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Research Article

Floristic Diversity and Evaluation of the Potential of Spontaneous Medicinal Plants in the Bigoudine Watershed (Moroccan Western High Atlas)

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The Bigoudine watershed (Western High Atlas) enjoys a floristic originality and a large number of plant species of therapeutic and aromatic interest widely used by the local population in traditional medicine. This region is subject to very difficult geographical conditions and is occupied by a poor population with a fairly high rate of illiteracy. Ethnobotanical surveys and floristic and phytoecological surveys carried out in two periods, the first in 2003–2004 and the second in 2016–2018, made it possible to identify the spontaneous medicinal flora and assess the potential of medicinal and aromatic plants in the region. The assessment of the biomass potential is carried out on three medicinal species among the most widely used plants in the area, *Thymus pallidus* Coss. ex Batt, *Lavandula dentata* L., and *Salvia lavandulifolia* Vahl. The results obtained made it possible to catalog 57 spontaneous medicinal species divided into 44 genera and 26 families, the most dominant of which are *Lamiaceae*, *Asteraceae*, *Amaranthaceae*, *Anacardiaceae*, *Asparagaceae*, *Cistaceae*, *Cupressaceae*, *Fabaceae,* and *Oleaceae*. The location of these species has been identified, and the plant formations concerned have been delimited. The estimated biomass potential of *Thymus pallidus* Coss. ex Batt, *Lavandula dentata* L., and *Salvia lavandulifolia* Vahl. varies according to species, types of plant formations, their structures, and their biological states. This spontaneous medicinal floristic wealth, within the region studied, is exposed to severe socioeconomic conditions, which are the main causes of non-respectful exploitation of natural resources threatening their balance and sustainable regeneration. Medicinal and aromatic plants in the Bigoudine watershed region require adapted measures allowing the rational development of certain potentially exploitable plants and the conservation of heavily used and threatened species.

1. Introduction

The Moroccan Western High Atlas presents a floristic diversity, rich in endemic species, favoured mainly by an orographic and climatic contrast presenting a variety of bioclimate and a high heterogeneity of ecological habitats [1].

The region of the Bigoudine watershed, part of the Western High Atlas, enjoys a floristic originality with a large number of plants of therapeutic interest widely used by the poor local population with a very high illiteracy rate.

The diversity of plant species, used in traditional medicine, is considered among the major alternative sources of this rural mountain population to compensate for the lack of health infrastructure in this area, despite the current existence of very advanced modern medicine in our country.

To contribute to the development of the national flora used in traditional Moroccan medicine and to highlight the traditional herbal medicine practiced in this Moroccan mountainous rural area, ethnobotanical surveys using questionnaire sheets, carried out in 2016–2019, made it possible to identify 258 medicinal and aromatic species used

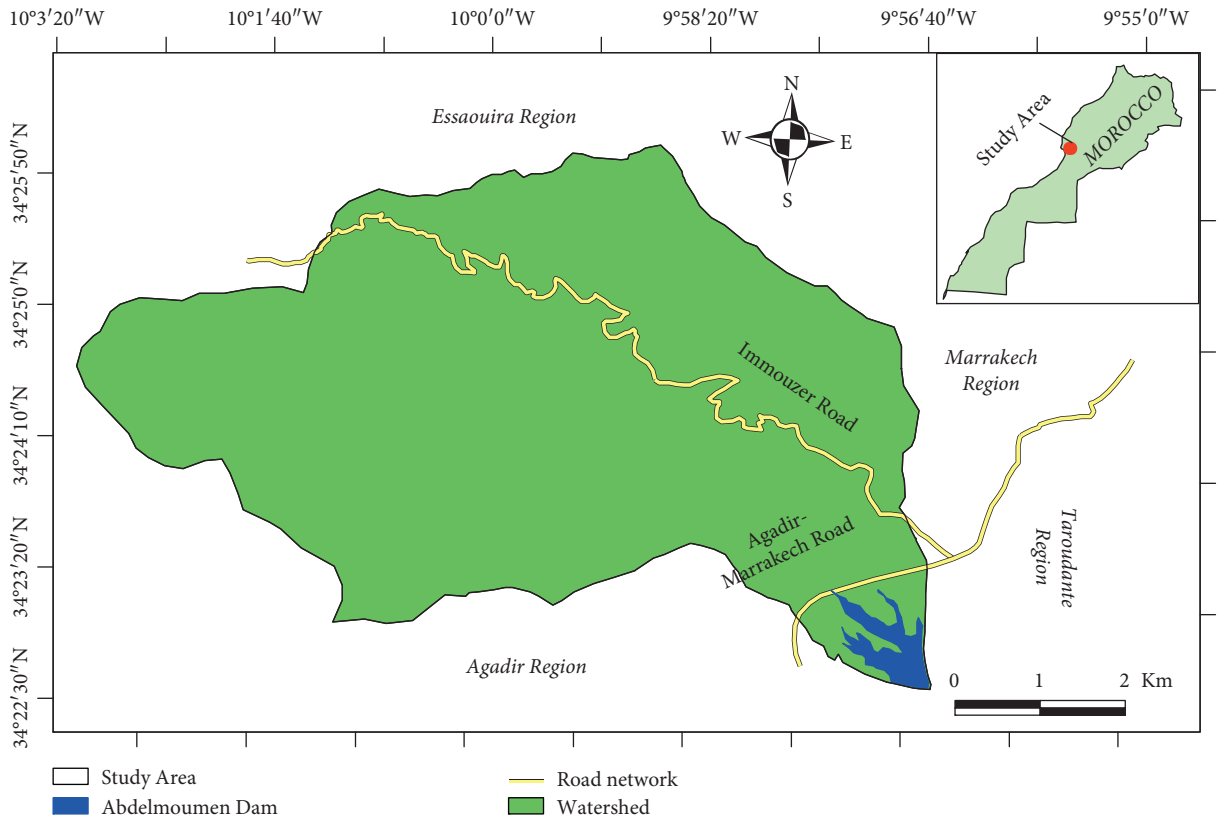


Figure 1: Situation map of the Bigoudine watershed region and the limits of the study area [3].

by the local population in traditional medication, of which 57 species are spontaneous in the region of the Bigoudine watershed and are the subject of this study. The results of the study, the subject of another article, showed that the most used part of the plant material is the leaf, as well as the majority of the remedies, which are prepared in the form of a decoction. However, this plant material, used in traditional daily care and in many informal commercial activities, is under significant anthropogenic pressure.

Indeed, this study showed that the living conditions, within the studied region, constitute the main causes of the overexploitation of natural resources and its sustainable regeneration. It is therefore becoming urgent that the local medicinal plant heritage must be preserved in its diversity and in its natural extent through a sustainable management approach. To do this, the promotion of medicinal and aromatic plants in the region is an activity, which is justified by the richness and diversification in spontaneous plants and also by their significant and potentially exploitable recoveries, thus through their essential roles in the subsistence economy in rural areas [2].

The rich flora and the biomass potential of spontaneous medicinal plants in the region call for conservation measures to allow the creation of employment for the benefit of the local rural population through the implementation of income-generating actions such as a system for the production of essential oils and dried plants. These types of actions are highly recommended for the safeguard and conservation of this natural heritage meeting the requirements of local sustainable development. These measures must relate to the rational valuation of certain potentially exploitable plants, in order to reduce the anthropogenic pressure, which threatens the sustainability of these natural environments.

The overall objective of this research work, which is part of an ethnobotanical, floristic, and ecological study, was to show the diversity and richness of the region in spontaneous medicinal species and to assess the biomass potential of some medicinal species.

The specific objectives assigned to this work are as follows:

(i) Identify spontaneous AMPs and their distribution in the study region

(ii) Estimate the biomass production potential of three species among the most used in the region

(iii) Propose measures for the conservation and enhancement of AMP

2. Material and Methods

2.1. Presentation of the Study Area. The Bigoudine watershed region is located in the Western High Atlas between the geographical coordinates 30°42′ and 30°48′ north latitude and 9°10′ and 9°18′ west longitude about 70 km north of the city of Agadir on the national road to Marrakech (Figure 1).

2.2. Weather. The climate of the region, which is of the typical Mediterranean type [4], is generally characterized by

its aridity. The presence of certain local factors such as the orography, the exposure of the slopes, and the degree of continentality, in this study region, is linked to the action of the north and northwest winds of the northern regions, which brings precipitation and humidity in winter, and that of southerly and southeasterly winds "Chergui" from tropical regions, which brings heat and drought in summer [5]. Also, the presence of Atlantic Ocean currents has a moderating influence on the climate and on the distribution of vegetation.

2.3. Geology. This study area belongs to the Western High Atlas, which does not have the appearance of high mountains [6]. The region is made up of a mosaic of topographic forms represented by a majority of mountains and ridges and plateaus.

It is located at the level of the Argana Corridor (the corridor is located between the regions of Agadir passing through the basin towards the region of Marrakech; Figure 1), which constitutes a well-marked depression between the ancient massif of the High Atlas and the Western Atlas. This region is composed of dolomitic limestones and fine sandstones and clays of the Permotrias and Regosols, and on the lower level appear the rocks of the secondary and primary (Saharan and Devonian) sandstones, schists, and clays [7–9].

The lithology is varied in this region. Precambrian and primary schists and quartzites are mainly found; limestones and dolomites form plateaus, which retain traces of the leveling surfaces; and finally, the Triassic clays and sandstones are found in which the Argana Corridor was formed [10].

3. Methodology

3.1. Ethnobotanical Approach. The ethnobotanical approach makes it possible to invent the plants used in traditional medicine and to constitute a national medicinal flora in order to safeguard the knowledge and popular knowledge of the different regions of Morocco. For this, many ethnobotanical and ethnopharmacological research has been carried out in various Moroccan universities to preserve the knowledge accumulated by the various local populations and to protect the floristic diversity, namely Kahouadji [11], Mehdioui & Kahouadji [12], Hseini [3], Lahsissene et al. [10], Ghourri et al. [13], Tahri et al. [14], El Hafian et al. [2], El Hilah et al. [15], Hachi et al. [16], Akka et al. [6], El Alami & Chait [17], Rhattas et al. [18], and Slimani et al. [19].

Following this research work, this floristic and ecological study, within the area, was preceded by ethnobotanical surveys. The latter allowed us to collect data relating to the plants used in local traditional herbal medicine, and this is from the questionnaire sheets.

3.2. Sampling Method. To carry out our work and to delimit the environments to be prospected, we are inspired by the "stratified" sampling method [4], which seemed to us to be the practical and appropriate way to choose the strata to be prospected. The strata were made from the following maps: hydraulic, topographic, population, and vegetation to delimit the area of the basin. Subsequently, we produced a map of the main plant formations identified (facies I, II, and III) within which we carried out our sampling.

Our floristic and ecological study, within the area, was preceded by ethnobotanical surveys. These ethnobotanical surveys enabled us to collect data relating to plants used in local traditional herbal medicine.

To carry out our work and to delimit the environments to be prospected, we were inspired by the "stratified" sampling method [4], which seemed to us to be the practical and suitable means for choosing the strata to be prospected. Sampling is carried out by following transects passing through the main plant formations.

The spontaneous medicinal species, used and recognized a priori by the population, are identified in the surveys carried out in the field. For each sampling station, the surveys were carried out over an area of 400 m^2, which is generally of the same order, particularly when operating in the forest domain [20]. The survey was carried out on a homogeneous "plot" surface, where the structure of the vegetation, the floristic composition, and the ecological conditions are more or less equal at its various points [20].

The transect was chosen based on the variation in vegetation and topography. The samples were taken during the spring and summer seasons for the period 2016–2019 (at the time of the harvesting of medicinal plants by the local population).

3.3. Determination of Harvested Species. The recognition of the medicinal species harvested is validated by the users before identification and determination. Species determination was carried out jointly with the Botanical Laboratory—Mohammed V Agdal University in Rabat, using available herbaria and by comparison with samples from the National Herbarium of the Scientific Institute and those from the Veterinary and Agronomic Institute of Rabat and by a certain number of essential works such as the catalog of plants of Morocco [13, 17, 21, 22], the Med-Checklist [23], the Flora of North Africa [24, 25], and Nouvelles Floras of Algeria and the southern desert regions [26]. Other more recent works have been used for species recognition such as catalogs of vascular plants of northern Morocco, including identification keys from Valdés et al. [27], Flore du Maroc, manual for the determination of vascular plants [15, 28], vascular flora of Morocco: inventory and chorology [29, 30], and practical flora of Morocco [15, 31, 32]. The angiosperm phylogenetic classification system [11, 33] that redefining families was used for this taxonomic level.

3.4. Potential Assessment Approach. The parameter chosen to assess the production potential of the selected species, *Thymus pallidus* subsp. *pallidus*, *Lavandula dentata* L., and *Salvia lavandulifolia* subsp. *blancoana*, is the phytomass relating to the aerial part and expressed in green matter (MV).

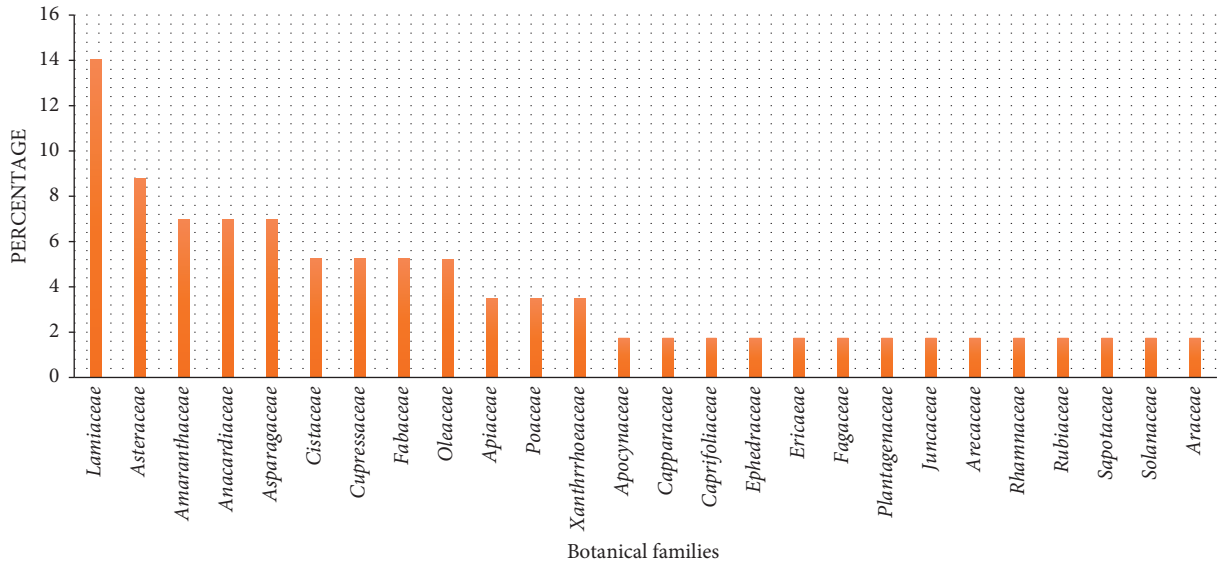


Figure 2: Distribution of botanical families according to specific medicinal richness. Classification of the degree of toxicity of species.

The methodological approach was based on a phytoecological diagnosis carried out on ninety survey points (90 plots) each distributed among the different homogeneous plant strata. To estimate the phytomass of the species, we used an extrapolation formula that takes into account the quantity of the species weighed, the area cut, and the cover of the species (relative to 400 m^2).

$$Q_{1m^2} = \frac{Q_c}{S_c},$$

$$Q_{400m^2} = Q_c * R\% * \frac{400\,m^2}{S_c}, \quad (1)$$

$$Q_{ha} = \frac{Q_{400m^2}}{0.04},$$

where Q_c: amount cut from the species, S_c: cut area, R%: coverage of the species compared with 400 m^2, $Q_{1\,m^2}$: quantity of the species over 1 m^2 (case where the Sc is not 1 m^2), $Q_{400\,m^2}$: quantity of the species over 400 m^2, and Q_{ha}: quantity of the species per hectare.

4. Results and Discussion

4.1. Floristic Richness. The results obtained from ethnobotanical and floristic research have made it possible to identify 57 spontaneous medicinal plants divided into 44 genera and 26 families, the most dominant of which are *Lamiaceae*, *Asteraceae*, *Amaranthaceae*, *Anacardiaceae*, *Asparagaceae*, *Cistaceae*, *Cupressaceae*, *Fabaceae,* and *Oleaceae* (Figure 2).

The *Lamiaceae* family is the most common of the species families identified. It is represented by eight (8) species, namely four species of lavender (Lavandula dentate L., *Lavandula stoechas*, *Lavandula multifida,* and *Lavandula maroccana* Murb.), two species of thyme (*Thymus pallidus* and Thymus *satureioides*), wild sage (*Salvia lavandulifolia* subsp. blancoana), and *Marrubium vulgare L.*

The *Asteraceae* family is represented by five (5) species as follows: *Launaea arborescens* (Batt.) Maire, *Launaea lanifera* Pau, sagebrush *Artemisia herba-alba* Asso., *Scorzonera undulata* Vahl., and *Warionia saharae* Benth. and Coss.

The *Amaranthaceae* family comes in third place, with *Anacardiaceae* and *Asparagaceae*, represented by four (4) species, which include *Atriplex halimus* L., *Hammada scoparia* (Pomel) Iljin, *Polycnemum fontanesii* Dur. and Mou., and *Salsola vermiculata* L. Thus, in the same row we find *Anacardiaceae* with four species (4), which include *Pistacia lentiscus* L., *Pistacia atlantica* Desf., *Searsia tripartita* (Ucria) Moffett, and *Searsia pentaphylla* (Jacq.) F.A. Barkley ex Moffett, and *Asparagaceae* with four species, which are *Asparagus acutifolius* L., *Asparagus horridus L.*, *Drimia maritima* (L.) Stearn., and *Drimia undata* (Desf.) Stearn.

The *Cistaceae* families (3), *Cupressaceae* (3), *Fabaceae* (3), and *Oleaceae* (3) are in fourth place. *Cistaceae* species include the following: *Cistus creticus* L., *Cistus salviifolius,* and *Helianthemum lippii* (L.) Dum. Cours.; *Cupressaceae* (3) includes the following species: *Juniperus oxycedrus L.*, *Juniperus phoenicea* L., and *Tetraclinis articulata* (Masters) Vahl.; and *Fabaceae* (3) includes the following species: *Ceratonia siliqua* L., *Ononis natrix L.,* and *Retama monosperma* (L.) Boiss.; and *Oleaceae* includes the following species: *Olea oleaster* Hoffmanns. & Link, *Jasminum fruticans* L., and *Phillyrea angustifolia L.*

The remainder of the seventeen (17) families are represented by two or one species each. The families are as follows: *Apiaceae* (2), *Poaceae* (2), *Xanthorrhoeaceae* (2), *Apocynaceae* (1), *Capparaceae* (1), *Caprifoliaceae* (1), *Ephedraceae* (1), *Ericaceae* (1), *Araceae* (1), *Fagaceae* (1), *Globulariaceae* (1), *Juncaceae* (1), *Palmaceae* (1), *Rhamnaceae* (1), *Rubiaceae* (1), *Sapotaceae* (1), and *Solanaceae* (1).

4.2. Biological Types. According to Figure 3, the biological types of the medicinal species of the study region show the dominance of the Chamaephytes, which occupy the first

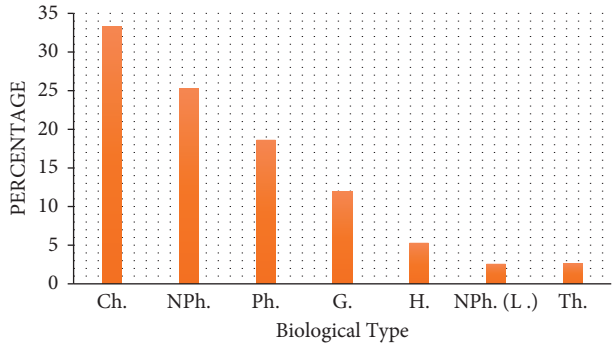
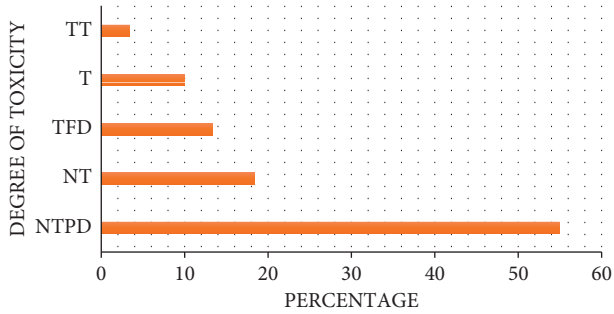


Figure 3: Biological type of medicinal species of the Bigoudine watershed. Ch: Chamaephytes; NPh: nanophanerophytes; Ph: phanerophytes; G: geophytes; H: Hemicryptophytes; Nph (L.): Lianas; Th: therophytes.



TT: very toxic;
T: toxic;
TFD: high dose toxicity;
NTPD: non-toxic at low dose;
NT: non-toxic.

Figure 4: Distribution of medicinal species according to their degree of toxicity. TT: very toxic; T: toxic; TFD: high-dose toxicity; NTPD: nontoxic at low dose; NT: nontoxic.

place with 33.33%, followed by the nanophanerophytes with 25.33% placing in second place before the phanerophytes, which represent 18.66%, in third place, the geophytes occupies fourth place with 12%, then come in fifth place the Hemicryptophytes with 5.33%, and finally we find the Lianas (Nph (L.)) with 02, 66% and therophytes with 01.36%.

Thus, this predominance of Chamaephytes characterizes the type of perennial plant of the mountainous regions of the study area, whose organs allow to pass the bad season (buds), which are located between 10 and 50 centimeters above the ground. These Chamaephytes are very abundant in the Lamiaceae, which are in great demand in traditional medicine.

The analysis of the 57 medicinal species of the Bigoudine watershed region (Figure 4) shows a category of species, which are nontoxic at low dose (NTPD), which occupies the first place with 55% (33), the second place is occupied by the category of nontoxic species (NT) with 18.33% (11), the third place comes the category of species, which exhibit high-dose toxicity (TFD) with 13.33% (08), followed in fourth place by

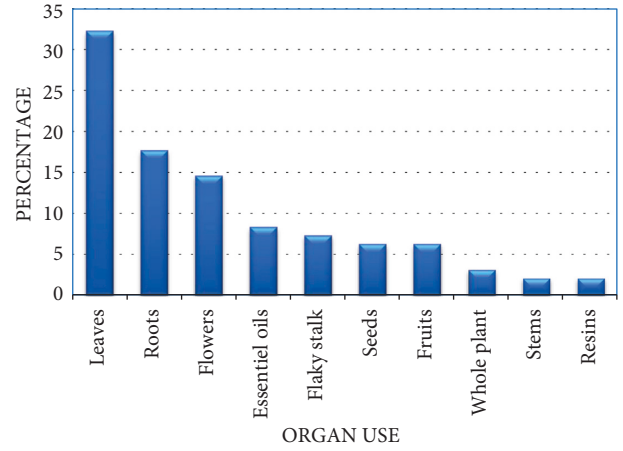


Figure 5: Percentage of organ use of medicinal species in the region studied.

species that are toxic (T) with 10% (06), and finally the category of very toxic species (TT) with 3.33% (2).

It can be clearly deduced that the handling of spontaneous medicinal species in situ requires knowledge of the risks that these types of plants can present. The experience of practitioners and the identification of species are highly recommended to avoid poisoning and even serious or even fatal incidents.

4.3. Classification of Used Parts of Species. Analysis of the organs relating to the used parts of spontaneous plants shows that the leaves cover 32.29% (Figure 5) of traditional therapeutic uses and constitute the main organs manipulated in the area. Some users put forward statements explaining that the leaves are exposed to the sun, which gives them good facts and virtues, so they are also harvested with ease and speed. Although these remarks are unfounded and often do not pose a problem from an ecological point of view, the finding concerning the second position occupied by roots, underground parts, with 17.70%, often threatens the destruction of the plant or even the contribution of its disappearance if it is rare or threatened species. In this case, conservation or safeguard measures are required immediately.

Then, in descending order, come the other categories of organs: flowers (14.58%), essential oils (08.33%), the flaky stalk (07.29%), the seed (06, 25%), fruits (06.25%), whole plant (03.12%), stems (02.08%), and resins (02.08%) (Figure 4).

However, it is noted that there is variation in the extent of participation of each category of organ. This can be explained by the fact that each of the categories is individualized by its reserves, which are specific to it and attributed to its natural environment.

4.4. Phytogeographic Distribution of Species in the Watershed. In the study region, the natural vegetation includes, from upstream to downstream, *Argania spinosa* (L.) Skeels formations on terraces and glacis, most of which are cultivated;

a mixture of *Tetraclinis articulata* (Vahl.) Masters and *Argania spinosa* (L.) Skeels with the presence of plants of *Ceratonia siliqua* L. on the slopes; and a dense formation of *Quercus rotundifolia* Lam. on the limestone plateaus (at 1600–1700 m). This region has a very diverse flora whose distribution is influenced by complex climatic gradients, which are superimposed by landscape models and lithologs [34].

The identified AMP species are distributed within three vegetation facies (3 areas), which are characterized by a floral procession and by their overlaps (Table 1). The results obtained showed that approximately 43.85 (25)% of the total inventoried species respond to each other on the 3 facies (FI-FII-FIII), followed by 28.09% (16) of common species between facies I and II, and finally 5.26% (03) of common species between facies II-III (Figure 6). The rest of the species of medicinal plants are as follows: about 12.28% (07) of the total spontaneous species inventoried within facies I, followed by facies II with 5.26% (03) and finally facies III with 5.26% (03).

Analysis of the results showed that the most distributed shrub and tree species found in all facies are as follows: *Argania spinosa* (L.) Skeels, *Tetraclinis articulata* (Vahl.) Masters, *Quercus rotundifolia* Lam., *Juniperus phoenicea* L., *Olea europaea* L. subsp. *maroccana* (Greuter and Burdet) P. Vargas et al., *Phillyrea angustifolia* L., *Pistacia lentiscus* L., and *Ceratonia siliqua L.*

Then, the bushy and herbaceous species are well distributed in the second row: *Thymus satureioides* Coss. & Ball., *Cistus creticus L.*, *Cistus salviifolius* L., *Lavandula dentata L.*, *Lavandula multifida L.*, *Lavandula stoechas L.*, *Globularia alypum L.*, *Chamaerops humilis L.*, *Artemisia herba alba* Asso., *Asparagus horridus L*, *Chamaerops humilis L.*, *Launaea arborescens* (Batt.) Mayor, *Asphodelus ramosus* L., and *Macrochloa tenacissima* (L.) Kunth.

Facies I (Figure 7) is the stratum with a specific richness of 47 species, of which the argan tree constitutes one of the most remarkable proportions of the Moroccan territory, both for its flora and its vegetation [6, 35]. The argan tree is one of the most characteristic trees in the study area. This tree is widely used by local residents as firewood, fruit for extracting oils, and even hanging grazing for goats.

At altitude, the argan tree forms stands mixed with thuja between 800 and 1500 m, very rarely with holm oak.

It is characterized by the presence of the species *Periploca laevigata* Ait., *Lavandula multifida L.*, *Helianthemum lippii* (L.) Dum. Cours., *Warionia saharae* Benth. and Coss., *Launaea arborescens* (Batt.) Mayor, *Launaea lanifera* Pau, *Searsia tripartita* (Ucria) Moffett, *Lavandula maroccana* Murb./*Lavandula abrotanoides* var. *attenuata* Ball, *Globularia alypum L.*, *Ononis natrix L.*, *Olea europaea* L. subsp. *maroccana* (Greuter and Burdet) P. Vargas et al., and *Lavandula dentata* L. Other xerophilic species are as follows: *Atriplex halimus L.*, *Hammada scoparia* (Pomel) Iljin, *Salsola vermiculata L.*, *Juncus maritimus* Lam., and *Lycium intricatum* Boiss.

It is characterized by the abundance of lavender, in particular *Lavandula dentata* L. in the exposures of the southern sector on the slopes under the Jurassic Coast and *Cistus* especially on the slopes of the Jurassic Coast of Tamsoult between 110 and 1500 m from altitude in SE exposure. This facies is characterized by the presence also of *Globularia alypum* L., which often accompanies *Juniperus phoenicea* L. in the region.

Facies II (Zone II) (Figure 7) at Tétraclinaie occupies almost the domain of the argan tree, except for the southern part and the northeastern part of certain slopes of the studied area. This tree is ranked second in order of importance after the argan tree in the edition. It forms pure populations on the western Jurassic plateau and in altitude in the old massif. Callitriaie appears globally from 1200 m on the northern slopes and then at any exposure from 1300 m.

It is characterized by the presence of the majority of PAMs and marked by the presence of *Globularia alypum* L., *Ephedra fragilis* Desf., *Ononis natrix L.*, *Argania spinosa* (L.) Skeels, *Lavandula dentata L.*, *Macrochloa tenacissima* (L.) Kunth, *Cistus salviifolius* L., *Juniperus phoenicea* L., *Thymus satureioides* Coss. & Ball., *Thymus pallidus* Batt. subsp. *pallidus*, *Chamaerops humilis* L., and *Artemisia herba-alba* Asso.

This facies is also marked by *Thymus pallidus* Batt. subsp. *pallidus,* which occupies a higher elevation range than that of *Thymus satureioides* Coss. & Ball., and *Thymus satureioides* Coss. & Ball. occupies the southern-facing slopes of the valleys coming from the Jurassic Coast of the plateaus, and it extends between 1100 to 1600 m altitude of the area.

Finally, facies III (Figure 7), the green oak grove, is located mainly at the level of the high slopes mixed with the cedar that it dominates and a few feet of carob tree. From mid-slope to downslope, this oak grove remains dominated by thuja.

It is mainly characterized by highlands, it has long been exploited for grazing and charcoal, and the size of which is about 3 m. The presence of *Cistus creticus* L. is well marked on this facies; in particular, on the plateaus, it is competed by *Thymus satureioides* Coss. & Ball., *Lavandula dentata* L., and *Macrochloa tenacissima* (L.) Kunth L. With regard to Salvia *lavandulifolia* subsp. *blancoana* (Webb & Heldr. Ex Walp.) Rosúa & Blanca despite its great importance in traditional care, it does not cover a large area within these facies and mainly occupies the N and NW sides whose altitude exceeds 1600 m.

4.5. Biological State of Species in the Watershed. The richness and the floristic diversity of the region, in spontaneous AMP, are considered among the major alternative sources of income for the local population to ensure their subsistence. These species all have specific uses for this rural mountain population. They are found everywhere in the region, and we find species in plateaus, valleys, and depressions; in altitude *Lavandula dentata L.*, *Lavandula stoechas L.*, *Cistus creticus L.*, and *Cistus salviifolius L.*; *Pistacia lentiscus L.*, *Ceratonia siliqua L.*, *Tetraclinis articulata* (Vahl.) Masters, etc.; and in the mountains *Thymus pallidus* Batt., *Thymus satureioides* Coss. and Ball., etc., while some species can be encountered by everyone in the basin such as *Argania spinosa* (*L.*) Skeels,

Table 1: Distribution of the main spontaneous species medicinal and aromatic properties by facies in the region studied.

Facies number	Voucher number	Scientific name	Common Moroccan name	Lambert coordinates		Used parts	Use
				X	*Y*		
I	FS-HR3201-17	*Hammada scoparia (Pomel) Iljin*	Tiwarmite-Ramt	−9,985743W	34,401886N	Leaves	Against stomach aches and in others as an antidiabetic
I	FS-HR3202-17	*Atriplex halimus* L.	Gu'ttef-Guettaf-Ar'masse	−9,950266W	34,416224N	Leaves	Anti-inflammatory, against anemia, stomachic, and as diuretics
I-II	FS-HR3203-17	*Polycnemum fontanesii* Durieu. & Moq.	Tigandaste	−9,961112W	34,398329N	Roots	Against cooling
I	FS-HR3204-17	*Salsola vermiculata* L.	Ajerwite; Ajerwah; Ghessal	−9,987911W	34,406506N	Leaves	Applied to skin eczema
I-II-III	FS-HR3205-17	*Pistacia lentiscus* L.	Tikkate; tiddak'te; Dro; D'bagh	−10,008175W	34,420519 N	Leaves	Used as stomachic, against liver ailments and fever. Some users recommend it as an antidiabetic
I-II	FS-HR3206-17	*Pistacia atlantica* Desf.	Btam, Btem, Igue , Tinif'te	−10,006517W	34,41778N	Leaves	Against colds and used as diuretics
I-II	FS-HR3207-17	*Searsia pentaphylla* (Jacq.) F. A. Barkley ex Moffett	Azad; Tazadt; Tizgha; Al aarena	−10,018141W	34,407444N	Seeds leaves	Used to treat gastrointestinal diseases, especially stomach ulcer
I-II	FS-HR3208-17	*Searsia tripartita (Ucria) Moffett*	Tazagha; *Tame'nighare; Jdari. Tass'nanete;*	−10,008732W	34,411549N	Berries	Used to treat stomach aches and ulcers and stomach colic
I-II	FS-HR3209-17	*Eryngium ilicifolium Lam.*	Saghmoch'n; Z'riga	−9,975154W	34,412445N	Leaves	Against breathing problems
I-II	FS-HR3210-17	*Eryngium tricuspidatum L.*	*Areg achouk; H'ssika*	−9,963856W	34,403445N	Roots	Against bowel problems
I-II	FS-HR3211-17	*Periploca laevigata Ait.*	Tif'dasse; Hallab	−9,953134W	34,397631N	Roots	Against joint pain and anti-rheumatism
II	FS-HR3212-17	*Arisarum vulgare Targ.*-Tozz.	*Azalime, Abkouke, Yarni,* Tabgouga	−9,993304W	34,415277N	Tuber	To treat skin cancer associated with Aristolochia longa used as emetic and purgative
I-II	FS-HR3213-17	*Asparagus acutifolius* L.	*Azzawi; asakoume; azz'wi*	−9,961975W	34,413588 N	Stem and leaves	Associated with vinegar considered as hypotensive and diuretic and stomachic
I-II-III	FS-HR3214-17	*Asparagus horridus L*	*Azzawi; asakoume;* Chouk	−10,006916W	34,415668N	Berries	With garlic, eggs, and olive oil as energizers and aphrodisiacs
I-II-III	FS-HR3215-17	*Drimia maritima* (L.) Stearn.	Bssal eddib; *azalime ouchen,*	−9,977394 W	34,409734N	Fresh bulb juice	To treat rheumatism and treat hair loss, scalp, hemorrhoids, and eczema
I-II-III	FS-HR3216-17	*Drimia undata* (Desf.) Stearn.	Tass'limet; Bassila; Igu'refile	−9,983477W	34,408435N	Bulbs	As a diuretic, to treat bronchitis and pneumonia
I-II-III	FS-HR3217-17	*Artemisia herba alba Asso.*	Chih; Izri; Azzeri	−9,979753W	34,396253N	Leaves and stem	To treat stomach ulcers and as a hypoglycemic agent associated with *Thymus satureioides*
I-II-III	FS-HR3218-17	*Launaea arborescens (Batt.) Maire*	Wijjane; Boukhalala; Ifress'kel	−9,973093W	34,396046N	Blossom	Used as a laxative; associated with honey considered fortifying
I-II-III	FS-HR3219-17	*Launaea lanifera Pau*	Wijjane; Ifress'kel	−9,983434W	34,398015N	Latex	Used as anti-wart
I-II	FS-HR3220-17	*Scorzonera undulata* Vahl.	Guiza; L'ghize; Allam	−9,966548W	34,402035N	Roots	As a diuretic and against kidney stones
I-II	FS-HR3221-17	*Warionia saharae* Benth. et Coss.	Ef'ssass; Kebbar sid Chikh	−9,957248W	34,397031N	Leaves	As a mouthwash against toothache and mouth ulcers and against colic, also against arthritis and epilepsy
I	FS-HR3222-17	*Capparis spinosa* L.	Taylouloute; tilouloute; Amsilikh	−9,97199W	34,412726N	Flower buds	As an analgesic, diuretic, and to treat gastrointestinal infections; combined with honey and nigella, against allergies, as antidiabetic

Table 1: Continued.

Facies number	Voucher number	Scientific name	Common Moroccan name	Lambert coordinates		Used parts	Use
				X	*Y*		
II	FS-HR3223-17	*Lonicera implexa* Aiton	Anarif/Tich'ki/ (anaref)	−9,96549W	34,408845N	Blossom	On the skin to treat inflammation and wounds
I-II-III	FS-HR3224-17	*Cistus salviifolius* L.	Yarrgal'te; Irguel; Chtib	−10,002285W	34,417508N	Leaves	To treat influenza, dysentery, against colic
I-II-III	FS-HR3225-17	*Cistus creticus L.*	Irgle	−10,005269W	34,406495N	Leaves	Against intestinal ailments, menstrual pain, rheumatism, and urinary tract infections
I	FS-HR3226-17	*Helianthemum lippii* (L.) Dum. Cours.	Rguiga	−9,958304W	34,416692 N	Leaves	To treat gastric and intestinal disorders, against diarrhea associated with olive oil
II-III	FS-HR3227-17	*Juniperus oxycedrus* L.	Tikki; Tiy'ki; Taga	−10,00673 W	34,399063N	Oil	Disinfectant, healing antiseptic and to treat skin problems. As an insect repellent. As a household air disinfectant
I-II-III	FS-HR3228-17	*Juniperus phoenicea* L.	Ayfasse; Araar Sahara	−9,956011W	34,399952N	Leaves	Against colic and inhalation against fever to treat diabetes, diarrhea, and rheumatism. To treat bronchitis and arthritis
I-II-III	FS-HR3229-17	*Tetraclinis articulata* (Masters) Vahl.	Azouka; El'ar'ar	−10,016328W	34,403857N	Leaves	Add to Tetraclinis articulata oil then on the scalp and to nourish the hair. To disinfect the ambient air of the house
I-II	FS-HR3230-17	*Ephedra fragilis* Desf.	Azreme; Timetarte	−9,968527W	34,404315 N	Leafy stem	To treat colds and breathing problems, especially bronchitis, colds, coughs, and asthma
III	FS-HR3231-17	*Arbutus unedo* L.	Azoubar; Sass'nou; Bakhenou	−10,017142W	34,414331N	Leaves	To treat diarrhea, diuretic, and to clean the bladder
I-II-III	FS-HR3232-17	*Ceratonia siliqua L.*	Tikkida; Tikidit; L'kharoube	−10,010881W	34,413991 N	Fruit	Combined with a little water, used to treat diarrhea and gastrointestinal disorders
I-II	FS-HR3233-17	*Ononis natrix* L.	Eff'zdade; Eff'zaze; Affazaz.	−9,975982W	34,413791N	Roots	Associated with olive oil in friction on the joints to treat the pain of rheumatism and the scalp
II	FS-HR3234-17	*Retama monosperma* (L.) Boiss.	R'tam; Alouguou; Talkoute	−9,989096W	34,414589N	Leaves	Associated with henna, against hemorrhoids. associated with fenugreek used to treat gastrointestinal disorders
I-II-III	FS-HR3235-17	*Quercus rotundifolia* Lam.	Tassafte; Abouhou; kerrouche	−9,979921W	34,43185N	Bark	Used tonic and antidiarrheal. glands as an aphrodisiac and antidiarrheal
I-II-III	FS-HR3236-17	*Globularia alypum* L.	Tassalgha; Aïn larneb; Tit'waklile	−9,976276W	34,402985N	Leaves	As hypoglycemics, antirheumatics, stomachics, purgatives, and laxatives, to treat gout
I	FS-HR3237-17	*Juncus maritimus* Lam.	Azlaf Alemesse; azli; Smar	−10,002087W	34,40544N	Rhizomes	To treat insomnia
I-II	FS-HR3238-17	*Lavandula maroccana* Murb.	Hal-hal; Iguize	−9,962279W	34,418273N	Leaves and blossom	On the skin to treat the pain of rheumatism in the joints against respiratory tract infections on the chest
I-II-III	FS-HR3239-17	*Lavandula multifida* L.	Hal-hal; Tamez'ria; Kohila	−9,993514W	34,405602N	Inflorescence	Against respiratory tract infections. against the pain of rheumatism
I-II-III	FS-HR3240-17	*Lavandula dentata* L.	Ijerche; khzama zerga; Tizourine	−10,010701W	34,407144N	Essential oil	As an antiseptic, applied pure to the skin, it relieves burns and insect bites
I-II-III	FS-HR3241-17	*Lavandula stoechas* L.	Elhalhal	−10,008604W	34,409036 N	Leaves	Against headache and cold applied pure on the skin. It relieves burns and insect bites

Table 1: Continued.

Facies number	Voucher number	Scientific name	Common Moroccan name	Lambert coordinates		Used parts	Use
				X	*Y*		
I-II-III	FS-HR3242-17	*Marrubium vulgare* L.	Oumlssa; Marriwta elharra; Ifzi	−9,987457W	34,40963N	Leaves	To treat respiratory problems associated with olive oil used to treat hemorrhoids and on the joints to treat pain
III	FS-HR3243-17	*Salvia lavandulifolia Vahl. subsp. blancoana* (Webb & Heldr.) Rosua et Blanca	Idergui; Tagol'temt; Tiifessite	−9,98413W	34,428908N	Leaves	As antiseptics, to treat menstrual disorders and fever, to treat stomach aches, gastrointestinal problems. To treat diabetes
II-III	FS-HR3244-17	*Thymus pallidus* Batt.	Tazoukenite	−9,997267 W	34,413946N	Leaves and fruit	Against diabetes, fever and as an antiseptic, antifungal, and to treat muscle spasms
I-II-III	FS-HR3245-17	*Thymus satureioides* Cosson.	Tazouknite; Azoukni	−9,985385W	34,405646N	Leaves and fruit	To treat respiratory and stomach disorders
III	FS-HR3246-17	*Jasminum fruticans* L.	Tazenzaw't; Agourmi; Gourmi	−9,992022W	34,394789N	Leaves and fruit	As sedatives, tranquilizers, against insomnia and anti-stress. Chills and stomach aches
I-II-III	FS-HR3247-17	*Olea europaea L. subsp. maroccana (Greuter et Burdet) P. Vargas et al.*	Zitoun; Azemmoure; Zebouje	−9,988139W	34,425816N	Leaves	To treat canker sores and toothaches. They are used as hypotensives and hypoglycemics
I-II-III	FS-HR3248-17	*Phillyrea angustifolia* L.	Tamet'wal'te; Amthal; L'ktam	−10,004698W	34,428472N	Leaves	To treat fever, high blood pressure, and as a diuretic and astringent
I-II-III	FS-HR3249-17	*Chamaerops humilis* L.	Tiznigh't; Tezzoumte; Doume	−10,033851W	34,404515N	Resin	As hypoglycemic and to alleviate lung ailments
I-II	FS-HR3250-17	*Cynodon dactylon* (L.) Pers.	Afer; N'jem; Tag'mayete.	−9,968328W	34,41354N	Rhizome	To eliminate kidney and urinary stones and to treat fever and respiratory and gastric disorders
I-II-III	FS-HR3251-17	*Macrochloa tenacissima* (L.) Kunth	Halfa; Awri; Iwri; Tizzi	−10,044959W	34,410557N	Leaves	To treat intestinal worms; combined with *Artemisia herba-alba, Rosmarinus officinalis,* and honey, to lower uric acid levels
I-II-III	FS-HR3252-17	*Ziziphus lotus* (L.) Lam.	N'bag; Sed'ra; Azouggar'te	−10,022712W	34,41106N	Fruit	Against stomach and intestinal ailments, and against kidney stones. As hypotensive, tonic, and to treat stomach ulcers and menstrual pain
II-III	FS-HR3253-17	*Rubia peregrina* L.	Tarroubia; Fouwwa; Tagh'mite	−9,947471W	34,411137N	Roots	To treat anemia with the dried husk of the Punica granatum fruit as a stomach dressing; and to treat jaundice
I-II	FS-HR3254-17	*Argania spinosa* (L.) Skeels	Argane	−9,95702W	34,420056N	Oil	Oil extracted from unroasted seeds (not edible) to treat skin infections, particularly chickenpox in children. As a moisturizing oil for the face, hands, and feet
I	FS-HR3255-17	*Lycium intricatum* Boiss.	Gardegue; az'kou; l'aaousaj	−10,008656W	34,421873N	Leaves	To treat respiratory disorders and asthma. To treat tuberculosis and albugo
I-II-III	FS-HR3256-17	*Asphodelus ramosus L.,*	*Ighri; L'berouag; Blalouz*	−10,036111W	34,412407N	Bulb	Used as an antiseptic and diuretic; and applied to the skin to treat warts, sores, and eczema.
I-II	FS-HR3257-17	*Asphodelus tenuifolius* Cav.	Azawa; Ighri; Tazya	−9,964067W	34,415348N	Tuber	To treat diabetes

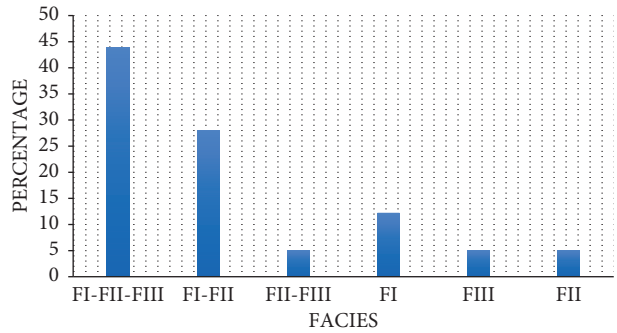


Figure 6: Distribution of medicinal species by facies in the Bigoudine watershed. FI: facies I; FII: facies II; FIII: facies III.

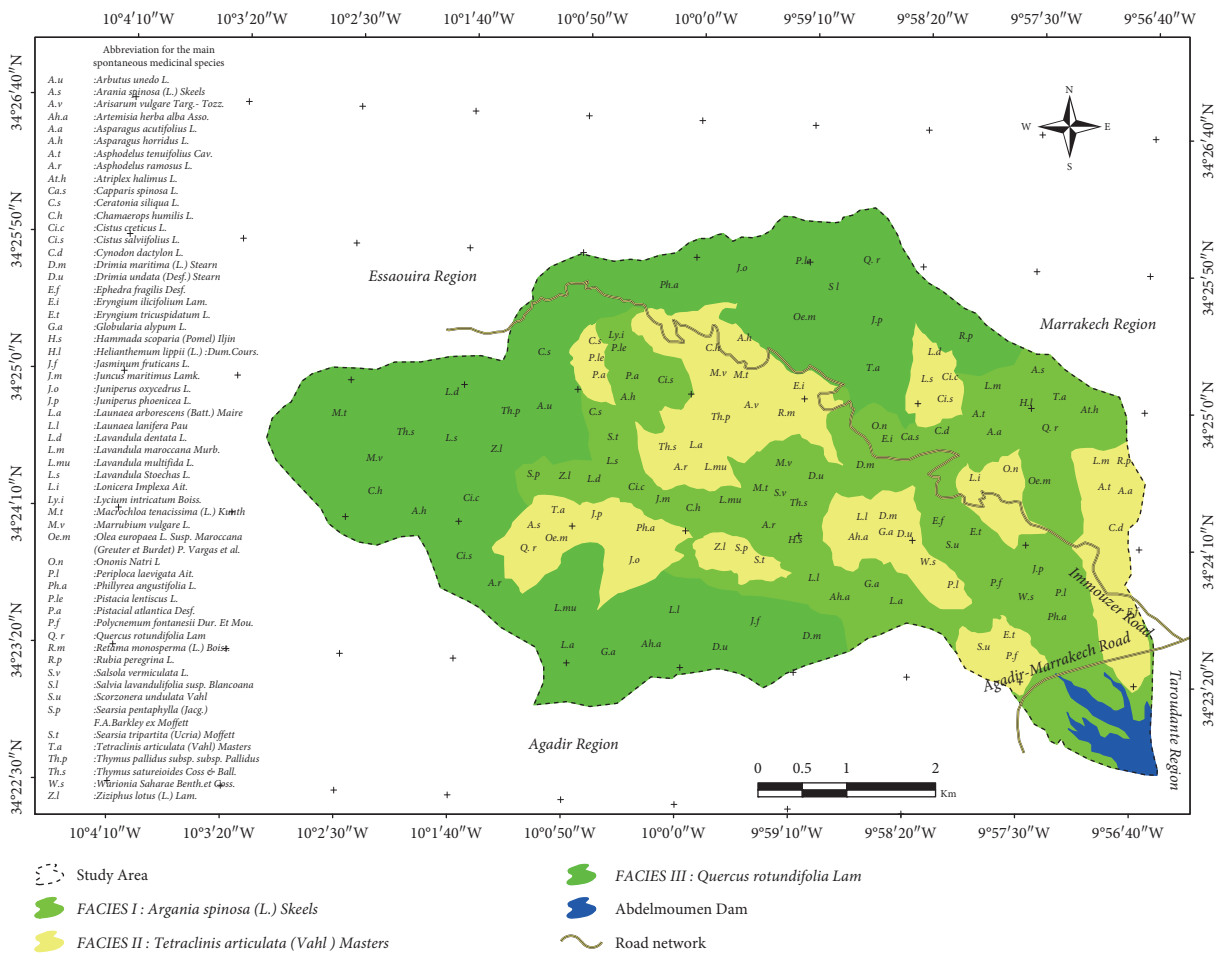


Figure 7: Map showing the distribution of the main spontaneous species medicinal and aromatic properties by facies in the region studied.

Juniperus phoenicea L. and *Juniperus oxycedrus L.*, *Artemisia herba-alba* Asso., *Globularia alypum L.*, *Chamaerops humilis L.*, and *Drimia maritima* (*L.*) Stearn.

Following the survey and observation in the field, the state of degradation was assessed on a scale of 1 (very degraded), 2 (degraded), 3 (moderately degraded), 4 (slightly degraded) to 5 (not degraded) allowing to express the state of degradation of the plant. This scale was carried out on the basis of the degree of degradation of the parts of the plant (morphological state) expressed as a percentage. This evaluation allowed us to observe that most of them are little degraded or moderately degraded and sometimes degraded (Tables 2 and 3).

These degradation states can be explained by human action given the various uses of plant species for the population. This human pressure manifests itself in overexploitation, overgrazing, logging, and burning. In addition, these causes of degradation are amplified by the effects of climate change, which are already manifested in the area by significant summer drought, causing plants to dry out.

Table 2: List of potentially exploitable AMPs within the Bigoudine watershed.

Name scientific	Recovery (R)	Facies	States of degradation
Launaea arborescens (Batt.) Maire	+, 1	I-II-III	3–5
Cistus creticus L.	+, 3	I-II-III	2–4
Cistus salviifolius L.	+, 1	I-II-III	2–4
Juniperus oxycedrus L.	+, 1	II-III	2–4
Juniperus phoenicea L.	+, 2	I-II-III	3–5
Tetraclinis articulata (Vahl.) Masters	+, 3	II-I-III	2–4
Pistacia lentiscus L.	+, 2	I-II-III	2–4
Olea europaea L. subsp. *maroccana* (Greuter et Burdet) P. Vargas et al.	+, 2	I-II-III	3–5
Ononis natrix L.	+, 1	I-II	4-5
Quercus rotundifolia Lam.	+, 4	III- I-II	2-3
Globularia alypum L.	+, 1	I-II-III	2–4
Lavandula dentata L.	+, 2	I-II-III	3–5
Salvia lavandulifolia subsp. *blancoana* (Webb & Heldr. ex Walp.) Rosúa & Blanca	+, 1	III	2–4
Thymus pallidus Batt. subsp. *pallidus*	+, 2	II-III	2–5
Thymus satureioides Coss. & Ball.	+, 3	I-II-III	2–4
Chamaerops humilis L.	+, 1	I-II-III	2–4
Argania spinosa (L.) Skeels	+, 3	I-II	2–5
Hammada scoparia (Pomel) Iljin	+, 2	I	2-3
Salsola vermiculata L.	+, 1	I	1–3
Searsia tripartita (Ucria) Moffett	+, 1	I-II	2-3
Searsia pentaphylla (Jacq.) F. A. Barkley ex Moffett	+, 1	I-II	2-3
Periploca laevigata Ait.	+, 1	I-II	1–3
Artemisia herba-alba Asso.	+, 1	I-II-III	1–3
Ephedra fragilis Desf.	+, 1	I-II	2-3
Phillyrea angustifolia L.	+, 2	I-II-III	2-3
Macrochloa tenacissima (L.) Kunth	+, 2	I-II-III	2-3
Lycium intricatum Boiss.	+, 1	I	2-3

The significance of the abundance-dominance coefficients is as follows: +: (1 à 5%), 1: (5 à 15%), 2: (15 à 25%), 3: (25 à 50%), 4: (50 à 75%), and 5: (+7 5%). The meaning of the degradation state coefficients is as follows: 1: (+75%), 2: (75 à 50%), 3: (50 à 25%), 4: (25 à 5%), and 5: (-5%).

Overgrazing is the predominant element, occupying the first position with a very large percentage estimated at over 50%, of all the causes of the degradation of medicinal and aromatic species in the area. In fact, animal husbandry in the area constitutes one of the main activities of the natural resource exploitation systems in the area, in an extensive manner. Almost all herbaceous and shrub species are grazed by livestock, in particular goats (goats). In the region remain the major activity and source of income for this rural population. Consequently, the result is great pressure from the local population putting on the course to ensure the feeding of their cattle. Medicinal and aromatic species are most affected by overgrazing: *Thymus satureioides* Coss. and Ball., *Thymus pallidus* Batt., *Lavandula dentata L.*, *Lavandula stoechas L.*, *Cistus creticus L.*, *Cistus salviifolius L.*, *Artemisia herba-alba* Asso., *Globularia alypum L.*, *Quercus rotundifolia* Lam., *Juniperus oxycedrus L.*, *Tetraclinis articulata* (Vahl.), and Masters and *Argania spinosa* (*L.*) Skeels.

The second main cause for the degradation of spontaneous medicinal and aromatic species is the cutting of wood, which contributes an estimated significant share of around 20%. Fuel wood meets the vital needs of the rural population to cook food and heat their homes, every day. The species most affected and concerned by this form of degradation are generally *Tetraclinis articulata* and *Quercus ilex*. They are exploited and cut almost daily by women to meet their needs for fuel wood and for grazing.

Overexploitation (uncontrolled picking) contributes by a not insignificant part of about 15% concerning the species *Thymus satureioides*, *Thymus pallidus*, *Lavandula dentata*, *Lavandula stoechas*, *Cistus creticus*, *Tetraclinis articulata* (Vahl.) Masters, and *Salvia lavandulifolia* subsp. *blancoana* (Webb & Heldr. Ex Walp.) Rosúa & Blanca. Finally come the other causes of degradation such as drought and fires, whether by accident or by recklessness (smokers, hunters, workers, shepherds, etc.), by more than 10%. The remainder of about 5% represents various parameters intervening directly or indirectly in this process of degradation of the natural environment, namely population increase, soil erosion, and construction (roads, structures).

The consequences of this degradation are significant on the plant cover and on the natural environment, especially when anarchic exploitation, far from good practices with an excessive harvest, exceeds the capacity to reconstitute the plant cover and generates a weakening and an imbalance of mountain ecosystems.

4.6. Exploitation Potential of Species in the Watershed. Potentially exploitable AMP species and those that are not potentially exploitable by vegetation facies within the Bigoudine watershed are identified and located according to the facies found there.

Table 2 shows the distribution of potentially exploitable medicinal species within the different facies of the Bigoudine

Table 3: List of potentially non-exploitable AMPs within the Bigoudine watershed production potentials in green matter of some medicinal species.

Name scientific	Recovery (R)	Facies	States of degradation
Pistacia atlantica Desf.	+	I-II	2–4
Ceratonia siliqua L.	+	I-II-III	2–4
Lavandula stoechas L.	+	I-II-III	2–4
Ziziphus lotus (L.) Lam.	+	I-II	3–5
Atriplex halimus L.	+	I	2-3
Polycnemum fontanesii Dur. Et Mou.	+	I-II	2-3
Eryngium ilicifolium Lam.	+	I-II	2-3
Eryngium tricuspidatum L.	+	I-II	2-3
Arisarum vulgare Targ.-Tozz.	+	II	2-3
Asparagus acutifolius L.	+	I-II	2-3
Asparagus horridus L.	+	I-II-III	2-3
Launaea lanifera Pau	+	I-II-III	2-3
Scorzonera undulata Vahl.	+	I-II	2-3
Warionia saharae Benth. et Coss.	+	I-II	2-3
Capparis spinosa L.	+	I	1–3
Lonicera implexa Ait.	+	II	2-3
Helianthemum lippii (L.) Dum. Cours.	+	I	2-3
Arbutus unedo L.	+	III	2-3
Retama monosperma (L.) Boiss.	+	II	2-3
Juncus maritimus Lam.	+	I	2-3
Lavandula maroccana Murb.	+	I-II	2-3
Lavandula multifida L.	+	I-II-III	2-3
Marrubium vulgare L.	+	I-II-III	2-3
Jasminum fruticans L.	+	III	2-3
Cynodon dactylon L.	+	I-II	2-3
Rubia peregrina L.	+	II-III	2-3
Asphodelus tenuifolius Cav.	+	I-II	3-4
Asphodelus ramosus L.	+	I-II-III	3-4
Drimia maritima (L.) Stearn.	+	I-II-III	2-3
Drimia undata (Desf.) Stearn.	+	I-II-III	3-3

watershed. However, there are places where these species may not be exploitable or difficult to exploit, but the operation depends on the domain in which they are found. There are three types of land: private land, rural community land, and forest land. Each of these last two areas is subject to specific regulations that govern them.

The potentially little or not exploitable species (Table 3) are the species having above all a weak recovery with an index + and having indices of their biological states often between 1 and 3 (very degraded to moderately degraded), although some species with places are little degraded (index 4) or not degraded (index 5).

Moreover, it should be noted that among these species *Warionia saharae* Benth. and Coss. and *Lavandula maroccana* Murb. are endemic and their farms must be taken into account. Thus, safeguard and conservation measures must be carried out to ensure their sustainability in the natural environment.

Knowledge of the natural potential and state of AMPs is an essential step in the rational exploitation and conservation of medicinal and aromatic plants [16].

During this stage of our work, we selected three of the most widely used species, namely *Lavandula dentata L.*, *Thymus pallidus* Batt. subsp. *pallidus,* and *Salvia lavandulifolia* subsp. *blancoana* (Webb & Heldr. Ex Walp.) Rosúa & Blanca. The goal of this part of our research work is to estimate the production potential of green matter (raw material to be exploited by PAM users) and to propose actions to create employment and income for neighboring populations to promote spontaneous AMP and preserve the natural biodiversity of the area.

The methodological approach was based on a phytoecological diagnosis carried out on ninety survey points (90 plots) each distributed in the different homogeneous plant strata.

Analysis of all biomass values shows that leaf green matter (MVF) constitutes approximately 55%–65% of total green matter (MVT) in *Lavandula*, *Thymus,* and *Salvia* (Figure 8). However, this difference is significant in the three species according to the result of the Student's minimum significant difference test (z-test) (XLSTAT software). *Lavandula dentata L.* is the species with the highest MVT/ha and MVF/ha in the Bigoudine watershed region compared with the other two species. It has an MVT of 393.41 kg/ha and an MVF of 251.97 kg/ha, followed by *Thymus pallidus* Batt. exhibiting an MVT of 279.54 kg/ha and an MVF of 137.91 kg/ha and then *Salvia lavandulifolia* with an MVT of 208.77 kg/ha and an MVF of 127.35 kg/ha.

The most important potential among the selected species is that of *Lavandula dentata* L., having a maximum MVT of 393.41 kg/ha and 251.97 kg/ha as a minimum value in MVF (Figure 8). It is localized in areas with sandstone or rocky

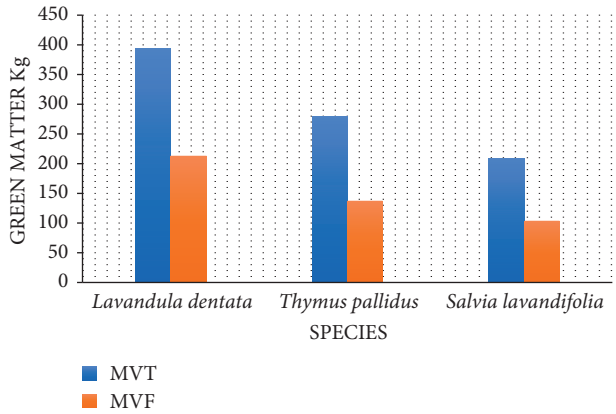


Figure 8: Average total green mass (MVT) and leaf green mass (MVF) curve per hectare in the Bigoudine watershed.



Lavandula dentata L.

Thymus pallidus Batt. subsp. *Pallidus*

Salvia lavandulifolia subsp. Blancoana (Webb & Heldr. ex Walp.) Rosúa & Blanca.

Figure 9: Biomass estimate for three species of the Bigoudine watershed.

limestone outcrops and on deep soils. Its altitudinal slice in the area is from 900 to 1550 m, and it is absent in the high oak groves of the plateaus where *Cistus villosus L.* rather dominates. It is present on the southwest slope of the Ida Ou Tanane massif from an altitude of 350 m, while in the western Anti-Atlas, it ranges from 1450 to 1900 m [1].

The potential of *Thymus pallidus* Batt. is also very important at the level of the zone, with a maximum MVT of 279.54 kg/ha and minimum MVF of 137.91 kg/ha. This species is abundant in the oak grove. It is a kind of mountain. Its altitudinal range is higher than that of *Thymus satureioides* Coss. & Ball. On the plateaus, along with *Adenocarpus artemisiifolius* Jahand., Maire & Weiller, and *Santolina rosmarinifolia L.*, it characterizes the clearings in the oak grove, on weak loose surface formation with a sandy clay texture with an abundance of gravel. On the plateau of Ida Ou Bouzia and Tizguine, it is located in the company of *Thymus satureioides* Coss. & Ball. and *Globularia alypum L.* in depressions where the thickness of the loose layer is deep with a silty clay texture.

The potential of *Salvia lavandulifolia* subsp. *blancoana.* also shows an important green biomass with an MVT of 208.77 kg/ha and 103.81 kg/ha in MVF (Figure 8). It does not cover a large area. It is individualized in the highest parts of the plateau, which are from north to south Aourir n'ou Gelmous and Tizi n'ou Alatas (1st northern bulge of the plateau), Amadel or Goulif (2nd bulge), Tassafine Zdinine (oaks aligned in Berber), constituting one of the high eastern massifs of the plateaus, Taourirt Moulay Ali at the S end of these massifs, and valleys of the plateau south of Aïn Asmama. The altitude of all these localities exceeds 1600 m. In addition, the sage oak grove mainly occupies the N and NW sides.

These results allowed us to provide a biomass estimate made of three species out of the 57 existing species (Figure 9). This estimate shows the availability of green matter (MV) in this region of the Bigoudine watershed. It is reported that the production of plant biomass, of all the species growing in this arid and semiarid zone, is subject to the influences of climatic hazards, particularly rainfall, which remains unstable and varies from year to year.

5. AMP Conservation Measures

The abundance of medicinal and aromatic species in a spontaneous state in the study area is a definite asset if their operations are managed in a rational manner, because currently traditional exploitation is a problem for the preservation of these plants.

Indeed, this type of species in the region is under pressure from the local population to meet their daily needs. Moreover, in addition to overexploitation, there are other forms of degradation such as overgrazing, firewood, and variations in climatic conditions. However, measures

relating to the conservation and preservation of these natural species are necessary to ensure their sustainability and development, by implementing actions to promote this mountain and rural population.

To this end, the species *Thymus pallidus* Batt., *Lavandula dentata* L., and *Salvia lavandulifolia* may be the subject of actions to be implemented by creating jobs and income for the local population, taking into account the different characteristics of the zoned. In addition, all other species can be the subject of other actions and be integrated thereafter according to choose and need.

These species are part of certain products, which are exported in the form of dried plants and/or in the form of plants used for the production of essential oils or aromatic extracts intended for the perfumery and cosmetic industry or for the preparation of aromas or hygiene products.

To do this, we propose actions, within the framework of this work, aimed at mitigating the processes of degradation of these natural environments and contributing to the conservation of PAMs in the region, namely, the enhancement of PAMs, the organization of the local population, and the domestication of certain spontaneous medicinal and aromatic species of the region.

5.1. Valuation of PAMs. The identification of potentially exploitable AMPs and the estimation of a production potential of these three species (thyme, lavender, and sage) constitute research work that will help to set up the process of enhancing AMP in the region. This study will make it possible to design actions that generate income and create jobs to reduce the pressure on biodiversity while combating poverty and improving the quality of local life. To do this, these natural resource management actions must ensure the long-term preservation of these resources in the service of local development.

This valuation must take place in the context of a diversified sector, both in terms of its production and in terms of product uses, taking into account all aspects of the value chain from collection to disposal on-site processing or export to other processing sites.

The proposals for installing PAM drying units and essential oil extraction are highly recommended and do not require a large budget in the first phase.

6. Conclusion and Perspective

The Bigoudine watershed is a rich and diverse environment in medicinal and aromatic species. Among these species, 57 taxa are spontaneous, play an important role, and contribute by their values in the subsistence of the local population. They are distributed throughout the watershed on a regular basis, and some species can be encountered by everyone in the basin. The demarcated facies help to know the distribution of these species in the region.

One of the most interesting results of this study is the identification of potentially exploitable AMPs. In addition, the estimate of the production potential carried out on the three species (thyme, lavender, and sage) will also help to encourage the population to take an interest in the promotion and exploitation of this type of plant.

This study has shown that among the main causes of degradation of AMPs is overgrazing, particularly of the following species: *Thymus pallidus* Batt., *Thymus satureioides* Coss. & Ball., *Lavandula dentata* L., etc. To cope with this situation, it is proposed to improve the range by introducing other species much more desired by livestock such as species of the genus *Atriplex (Atriplex halimus* or *Atriplex nummularia*).

Rational exploitation and conservation of medicinal and aromatic species can only be achieved on the basis of an assessment of their potential and natural biological states. The conservation measures proposed locally, as part of this work, would prevent excessive harvesting and ensure the protection of the natural ecosystems of species under pressure, especially rare or overexploited plants.

These measures, which contribute to their sustainability in the region, lie in the enhancement of potentially exploitable species and their domestication by carrying out actions for their crops, thus the organization of the population into an economic interest group. These actions must take into account the following aspects:

(i) Environmental: ensuring conservation and sustainability

(ii) Social: by creating social activities, based on the participatory approach, empowerment, and awareness of the local population

(iii) Economic: by creating jobs by setting up lucrative economic activities for medicinal and aromatic plants, by delimiting potentially exploitable areas, the species to be exploited, the period of exploitation, and ensuring their marketing

Finally, the richness, diversity, and potential in medicinal and aromatic plants (PAMs), the experience of the local population, and the know-how of the women of the region, in terms of traditional herbal medicine, constitute an asset and a basis for the establishment of a PAM sector by creating local associations or cooperatives to promote the PAMs and generate income by improving their social life with the aim of safeguarding and conserving this natural heritage, in a spirit of requirements of local sustainable development.

Data Availability

The data used in this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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