

Characterization of Natural Ecosystems, Biodiversity, Socioeconomic and Infrastructures for Sustainable Tourism in the National Park of Tazekka in Taza Province (Morocco)

Soukaina Chellik¹, Youssef Dbiba², Ismail Mansouri³, Wafae Squalli^{4*},
Hamid Achiban⁵, Abdelbari El Agy⁴, Lahcen Zidane¹

¹ Plant, Animal Productions and Agro-Industry Laboratory, Department of Biology, Faculty of Sciences, Ibn Tofail University, Kénitra, Morocco

² Laboratory of Water, Biodiversity and Climate Change, Faculty of Sciences Semlalia, Cadi Ayyad University, Marrakech, Morocco

³ Research Team "Biology, Environment and Health", Department of Biology, Faculty of Sciences and Technologies Errachidia, Moulay Ismail University of Meknes.

⁴ Laboratory of Functional Ecology and Environmental Engineering, Faculty of Sciences and Technology, Sidi Mohamed Ben Abdellah University, Fez, 30000, Morocco

⁵ Laboratory of Geo-Environmental Analysis and Sustainable Development Planning, University, Sidi Mohamed Ben Abdellah, Fez, Morocco.

* Corresponding author's e-mail: wafaesqualli7@mail.com

ABSTRACT

This study aimed to explore the diversity of natural landscapes, faunae, florae, and touristic infrastructures in Taza province and their attractiveness to visitors. Equally, visitors and local populations were interviewed on the socioeconomic activities in the study area. Field visits were realized to delimit the ecosystems, road network, and infrastructures in Taza province. Transects were used to collect faunae and florae data, while a questionnaire was used to collect demographic features and socioeconomic activities in Tazekka National Park. The obtained results showed a high diversity of ecosystems, including forests, steppes, farmlands, and aquatic systems. The documented faunae and florae were diverse with 86 avian species and 16 mammalian species. Two birds *Carduelis carduelis* and *Streptopelia turtur arenicola* were classified as vulnerable, while *Neophron percnopterus* was classified as an endangered species. Two mammals *Macaca sylvanus* and *Cervus elaphus barbarus* were endangered. The road network was advanced with four types of roads (highway, national, regional, and provincial) and hotel infrastructures (hotels, restaurants, diesel stations) were diverse and well distributed in each corner of the area. The availability of natural resources and well-developed infrastructures are suggested to support sustainable activities, such as ecotourism, which are expected to add income to local populations. In fact, field interviews showed that the area, principally Tazekka National Park was visited by national and international tourists, which creates jobs for local residents. Equally, many other activities such as agriculture, pastoralism, transportation, and commerce were recorded among the inhabitants. Therefore, more advanced research is needed to characterize new ecosystems that deserve tourist visits as well as how to balance between human activities and the sustainability of natural resources.

Keywords: ecosystems, biodiversity, infrastructures, sustainable tourism.

INTRODUCTION

Morocco has devoted increased attention in the last two decades to the tourist industry due to its positive effects on the nation's economy and social

development (Lamnadi 2016; El Menyari 2021). In search of a robust and diverse economic pillar, the state created integrated programs and management plans (Vision 2010; Vision 2020, etc.) (Lamnadi 2016). These initiatives advanced Morocco's

position in terms of international visitor arrivals and offered a sizable economic resource (del Mar Alonso-Almeida 2012). However, the majority of the tourism services provided by Morocco are still focused on the sea (3S tourism or mass tourism) (Kagermeier et al., 2019). In contrast, other forms of tourism that are more environmentally friendly (such as mountain, natural, cultural, green, and eco) continue to face challenges in becoming a viable national product (Mohamed and Rachid 2019; Edaoudi et al., 2021; Wakass et al., 2023a). Despite the economic benefits of mass tourism, the ecosystems and the components that make up those ecosystems are negatively impacted by these activities (Garau-Vadell et al., 2018; Chong 2020). The preservation of natural resources and ecotourism issues are also currently top priority for the general people. In order to expand the share of sustainable tourism in the local market, further efforts are required (Mohamed and Rachid 2019).

According to the authorities in charge of managing protected areas, the conservation of natural resources is their top priority (Maxwell et al., 2020; Mirari et al., 2020). The effects of unregulated, mass ecotourism in Morocco on these resources have not yet been assessed. The public's attention is currently focused on the concerns related to conservation and ecotourism. The public's awareness of and support for conservation have increased as a result of the deterioration of natural resources, particularly environmental pollution, the extinction of endangered plant species, and global heating (Heshmati et al., 2022; Wudu et al., 2023). In order to balance the social, cultural, economic, and environmental prospects for development, sustainable forms of tourism are regarded as an implement for sustainable environment (Sahni et al., 2021).

Ecotourism must meet economic, cultural, and political conditions to flourish; however, in certain nations, like Iran, political will is the most crucial element (Veicy 2015). According to a thorough study grounded on social and geographic factors, as well as the support of the local authority supplying infrastructure, the right location must be chosen for the sustainable growth of ecotourism (Yee et al., 2021). Physical infrastructure (road, hotel, canteen, and water), regional cultures (festivals, community, dress, traditional art, and cuisine), services (travel agency, banking, tour guides), and governmental obligations (measures of security, laws, visas, etc.) are all included in this list of infrastructures (Jovanovic and Ilic 2016); TTF (Tourism and Transport Forum 2015). The treasure of

natural sources, including flora and fauna, geological structures, and their related activities, is also necessary to support sustainable activities.

In Morocco, many studies have reported the ecological landscapes with potential ecotouristic activities. Wakass et al. (2023b, 2023a) reported the existence of geosite structures with abundant animal species in Central and Eastern High Atlas. In El Ksiba belonging to Beni Mellal region (Central Morocco), a heritage of Travertine Waterfall Geosites was described for conservation purposes. Equally, Aboutayeb et al. (2017) mentioned the Souss-Massa wadi catchment with its safeguarded areas as a potential ecotouristic area. In contrast to the physical landscapes, living organisms have received little interests in these areas. Wakass et al. (2023b) mentioned the existence of 175 avian species including 20 birds with ecotouristic interests. These animal and vegetation species constitute with their ecosystems a unique unit that needs more interest in order to ensure its sustainability. However, these natural landscapes and their associated florae and faunae are threatened by human as well as environmental factors (Conesa and Jiménez-Cárceles, 2007; Maldonado-Oré and Custodio, 2020). Human activities, such as overexploitation, farmlands, pollution, and noise, disturb the ecosystems and their living organisms (Dudley and Alexander 2017; Kumar et al., 2021; Teff-Seker et al., 2022). Therefore, the integration of the human compartment in the investigations addressing ecotouristic potential of landscapes is required to ensure the sustainability of natural sources.

This investigation aimed to characterize the natural landscapes and tourist visitors of the Tazzeke National park in Taza (Eastern Morocco). The sites with ecotouristic interests, their faunae and florae were evaluated in detail and the most interesting trajectories for future management were mapped. Then, the features of tourists were evaluated using these ecosystems, including demography features, and their principal activities in visited sites. Equally, the economic values of the ecotouristic activities of visitors and the incomes for local populations were estimated.

MATERIALS AND METHODS

Study area

Tazekka National Park was created by the Viziriel Decree of July 11th, 1950 and extends

over 680 hectares (Figure 1). It is situated in the northernmost position of the Middle Atlas, close to the Taza city (21 km). The objective of its creation was part of the forestry and environmental outline in order to safeguard the protection of all the natural resources of the summit of Jbel Tazekka (culminating at 1.980 meters above sea level). Simultaneously, this massif constitutes a site feeding the hydrological system of the region from Taza.

The Park is part of a remarkable tourist circuit with a total length of 76 km, which begins from the vicinity of Taza, passing close to a series of natural curiosities (waterfalls, caves, large wooded areas, etc.). Atlas deer or Barbary deer (*Cervus elaphus barbarus*) was reinstated in the Park in 1994. Further, the Tazekka site represents a preferred habitat for this animal due to favorable climatic and environmental conditions. Indeed, the specific biotope of the Barbary deer is the maquis and forests of cork oak, Zean oak (*Quercus canariensis*) and holm oak with their phyto-ecological associations.

One can observe varied and characteristic landscapes of the Tazekka massif. The summit of Jbel Tazekka, with its natural cedar grove that surrounds it, offers a very remarkable point of view over the entire surrounding region: the Middle Atlas Mountains, humid and wooded massif.

Climatic characteristics

The average annual rainfall in the massif varies between 500 mm at the Taza station (500 m) and 1267 mm at the Bab Bou Idir station (1570 m). The mean of maximal temperatures of the hottest month fluctuates between 34.5 °C at the station of Taza and 28 °C at the station of Tazekka (1380 m). The mean of minimal temperatures of the coldest months swings between −2.8 °C at the station of Bab Bou Idir and 5.5 °C at the station of Taza. The number of dry months varies between 2 to 3 at Bab Bou Idir and 4 to 5 at Taza station. The bioclimatic stages in the massif are subhumid in low altitude and humid stations for high altitude stations (Fougrach et al., 2007).

Delimitation and mapping of ecosystems

The natural and human-made ecosystems of Taza province including those of Tazekka National Park were delimited to clarify the land cover of the study area. Two mapping software were used to create the maps that combined the Digital Elevation Models (DEMs) and the limitations of habitat types.

First, Google Earth pro software was used to delimit the administrative borders of the study area (province of Taza), and then the geospatial

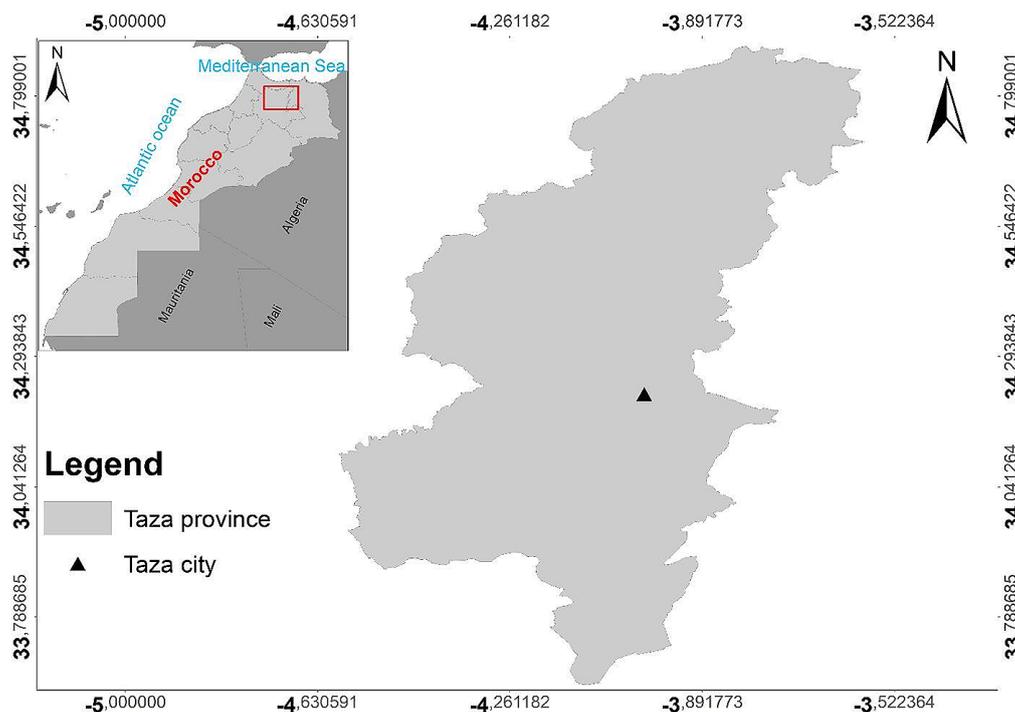


Figure 1. Geographical location and delimitation of the study area

data of each ecosystem were created (polygons that reflect the areas of each type). Secondly, the created geospatial data or polygons were imported to ArcMap 10.8 using ArcToolbox tools (Conversion Tools, From KML, KML to Layer). In order to create the Elevation gradients of the study area, the Digital Elevation Models were uploaded from Earth explorers (<https://earthexplorer.usgs.gov/>). These files were imported into Arc map and merged using ArcToolbox tools (Data Management Tools, followed by Raster Dataset, Mosaic To New Raster). Then, the authors proceeded to the classification process to create the elevation gradient of the study area.

Faunae potential

Bird species

To collect avian data, the explored zone was partitioned into human-made and natural ecosystems. The natural landscapes include wooded areas (forests, reforested areas, steppes, and riparian forests), Mountains, rivers, and cliffs. The human-made landscapes include dams, roads, villages, and farmlands (orchards and cereals). The field surveys were realized with transects with different distances depending on the occupancy of each ecosystem. In open areas, such as farmlands, transects of nearly 7 km were used, while in forests and riparian vegetation avian species were recorded in transects of only 3–4 km due to dense vegetation. In dams, birds were recorded in observation points characterized by an overview of the habitats (uplands with a clear view of the entire ecosystem). All transect was partitioned into surveillance / hearing sites parted by 300 to 500 m depending on the density and height of the vegetation (short distances in dense areas and long distances in open areas). Field visits were started in January 2018 and continued to July 2023. During each visit, the species of avifauna, their abundance, and habitat use were recorded from the morning (fixed at 06:00 AM) to the sunset (fixed at 18:00 PM). In dense forests, recording was based principally on the acoustic calls of birds, while in the open areas, it was based mainly on observations. Binoculars and telescopes were used for visual identification of birds.

Mammalian faunae

Large mammals were counted during bird transects with visual and acoustic identification

due to their large form. In contrast, the chiropteran species were identified with acoustic calls. These species were monitored in the caves and gardens. An automated bat detector, Song Meter SM4BAT-FS ultrasonic recorder connected to an SMM-U2 microphone (Wildlife Acoustics Inc., Maynard, Massachusetts, USA), was used. The sampling frequency of 384 kHz was used from midnight to sunset. The microphone was located at 4 m of height at a fixed point and close to a garden lamp. The length of recorded sequences was fixed at 5 seconds. Next, a “bat pass” was identified as one or more bat calls made in a predetermined amount of time (Kerbirou et al., 2019). The recorded sequences were analyzed with the use of the Kaleidoscope program version 5.4.8 (Wildlife-Acoustics, Maynard, MA, USA). Each bat pass produced one sound that was carefully identified to the species level according to the call library of Barataud (2021).

RESULTS AND DISCUSSION

Diversity of ecosystems

The recorded ecosystems of Taza province and Tazekka Park are presented in Figure 2. The study area is dominated by forests, which extend over 117 055 ha. These forests are located in high-altitude zones and are dominated by *Quercus ilex*, *Quercus canariensis*, *Quercus suber*, and *Cedrus atlantica*. Other species such as *Ceratonina siliqua*, *Olea oleaster*, and *Thuja occidentalis* were less abundant. Steppes cover 259 018 ha and were recorded in medium altitudes; they are dominated by *Pistacia lentiscus*. The farmlands cover 127 595 ha and are dominated by cereal cultures of durum wheat, soft wheat, and corn, as well as orchards of olives, prunes, and peaches. The hydrological ecosystems are dominated by rivers, dams, and small temporary pounds during winter.

Taza province is located in the Eastern Middle Atlas of Morocco and is dominated by a diversity of ecosystems including forests and wooded areas (Saadi et al., 2020; Kamal et al., 2023). The forests of these zones are dominated by cedar *Cedrus atlantica*. However, significant surfaces were reforested with planted species such as *Pinus halepensis* (Mahmoud et al., 2023). These plants and their ecosystems could serve as breeding and feeding habitats for a wide range of animal species. Equally, many plants of Taza province

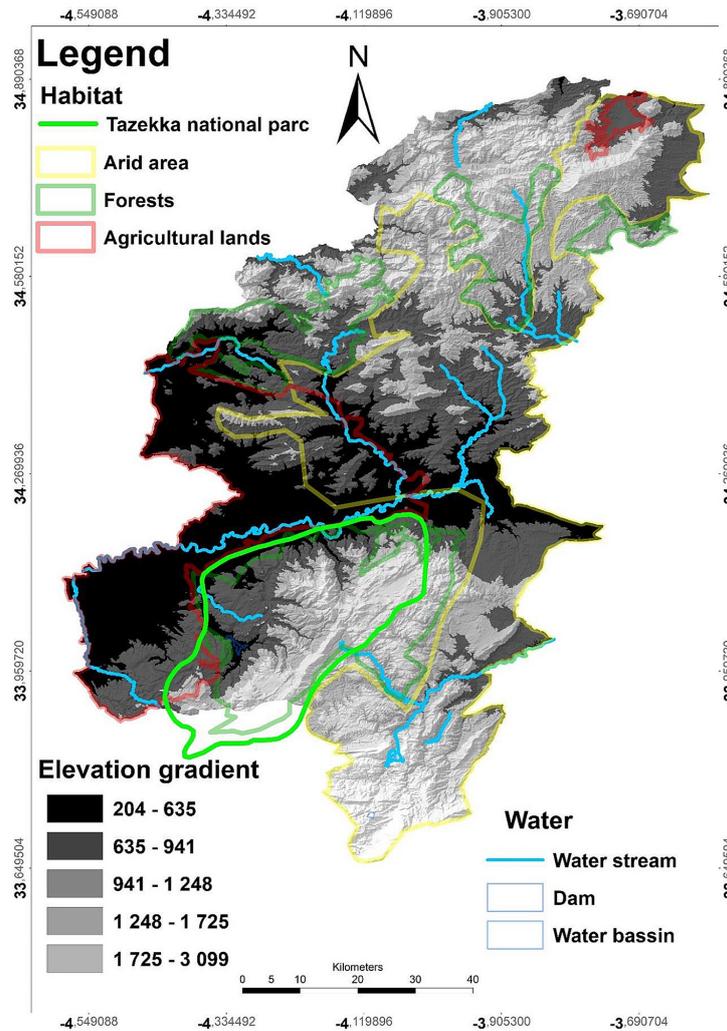


Figure 2. Delimitation of recorded ecosystems and habitats in the province of Taza and Tazekka national park

have showed significant therapeutic uses as recorded by (Haouari et al., 2018; Brahimi et al., 2022). El Haouari et al. (2021) investigated the phytochemical compounds of *Arbutus unedo* and demonstrated that fruits and leaves contain the most significant number of phytochemicals among the species and exhibited anticancer, antioxidant, antibacterial, antiaggregant, antidiabetic, and antihypertensive activities. This study reported other ecosystems counting steppes, and hydrologic systems counting rivers and dams. Similar results were recorded in other studies, including the river of Inaouene (Sghiouer et al., 2023), Oued Lârbaa (Lakhloufi et al., 2021), and the Tamourghout River (Abbach et al., 2021), as well as Ras El Ma Karst Spring (Naoura et al., 2021). Caves are also reported, which is in accord with the results stated by Barrientos et al. (2020) and Benani et al. (2023), who recorded the Chaara and Friouato caves in the Middle Atlas of Taza. The diversity of these ecosystems

could attract tourists, principally Mountain visitors to visit these landscapes. Similar cases were reported in other National Parks of Morocco. For example, Aboutayeb et al. (2017) demonstrated the relationship between the Protected Areas of Souss-Massa Park and Ecotourism. In another study, Lamnadi (2020) mentioned the importance of natural landscapes and cultural heritage in ecotouristic managements of both Talassemthane and Alhoceima National Parks located on the Mediterranean coasts of Morocco.

Diversity of birds

The diversity of avifauna species documented in the province of Taza between 2017 and 2023 is displayed in Figure 3. In total, 86 species were recorded in all visited ecosystems. These birds belonged to 25 families and grouped in 8 orders with different percentages. The most dominant families were Accipitridae and Muscicapidae with 12 and

10 avian species, respectively. Motacillidae and Fringillidae counted 6 species each. In comparison, only one avian species was documented in six families counting Prunellidae, Oriolidae, Upupidae, Meropidae, Troglodytidae, and Sturnidae. Concerning the orders, the Passeriformes was the most dominant with 61 avian species grouped in 20 families, followed by Accipitriformes with 12 bird species grouped in one family. In contrast, Ciconiiformes, Caprimulgiformes, and Bucerotiformes recorded only one species each.

The recorded birds showed different phenological status (Figure 3). Resident-breeder birds were the most dominant with 61 species, followed by migrant-breeders with 25 species. Equally, the recorded avian species showed different conservation statuses. In total, 83 bird species showed least concern conservation status, while three species had different statuses. Further, two birds including *Streptopelia turtur arenicola* and *Carduelis carduelis*, as well as the endangered *Neophron percnopterus*.

This field study provides deep ornithological research of the areas surrounding Taza province. Many studies have addressed birds in the Middle Atlas Mountains and recorded similar results. Achiban et al. (2022) investigated the richness of avian species in the Western zone of Taza and recorded 85 birds counting 60 resident and 25 migrant birds. In another study, Nekhla et al. (2022) investigated the ecological value of steppes dominated by *Chamaerops humilis* for avian richness in the Eastern Middle Atlas near Sefrou. These authors recorded 90 avian species, including 22 migrant breeders. These recorded species can be used in sustainable activities. For example, the Northern bald ibis *Geronticus eremita* was used in ornithological visits for tourists and for students in Souss Massa National Park. Equally, Wakass et al. (2023b) recorded 175 avian species including *Streptopelia turtur*, *Carduelis carduelis*, *Chersophilus duponti*, and *Neophron percnopterus* with ecotouristic purposes. Generally, many tourists conduct bird watching activities, which record significant incomes for local populations.

The present study offers a comprehensive and in-depth analysis of the bird biodiversity within the Bouhelou watershed. A total of 85 avian species, encompassing both resident and migratory populations, were recorded within the designated research regions. The Midelt province, situated in the Southern areas of Morocco, was found to have a total of 131 bird species according to a study

conducted by Mansouri et al. (2019). Similarly, Cherkaoui et al. (2009) reported the existence of 63 bird species in the cork oak forest of Maamora, sited in the Northwest of Morocco. Conversely, the abundance of avian species is sustained by the wide range of environments and the ample supply of resources for breeding and feeding. Indeed, aquatic ecosystems that provide a source of water, agricultural lands that yield grains and insects, as well as woods and orchards that give essential tree species for nesting purposes were documented. Nonetheless, it is imperative to implement conservation measures for these ecosystems and its bird population in order to prevent their decline. Similarly, further comprehensive investigations are required to elucidate the significant role of Moroccan ecosystems in terms of biodiversity and conservation objectives.

Mammalian species

The recorded mammalian species are presented in Figure 3. During field visits and interviews with local residents, 16 mammals belonging to 6 orders and grouped in 10 families were identified. The order of Carnivora was presented by four species, including *Vulpes vulpes* and *Canis anthus* from Canidae, *Lutra lutra* from Mustelidae, and *Genetta genetta* from Viverridae. The order of Artiodactyla was presented by two species including *Sus scrofa barbarous* (Suidae) and the only representative of the Cervidae family in Africa *Cervus elaphus barbarous*. Similarly, Lagomorpha was presented by two species *Lepus capensis* and *Oryctolagus cuniculus* belonging to the family of Leporidae. Two orders including Rodentia and Primates were presented by *Atlantoxerus getulus* (Sciuridae) and *Macaca sylvanus* (Cercopithecidae), respectively. The order of Chiropteran was the most observed with 10 species belonging to 3 families. The Vespertilionidae family was the most abundant with three species, including *Pipistrellus pipistrellus*, *Eptesicus isabellinus*, and *Myotis punicus*. In contrast, Rhinolophidae and Miniopteridae were represented only by one species each, *Rhinolophus hipposideros* and *Miniopterus schreibersii*, respectively. These species were detected in caves and foraging areas, as presented in Figure 3. The distribution of recorded species was variable among the ecosystems of the study area. This study is the first to reveal the existence of *Macaca sylvanus* and *Cervus elaphus barbarous* in Taza province and the entire eastern

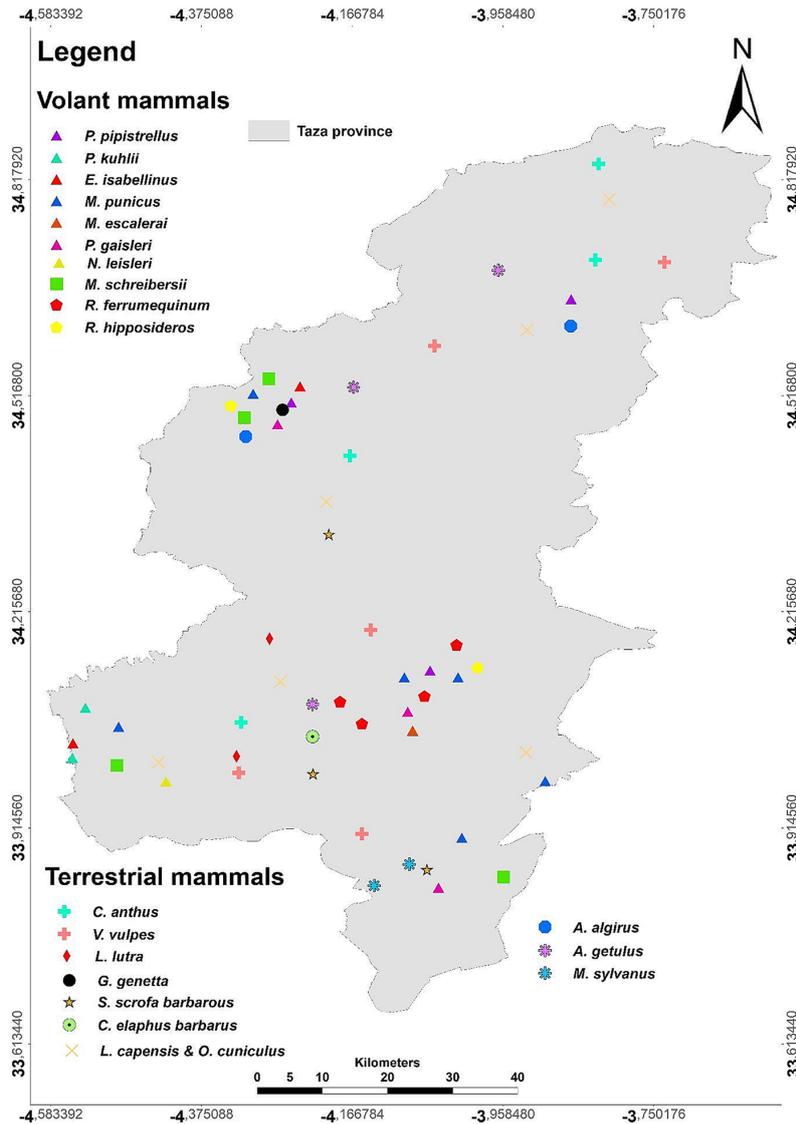


Figure 3. Distribution of recorded mammals in Taza province (Northwest of Morocco)

region of Morocco. *Macaca sylvanus* is the only representative species of Cercopithecidae in Africa (Ciani et al., 2005; Bergin et al., 2018), which is more present in Asia (Frost, 2017), while *Cervus elaphus barbarus* is the only representative of Cervidae family in North Africa (Ismaili et al., 2018). *Macaca sylvanus* was previously reported in the Middle Atlas near Azrou and Khenifra, and the Central and Western High Atlas near Marrakech and Azilal, respectively (Machairas et al., 2003; El Alami et al., 2012; Namous et al., 2017). This species is highly appreciated by local and international visitors, and sometimes is sold for show and rearing purposes (Bergin et al., 2018). Similarly, *Cervus elaphus barbarus* is highly appreciated by visitors. Therefore, these species need to be protected. On the other hand, important populations of chiropteran species

were recorded, which is in accord with the results registered by Baadi et al. (2021) and Baadi and Lebreton (2023) in the same area. These species could attract visitors to caves to discover the cavernicole mammals (Chiarini et al., 2022).

Accessibility and infrastructures

The road network and tourism facilities of Taza province and Tazekka province are presented in Figure 4. The total distance of roads in the study area was estimated at 587.15 km. These roads were divided into four types, including highway, regional, national, and provincial roads. The recorded roads were pointed with an important number of diesel stations (4 stations) distributed only on highway and national roads. Equally, many hotels and tourist complexes were recorded in the study

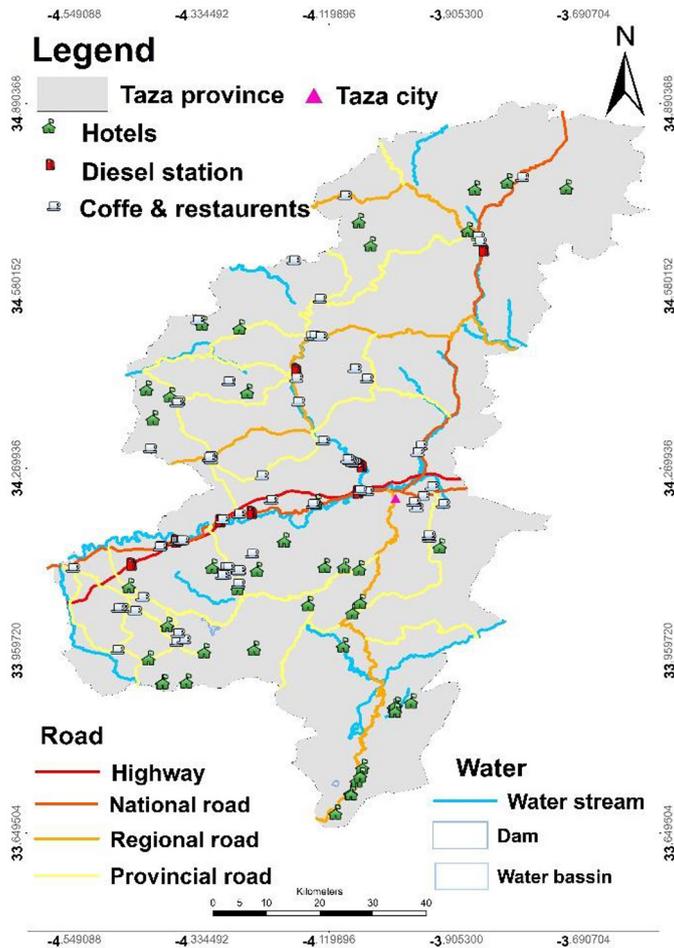


Figure 4. Road network and tourism facilities in Taza province

areas. This infrastructure was divided into hotels, lodges, and apartments with touristic destinations. Similarly, the study area comprises restaurants and coffees which offer food and services.

Morocco is one of the most important touristic destinations on regional and international scales (Gourfi et al., 2022; Ouali et al., 2022). In terms of touristic infrastructures, Morocco possesses developed road networks, hotels, and restaurants distributed throughout the entire country (Arcila Garrido et al., 2016; Bouzekraoui et al., 2018; Boulakhbar et al., 2020; Ouariti and Jebrane 2020). (Chehlafi et al., 2019) recorded an important portion of the road network counting highways in Taza province and many authors recorded the importance of some geological sites in offering materials for the construction of roads (Ettayeb et al., 2023). In a current study, Taher et al. (2023) recorded some high-end brand international hotels in Taza province such as Radisson hotels and Souani Hotel, which is in agreement with the results obtained in this paper. In

another study, El-Ammari et al. (2020) reported a diversity of restaurants and dietary habits of local populations in Taza, which are suggested to meet the requirements of visitors, principally with local dishes such as ‘Tagine’ and ‘Harira’ known for their nutritive quality and good presentation.

Socioeconomic activities of residents and visitors

The field questionnaire addressed the local populations and visitors of Tazekka National Park. The participants (600) were aged from 20 to 50 years old. The totality of participants was male, while women were absent among the investigated persons. The local populations benefit from the land and natural landscapes to realize their activities. The most important activities were agriculture, commerce, pastoralism, transport, wood manufacturing, tourism activities, restaurants, and artisanal activity (Table 1). These activities have great economic incomes for the local population. Equally,

Table 1. Principal socioeconomic features recorded in Tazekka National Park (Taza province)

| Specification | Principal activities | Destination of production | Participants |
|--------------------|----------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------|------------------------------------------|
| Agriculture | Olives, cereals, vegetables, | Local markets and exportation | Local residents |
| Commerce | Big markets, medium markets, and Traditional souks, | Local markets and exportation | Local residents and investors |
| Pastoralism | Cattle, sheep, and goats | meat, eggs, milk, fur, leather, and wool for local markets | Local residents (nomads) |
| Transport | Drivers of buses, taxis, and car rental | Cities, Tazekka Park, and other landscapes. | Local residents and investors |
| Wood manufacturing | Tree harvesting, lumber, and wood products | Plywood, timber for framing, woodworking, and wood industry | Local residents, investors, and tourists |
| Tourism activities | Trips, cycling, walking and hiking, mountain biking, canoeing, fishing, and water sports | Local, national, and international tourists | Local residents, visitors, and investors |
| Restaurants | Food services, traditional dishes, and sale of local food products, | Visitors and local populations | Local residents, visitors, and investors |
| Artisanal | Carpets, traditional clothing, jewelry, ceramics, pottery, wrought iron, marquetry, tree, plaster, zellige, and dinanderie | Visitors and local populations | Local residents, visitors, and investors |

visitors bring significant incomes to the area, including transport, restaurants, hotels, and commerce. Generally, tourists visit aquatic ecosystems, such as dams and rivers; forest landscapes, spiritual sites; historical monuments; and caves. In Morocco, many studies have investigated the socioeconomic features of local populations in protected areas. El-Bekky et al. (2013) and Ben-Haddad et al. (2023) assessed the economy of Ramsar site of Massa in the south of Morocco. Similarly, Redouan et al. (2022) addressed the social and economic aspects of local inhabitants of Talassemtane National Park in northern Morocco. These studies reported different activities among local populations of protected areas. Redouan et al. (2022) recorded the dominance of males among participants in Talassemtane National Park, which is in agreement with the obtained results. Boukherouk and Ed-Dali (2019) reported the dominance of agriculture, pastoralism, and touristic activities in Souss Massa National Park. In another study, Zouiten (2021) reported the dominance of agricultural activities in Tazekka Park via a Cellular Automata-Markov Modeling of Satellite Images. These are in agreement with the obtained results and this study reported for the first time the interaction between visitors and local residents and how the activities of residents affect local and international markets, which is suggested to increase the incomes.

CONCLUSIONS

In review, throughout this investigation, the diversity of natural ecosystems, animal species,

and vegetation cover in Taza province and Tazekka National Park was recorded. Equally, the touristic infrastructures and road networks, which are proposed to participate with a key role in sustainable activities, were assessed. The obtained results showed a significant diversity of ecosystems (forests, farmlands, steppes, and caves) that support a high richness of avian and mammalian species with foraging and breeding resources. These ecosystems and their associated faunae could attract local, national, and international tourists to observe the natural sites and most attractive faunae. Equally, the road network was diversified (highway, national, regional, and provincial roads) and is suggested to increase the accessibility of tourists to visit recorded landscapes and their associated species. In the same sense, the study area includes hotels, restaurants, coffee stations, and touristic complexes, which are suggested to offer necessary food and services. These results are of great interest for sustainable tourism, local populations, and conservation purposes. Natural landscapes, florae and faunae, and infrastructures offer attractive opportunities for visitors, while tourists offer a source of income for local populations. Therefore, local populations and authorities are invited to protect these natural resources to ensure the sustainability of touristic activities. However, deeper studies are urgently needed to delimit the sites that need to be visited and those where human activities need to be forbidden. Equally, the habitats of breeding for threatened species need to be investigated in order to reduce the effect of visitors on their breeding features.

Acknowledgements

We are grateful to our colleagues Anas Alaoui and Abdelkader Chellik who helped in collecting data.

REFERENCES

1. Abbach J., Talibi H.E., Moussaoui S.E., Dekkaki H.C. Etebaai I. 2021. Geological and geomorphic investigations on palaeo-landslide dammed the Tamourghout River (Middle Atlas, Morocco). E3S Web Conf. 298, 01003.
2. Aboutayeb H., Beraouz M. Ezaidi A. 2017. The great catchment of Souss-Massa Wadi (Morocco): relationship between protected areas and ecotourism. In: Choukr-Allah R., Ragab R., Bouchaou L., Barceló D. (eds), The Souss-Massa River Basin, Morocco, Springer International Publishing, Cham. 285–302
3. Achiban H., Mansouri I., Squalli W., Achiban H., Lagsaibi H., Afenzar M. Taous A. 2022. Avifauna of the Oued Bouhellou Valley (Morocco): remarkable diversity, five new breeding cases and mapping of nesting sites. Zoology and Ecology, 32, 36–48.
4. Arcila Garrido M., Sánchez J.A., Chica Ruiz J., Cayeiro M. 2016. Moroccan tourism strategy: its repercussions on sun and beach tourism in the Tangier-Tetouan Region. International Journal of Humanities and Social Science Invention, 5, 47–56.
5. Baadi K., Lebreton B. 2023. Exo and endokarst of the middle atlas (morocco): from inventory to promotion. pp. 143–166. In: Baadi K. (eds), Geoheritage of the Middle Atlas (Morocco), Springer International Publishing, Cham.
6. Baadi K., Lebreton B., Sabaoui A., Atrops F. 2021. The karst of the Northern Middle Atlas (Morocco): an Invaluable Heritage to Inventory. Geoheritage, 13(37).
7. Barataud J. 2021. Caractérisation acoustique des différentes espèces du genre *Phaneroptera* Audinet-Serville, 1831 en Europe occidentale, et description d'une nouvelle espèce cryptique en France et en Espagne (Orthoptera, Tettigoniidae, Phaneropterinae). Zoos. 43, 691–727.
8. Barrientos J.A., Brañas N. Mederos J. 2020. The high complexity of Micronetinae Hull, 1920 (Araneae, Linyphiidae) evidenced through ten new cave-dweller species from the Morocco. Zoos. 42, 1–29.
9. Benani H., Nehili A., Ouzaouit L.A. Boudad L. 2023. Geomorphological study of the endo-arst of the Middle Atlas as a geological heritage to be preserved, case of the chaara cave, Province of Taza. pp. 167–182. In: Baadi K. (eds), Geoheritage of the Middle Atlas (Morocco), Springer International Publishing, Cham.
10. Ben-Haddad M., Abelouah M.R., Hajji S., Bergayou H., Rangel-Buitrago N., Alla A.A. 2023. Comparative study of pristine and polluted estuaries in Souss Massa National Park (Morocco): Implications for conservation strategies. Marine Pollution Bulletin. 192, 115053.
11. Bergin D., Atoussi S., Waters S. 2018. Online trade of Barbary macaques *Macaca sylvanus* in Algeria and Morocco. Biodiversity and Conservation, 27, 531–534.
12. Boukherouk M., Ed-Dali R. 2019. Tourism, local, communities and environmental governance: analysis of the Souss Massa nature park governance in Morocco. Athens Journal of Tourism. 6, 245–276.
13. Boulakhbar M., Lebrouhi B., Kousksou T., Smouh S., Jamil A., Maaroufi M. Zazi M. 2020. Towards a large-scale integration of renewable energies in Morocco. Journal of Energy Storage. 32, 101806.
14. Bouzekraoui H., Barakat A., Mouaddine A., El Youssi M., Touhami F. Hafid A. 2018. Mapping geoheritage for geotourism management, a case study of Aït Bou Oulli Valley in Central High-Atlas (Morocco). Environ Earth Sci, 77, 413.
15. Brahimi R., El Barnossi A., Amrani M. Bari A. 2022. Ethnobotanical study and biodiversity of medicinal plants used in the province of Taza North-Eastern Morocco. 6, 1814–1831.
16. Chehlafi A., Kchikach A., Derradji A., Mequedade N. 2019. Highway cutting slopes with high rainfall erosion in Morocco: Evaluation of soil losses and erosion control using concrete arches. Engineering Geology. 260, 105200.
17. Cherkaoui I., Selmi S., Boukhriss J., Hamid R.I., Mohammed D. 2009. Factors affecting bird richness in a fragmented cork oak forest in Morocco. Acta Oecologica, 35, 197–205.
18. Chiarini V., Duckeck J., De Waele J. 2022. A global perspective on sustainable show cave tourism. Geoheritage, 14(82).
19. Chong K.L. 2020. The side effects of mass tourism: the voices of Bali islanders. Asia Pacific Journal of Tourism Research. 25, 157–169.
20. Ciani A.C., Palentini L., Arahou M., Martinoli L., Capiluppi C., Mouna M. 2005. Population decline of *Macaca sylvanus* in the middle atlas of Morocco. Biological Conservation. 121, 635–641.
21. Conesa H.M., Jiménez-Cárceles F.J. 2007. The Mar Menor lagoon (SE Spain): A singular natural ecosystem threatened by human activities. Marine Pollution Bulletin, 54, 839–849.
22. Dudley N. Alexander S. 2017. Agriculture and biodiversity: a review. Biodiversity. 18, 45–49.
23. Edaoudi A., Houssas M., Lahfidi A. 2021. Sustainable tourism; vector of the social and solidarity economy: case of region Souss Massa, South of Morocco. 201–213.
24. El Alami A., Van Lavieren E., Rachida A., Chait

- A. 2012. Differences in activity budgets and diet between semiprovisioned and wild-feeding groups of the endangered Barbary macaque (*Macaca sylvanus*) in the Central High Atlas Mountains, Morocco. *American Journal of Primatology*, 74, 210–216.
25. El Menyari Y. 2021. Effect of tourism FDI and international tourism to the economic growth in Morocco: Evidence from ARDL bound testing approach. *Journal of Policy Research in Tourism, Leisure and Events*, 13, 222–242.
26. El-Ammari A., Kazdough H.E., Bouftini S., Fakir S.E., Achhab Y.E. 2020. Social-ecological influences on unhealthy dietary behaviours among Moroccan adolescents: a mixed-methods study. *Public Health Nutrition*. 23, 996–1008.
27. El-Bekky M., Moukrim A.I. Benchakroun F. 2013. An economic assessment of the Ramsar site of Massa (Morocco) with travel cost and contingent valuation methods. *African Journal of Environmental Science and Technology*, 7, 441–447.
28. Ettayeb M., Chaoui A., Cherifi H. 2023. Reuse of Taza marl-limestone in Morocco for road construction. *Materials Today: Proceedings*. 72, 3420–3426.
29. Fougrach H., Badri W., Malki M. 2007. Flore vasculaire rare et menacée du massif de Tazekka (région de Taza, Maroc). *Bulletin de l'Institut Scientifique, Rabat, section Sciences de la Vie*. 29: 1–10.
30. Frost S. 2017. Evolution of the Cercopithecidae. *The international encyclopedia of primatology*. 2017(2), 1–3.
31. Garau-Vadell J.B., Gutierrez-Taño D., Diaz-Armas R. 2018. Economic crisis and residents' perception of the impacts of tourism in mass tourism destinations. *Journal of Destination Marketing Management*. 7, 68–75.
32. Gourfi A., Taïbi A.N., Salhi S., Hannani M.E., Boujrouf S. 2022. The surface urban heat island and key mitigation factors in arid climate cities, case of Marrakesh, Morocco. *Remote Sensing*. 14, 3935.
33. Haouari M., el Makaoui S., Jnah M., Haddaouy A. 2018. A survey of medicinal plants used by herbalists in Taza (Northern Morocco) to manage various ailments. *Journal of Materials and Environmental Science*, 9, 1875–1888.
34. Heshmati M., Gheitury M., Shadfar S. 2022. Factors affecting possibility of ecotourism development and sustaining natural resources using SWOT approach in west Iran. *International Journal of Geoheritage and Parks*. 10, 173–183.
35. Ismaili B., Diouri M., Ouïjja A. 2018. Getting the dietary knowledge to restore a missing species: seasonal diet of Atlas deer *Cervus elaphus barbarus* in Tazekka National Park, Morocco. *Wildlife Biology*, 2018, wlb.00387.
36. Jovanovic S., Ilic I. 2016. Infrastructure as important determinant of tourism development in the countries of Southeast Europe. *Ecoforum*, 5, 1(8), 288–294.
37. Kagermeier A., Amzil L., Elfasskaoui B. 2019. The transition of governance approaches to rural tourism in Southern Morocco. *European Journal of Tourism Research*, 23, 40–62.
38. Kamal S., Khalid A., Amal E.K., Lahcen Z., Jamila D., Nadia B. 2023. Diversity of the Bryoflora of the Tazekka National Park, North-East Morocco, 645–672.
39. Kerbirou C., Bas Y., Le Viol I., Lorrilliere R., Mougnot J., Julien J.F. 2019. Potential of bat pass duration measures for studies of bat activity. *Bioacoustics*, 28, 177–192.
40. Kumar R., Verma A., Shome A., Sinha R., Sinha S., Jha P.K., Kumar R., Kumar P., Shubham, Das S., Sharma P., Vara Prasad P.V. 2021. Impacts of plastic pollution on ecosystem services, sustainable development goals, and need to focus on circular economy and policy interventions. *Sustainability*, 13, 9963.
41. Lakhroufi M.Y., Lamchouri F., El Haisoufi M., Boulfia M., Zalaghi A., Toufik H. 2021. Evaluation of anthropic activities impact through the monitoring of aquatic fauna on Oued Lârbaa in Taza City of Morocco. *Environ Monit Assess*, 193, 153.
42. Lamnadi Y. 2016. Signs of hope or wrong way? The implementation of ecotourism as a touristic product within Morocco destination. In: Blázquez, M., Mir-Gual, M., Murray, I.Y., Pons, G.X. (eds.). *Turismo y crisis, turismo colaborativo y ecoturismo*. XV Coloquio de Geografía del Turismo, el Ocio y la Recreación de la AGE. *Mon. Soc. Hist. Nat. Balears*, 23, 357–367.
43. Lamnadi Y. 2020. Ecotourism as a tool for natural and cultural heritage conservation: A case study of Alhoceima and Talassemtane national parks from Northern Morocco. *Universitat Rovira i Virgili*, 435.
44. Machairas I., Camperio Ciani A., Sgardelis S. 2003. Interpopulation differences in activity patterns of *Macaca sylvanus* in the Moroccan Middle Atlas. *Hum. Evol.* 18, 185–202.
45. Mahmoud R., Hjouji K., Mehdaoui I., Saoudi Hasani E.M., Ben Abbou M., Majbar Z., Taleb M., Rais Z. 2023. The needles of aleppo pine from the province of taza-morocco—a biomaterial of great potential. *Journal of Ecological Engineering*, 24(1), 41–50.
46. Maldonado-Oré E.M. Custodio M. 2020. Visitor environmental impact on protected natural areas: An evaluation of the Huaytapallana Regional Conservation Area in Peru. *Journal of Outdoor Recreation and Tourism*, 31, 100298.
47. Mansouri I., Al-Sadoon M.K., Rochdi M., Paray B.A., Dakki M. Elghadraoui L. 2019. Diversity of feeding habitats and diet composition in the turtle doves *Streptopelia turtur* to buffer loss and modification of natural habitats during breeding season.

- Saudi Journal of Biological Sciences. 26, 957–962.
48. del Mar Alonso-Almeida M. 2012. Water and waste management in the Moroccan tourism industry: the case of three women entrepreneurs. *Women's Studies International Forum*, 35, 343–353.
 49. Maxwell S.L., Cazalis V., Dudley N., Hoffmann M., Rodrigues A.S.L., Stolton S., Visconti P., Woodley S., Kingston N., Lewis E., Maron M., Strassburg B.B.N., Wenger A., Jonas H.D., Venter O. Watson J.E.M. 2020. Area-based conservation in the twenty-first century. *Nature*, 586, 217–227.
 50. Mirari S., Aoulad-Sidi-Mhend A., Benmlih A. 2020. Geosites for Geotourism, Geoheritage, and Geoconservation of the Khnefiss National Park, Southern Morocco. *Sustainability*, 12(17), 7109.
 51. Mohamed H. Rachid D. 2019. Assessing sustainable tourism: trends and efforts in Essaouira in Morocco as a coastal city. *International Journal of Sustainability Management and Information Technologies*, 5, 23.
 52. Mohammed Zouiten J.C. 2021. Predicting land use changes within the Tazekka park and its borders via a cellular automata-Markov modeling of satellite images. *Journal of Southwest Jiaotong University*, 56(2).
 53. Namous S., Znari M., Baamrane M.A.A., Naimi M., Aourir M., Siess J. Mokhtari S. 2017. Size and structure of the southernmost population of the Endangered Barbary macaque *Macaca sylvanus* in the western Moroccan High Atlas. *Oryx*, 51, 694–700.
 54. Naoura J., El Kati I., Benaabidate L. 2021. Assessment of Ras El Ma Karst Spring Features by Structural and Functional Approaches at the Region of Taza, Morocco. *Journal of Ecological Engineering*, 22(9), 2021.
 55. Nekhla H., Mansouri I., Zahri A., Squalli W., Achiban H., Hmidani M., El Agy A., Harrach A. El Ghadraoui L. 2022. The ecological importance of *Chamaerops humilis* steppe for animal biodiversity in Northwest Africa (Morocco). *Zoology and Ecology*, 74–83.
 56. Ouali L., Hssaisoune M., Kabiri L., Slimani M.M., El Mouquaddam K., Namous M., Arioua A., Ben Moussa A., Benqlilou H. Bouchaou L. 2022. Mapping of potential sites for rainwater harvesting structures using GIS and MCDM approaches: case study of the Toudgha watershed, Morocco. *Euro-Mediterr J Environ Integr*, 7, 49–64.
 57. Ouariti O.Z., Jebrane E.M. 2020. The impact of transport infrastructure on tourism destination attractiveness: A case study of Marrakesh City, Morocco. *African Journal of Hospitality, Tourism and Leisure*, 9(18).
 58. Redouan F.Z., Yebouk C., Crisafulli A., Picone R.M., Merzouki A. 2022. Ethnopharmacological preparations used for digestive system disorders in Talassemtane National Park (North of Morocco). *Ethnobotany Research and Applications*, 24, 1–25.
 59. Saadi K., Dahmani J., Zidane L., Belahbib N. 2020. Contribution to the bryoflora inventory of jbel Tazekka (middle eastern atlas, Morocco): new data on the presence of new, rare or abundant species. 20(2), 4639-4647.
 60. Sahni H., Nsiah C., Fayissa B. 2021. The African economic growth experience and tourism receipts: A threshold analysis and quantile regression approach. *Tourism Economics*, 27, 915–932.
 61. Sghiouer F.E., Nahli A., Bouka H., Chlaida M. 2023. Evaluation of the effects of riparian population activities on the physicochemical quality of water in a Mediterranean river: the Inaouene River (Taza, North East Morocco). *Asian Journal of Water, Environment and Pollution*, 20, 93–100.
 62. Taher M., Mourabit T., Bourjila A., Errahmouni A., Lamgharbaj M. Etebaai I. 2023. Assessment of coastal caves in Nekor bay - North-eastern Morocco: Development Opportunities of Caves Tourism, 10(16).
 63. Teff-Seker Y., Berger-Tal O., Lehnardt Y., Teschner N. 2022. Noise pollution from wind turbines and its effects on wildlife: a cross-national analysis of current policies and planning regulations. *Renewable and Sustainable Energy Reviews*, 168, 112801.
 64. Veicy H. 2015. A study of the effect of political ideology on tourism industry (case study: Iran). *Journal of Tourism Planning and Development*, 4, 45–66.
 65. Wakass S., Ezaidi A., El Youssi M., Mansouri I., Achiban H., Chellik S., El Azzouzi M. 2023a. Geosites of high atlas of Marrakech (Morocco): geological characterization, accessibility, and potential interests for sustainable tourism. *Geoheritage*, 15(107).
 66. Wakass S., Mounir M., Squalli W., Mansouri I., Dbiba Y., Hmidani M., Chellik S., Douini I., Youssi M.E. Azzouzi M.E. 2023b. Diversity of avian species, their ecosystems and climate conditions in two zones of High Atlas (central Morocco) for ecotouristic purposes. *Journal of Animal Behaviour and Biometeorology*, 11, 0–0.
 67. Wudu K., Abegaz A., Ayele L., Ybabe M. 2023. The impacts of climate change on biodiversity loss and its remedial measures using nature based conservation approach: a global perspective. *Biodivers Conserv*, 32(12), 3681–3701.
 68. Yee J.Y., Loc H.H., Poh Y.L., Vo-Thanh T., Park E. 2021. Socio-geographical evaluation of ecosystem services in an ecotourism destination: PGIS application in Tram Chim National Park, Vietnam. *Journal of Environmental Management*, 291, 112656.