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Nature's Contributions to People (NCP): case of aromatic and medicinal plants in Morocco

Abstract

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Nature's contributions to people (NCP) refers to all contributions, beneficial or harmful, that people, individually or collectively, derive from nature at various scales. NCP offers a pluralistic framework for understanding how the status and trends of nature - including biodiversity and ecological processes - are linked to changes in people's quality of life, while at the same time acknowledging a plurality of perspectives and world views on human-nature relations. NCP serves as an umbrella embodying different concepts, such as ecosystem goods and services, nature's gifts, and many others, and facilitates respectful collaboration between knowledge systems and world views.
Morocco's aromatic and medicinal plants (AMP) are classified as a type of NCP by IPBES (Intergovernmental Platform on Biodiversity and Ecosystem Services). These high-value products contribute to the country's socio-economic development. In addition to this material contribution, the Moroccan pharmacopoeia is a nonmaterial contribution strongly linked to the use of AMPs. Morocco has a long-standing tradition and considerable expertise in phytotherapy.

Key words: phytotherapy, ecosystem services, phyto-resources, North Africa.

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Introduction

Multiple frameworks have been deployed in efforts to reconceptualize the nature–people relationship and improve sustainability outcomes. For example, the ecosystem service framework which describes the benefits people obtain from ecosystems has been developed to change how communities view and value natural resources (Costanza & al. 2017). But there is scant evidence that the ecosystem services framework has improved biodiversity conservation outcomes (Dempsey 2016). Recently, Diaz and colleagues (2018) proposed a shift from ecosystem services to nature's contributions to people (NCP), incorpo-

rating broader and more inclusive perspectives of nature–people relationships. The NCP framework encompasses "all the positive contributions, losses or detriments, that people obtain from nature" to understand the beneficial and harmful effects of nature (Díaz & al. 2018). The NCP framework emerged from the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), which was established by the United Nations (Díaz & al. 2018). The framework has roots in the social sciences, biocultural diversity, and Indigenous or local perspectives (Díaz & al. 2018).

The use of aromatic and medicinal plants and their derivatives for food and therapeutic purposes is very common worldwide since ancient times. Currently, almost 80% of the world's population, mainly in developing countries, depend on herbal medicines to answer their basic primary health needs for the management of numerous diseases (WHO 2004, 2018). Traditional medicine in Morocco is an integral part of Moroccan culture, a culture that is directly stems from it and serves as its concrete manifestation in areas such as care, hygiene, prevention, nutrition, and, more broadly, the fight against diseases. It is this transhistorical cultural dimension, this continuity, that gives traditional medicine practiced in Morocco extraordinary adaptability and a very practical sense of the tasks of our time (Bellakhdar 2020). Faced with threats of anthropogenic and climatic nature to the survival of plant resources, it was important to acquire as much information as possible about plant species for which Moroccans had traditional know-how and knowledge, to protect floristic diversity and preserve traditional knowledge.

The objective of this work is to study one of the aspects of nature's contribution to people by focusing on the different uses of AMP in Morocco.

Materials and Methods

Consultation of bibliographic data (Jamaleddine 2021) allowed us to establish an exhaustive list of all the aromatic and medicinal plants of Morocco. The uses of these AMPs, their therapeutic properties, and the parts used have been extracted from ethnobotanical studies conducted at the national level (Jamaleddine 2021) and from the book of Bellakhdar (2020) on the traditional Moroccan pharmacopeia. The various indications collected are classified according to the type of use (medicinal, food, or technical).

Data concerning aromatic and medicinal plants used in traditional phytotherapy in Morocco were organized using computer-aided systems engineering (CASE) Windev version 17 to create a database called "MaPlanteMedicinal" using the HyperFilSQL database search engine. Windev, published by the French company PC SOFT, is a software engineering workshop designed to rapidly develop data-oriented applications. As an advanced RAD tool, Windev uses MERISE or UML analysis to build operational applications and can generate code for Java, standard, or .NET platforms. It supports both the procedural and object-oriented programming paradigms (https://etcsoft.fr/blog/definition-logiciel-sur-mesure/).

This database has the advantage of being dynamic and up-to-date as knowledge of plant uses evolves. The use of this database allowed us to study the different characteristics of AMP in Morocco (uses of AMP, therapeutic properties, parts used), calculate the percentages, and analyze the results after their graphical representations. Regarding the taxonomy

and nomenclature of the inventoried AMPs, the two catalogues of the vascular flora of Morocco (Fennane & Ibn Tattou 2005, 2008) as well as the three volumes of the practical flora of Morocco (Fennane & al. 1999, 2007, 2014) are the main references.

Results and discussion

The total number of inventoried taxa used in traditional Moroccan phytotherapy is 750, belonging to 102 families and 375 genera. The most represented families are *Lamiaceae* with 82 taxa (10.93%), *Asteraceae* with 80 taxa (10.66%), *Fabaceae* (6.26%), *Apiaceae* (5.06%), *Brassicaceae* and *Poaceae* (3, 73%).

1. Uses of aromatic and medicinal plants

1.1. Medicinal uses

There are 2748 indications for medicinal use listed, 93.9% of which are for human medicine, 5.1% for cosmetology and hair care, and 1% for veterinary medicine. (Fig.1a). The list of AMPs used in cosmetology - hair care and veterinary medicine is presented in the Electronic Supplementary File (ESF, Table S1).

Analysis of the therapeutic indications used in cosmetology and hair care shows that cosmetic hair care predominates with more than half of the indications (54%), while cosmetic facial care accounts for about a quarter (22%). Cosmetic skin care comes third with 11% of the therapeutic indications (Fig. 1b).

Concerning indications intended for veterinary medicine, one-third of these indications (30%) mention use in the case of scabies for pasture and farmed animals, and 16.6% are used against colic (mainly in dromedaries). In third place are skin diseases (13.3%), and in fourth place with 6.6% are treatments for diseases of the pulmonary system (dromedaries, horses, and mules) and the application of emollient cataplasms (cows) (Fig. 1c).

The therapeutic indications used in human medicine by the local Moroccan populations, come first with more than 25% of the indications for use against diseases of the digestive system and its annexes (Fig. 1d).

The percentage of indications treating dermatological infections is 15%, while neurological infections are 11.4%. Other pathologies treated have less than 10%; bronchopulmonary, urinary, and osteoarticular pathologies each (6%), pathologies of the ENT sphere and gyneco-obsteric each (5.6%), metabolic pathologies (4.5%), pathologies of the buccodental sphere and cardiovascular and blood 3.8% and 3.6% successively (Fig. 1d).

1.2. Food use

On the whole 324 aromatic and medicinal plants inventoried have food uses in addition to their medicinal use. They represent 43% of all AMPs inventoried. 67% of these plants are used in human food, 12.6% in animal feed, while the rest (20.4%) are used in both human and animal food (Fig. 1f)

In terms of animal feed, these plants in their fresh or dry state provide either pasture for animals (sheep, cattle, goats, horses, camels, wild boars, gazelles, etc.) or fodder for live-

Fig. 1. a) Types of uses of Aromatic and Medicinal Plants (AMPs); b) Distribution of therapeutic indications used in cosmetology and hair care; c) Distribution of therapeutic indications used in veterinary medicine; d) Distribution of indications used in human medicine; e) Food use of Aromatic and Medicinal Plants; f) Types of uses of Aromatic and Medicinal Plants (AMPs) in human food.

stock (horses, cattle, mules, etc.). Common millet (*Panicum milaceum* L.) seeds are used for bird and poultry feed.

On the other hand, an analysis of the various types of use of these aromatic and medicinal plants in human food showed that more than half of these plants are consumed as vegetables 37% (leaves, stems, rhizomes, young plants, etc.), as fruit (16.5%). The consumption of seeds in various forms (basic food cereals, flavoring bread, flour, etc.) accounts for a significant proportion (12%). They can be used to perfume tea (8%), as a condiment (7%), to make sauces (5%), and more other uses (Fig. 1f).

1.3. Other uses (technical uses)

Other uses of AMPs mentioned in the bibliography (Jamaleddine 2021) are grouped under technical uses. The main areas concerned by these indications are saponiferous plants, handicrafts, tanneries, manufacture of household and other objects, charcoal, fuels, natural pesticides, etc. (Table 1).

Table 1. List of technical uses of Aromatic and Medicinal Plants (AMPs) in Morocco.

Indication area	Examples
Saponiferous plants	-
Handicrafts	Baskets, mats, basketry, marquetry, cabinetmaking
Tanneries	Skins, waterskins, leathers, fishing nets
Domestic objects and others	Wooden poles, net floats, handles
Charcoal	-
Fuels	-
Natural pesticides	Insecticide (mosquito, mites…), raticide, against worms
Dyeing	Wool, leather, fabrics, skins, waterskins, hands and feet
Woodworking	-
Perfumery	Deodorant, eau de toilette, perfume linen
String Manufacturing	-
Poison	-
Inks	Delebile or indelible
Traditional glue	-
Cellulose industry	-
Gunpowder	-
Mattress making	Mattress padding
Toothpicks	-
Cochineal farming	-
Polish utensils	-

Table 2. The principal therapeutic properties in order of decreasing frequency.

Therapeutic properties	Linked pathology
Diuretic	Urinary
Antidiabetic	Digestive
Antiseptic	Dermatological
Stomachic	Digestive
Laxative	Digestive
Anti-inflammatory	Several pathologies
Antidiarrheal	Digestive
Tonic	Neurological
Aphrodisiac	Neurological
Stimulating	Neurological
Astringent	Dermatological
Healing	Dermatological
Purgative	Digestive
Sedative	Neurological
Emmenagogue	Gyneco-obstetric
Vermifuge	Digestive
Depurative	Several pathologies
Abortive	Gyneco-obstetric
Expectorant	Broncho-pulmonary

2. Therapeutic properties

Many AMPs (130) have one or more uses in traditional Moroccan medicine but lack therapeutic properties. This means that additional work must be done within research laboratories to fill this gap, especially since seven species of them are endemic to Morocco: *Nepeta atlantica* Ball; *Calendula maroccana* (Ball) B. D. Jacks.; *Lavandula maroccana* Murb.; *Abies maroccana* Trab.; *Centaurium pulchellum* subsp. *grandiflorum* (Batt.) Maire; *Clinopodium atlanticum* (Ball) N. Galland; *Micromeria peltieri* (Maire) R. Morales.

On the other hand, although more than 50 plants are included in the list of AMPs used in traditional Moroccan medicine, they have no medicinal use in ethnobotanical studies carried out at the national level to date. Using our database to analyze the various characteristics of these AMPs, we found that 25% of them fall into the endangered categories according to Fennane (2021): seven endangered species EN (*Nymphaea alba* L.; *Ligustrum vulgare* L.; *Phlomis purpurea* L.; *Astragalus monspessulanus* L.; *Persicaria bistorta* (L.) Samp.; *Nepeta hispanica* Boiss. & Reut.; *Carum jahandiezii* Litard. & Maire) and five others vulnerable VU (*Digitalis purpurea* L.; *D. obscura* L. *Quercus lusitanica* Lam.; *Argyrocytisus battandieri* (Maire) Raynaud; *Salix elaeagnos* Scop.). Local populations have used them less over time, which may be why there is less data on their medicinal use. For the rest, ethnobotanical field studies are likely to fill in the remaining gaps (Fig. 2a).

The analysis of the distribution of human medicine's therapeutic indications (Fig. 1d) shows that the latter is strongly correlated with the frequency of therapeutic properties (Table 2).

3. Used parts of aromatic and medicinal plants

All parts of aromatic and medicinal plants are used in traditional Moroccan medicine. A total of 37 parts have been listed in medicinal uses (ESF1, Table S2). This number reflects the richness of traditional Moroccan herbal medicine.

Analysis of these results shows that the whole plant and the leaf are the most cited plant parts with 21.6 % and 20.6 % respectively. Seed and root ranked third and fourth with 10.5% and 10.4% respectively, followed by fruit (8.7%), flower (7.2%), stem (5%), bark (3.2%), and latex (2%). All remaining used parts are represented by a cumulative rate of 10.8% (Fig. 2b).

The high percentage of use of the whole plant indicates, in most cases, the uprooting of the entire plant. This anarchic method of gathering seriously compromises the sustainability of aromatic and medicinal species and causes the degradation of ecosystems and natural resources (Alaoui & al., 2018). Similarly, the high frequency of use of leaves may be explained by the ease and speed of harvesting (Bitsindou 1986), but also by the fact that they are the site of photosynthesis and sometimes storage of secondary metabolites responsible for the plant's biological properties (Bigendako-Polygenis & Lejoly 1990). The use of leaves is safe for plant regeneration and will ensure the conservation of plant richness. There is a clear relationship between the used part of the plant exploited and the effects of that exploitation on its existence and long-term sustainability (Cunningham 1996). The exploitation of certain plant parts, such as the example of pyrethrum (*Anacyclus pyrethrum* (L.) Lag.) could harm the survival and sustainability of the species.

A collaborative, integrated approach is key to preserving Morocco's plant biodiversity (Labrighli & al. 2025).

4. Nature's Contributions to People (NCP)

The IPBES identifies 18 types of NCP and classifies them according to the nature of their contribution to the quality of life.

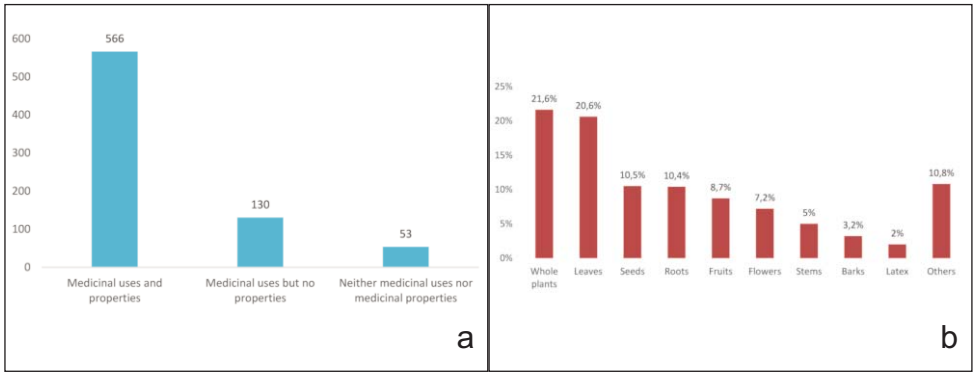

Fig. 2. a) Proportion of Aromatic and Medicinal Plants (AMPs) according to their therapeutic properties and medicinal uses; 2b) Distribution of plant part used in AMPs in Morocco.

Classified among the elements of the 14th NCP proposed by IPBES, aromatic and medicinal plants constitute products with very high added value which contribute to the valorization of Moroccan plant biodiversity and the socio-economic development of the country. Indeed, the total number of AMPs used in traditional Moroccan medicine is 750, belonging to 102 families and 375 genera. The most represented families are: *Lamiaceae*, *Asteraceae*, *Fabaceae*, and *Apiaceae*. The number of endemics in Morocco is 48 taxa (representing more than 6 % of the total). Thus, the analysis of data concerning the status of these plants shows that 75 % are spontaneous (Jamaleddine & al. 2019). The collection of AMP constitutes a means of diversifying agricultural production and remains an income-generating activity for local rural populations. Morocco is ranked 12th among the world's AMP exporters as a result. In detail, around 60% of these exports are from the food sector (carob, spices, etc.), while 35% are from perfumery and cosmetics, and 5% are from the exploitation of their medicinal properties. Over the last decade, Moroccan exports of AMP have grown significantly. Over the last decade, Moroccan exports of AMP products have grown significantly. AMPs exports increased from 12,386 tons in 2014 to 46,000 tons in 2019, which represents an average annual growth rate of 30%. The European Union market is the main destination, absorbing around 60% of exports. From 2014 to 2019, exports of essential oils, extracts, and perfumes rose from 350 to 687 tons, representing an average annual growth rate of 14.5% (https://agadirinvest.com/etudes-data/).

In addition to these material contributions from nature, Moroccan pharmacopeia as a non-material contribution is strongly linked to the use of AMPs. Morocco has an ancient tradition and significant know-how in traditional phytotherapy, and not far, the number of indications of medicinal use listed in this present work which is of the order of 2748 indications reflects the extent of this tradition. Another important factor that makes this knowledge unique is its deep roots in the natural environment of the country that supplies it with most of its resources, its innovative character concerning written knowledge (Greek, Arabic, essentially) is manifested in particular by the presence in the Moroccan drogue of certain products that are specific to it and that are provided by the environment, characterized by a high rate of endemicity of the taxa (Bellakhder 2020).

Conclusion

Morocco's traditional medicine is undoubtedly a cultural treasure rooted in history. Centuries of interaction between humans and nature have led to a wealth of knowledge and expertise in treating illnesses. For a long time, this was the only way to be cured. The use of AMPs, the mainstay of traditional medicine, has created a strong link between local populations and nature. In Morocco today, collecting aromatic and medicinal plants is a means of diversifying agricultural production and remains an income-generating activity for rural populations. In addition to these material contributions, the Moroccan pharmacopoeia provides non-material contributions.

Using our newly created database, we studied the uses of AMPs in traditional medicine and counted all the therapeutic indications. There are 2748 indications for medicinal use, 93.9% of which are for human medicine, 5.1% for cosmetology and hair care, and 1% for veterinary medicine. The most common therapeutic indications used in human medicine

by the local Moroccan populations are those employed to treat affections of the digestive system and its annexes, accounting for more than 25% of all cases. In traditional Moroccan medicine, all parts of aromatic and medicinal plants are used. Depending on the therapeutic indication, the entire plant or a small part, such as buds, leaf ribs, or stigmas, may be used. A total of 37 parts are listed for medicinal use. This number reflects the richness of traditional Moroccan phytotherapy.

On the other hand, the latest economic data confirms the growth of the AMP sector. For instance, the volume of AMP exports and essential oils and their derivatives increased from 12,386 and 350 tons in 2014 to 46,000 and 687 tons, respectively, in 2019.

Undoubtedly, all this gives Morocco's AMP sector an important role in NCP.

The collection of AMPs constitutes a means of diversifying agricultural production and remains an income-generating activity for local rural populations, in addition to these material contributions of nature, Moroccan pharmacopeia as a non-material contribution is strongly linked to the use of AMPs. Morocco has an ancient tradition and significant know-how in traditional phytotherapy. This undoubtedly gives the AMP sector in Morocco an important role in the NCP.

However, it should be noted that AMP resources are being abused and exploited excessively and haphazardly, which poses a real threat to biodiversity and ecosystem services. These services are an integral part of nature's contribution to people.

Conserving and enhancing traditional knowledge related to AMPs, as well as building capacity in terms of awareness, education, training, and taxonomy, contributes greatly to the conservation and sustainable use of AMPs. This ensures the socioeconomic development of local populations and, consequently, human well-being.

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