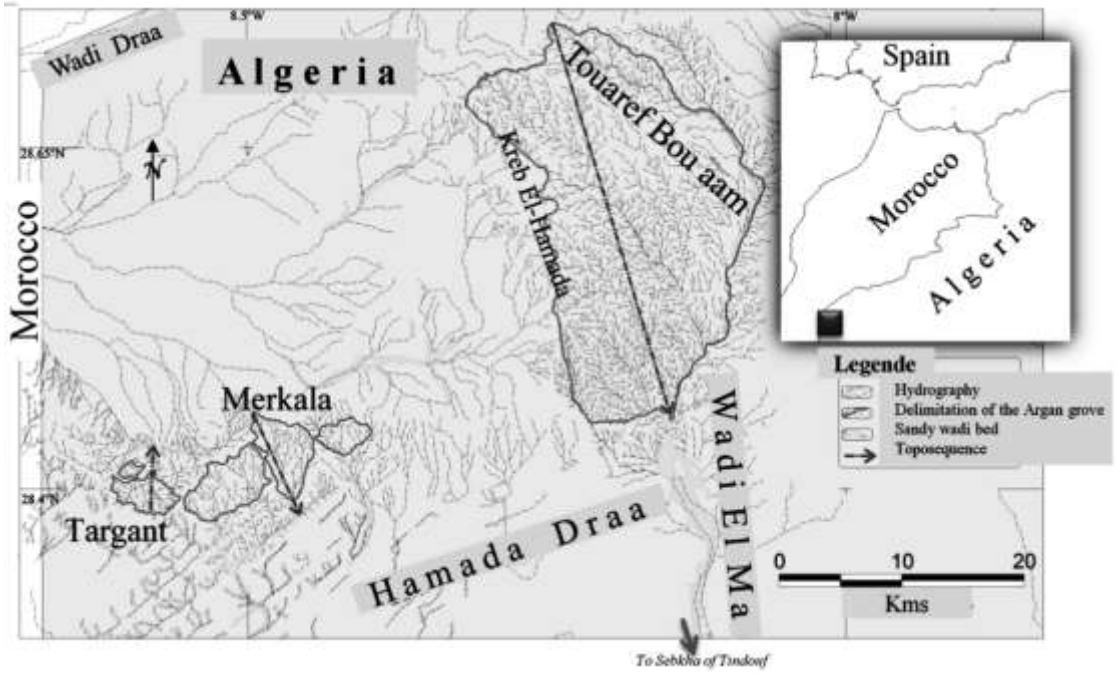

Figure 1.- Delimitation of the hydrography of Argan grove of Tindouf [13] and topographic profiles

1.2.- Hydrogeomorphological analysis

The purpose of this work is the analytical description of the hydrographic flow in the middle of Tindouf's Argan grove. The *Global-Mapper* software (3.0) was used in this study to highlight the geomorphological characteristics of the stations at *Argania spinosa* by Toposequences from the DTM (Digital Terrain Model).

2.- Results and discussion

2.1.- Description of the hydrography

In arid regions, the wadi has developed a system of alluvial terraces, which reach several tens of meters in thickness, an exceptional magnitude for North Africa [15]. At the mouth of Wadi El-Ma, the thickness of the sandy major wadi bed is about 250 meters (Fig. 2). This Upper Pleistocene formation recorded some more or less rapid variations in the middle [15]. This sandy substrate shows increasing sterilization by leaching and intensive overgrazing [14, 16]. As a result, vegetation seems to be absent, and the Argan tree is represented only by a few very distant subjects scattered with the feet of *Acacias*.

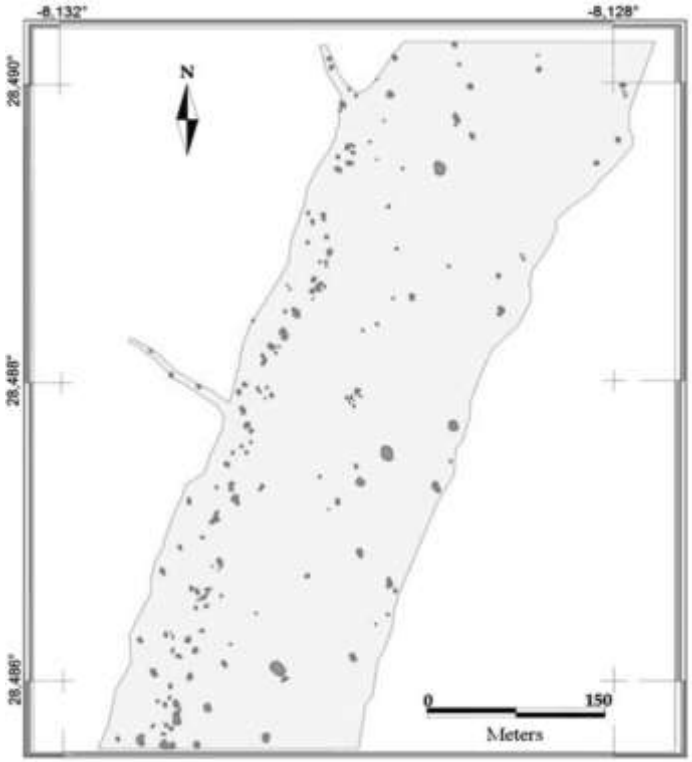

Figure 2.- Major wadi bed at the mouth of Touaref Bou-aam

2.2.- Water Resources

In the natural environment of the Tindouf Argan grove, the climatic conditions are severe. The dry period lasts all year round, sometimes three years pass without rain. The Argan tree is endemic and continues to be present since an older retreat in the dry wadi beds.

In these extremely arid environmental conditions, the vegetation in *Argania spinosa* compensates for the rainfall deficit by:

2.2.1.- Underflow

The wadis are called seasonal watercourses especially in North Africa, and the presence of vegetation on these wadis can be explained by the availability of water stored in the substrate [15]. The Argan tree takes advantage of underflows, where additional water is accumulated below the substrate. This phenomenon called "underflow" allows the vegetation and especially the Argan tree to see compensation in water necessary to continue to live in a region where annual rainfall does not exceed 50mm [16, 17].

2.2.2.- Guelta

In the lowlands of Targant, the limestone formations maintain sources that are at the origin of the perennial supply of Targant wadi. In this landscape of Argan oasis is a set of "*Gueltas*" in micro-basins where animals can come to drink even in the driest years [15]. In the Targant valley, spring water feeds the hydrographical network and converges in small reservoirs "*Gueltas"* (fig. 3).

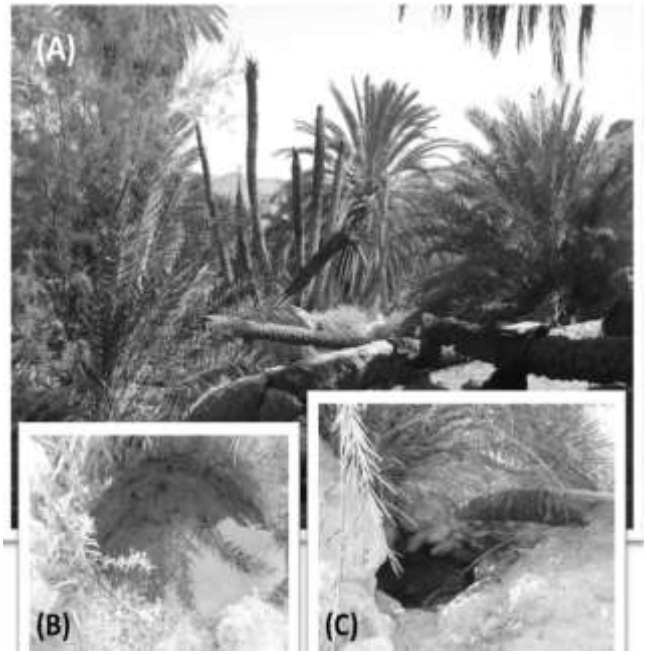

Figure 3.- Water sources at the oasis of the Targant valley
(A- Oasis of Targant; B- Water source; C- Gueltat)

2.2.3.- Ouglat

During all the field trips we observed a traditional system called "*Ouglat*" which is used to drain the water resulting from the inflow under the wadi bed by a small well [16, 18]. This one is founded by a cylindrical cavity, well built in stones, dug vertically the wadi bed; it has a depth of about one to two meters. Figure 4, shows "*Ouglat En-Sara*" at the midpoint of the El-

Ma wadi (8.155752°N; 28.564835°W). It is considered to be a small water reservoir for Saharawi nomads. This traditional technique is currently rare. It is substituted by pumping underground water.

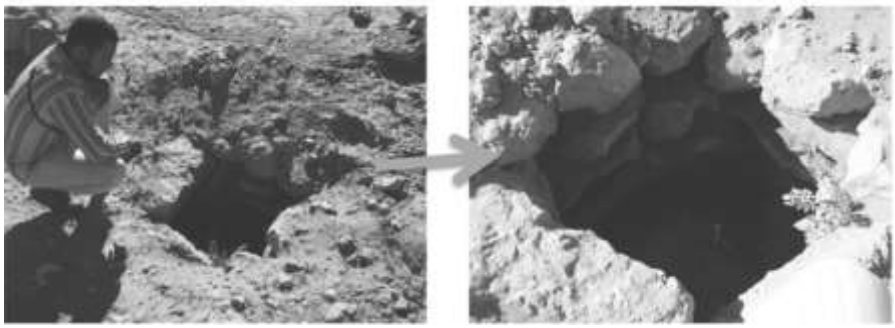

Figure 4.- "*Ouglat En-Sara*" at the mid-slope of wadi El Ma

2.3.- Effect of wind on the physiology of the Argan tree

The wind exerts a very important action on the Argan tree and its environment [19]. It has an effect on the phenomenon of transpiration which also acts on the physiology of the plant. The dominant winds in the study area are from the north-west, this is called *'Gharbi'* which represents almost all the winds of the year. Coming from the Atlantic Ocean, these winds soften the temperatures and increase the humidity of the air. Warm air waves from the southeast are called *'Chergui'*. They last a few days and show superficial leaf scorching between June and August.

The Argan tree in Merkala is constantly subjected to cruel winds because of the exposure and its altitude in front of the northern depression. This contributes to put the stand a little stressed compared to the Argan tree of the other stations of Targant and Touaref Bou-aam. The air currents blow stronger at Kreb El-Hamada "*Ross El-Ma"* between Merkala and the upstream northwest of Wadi El-Ma. These air currents generate strong evapotranspiration which increases the water needs of the trees [20]. The water that is already insufficient upstream where the remainder of the argan population becomes pure, in the form of bushes barely exceeding 2 meters in height. These bushes contain dwarf leaves and fruits that do not exceed the stage of small green buds, then fall (fig. 5).

Figure 5.- Geomorphological nature of Hamada Draa; the cliffs of Hamada “Kreb El Hamada” (a_1); northern depression (a_2); upstream "Ross El Ma" (b)

3.4.- Water flow

Table 1 shows the hydro-geographic data for the three stations studied. In Wadi El Ma, the harsh nature of the Hamada where the Argan tree settles in troubled Chaabats, contributes to the creation of water repellents that promote the good development of the species. With a low slope recorded in Touaref Bou-aam and Merkala (1.5 and 2.4%), almost all water runoff infiltrates and the mass of imported soil accumulates under the feet of trees by enlarging the mounds.

Table 1.- Hydrogeographic flow data for the three stations studied

Stations	Touaref Bou-aam	Merkala	Targant
Slope α (%)	1.5	2.4	3.9
Exhibition	from South to North-West	from South to North-West	from the North-West to the South-East
Altitude (m)	550 à 600	540 à 570	375 à 525

Figure 6, shows the geomatics data for three topographic profiles (Toposequences). These were extracted from the DEM (*Digital Elevation Metric*: satellite image of the SRTM radar system, resolution 25m) processed by the Global-mapper software. The flow of Wadi El Ma converges from the extreme northern cliffs of *K'reb El-Hamada* "*Ross El Ma"* southward to join the Sebkha of Tindouf. The flow of Wadi Merkala converges from north to southwest in micro depressions on the Hamada and then follows the furrows of the Hamada Draa to the southwest to Hamada El Hamara. Regarding Wadi Targant, one of the tributaries of the Draa Valley, its flow converges from south to northwest to join the Atlantic Ocean. At the natural reserve of the Argan grove, the water temporarily submerged at wadi El Ma at the time of torrential rains and built a hill reservoir at the mouth of Touaref Bou-aam. Thereafter, the water infiltrates to feed the underflows to the Sebkha of Tindouf.

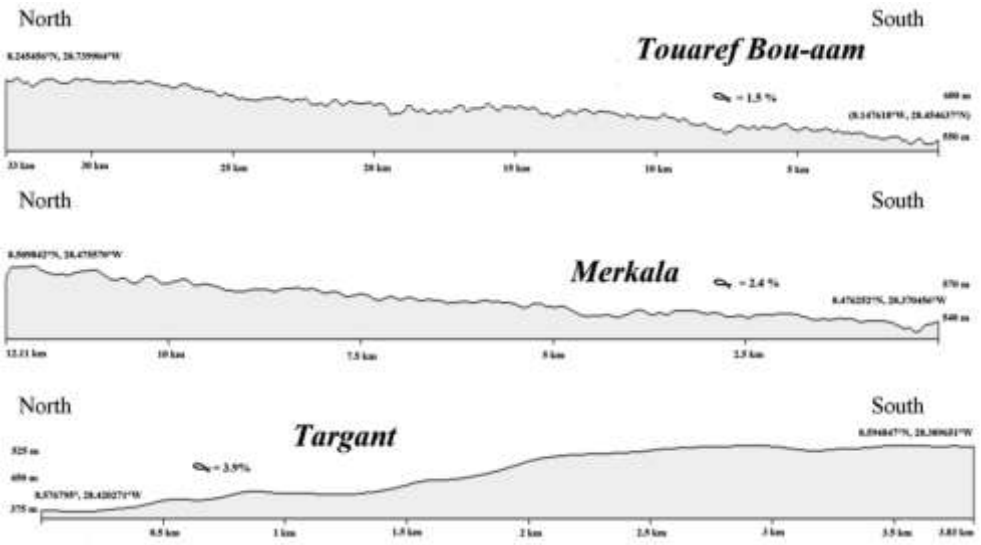

Figure 6.- Toposequences of the three stations of the Tindouf Argan grove

Conclusion

The distribution of the settlement in spatial discontinuity seems well attached to the nature of the hydrography of the wadis on Hamada. Indeed, the intensity of the flows during certain ancient periods increased the base of the hollows of the wadis (of varisque type) which increased the accumulation of the soils of contribution and favoured the installation of *Argania spinosa*.

The ecosystem of the Argan grove is threatened by the severity of the climate. In addition, the anthropogenic impact apparently leaves harmful footprints that risk minimizing water potential through the adversity of fatal depletion of the water table underlying the Argan forest nature reserve.

Disclosure statement: No potential conflict of interest was reported by the authors.

References

[1].- Harfouche A, Nedjahi A, Fallah, M, Daly-Hassen H, 2005.- Les ressources génétiques forestières nord-africaines et leur conservation. Revue Forestière Française, 58(1): 15-32.

[2].- Challot J.-P, 1949.- L'arganier. Revue de bois, Pp 7-12.

[3].- Ehrig F.-R, 1974.- Die Arganie Charakter, Ökologie und wirtschaftliche Bedeutung eines Tertiärreliktes in Marokko. Petermans geographische Mitteilungen, 118 (2): 117-25.

[4].- Nouaim R, Chaussod R, El Aboudi A, Schnabel C, Peltier JP, 1991.- L'arganier: Essai de synthèse des connaissances sur cet arbre. Physiologie des arbres et arbustes en zones arides et semi-arides, John Libbey Eurotext, Paris, Pp 373-388.

[5].- Errouati A, 2005.- Problématique de la régénération assistée et des reboisements à base d'Argania spinosa dans la région du massif forestier d'Amsitten (Province d'Essaouira). Doctorat Thesis, École Nationale Forestière d'Ingénieurs de Salé, Maroc, 42p.

[6].- Fabre J, 2005.- Géologie du Sahara Occidental et Central. Musée royal de l'Afrique centrale, Tervuren African geoscience collection, Belgique, vol. 108, 572p.

[7].- Papy L, Richard-Molard J, Pélissier P, 1952.- Cartes ethno-démographiques de l'Afrique occidentale. Feuille nº 1, Institut Français d'Afrique Noire, Cahiers d'outre-mer, Dakar, 1953, 22 (6): 198.

[8].- Casenave A, Valentin C, 1989.- Les états de surface de la zone sahélienne: influence sur l'infiltration. ORSTROM, Paris, 229p.

[9].- B.E.N.D.E.R., 2002.- Étude de la préservation et de la valorisation de l'espèce cameline au niveau de la Wilaya de Tindouf. Phase 02. Analyse de la situation actuelle de l'élevage camelin. Agricultural Services Directorate, Tindouf, 22p.

[10].- Fabre J, Arnaud-Vanneau A, Belhadj Z, Monod Th, 1996.- Évolution des terrains méso-cénozoïques d'une marge à l'autre du craton ouest africain, entre le Tanezrouft (Algérie) et l'Adrar de Mauritanie. Mémoires du Service Géologique de l'Algérie, 8: 187-229.

[11].- Beladjemi S, Kechairi R, 2018.- Varietal Variabilty of Argan tree foliage *Argania spinosa* (L.) Skeels in various bioclimatic stages in Algeria. Gentics and Biodiversity Journal, 2(1): 1-8.

[12].- Boudad L, Kabiri L, Weisrock A, Wengler L, Fontugne M, El Maatoui M, Makayssi A, Vernet J.-L, 2003.- Les formations fluviatiles du Pléistocène supérieur et de l'Holocène dans la plaine" de Tazoughmit (Oued Rheris, piémont sud-atlasique de Goulmine, Maroc. Quaternaire, 14(3): 139-154.

[13].- Kechairi R, Abdoun F, 2016.- État des lieux cartographiques de l'arganier *Argania spinosa* (L.) Skeels (Sapotaceae) en Afrique Nord-Occidentale (Algérie et Sahara Occidental). International Journal of Environmental Studies, 73(2): 286-393.

[14].- Kechairi R, 2018.- Étude de l'arganeraie de Tindouf: État des lieux, contraintes et perspectives de son développement. Doctorate Thesis, University of Tlemcen, Algeria, 196p.

[15].- Wengler L, Weisrock A, Brochier J.-E, Brugal J.-P, Fontugne M, Magnin F, Mathieu J, Mercier N, Ouammou A, Reyss J.-L, 2002.- Enregistrement fluviatile et paléoenvironnements au Pléistocène supérieur sur la bordure méridionale atlantique de l'Anti-Atlas (Oued Assaka, S.O. Marocain). Quaternaire, 13(3): 179-192.

[16].- Kechairi R, 2009.- Contribution à l'étude écologique de l'arganier *Argania spinosa* (L) skeels dans la région de Tindouf (Algérie). Magister Thesis, University of USTHB, Algiers, 75p.

[17].- Quézel P, Barbero, M, 1993.- Variations climatiques au Sahara et en Afrique sèche depuis le Pliocène: enseignements de la flore et de la végétation actuelles. Bulletin d'écologie, 24(2-3-4): 191-202.

[18].- Bendou S, 2011.- Contribution à l'étude de la diversité floristique et écologique de l'arganeraie d'Oued El-Ma, Wilaya de Tindouf Magister Thesis, University of USTHB, Algiers, 91p.

[19].- Bendaanoun M., 1991.- Contribution à l'étude écologique de la végétation halophile, halohygrophile et hygrophile des Estuaires, Lagunes, Delta et Sebkhas au littoral atlantique et mediterranéen et du domaine continental du Maroc: Analyse climatique, pédologique et chimique ; phytoécologique, phytosociologique et phytogéographique. Perspective de gestion, d'aménagement et de développement. Doctorate Thesis, Faculty of sciences, Marseille, 680p.

[20].- Perrin H, 1953.- Sylviculture, I. Base scientifique de la sylviculture. École nationale des eaux et forêts, Nancy, 318p.