sciendo

Ekológia (Bratislava) - Journal of the Institute of Landscape Ecology, Slovak Academy of Sciences Vol. 43, No. 2, p. 214–218, 2024
DOI:10.2478/eko-2024-0022

USING A GIS FOR MAPPING LAND USE, FLORAL RICHNESS, AND URBANIZATION IN THE PERI-URBAN FOREST OF HAROUZA (TIZI OUZOU, ALGERIA)

MOHAMED YAMINE LARBI ✉[1], AREZKI DERRIDJ[1], OUAHID ZANNDOUCHE[2]

[1]Department of Agronomic Sciences, Faculty of Biological Sciences and Agronomic Sciences Mouloud Mammeri University of Tizi Ouzou 15000 Tizi Ouzou, Algeria; e-mail: mohamedyamine.larbi@ummto.dz
[2]Forest Research National Institute, Arboretum of Bainem - BP37, Cheraga 16014, Algeria

✉ Corresponding author

Received: 25 March 2024 / **Accepted:** 11 June 2024

Abstract

Larbi M.Y., Derridj A., Zanndouche O.: Using a GIS for mapping land use, floral richness, and urbanization in the peri-urban forest of Harouza (Tizi Ouzou, Algeria). Ekológia (Bratislava), Vol. 43, No. 2, p. 214–218, 2024.

The peri-urban forest of Harouza, located near the city of Tizi Ouzou in Algeria, is currently facing significant preservation challenges. These wooded areas, crucial for the country's ecological and socioeconomic balance, are experiencing increasing pressures of human and climatic origin. Rapid urbanization, forest exploitation, and the consequences of climate change have significantly influenced its ecosystem, leading to visible degradation. The repercussions include a noticeable decrease in forest cover, a reduction in biodiversity, and the emergence of degraded areas. To address these issues, our study relied on Geographic Information Systems (GIS). These tools allowed for precise mapping of land use in our study area, revealing a total area of 201.5 ha. Most of this land is occupied by scrubland, a formation associated with forest degradation, covering 74.9 ha. The actual forest covers only 21.4 ha. The presence of 75 wild species, including 20 chamaephytes and 21 therophytes, reflects the disturbances experienced by this ecosystem. The use of multi-date images (2006, 2013, and 2022) over a 15-year period reveals a concerning trend of urbanization. Between 2006 and 2022, the low risk of urbanization decreased from 6.974 to 3.573 km, while the high risk increased from 0.753 to 3.528 km. This analysis of urbanization dynamics thus provides a detailed perspective on the most affected and potentially vulnerable areas.

Key words: mapping, GIS, urbanization, climate change, biodiversity, peri-urban forest.

Introduction

Algeria, endowed with rich natural diversity, places great importance on its forests. These are not only considered the green lungs of the country, but also play an essential role in maintaining ecological and socioeconomic balance. They constitute the first line of defense against scourges such as desertification, while providing vital support to agropastoral activities and serving as a refuge for biodiversity. However, managing these green spaces is complex, requiring both in-depth knowledge of the terrain and mastery of constantly evolving spatial data. In this context, Geographic Information Systems (GIS) associated with mapping prove to be invaluable tools. The Mediterranean forest, despite its specific richness, faces numerous challenges, including irregular rainfall patterns with long periods of summer drought. The peri-urban forest of Harouza, located near the city of Tizi Ouzou, exemplifies the difficulties encountered by these Mediterranean forests. Its strategic location makes it vulnerable to human activities such as forest exploitation, agropastoralism, and especially rapid urbanization. The latter, combined with the effects of climate change, exacerbates the degradation of this forest, resulting in reduced forest cover, decreased biodiversity, the formation of degraded areas, and the expansion of urbanized zones. In our study area, the lack of dedicated studies on mapping floral richness and urbanization is notable. Existing research primarily focuses on the Tizi Ouzou region, addressing issues such as wildfires (Sahar, 2008; Meddour Sahar, Derridj, 2010; Chenoune, 2017; Sahar et al., 2020) and the socioeconomic evaluation of rural development projects (Chenoune, 2017). To date, Larbi's (2000) study remains the only one to have examined the mapping of the peri-urban forest of Harouza. All these studies have explored various aspects of vegetation, but have not explicitly proposed a clear methodology for mapping floral richness and urbanization risk. Our approach is inspired by European experiences, particularly the Corine Biotope typology (Bissardon et al., 1997), as well as Zanndouche's (2023) study on the use of GIS for vegetation mapping and urbanization risks. Given this concerning situation, our study aims to utilize GIS to accurately map land use in the peri-urban forest of Harouza. We will seek to assess the extent of urbanization, current floral richness, and the areas most affected by degradation. This change detection can only be achieved with the help of remote sensing techniques and GIS (Al-Obaidi, Al-Timimi, 2022). The ultimate goal is to

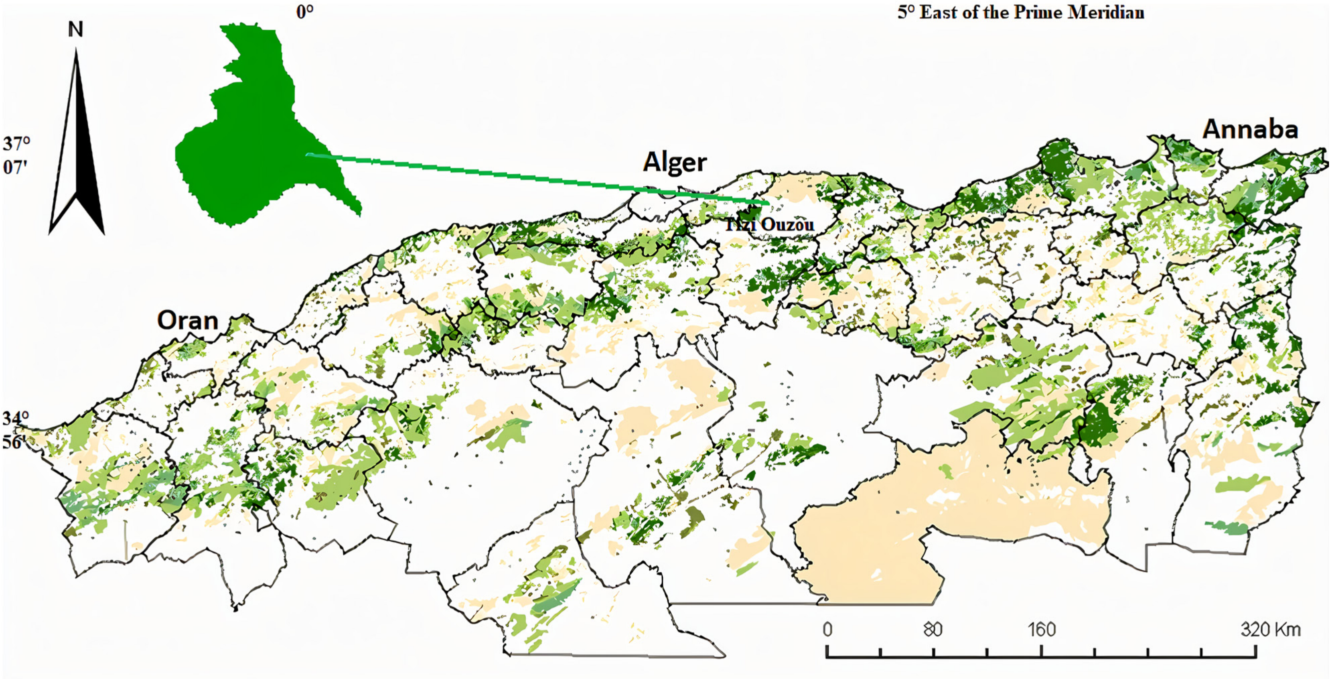

Fig. 1. Location map of the study area.

provide tangible tools for better management and preservation of this forest heritage.

Material and methods

Description of the study area

The peri-urban forest of Harouza, stretching along the slopes of Djebel Belloua, covers an area of approximately 200 ha. This forest massif exhibits significant altitudinal variation, ranging from nearly 70 m along the left bank of the Sebaou River to just over 500 m at its western boundary. This ecosystem belongs to the thermo-Mediterranean bioclimatic stage. The predominant vegetation is characterized by the presence of *Quercus suber* and *Olea europaea*, accompanied by a diverse understory, as highlighted by Quezel and Medail (2003).

The rugged topography of the region is evidenced by slopes reaching up to 45% in some areas, creating conditions conducive to potential water erosion, as indicated by Larbi (2000). The geographic coordinates of the forest range from 4°3’33.04” to 4°4’59.62” east longitude and from 36°43’13.54” to 36°44’17.59” north latitude. Geographically, the forest of Harouza is bordered to the north by the village of Redjaouna, to the south and west by the city of Tizi Ouzou, and to the east by the Sebaou River (Fig. 1).

Methodology

The methodology applied to mapping land use, floral richness, and urbanization in the peri-urban forest of Harouza relies on a diachronic approach integrating various data sources, including satellite images as well as images from Google Earth such as Ikonos, Quickbird, and Pléiades. Concurrently, continuous field observations, including phytoecological surveys, are conducted. The use of the open-source software QGIS 3.4.9 Madeira facilitated the completion of this analysis, allowing for an in-depth study of the spatial and temporal dynamics of land use. The results of this study will help identify the causes and consequences of this dynamics on ecosystems, while the thematic maps developed will play a crucial role in the management and monitoring of natural environments, in accordance with the works of Gressin et al. (2014), Nguyen et al. (2021), Khalaf and Al-alaf (2021).

Photo-interpretation, involving the analysis of information extracted from aerial photographs or satellite images, occupies a central position in this methodology. This technique, widely used in fields such as cartography, geology, and forestry, enables the precise identification of specific features, map creation, and detection of changes over time. In addition, it seamlessly integrates with other forms of remote sensing analysis and GIS, as indicated by Bakis and Bonin (2000).

The approach based on field observations proves indispensable for mapping land use and floral richness, in accordance with the work of Cajeri et al. (2012). Following a subjective sampling plan, based on the principles of Gounot (1969), 32 surveys were conducted in areas exhibiting physiognomic, floristic, and ecological homogeneity, allowing for a detailed analysis of vegetation on approximately 400 m² surfaces for each survey. For the identification and determination of plant species, we used two floristic references: the works of Quezel and Santa (1962–1963) as well as those of Dobignard and Chatelain (2010, 2011a,b, 2012, 2013). In addition, the digital tool eFlore, developed by Tela Botanica, was used in conjunction with fieldwork conducted between 2006 and 2022, primarily in spring.

In the context of increasing forest management, mapping and the use of GIS play a crucial role in providing crucial sup-

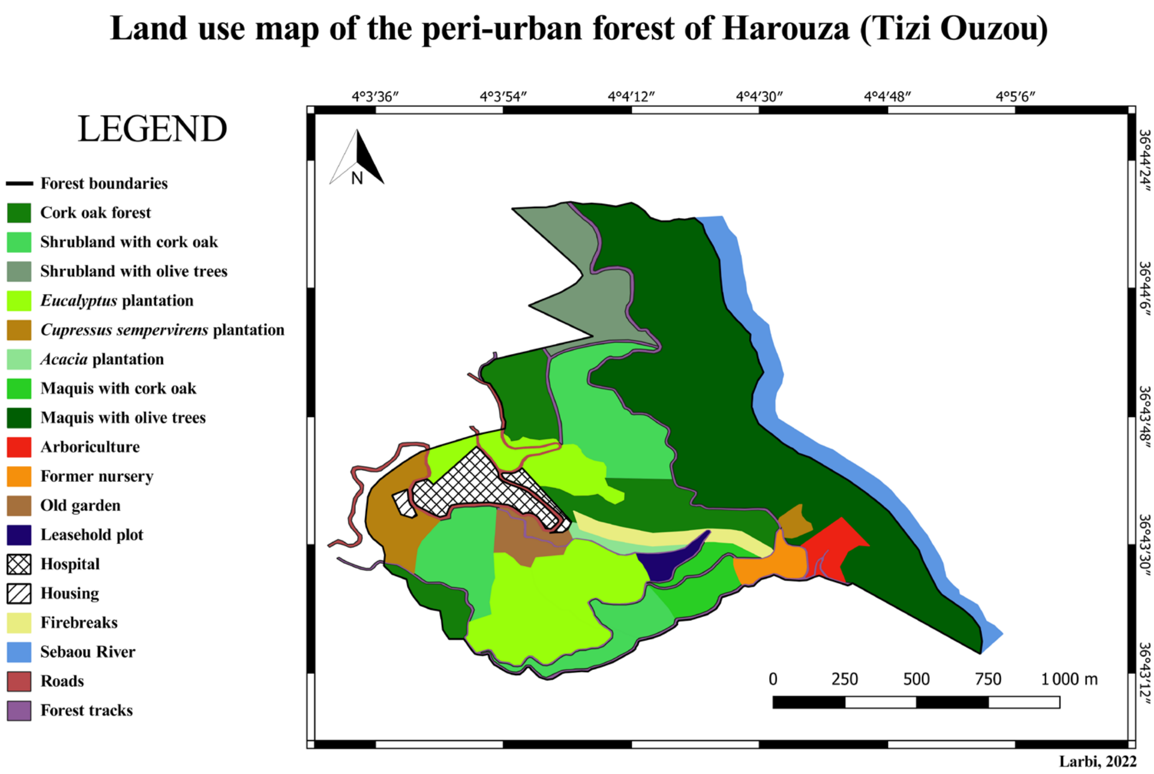

Fig. 2. Land use map of the peri-urban forest of Harouza.

port for the mastery and interpretation of a variety of spatial information as well as information on the dynamics of vegetation cover (El Zerey, 2014; El Mazi et al., 2017; Zakari et al., 2018; N'Guessan et al., 2019).

Results and discussion

The use of GIS enabled us to produce a land use map by overlaying different digitized layers. Thus, we created a database by combining all layers and their attributes.

This database contains all information related to the cartographic units. It includes the survey number, the type of vegetation formation, its floristic composition, density, as well as data such as altitude, exposure, and observations.

The results obtained are represented in the form of cartographic supports identifying the different components of the studied area. We distinguished four physiognomic types: forests, shrublands, scrublands, and plantations.

The peri-urban forest of Harouza spans a total area of 201.5 ha. Majority of this area is occupied by maquis with *Quercus suber* and *Olea europaea*, covering 74.9 ha, which accounts for 37.13% of the total forest area. Next, there are shrublands with *O. europaea* and *Quercus suber*, plantations including species such as *Eucalyptus* sp., *Acacia* sp., and *Cupressus sempervirens*, as well as a natural forest with *Quercus suber*, covering 43.7, 38.3, and 21.4 ha, respectively. These formations occupy a total area of 178.3 ha.

Leased lands as well as plots intended for arboriculture and gardens cover 8.4 ha, while residential areas, hospital, and a former nursery occupy 11.15 ha. Firebreak trenches represent only 3.7 ha (Fig. 2, Table 1).

Table 1. The land use areas of the peri-urban forest of Harouza.

Land occupation	Surface area (ha)
Cork oak forest	21.4
Shrubland with cork oak	30.0
Shrubland with olive trees	13.7
Maquis with cork oak	6.0
Maquis with olive trees	68.9
Eucalyptus plantation	29.4
Acacia plantation	1.4
Cupressus sempervirens plantation	7.5
Arboriculture	3.0
Leasehold plot	1.7
Old garden	3.7
Firebreaks	3.7
Former nursery	2.7
Housing	0.5
Total	201.5

In terms of floral diversity, we have identified a total of 80 species in our study area, including five introduced species (*Agave americana* L., *Gleditsia triacanthos* L., *Morus alba* L., *Cupressus sempervirens* L., and *Opuntia ficus indica* (L.) Mill.) belonging to 41 distinct families. As for the native species of the forest, they amount to 75, distributed among 39 families. The most represented families in terms of species in this ecosystem are, in descending order, Asteraceae (nine species), Fabaceae (eight species), Lamiaceae (five species), Apiaceae (four species), and Poaceae with three species. The other families have only two or one species.

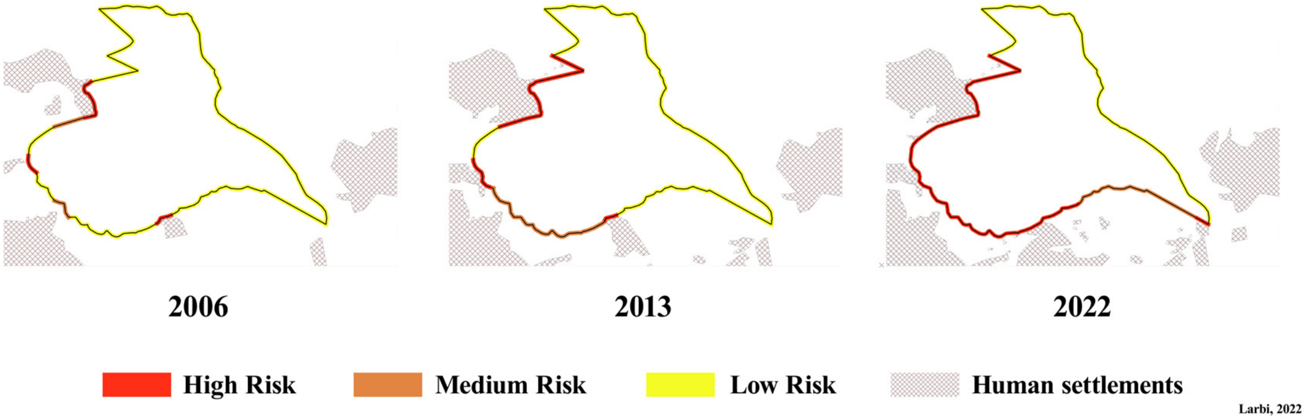

Fig. 3. Evolution of urbanization around the peri-urban forest of Harouza.

Table 2. The evolution of urbanization risk around the peri-urban forest of Harouza.

(Years) Risk	Low (km)	Medium (km)	High (km)
2006	6.974	0.405	0.753
2013	5.261	1.140	1.731
2022	3.573	1.031	3.528

On examining the distribution of species according to their biological types, phanerophytes were found to dominate, representing 33.3%, closely followed by therophytes and hemicryptophytes with 28 and 26.6%, respectively. In contrast, geophytes and chamaephytes account for only 9.3 and 2.6%, respectively.

Overall, phanerophytes in our study area play a significant role in shaping the floral composition typical of forest environments (Lecompte-Barbet, 1975). As for the presence of therophytes, it is directly attributable to the destructive anthropogenic activities to which these ecosystems have been subjected. This phenomenon reflects the negative impact of wildfires, deforestation, overgrazing, and especially urbanization on indigenous flora. Therophytism is considered as an adaptation strategy to unfavorable environmental conditions and as a form of resistance to climatic rigors, particularly summer drought in a Mediterranean context (Madon, Médail, 1997).

Urbanization has significant negative consequences on biodiversity, air and water quality, as well as climate. It is, therefore, important to consider the environmental impacts of urbanization and to implement measures to protect forest ecosystems (Zanndouche, 2023). This could involve establishing protected areas, restoring degraded ecosystems, and designing environmentally friendly urban plans. In line with these concerns, the Harouza forest is located on the urban periphery, and housing growth mainly extends into the sloping marginal areas in its southern and western parts. This urbanization is dynamic and continues to encroach on spaces in close proximity to the forest. In 2006, the risk was low over most of the forest, limited to 0.753 km, with a high risk only threatening the western part. By 2013, the low risk decreased in favor of medium and high risks. In 2022, the high risk covered practically the entire length of the western part of the forest over 3.5 km, while the medium risk extended over its entire southern part, covering just over 1 km (Fig. 3, Table 2).

The growth of the city of Tizi Ouzou appears to be heading toward this forest, thereby compromising natural forest habitats. Meanwhile, the village of Redjaouna, located at the top of the forest in its northern part, is expanding at the expense of the same forest.

The high rate of urbanization risk in the western and southwestern regions is a warning signal for decision-makers, highlighting the worsening threat to the forest.

This rapid urbanization over the past decade carries the risk of habitat loss, endangering species diversity. In addition, it threatens essential ecosystem services, which could have detrimental consequences for the communities located downstream. The degradation of natural ecosystems can lead to more frequent and severe floods, thus jeopardizing the safety and well-being of local communities. It is imperative to adopt conservation measures and sustainable urban planning to prevent these negative impacts on the environment and populations.

Conclusion

The influence of human activity within the peri-urban forest of Harouza is evident in the disruption of the ecological balance of fragile ecosystems. This is reflected in the preference given to the expansion of maquis and matorrals at the expense of the forest, simultaneously promoting the growth of annual plants over slower-growing species. The high rate of therophytes clearly illustrates this disturbance, with potentially severe consequences for regional biodiversity.

The high risk of strong urbanization throughout its western part is a warning signal for decision-makers, highlighting the worsening threat to the forest. The growth of the city of Tizi Ouzou appears to be heading toward this forest, thereby compromising natural forest habitats. It becomes imperative to implement conservation and restoration measures to reduce the impact of human activities on local flora and fauna. These initiatives could include fire prevention, restriction of overgrazing, reduction of deforestation, and promotion of natural regeneration of indigenous habitats. By adopting such measures, we contribute to preserving the rich biodiversity of these areas, ensuring a sustainable legacy for future generations.

Furthermore, to slow down the rampant urbanization threatening the Harouza forest, it is essential to introduce environmentally friendly policies and urban planning. This could involve creating protected areas, rehabilitating degraded ecosystems, and imposing restrictions on urban development in sensitive areas. By taking such measures, we can halt harmful urban expansion and preserve the forest, ensuring its longevity in the face of this growing threat.

References

Al-Obaidi, M.A. & Al-Timimi Y.K. (2022). Change detection in mosul dam lake, north of Iraq. Using remote sensing and gis techniques. *Iraqi Journal of Agricultural Sciences*, 53(1), 38–47. DOI: 10.36103/ijas.v53i1.1506.

Bakis, H. & Bonin M. (2000). *La photographie aérienne et spatiale*. Paris: PUF.

Bissardon, M., Guibal, L. & Rameau J.C. (1997). *Corine Biotopes*. French Habitat Types. Nancy: ENGREF.

Cajeri, P., Curti, C., Lafon, V., Launay, R. & Sauriau P.G. (2012). Cartographie des habitats intertidaux des sites Natura 2000 des Pertuis charentais: complémentarité des approches inventaire terrain, télédétection et SIG. In *XIIèmes Journées Nationales Génie Côtier, Génie Civil* (pp. 855–864). Cherbourg, 12-14 juin 2012. DOI: 10.5150/jngcgc.2012.093-C.

Chenoune, O. (2017). *Evaluation socioéconomique des projets de développement rural dans la wilaya de Tizi-Ouzou et perspective de développement rural durable des territoires*. Thèse Doctorat en Science, UMMTO, Algérie.

Dobignard, A. & Chatelain C. (2010). *Index synonymique de la Flore d'Afrique du Nord*. Vol. 1. Genéve : Éditions Des Conservatoire Et Jardin Botaniques.

Dobignard, A. & Chatelain C. (2011a). I*ndex synonymique de la Flore d'Afrique du Nord*. Vol. 2. Genève: Éditions Des Conservatoire Et Jardin Botaniques.

Dobignard, A. & Chatelain C. (2011b). *Index synonymique de la Flore d'Afrique du Nord*. Vol. 3. Genève: Éditions Des Conservatoire Et Jardin Botaniques.

Dobignard, A. & Chatelain C. (2012). *Index synonymique de la Flore d'Afrique du Nord*. Vol. 4. Genève: Éditions Des Conservatoire Et Jardin Botaniques.

Dobignard, A. & Chatelain C. (2013). *Index synonymique de la Flore d'Afrique du Nord*. Vol. 5. Genève: Éditions Des Conservatoire Et Jardin Botaniques.

El Mazi, M., Houari, A. & El-Fengour M. (2017). Contribution of Remote Sensing and GIS to Monitoring the Spatiotemporal Dynamics of Forests in the Jbel Outka Numidian Massif (Central Rif, Morocco). *Journal of Geography and Spatial Planning*, 11, 171–187. DOI: 10.17127/got/2017.11.008.

El Zerey, W. (2014). *Application of Remote Sensing and GIS in the Study of Desertification: Case of the Algerian Steppe Ecosystem*. EUE.

Gounot, M. (1969). *Méthodes d'étude quantitatives de la végétation*. Paris: Masson.

Gressin, A., Mallet, C., Paparoditis, N. & Vincent N. (2014). Mise à jour d'une base de données d'occupation du sol à partir d'une image satellite très haute résolution: application aux données Pléiades. *Revue Française de Photogrammétrie et de Télédétection*, 208, 5–10. DOI: 10.52638/rfpt.2014.118.

Khalaf, A.B. & Younis Al-Alaf M. (2021). Use of Remote Sensing and GIS Techniques in Monitoring Land Use/Land Cover Changes: Case Study of Kanaan area of Diyala Province, Central Iraq. *Indian Journal of Ecology*, 48(4), 990–994.

Larbi, M.Y. (2000). *Cartographie de la forêt périurbaine de Harouza (Tizi-Ouzou): approche morphopédologique et physionomique de la végétation*. Thesis de Magistère en Agronomie, UMMTO.

Lecompte-Barbet, O. (1975). Introduction à une étude de l'endémisme végétal au Maroc. *Travaux de la R.C.P.*, 3, 15–46.

Madon, O. & Médail F. (1997). The ecological significance of annuals on a Mediterranean grassland (Mt Ventoux, France). *Plant Ecol.*, 129, 189–199. DOI: 10.1023/A:1009759730000.

Meddour Sahar, O. & Derridj A. (2010). Le risque d'incendie de forêt : évaluation et cartographie. Le cas de la wilaya de Tizi Ouzou, Algérie (période 1986-2005). *Sécheresse*, 21(3), 187–195. DOI: 10.1684/sec.2010.0249.

N'Guessan, A.E., Akpa, Y.L., Yao, N'G.O. & Kassi J.N'D. (2019). Cartographie de la dynamique du couvert vegetal de la foret classee d'Agbo 1 cote d'Ivoire. *Agronomie Africaine*, 31(1), 87–99.

Nguyen, D.H., Ngo, T.D., Nguyen, Q.K., Dang, H.C., Kolesnikov, S.I. & Ha D.T.J. (2021). Remote Sensing Planet Images Application in Mapping the Status of Tropical Forests: A Case Research in Kontum Province, Vietnam. *Indian Journal of Ecology*, 48(4), 970–976.

Quezel, P. & Medail F. (2003). *Ecologie et biogéographie des forêts du bassin méditerranéen*. Paris: Elsevier.

Quezel, P. & Santa S. (1962–1963). *Nouvelle flore de l'Algérie et des régions désertiques méridionales*. Paris: CNRS.

Sahar, O. (2008). *Contribution à l'étude des feux de forêts en Algérie: approche statistique exploratoire et socio-économique dans la wilaya de Tizi Ouzou*. Thèse de Magister, ENSA El Harrach, Algérie.

Sahar, O., Hamel, H. & Meddour R. (2020). Etude des grands feux de forêts en Algérie: Cas de la wilaya de Tizi Ouzou. *Geo-Eco-Trop*., 44(3), 427–442.

Zakari, S., Imorou, I.T., Thomas, O.A.A., Djaouga, M. & Arouna O. (2018). Application of Remote Sensing and GIS in Monitoring Vegetation Formations of the Classified Forest of Trois Rivières in Northeast Benin. *European Scientific Journal*, 14(15), 450. DOI: 10.19044/esj.2018.v14n15.

Zanndouche, O. (2023). *Apports du système d'information géographique (SIG) à la cartographie et la gestion des forêts. Cas des forêts de: Bouchaoui, Bainem et El Kala*. Thèse de Doctorat en Sciences, Université Mouloud Mammeri de Tizi Ouzou (UMMTO), Algérie.