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ETHNOBOTANICAL AND SOCIO-ECONOMIC EVALUATION OF THE MEDICINAL AND AROMATIC PLANTS IN THE OUED BEHT WATERSHED, MOROCCO

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Abstract

This study was carried out in the Oued Beht watershed in Morocco, it aimed to inventory the wild medicinal and aromatic plants (MAPs) used and marketed in the study area and to calculate their economic value using the market price. The survey led with the local population in 2019, using face-to-face interviews and focus groups with 200 collectors and 5 cooperatives operating upstream of the sector of MAPs. This study used the Geographical Information System (GIS) tool to develop spatial maps covering medicinal plants prevalent in the Oued Beht watershed. The results permitted the identification of 23 species of MAPs collected, of which root and whole constitute the most used parts. Their economic value was estimated at 34,745,943 MAD·yr^{-1} distributed between collectors and cooperatives. The profits of the cooperatives exceed 61 %, with a supply of MAPs of only 24.63 % (700 t·yr^{-1}). This important economic value encourages the local population to depend on these resources. For this reason, we propose sustainable exploitation of the MAPs to provide their sustainability.

Key words: economic value, geographical information system, sustainability, wild MAPs.

Introduction

Recognized for its geographical location, Morocco benefits from specific natural ecosystems, which provide a wide range of ecosystem services (ES) defined as direct or indirect contributions of ecosystems to human well-being (MEA 2005, Braat and de Groot 2012).

However, most ES are provided by nature, and their economic values are often underestimated or ignored in commercial markets and decision-making processes (Pascual et al. 2010), which create serious problems for the conservation and the valorization of these resources.

Wild medicinal and aromatic plants (MAPs) represent an essential ecosystem services category described as provisioning services (MEA 2005), it constitutes a genetic reserve offering rich ecological and floristic diversity (Zrira 2017). On national level, MAPs are represented by 4200 vascular plants belonging to 940 genera and 135 families (MATUHE 2002, Fennane et al. 2014), including 900 endemic species

(Idm'hand et al. 2020). MAPs contain 9 % of the total flora of Morocco, of which the cedar ecosystem represents 31 % of all MAPs (Aafi et al. 2011). This diversity is highly recognized compared with other Mediterranean countries (Zrira 2017, Lamrani-Alaoui and Hassikou 2018).

The harvesting of wild species represents more than 90 % of national production (Zrira 2017). This sector of exploitation and use of aromatic and medicinal plants enjoys a privileged place in the national economy (Bellakhdar 1997, Benjilali et al. 2000, El Mansouri et al. 2011). It is estimated that 20 % of the population lives at least partially from these products (Ennabili et al. 2000). More than 500 medicinal plants are economically important (Bellakhdar 1997, Benjilali et al. 2000). The MAPs sector has a significant socio-economic value (Ghanmi et al. 2009), which enhances the value areas with limited economic potential (Chemli and Sid 2006).

Due to the traditional knowledge of the Moroccan population, MAPs represent a source of income and a means of creating new jobs for local communities (Eddouks et al. 2002, Benkhnigue et al. 2010, El Hafian et al. 2014, Akdime et al. 2015). The sector could also be one of the keys to promoting, developing and improving the livelihoods of unfortunate local population. Indeed, medicinal and aromatic plants give rise to two types of economic benefits. Thus, the calculation of the economic value of MAPs includes, on the one hand, the use-value of the quantities collected by local populations for immediate therapeutic, cosmetic, dietary, pharmaceutical, food and industrial uses (Kassel 2001). On the other hand, the option value constitutes a source of genes that can be commercially exploited in the future (Fadil et al. 2015). In the first case, it consists to estimate the in-situ use-value of these plants. In the second case, it involves assessing the expected future value of the option value of these genetic resources.

Nevertheless, the exploitation of this sector is not rational, most of the collections are irregular and uncontrolled, which affects negatively the sustainability of these resources. Over-collection of species had a significant threat to the most commercially valuable wild species (Lamrani-Alaoui and Hassikou 2018).

Despite the existence of several floristic and ethnobotanical studies describing the uses of MAPs in traditional medicine by the local population, few studies analyze the distribution, harvesting practices of the wild MAPs and their socio-economic values in the livelihood of the local population. That causes an underestimation of the economic value of these aromatic and medicinal plants and the attention they deserve (Maseyk et al. 2017).

The present study aimed to inventory the botanical species of wild MAPs picked in the study area and to estimate their economic value for the local populations. It also fixes as a goal to analyze the distribution of these MAPs, the collection practices, and the selling prices. This analysis will help raise the awareness of wild MAPs as an important natural resource and promote sustainable utilization.

Materials and Methods

Study area

The present study is conducted in Morocco, in the upstream part of the Oued Beht watershed, which covers an area of 1683.5 km^2 (Fig. 1). This area is a part of the Atlas Cedar Biosphere Reserve, which is recognised for its diverse vegetal

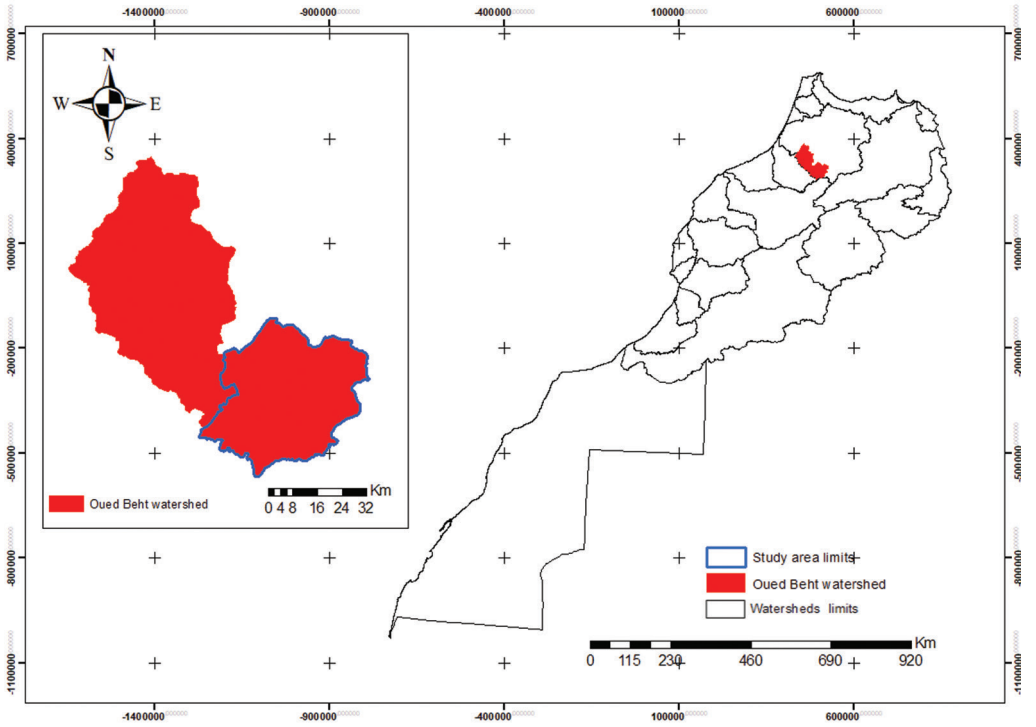

Fig. 1. Mapping representation of study area.

biodiversity.

Administratively, our study area is a part of two administrative regions, namely Fés-Meknes and Beni Mellal-Khenifra, it extends over three provinces and nine communes. The study area includes 76.76 % of the total area of Ifrane province and 17.32 % of Khenifra Province. The province of El Hajeb remains the least represented by a surface area not exceeding 6 %.

The study area is characterized by its Mediterranean climate with rainy winter and dry summer seasons. According to the National Census Report (HCP 2014), the total population is estimated at 41,647, and the number of households at 9330 with an average size of 4.46 inhabitants per household, which is lower than the national average (4.6 inhabitants/ household). The number of households is shared between rural households representing 88.54 % and urban households, which account for only 16.46 %. The unemployment average rate was 10.47 %. This rate is higher than the national average of 9.9 %, which reflects the poverty of households in the study area and consequently the intensity of exploitation of natural resources.

Data collection

The first step of this work is focused on the bibliographic exploitation of national and regional ethnobotanical studies on medicinal and aromatic plants (Benabid and Fennane 1994, Fennane et al. 1999, Benabid 2000, MATUHE 2002, Benjilali and Zrira 2005, Ghanmi et al. 2009, Akdime et

al. 2015, Jamaleddine et al. 2017). A GIS mapping approach is also used to determine the land use of the study area by exploiting and analyzing data from different regional and local maps. These data are integrated into ArcGIS 10.7.

In terms of land use, rangelands are the most dominant. They occupy 50.83 % of the total area of the target zone. Forests come in second place with 19.79 %, in the third place, we find denuded land with a percentage of 13.64 % and agricultural land, which is represented by 12.10 % (Fig. 2).

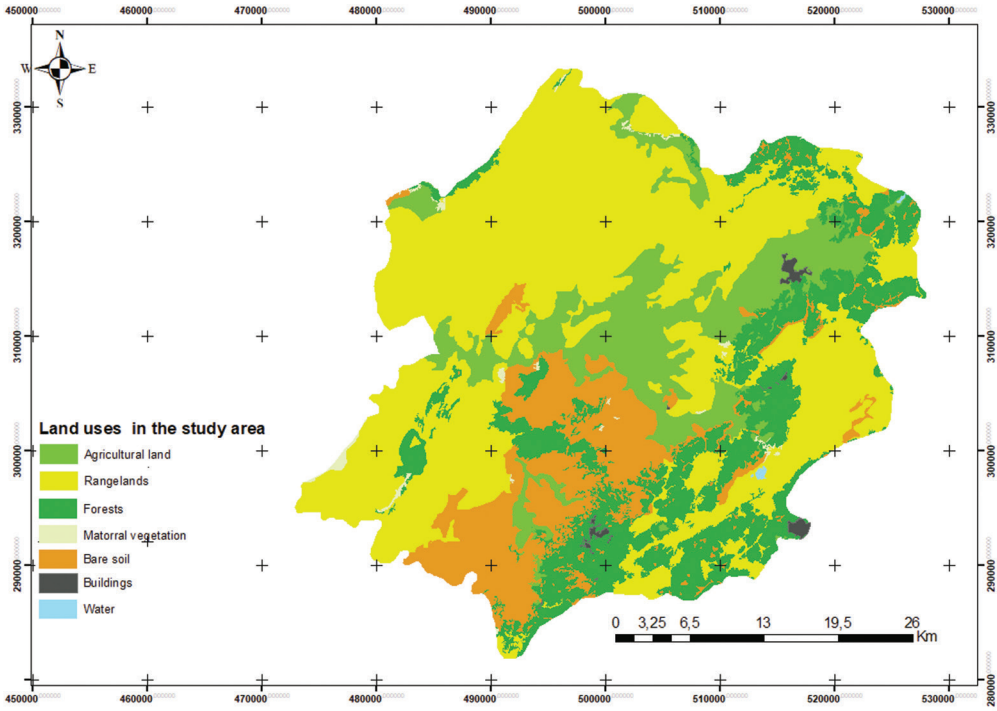

Fig. 2. Land uses of study area.

The results of the land use map are used to determine the survey sites and to ensure that most of the MAP exploitation areas are covered. The choice is guided by the distribution of the poverty rate in the study area, trying to cover the areas with high poverty rates located near the forests and rangelands and whose household living conditions are highly dependent on natural resources. We selected 47 sites (Fig. 3) to collect information on the most collected and commercialized wild medicinal and aromatic plants, locate them, quantify their removals, and estimate their economic values. A socio-economic survey was conducted between February and September 2019 at the above-selected sites.

Semi-structured questionnaires were conducted with 200 collectors and 5 cooperatives based on free listings submitted to respondents through face-to-face interviews and focus groups.

The collectors interviewed are local peasants living in the study area whose collected MAPs are sold to cooperatives

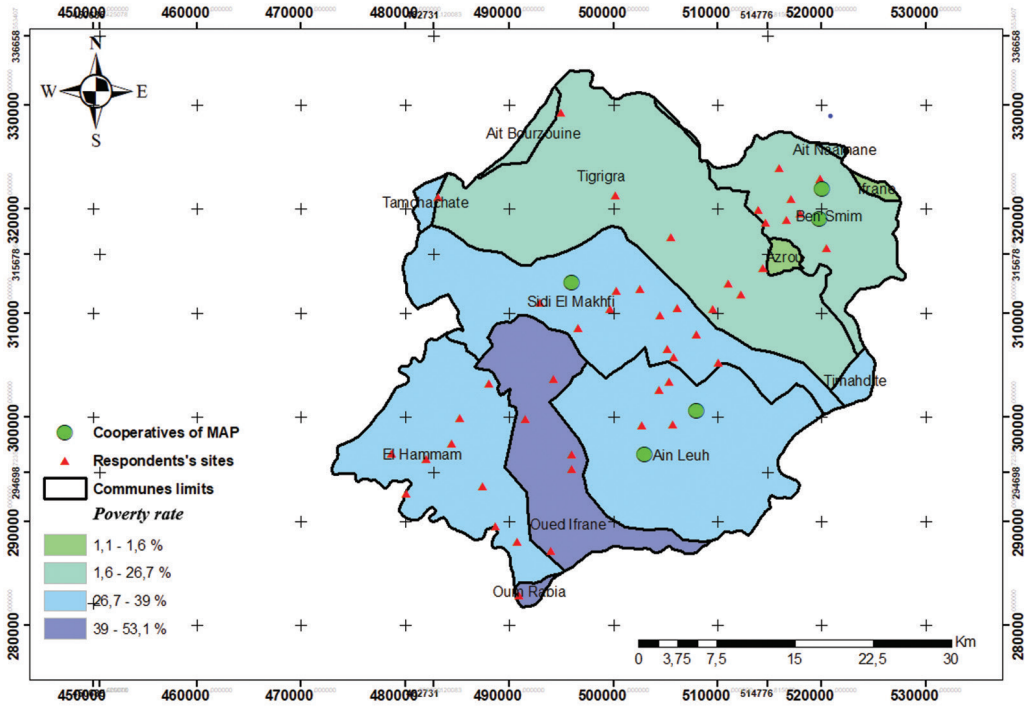

Fig. 3. Distribution of respondents site and cooperatives.

or other intermediaries. The selected cooperatives are those operating in the study area founded by practitioners from the population active in the MAPs sector. The collectors are randomly selected among the local populations. The questionnaire determines the profile of the collector (gender, age, level of education), the place of collection, the distance traveled to collect MAPs, harvesting season, the time passed per day and week, and the local name of each species and the part of the plant used. Other informations such as the quantities collected per day and per year, the place of supply, number of collection days, and the selling price was also requested from the collectors. For the five cooperatives operating upstream of the sector, the questionnaire aimed to determine the year of creation, the number of memberships, the quantities of each species marketed in dry form, the purchase price from collectors, and the selling price. The sample is developed using a stratified random sampling method. The interviewees are selected by the random sampling method.

To determine the species of MAPs, we referred to the following documents: the medicinal plants of Morocco (Sijelmassi 1993), Practical flora of Morocco (Fennane at al. 1999) and catalogs of vascular plants of northern Morocco, volumes I and II (Valdés 2002). The identification has been made at the Biodiversity and Resources Laboratory, Department of Biology, Faculty of Science, Ibn Tofail University Kenitra, Morocco. The identified plant species were arranged by family name, scientific name, collection location, quan-

tity and selling price. In order to develop spatial distribution maps of the prevalent medicinal plants in the area, the assessment was made using a GIS.

Results

Wild collection of medicinal and aromatic plants

Characteristics of the collectors

In total, 68 % of the respondents were female and 32 % - male. This predominance of females explains that this activity is largely practiced by women who collected plants while keeping their animals and collecting firewood in the forests. Regarding the age, the majority of the respondents were 45–55-year-old (60 %), followed by 33 % of 18–45-year-old, and by 5 % above 55-year-old. The least (3 %) were under 18-year-old. This shows that MAPs collecting is mainly practiced by the aged and that young people are not interested by this sort of activity. The interviewees status education is 77 % illiterate, 13 % primary school and 10 % secondary school. Many collectors collect MAPs without respect for their life cycle, which leads to overexploitation and negatively influences the regeneration of the resource and its future value to local people. As a result, if this overexploitation is not managed wisely, it can cause genetic erosion and ultimately species extinction (Bijlsma and Loeschcke 2011). In our study, 67.6 % of the interviewees were unemployed, 16.1 % had a monthly income between 500–900 Dirham marocain (MAD), 13.3 % had 900–1300 MAD, and 3 % had an income higher than 1300 MAD. Most collectors are shepherds or part-time employees. The distance traveled to collect MAPs varies from one collector to another, it can be estimated as 9 km for collectors who use collective tractors (18.2 %). However, almost 81.8 % of the distances, from 1 to 5 km, are covered either by foot or using a mule. The collection of MAPs is done either individually or in groups, the collectors prefer to go in groups (85 %) to reduce more risks during the collection.

Quantification of collected MAPs

Table 1 present the informations about the MAPs collected in our study area.

According to the results of the survey, 23 species belonging to 13 botanical families are identified, the most representative in terms of quantities collected were *Anacyclus pyrethrum, Crataegus laciniata*, *Evernia prunastri*, *Evernia furfuracea* and *Thymus algeriensis*. It is explained by the ecological factors that favor the growth of the majority of these species. The total collected quantity of medicinal and aromatic plants was 2141 $t \cdot yr^{-1}$, varying from one species to another (6 $t \cdot yr^{-1}$ to 400 $t \cdot yr^{-1}$). Root and whole plant were the most common parts used by collectors, which are considered the most destructive method that differs from the non-destructive method (Sharma and Kala 2022), which removes part of the plant without harming the plant or the environment (Cunningham 1993).

Collected quantities depend on the number of harvests and the area occupied by the MAPs, those marketed represent 90 % of those collected after the removal of the indiscernible part. Interviews with collectors indicate that the number of harvest days was five days per week, except the day dedicated to the market and the one of prayer. A day starts at 6 a.m. and ends around 3 pm, representing 9 h of work per day for four months. Most plants are collected between April and August of

Table 1. List of collected medicinal and aromatic plants by local population.

MAP species	Family	French name	Part used	Quantity collected, $t \cdot yr^{-1}$	Spatial distribution in habitats
Anacyclus pyrethrum L.	Asteraceae	Pyrèthre	root	380	rangelands and forests
Crataegus laciniata Ucr.	Rosaceae	Aubépine	flowers, fruits, leaves	400	forests
Salvia verbenaca L.	Lamiaceae	Sauge	whole plant	6	rangelands and forests
Evernia prunastri Ach.	Parmeliaceae	Lichen de chêne	whole plant	80	forests
Evernia furfuracea Mann.	Parmeliaceae	lichen de cèdre	flowers, fruits, leaves	100	forests
Thymus algeriensis Boiss. & Rent.	Lamiaceae	Thym	whole plant	200	forests
Mentha pulegium L.	Lamiaceae	Menthe pouliot	whole plant	52	forests
Saponaria vaccaria (L.) Sm.	Caryophyllaceae	Saponaire	leaves, roots	210	rangelands
Satureja alpina L.	Lamiaceae	Calament des Alpes	whole plant	17	rangelands and forests
Ferula communis L.	Apiaceae	Férule	flowers	84	rangelands and forests
Ruta chalepensis L.	Rutaceae	Rue d'Alep	whole plant	36	rangelands
Arbutus unedo L.	Ericaceae	Arbousier	fruit, leaves	32	and forests
Corrigila telephiifolia Pourr.	Caryophyllaceae	Corrigiole	root	82	rangelands
Calendula officinalis L.	Asteraceae	Souci	leaves, flowers	72	rangelands
Lavandula pedunculata (Mill.) Cav.	Lamiaceae	Lavande pédonculée	whole plant	50	rangelands
Fraxinus dimorpha Coss. & Durieu	Oleaceae	Frêne dimorphe	flower	42	forests
Origanum compactum Benth.	Lamiaceae	Origan	leaves	18	rangelands and forests
Silybum marianum L.	Asteraceae	Chardon marie	flower heads	24	rangelands and forests
Taraxacum atlantico H. Lindb.	Asteraceae	Pissenlit	Root, leaves	200	rangelands
Ceratonia siliqua L.	Fabaceae	Caroubier	Fruit	16	and forests
Zizyphus lotus Lam.	Rhamnaceae	Jujubier	Fruit	8	forests

MAP species	Family	French name	Part used	Quantity collected, t·yr^{-1}	Spatial distribution in habitats
Daphne gnidium L.	Thymelaeaceae	Garou	Leaves	20	rangelands
Inula viscosa L.	Asteraceae	Aunée visqueuse	Root	12	rangelands
Total collected, t·yr^{-1}				2141	

each year. The average quantity collected per day per collector is 12.6 kg·collector^{-1}·day^{-1}, if we consider that the average number of collection days is five days per week, the average quantity collected per week is 63 kg·collector^{-1}·week^{-1}. This quantity collected per day was low compared to the working hours (9 h·day^{-1}) explained by the size and weight of the collected plants (young plants) and the low density of species distributed over a large surface area of forest and/or rangelands.

Characteristics of the cooperatives

Five cooperatives in our study area covering three communes with 49 memberships were also surveyed. The Chifae cooperative is the old one (Table 2). The cooperatives are supplied by the collectors for the majority of species or by their collectors who had also a good experience in the sector.

Table 2. Presentation of the cooperatives opering in study area.

Name of cooperative	Commune	Year of creation	Membership
Chifae	Ben Smim	2006	8
Ajaabou	Ain Leuh	2013	8
Al amal	Tgrigra	2006	7
Konouz al atlas	ben smim	2016	16
Ittihad toufstlt	Ain Leuh	2012	10

The quantities of dried plants commercialized differ from one cooperative to another. The storage and packaging capacity of the plants also determine the quantities of MAP marketed by each cooperative. The quantity of the eleven (11) species marketed as dried plants by the cooperatives in the study area is listed in Table 3.

Table 3. List of collected medicinal and aromatic plants by cooperatives.

MAP species	Chifae	Ajâabou	Itihad tousftl	Al Amal	Kounouz Al Atlas	Totale commercealised, t·yr^{-1}
Anacyclus pyrethrum	0.00	0.00	10.00	0.00	75.00	85.00
Calendula officinalis	2.00	4.40	1.00	3.50	0.00	10.90
Corrigila telephiifolia	2.10	0.30	1.00	14.00	17.00	34.40
Crategus laciniata	0.00	1.00	0.00	3.00	11.00	15.00
Fraxinus dimorpha	2.30	2.00	0.40	2.70	10.00	17.40
Lavandula pedunculata	0.00	2.60	3.20	2.80	4.00	12.60
Mentha pulegium	3.70	2.00	2.80	3.00	12.00	23.50
Origanum compactum	1.70	2.40	2.00	3.10	11.60	20.80
Thymus algeriensis	3.00	5.00	3.50	4.00	100.00	115.50
Salvia verbenaca	2.70	1.90	1.00	1.30	8.00	14.90
Evernia furfuracea	0.00	0.00	0.00	0.00	350.00	350.00
Total, t·yr^{-1}	17.5	21.6	24.90	37.4	598.6	700.00

The maximum quantities commercialized as dry plants are 598.6 t by the Kounouz Al Atlas, and the minimum is 17.5 t by the Achifae cooperative. These quantities differ from one species to another, the most represented are *Evernia furfuracea* with 50 %, *Thymus algeriensis* coming in second place with 16.5 %. In the last position, we find *Calendula officinalis* with 1.5 %.

Mapping the distribution of wild MAPs

To develop spatial maps covering the most prevalent MAPs collected and marketed in the study area, we used the land-use map developed for the study area and the results of surveys with collectors and cooperatives indicating harvest locations. The result of the mapping is presented in Figure 4.

Analysis of the map shows that the total planimetric area of the various MAPs facies is 95,220 ha, which represent 69 % of the total area. Three classes of medicinal and aromatic plants are identified:

- Class 1: High potential and medium coverage, representing MAPs found in forests with high collection quantities, which represents17,139.6 ha;
- Class 2: Medium potential and high coverage, representing MAPs found in rangelands with medium quantities collected, which represents 30,470.4 ha;
- Class 3: Low potential, representing MAPs that are found at the same time in forests and adjacent rangelands and whose collected quantities are low, which represents 11,426.4 ha.

This floristic richness is explained by appropriate ecological conditions in the study area, characterized by a wide var-

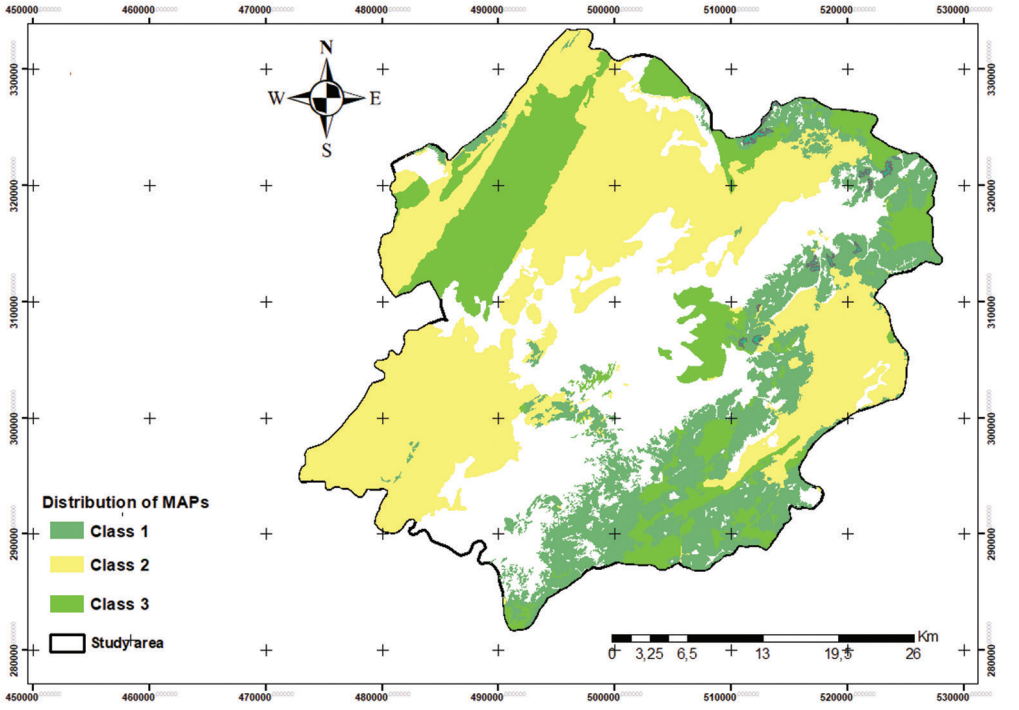

Fig. 4. Distribution of wild medicinal and aromatic plants in the study area.

iation in altitudes, high rainfall, rich soil conditions and a very high forest cover, which explains the large quantities of wild species.

Total economic value of medicinal and aromatic plants

Figure 5 shows that the total quantity of MAPs collected annually for the 23 species was 2141 t·yr^{-1}. The total quantity marketed after cleaning of the undesirable parts was 1930 t·yr^{-1}, giving an estimated value of 13,208,400 MAD, i.e. the collected MAPs are sold at the roadside or the tourist sites or the weekly souks by women having a good knowledge of the use of each plant.

The economic value of each species reflected its abundance in the study area

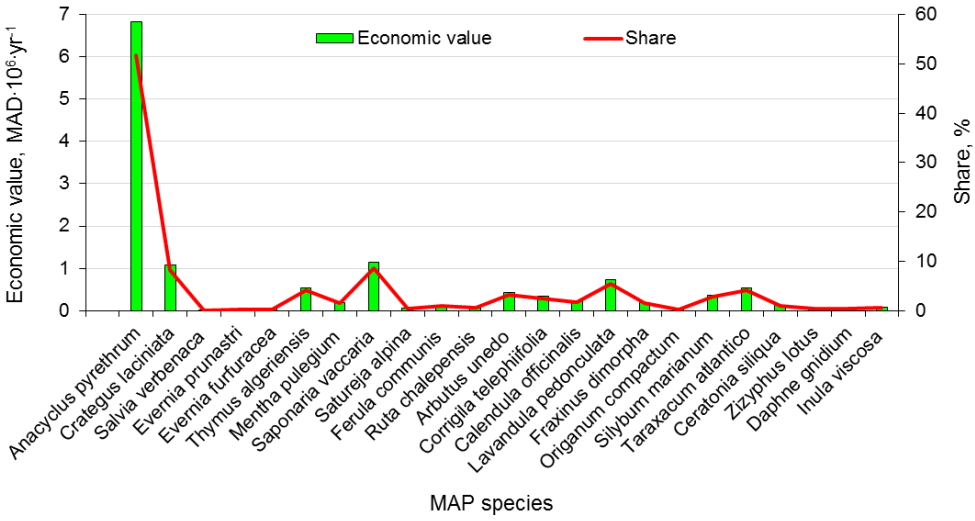

Fig. 5. Distribution of most frequently marketed MAPs for collectors.

and the unit selling price. Figure 6 shows that selling prices are mostly less than 5 MAD·kg^{-1}. Only 21 % of marketed plants had a price higher than 15 MAD·kg^{-1}, and 11.4 % between 5 and 10 MAD·kg^{-1}. This study showed that *Anacyclus pyrethrum* was the most expensive species, which makes it highly exploited and influences its suitability. This species is mentioned on the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) list for Morocco as plant species subjected to trade authori-

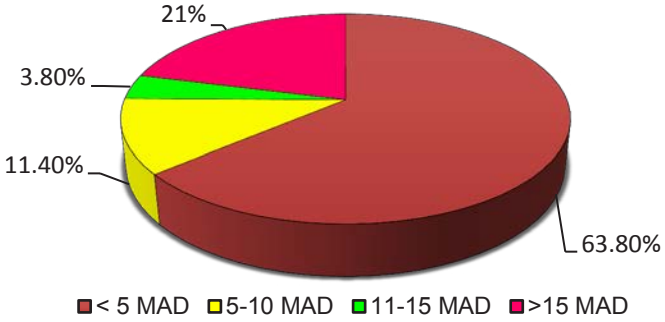

Fig. 6. Distribution of medicinal plants according to their selling price.

zation, it had also been demonstrated in Ait M'hamed Valley (Morocco) that it is suffering significant declines caused by poaching and premature root harvesting (Ouarghidi et al. 2017).

To determine the economic value of dried MAP marketed by the cooperatives, we are based on the selling price at the market after deducting the purchase price from the collectors (Table 4). Surveys with cooperatives show that cooperatives buy also from collectors in addition to collecting MAPs distributed on their land acquired for legal exploitation from the administration. The annual quantity of MAPs commercialized by the cooperatives is estimated at 700 $t \cdot y^{-1}$. This quantity generates an annual economic value of 24,661,500 MAD of which the annual value of purchases is estimated at 3,123,957 MAD giving a net value of 21,537,543 MAD. This value is realized by the cooperatives, which buy from collectors at very cheap prices, not exceeding 15 $MAD \cdot кg^{-1}$ except for pyrethrum (50 $MAD \cdot кg^{-1}$), and who were selling at high prices that exceeded 20 $MAD \cdot кg^{-1}$ and would in some cases go up to 90 $MAD \cdot кg^{-1}$.

The Upstream chain of the MAPs have two main actors, the collectors of the local population and the cooperatives. The results show that the MAPs collection and marketing chain offers an overall annual net value of 34,745,943 $MAD \cdot yr^{-1}$ distributed between collectors and cooperatives, representing a value of 365 $MAD \cdot ha^{-1}$. The cooperatives profits exceed 61 % with a MAPs supply of only 24.63 % (700 $t \cdot yr^{-1}$), showing that even if the collectors' harvests are more important (75.37 %), they receive the lowest value (38.01 % of the total economic value). These quantities underline the role of informal harvesting in the over-exploitation of MAPs in the study area. *Anacyclus pyrethrum*, *Crataegus laciniata*, *Evernia furfuracea*, *Evernia prunastri*, *Thymus algeriensis* are the most collected species generating important monetary values and which are susceptible to problems of overexploitation in the future.

Discussion

The wild medicinal and aromatic plants are a promising sector with enormous commercial purposes for the local popu-

Table 4. Distribution of most frequently marketed MAPs for cooperatives.

MAP species	Total quantity commercialised, $t \cdot yr^{-1}$	Unit selling price, $MAD \cdot kg^{-1}$	Gross annual value, MAD
Anacyclus pyrethrum	85	90	8,550,000
Calendula officinalis	10.9	35	381,500
Corrigila telephiifolia	34.4	30	1,032,000
Crataegus laciniata	15	25	375,000
Fraxinus dimorpha	17.4	25	435,000
Lavandula pedunculata	12.6	40	504,000
Mentha pulegium	23.5	40	940,000
Origanum elongatum	20.8	45	936,000
Thymus algeriensis	115.5	30	3 465 000
Salvia verbenaca	14.9	70	1,043,000
Evernia furfuracea	350	20	7,000,000
Total, $t \cdot yr^{-1}$	700,000		24,661,500

lations. Wild MAPs offer an overall annual net value of 34,745,943 MAD·yr^{-1} distributed between collectors and cooperatives. Generating an income for collectors who did not have permanent jobs, MAPs create financial capital that impacts positively the livelihood's collectors. However, these incomes are not representative of the real value of these MAPs, which explains the need to restructure the sector to increase the value of these resources.

The results show that the exploitation of wild MAPs is practiced by women and men (68 % against 32 %) and that exploitation increases with people's age (60 % of collectors were 45–55-year-old). Wild MAPs are collected mainly in forests or collective rangelands; private lands are always preferred over cultivated species (Schippmann et al. 2006). The collection of plants is often done by poor and illiterate collectors who influence the good collection practices, collectors pull up MAP species brutally and sometimes even during the flowering period. These results are similar to the bibliographic research that has been carried out in the region (Fadil et al. 2015, Rhafouri et al. 2015). Drying plants by cooperatives is also far from the modern way, plants dried directly in the sun are the most commonly used techniques.

The botanical analysis permitted the identification of 23 species collected and marketed by the local population. This number is less important than the one found in the Ifrane National Park. The exploited phytomass varies in the function of the biology of the plant and its use, it depends on the targeted part of the plant. When the whole plant is used, the quantities collected are significant (El Mansouri et al. 2011).

MAPs are considered by collectors as natural plants that are always available, and therefore harvested without any consideration for the regeneration of the resource. Therefore, the regeneration of natural resources is negatively correlated with sustainable exploitation, this causes a decrease in the reproductive capacity of species (Sharma and Kala 2018), which could lead to genetic erosion, extinction of certain species and the destruction of their natural habitats. Unsustainable harvesting threatens not only the survival of medicinal plant species but also the people that depend on them (Andel and Havinga 2008).

Thus, the future of medicinal and aromatic plants depends on today's ability to reconcile the conflicts between conservation and use. Proactive management policies are needed to mitigate biodiversity loss and ensure sound socio-economic development.

In technical terms, MAPs must be collected using the good practices, an appropriate harvesting plans specific to each species are necessary to ensure the sustainability of these precious species. The supervision and organization of the actors in this sector, their involvement in the whole development process, the technical modernization of collection and production will have positive repercussions on the management of the natural environment and the value of MAPs. These products can be promoted as representative products of territorial marketing initiatives give a label the geographical area.

Cultivation of wild MAPs, especially those of high economic value, is also a way to assure the conservation of these species and reduce the pressure on wild plants, and to increase their economic value. Though cultivated MAPs do not have the same quality of biomass or derived products and the wild MAPs are always preferred to cultivated species (Schippmann et al. 2006), wild nurseries can be

an appropriate option for the in-situ conservation of endangered, and in-demand medicinal plants (Liu et al. 2011). On the institutional level, appropriate regulations for the harvesting of wild MAPs need to be formulated. For example, each collection should only be done with a legally issued permit that indicates the amount to collect for each species and sustainable harvesting approaches that minimize biodiversity and ecosystem loss.

Conclusion

The MAP sector can be presented as a pillar for the socio-economic development of the poor rural population in the study area. However, the development of the sector faces several constraints like the excessive exploitation of spontaneous MAP and the limited use of modern production, harvesting, transformation and marketing techniques, which causes a loss of very important added value to the collectors

Our mapping and categorization of MAPs can contribute to the development of comprehensive scientific research on the theme to organize this informal sector.

The results provide a global and shared view of this type of ecosystem service in the study area and raise awareness among decision-makers and users to encourage the economic and environmental sustainability of the MAP sector without compromising the existing populations.

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Conflict of interest statement

There is no conflict of interest in the submission of this manuscript and all authors have given their approval for publication.

References

Aafi A., Ghanmi M., Satrani B., Aberchane M., Ismaili M.R., al-Abd A. 2011. Diversité et valorisation des principales plantes aromatiques et médicinales (PAM) de l'écosystème cédraie au Maroc. Annales de la Recherché Foresriere au Maroc 41: 190–207.

Akdime H., Boukhira S., El Mansouri L., el Youbi A., Bousta D. 2015. Ethnobotanical study and traditional knowledge of medicinal plants in Ain Leuh region (Middle-Atlas of Morocco). Advanced Drug Delivery 3: 248–263.

Andel T.V., Havinga R. 2008. Sustainability aspects of commercial medicinal plant harvesting in Suriname. Forest Ecology and Management 256: 1540–1545.

Bellakhdar J. 1997. La pharmacopée marocaine, traditionnelle. Médecine arabe ancienne et savoirs populaires. Saint-Etienne, Edit. Ibis Press, Paris. 764 p.

Benabid A. 2000. Flore et écosystème du Maroc: évaluation et préservation de la biodiversité. Ibis Press Paris. 357 p.

Benabid A., Fennane M. 1994. Connaissances sur la végétation du Maroc: phytogéographie, phytosociologie et séries de végétation. Lazaroa 14: 21–97.

Benjilali B., Zrira S., Aboulkassim E. 2000. Les filières des plantes aromatiques et médicinales au Maroc. Dans les actes de la journée de réflexion sur les plantes aromatiques et médicinales, Annales de la recherche forestière au Maroc: 14–16.

Benjilali M., Zrira S. 2005. Plantes aromatiques et medicinales: Atouts du secteur et exigences pour une valorisation durable.

Actes Editions, Rabat. 346 p.

Benkhnigue O., Zidane L., Fadli M., Elyacoubi H., Rochdi A., Douira A. 2010. Etude ethnobotanique des plantes médicinales dans la région de Mechraâ Bel Ksiri (Région du Gharb du Maroc) Acta Botánica Barcinonensia 53: 191–216.

Bijlsma R., Loeschcke V. 2011. Genetic erosion impedes adaptive responses to stressful environments Evolutionary Applications 5(2): 117–129.

Braat L.C., de Groot R. 2012. The ecosystem services agenda: bridging the worlds of natural science and economics, conservation and development, and public and private policy Ecosystem Services 1(1): 4–15. https://doi.org/10.1016/j.ecoser.2012.07.011

Chemli R., Sid A. 2006. Partenariat Euroméditerranéen et projets de développement des plantes aromatiques et médicinales. IIème symposium international sur les plantes aromatiques et médicinales, Marrakech, 14–16 Septembre 2006, SIPAM 2. 63 p.

Cunningham A.B. 1993. Setting priorities at the interface between conservation and primary health care. In: African Medicinal Plants. People and Plants Working Paper to United Nations Educational, Scientific and Cultural Organization (UNESCO). 53 p.

Eddouks M., Maghrani M., Lemhadri A., Ouahidi M.L., Jouad H. 2002. Ethnopharmacological survey of medicinal plants used for the treatment of diabetes mellitus, hypertension and cardiac diseases in the south-east region of Morocco (Tafilalet). Ethnopharmacol 82(2–3): 97–103.

El Hafian M., Benlandini N., Elyacoubi H., Zidane L., Rochdi A. 2014. Étude floristique et ethnobotanique des plantes médicinales utilisées au niveau de la préfecture d'Agadir-Ida-Outanane (Maroc). Applied Biosciences 81(1): 7198–7213.

El Mansouri L., Ennabili A., Bousta D. 2011. Socioeconomic interest and valorization of medicinal plants from the Rissani oasis (SE of Morocco). Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas 10(1): 30–45.

Ennabili A., Gharnit N., El Hamdouni EM. 2000. Inventory and social interest of medicinal, aromatic and honey- plants from mokrisset region (NW of Morocco). Botanical Studies 19: 57–74.

Fadil M., Farah A., Haloui T., Rachiq S. 2015. Étude ethnobotanique des plantes exploitées par les coopératives et les associations de la région Meknès-Tafilalet au Maroc. Phytothérapie 13: 19–30. DOI 10.1007/s10298-014-0902-2

Fennane M., Ibn Tattou M., El Oualidi Y. 2014. Flore pratique du Maroc. Vol. 3. Travaux de l'Institut Scientifique, Série Botanique, n° 40, Rabat. 44 p.

Fennane M., Ibn Tattou M., Mathez J. 1999. Flore pratique du Maroc. Vol. 1. Travaux de l'Institut scientifique. Série Botanique. 558 p.

Ghanmi M., Satrani B., Aberchane M., Ismaili M.R., Aafi A. 2009. Plantes aromatiques et médicinales du Maroc. Collection Maroc Nature. Centre de Reherche Forestière. Rabat. 128 p.

HCP (Haut Commissariat au Plan) 2014. Base de données inventaire communal rural. High Commission for the Plan of Morocco National Documentation Center. Internet site. Available at: https://www.hcp.ma/RGPH-2014_r230.html

Idm'hand E., Msanda F., Cherifi K. 2020. Ethnobotanical study and biodiversity of medicinal plants used in the Tarfaya Province, Morocco. Acta Ecologica Sinica 40(2): 134–144. https://doi:10.1016/j.chnaes.2020.01.002

Jamaleddine M., El Oualidi J., Taleb M.S., Thévenin T., El Alaoui-Faris F.E. 2017. Inventaire et état de conservation des plantes aromatiques et médicinales (PAM) au Maroc. Phytothérapie 15: 114–122. https://doi. org/10.1007/s10298-017-1131-2

Kassel Y. 2001. Elaboration d'une base de données sur les plantes aromatiques et médicinales du Maroc (ACHIFAA). Mémoire de troisième cycle (IAV Hassan II, Rabat). 279 p.

Lamrani-Alaoui M., Hassikou R. 2018. Rapid risk assessment to harvesting of wild medicinal and aromatic plant species in Morocco for conservation and sustainable

management purposes. Biodivers Conserv 27: 2729–2745. https://doi.org/10.1007/s10531-018-1565-3

Liu C., Yu H., Chen S.L. 2011. Framework for sustainable use of medicinal plants in China. Plant Diversity 33(01): 65–68. DOI: 10.3724/SP.J.1143.2011.10249

Maseyk F.J.F., Demeter L., Csergő A.M., Buckley Y.M. 2017. Effect of management on natural capital stocks underlying ecosystem service provision: a 'provider group' approach. Biodivers Conserv 26: 3289–3305. https://doi.org/10.1007/s10531-017-1406-9

MATUHE (Ministère de l'Aménagementdu Territoire, de l'Urbanisme, de l'Habitat et de l'Environnement) 2002. Etude Nationale sur la Biodiversité. Rapport de synthèse, Maroc. 215 p.

MEA (Millennium Ecosystem Assessment) 2005. Ecosystems and Human Well-being. Synthesis. Island Press, Washington, DC. 151 p.

Ouarghidi A., Powell B., Martin G.J., Abbad A. 2017. Traditional Sustainable Harvesting Knowledge and Distribution of a Vulnerable Wild Medicinal Root (*A. pyrethrum* var. *pyrethrum*) in Ait M'hamed Valley, Morocco. Journal Economic Botany 71: 83–95. https://doi.org/10.1007/s12231-017-9374-2

Pascual U., Muradian R., Brander L., Gómez-Baggethun E., Martín-López B., Verma M. 2010. Chapter 5: The economics of valuing ecosystem services and biodiversity, in The Economics of Ecosystems and Biodiversity. Ecological and economic foundations. 133 p. Available at: http://africa.teebweb.org/wp-content/uploads/2013/04/D0-Chapter-5-The-economics-of-valuing-ecosystem-services-and-biodiversity.pdf

Rhafouri R., Aafi A., Zair T., Strani B., El Omari M., Ghanmi M., Bentayeb A. 2015. Ethnobotanical study of medicinal plants in Ifran's National Park (Morocco). Materials and Environmental Science 6(3): 619–630.

Schippmann W., Leaman U.D., Cunningham A.B. 2006. A comparison of cultivation and wild collection of medicinal and aromatic plants under sustainability aspects. In: Bogers R.J., Craker L.E., Lange D. (Eds), Medicinal and aromatic plants. Wageningen UR Frontis Series No 17: 75–95.

Sharma N., Kala C.P. 2018. Patterns in distribution, population density and uses of medicinal plants along the altitudinal gradient in Dhauladhar mountain range of Indian Himalayas. Current Science 114(11): 2323–2328.

Sharma N., Kala C.P. 2022. Harvesting patterns, risk of harvesting and sustainability of medicinal and aromatic plants in Kangra district of Himachal Pradesh in India. Journal of Applied Research on Medicinal and Aromatic Plants 26, 100367.

Sijelmassi A. 1993. Les plantes médicinales du Maroc 3ème édition (Fennec, Casablanca Moroc). Casablanca, Editions Le Fennec. 285 p.

Valdés B. 2002. Catalogue des plantes vasculaires du Nord du Maroc incluant des clés d'identification. Vol. 1, Editorial CSIC-CSIC Press. 1007 p.

Zrira S. 2017. Some Important Aromatic and Medicinal Plants of Morocco. In: Neffati M., Najjaa H., Máthé Á. (Eds), Medicinal and Aromatic Plants of the World. Springer, Dordrecht, vol. 3: 91–125. https://doi.org/10.1007/978-94-024-1120-1_5