



Crop wild relatives and wild harvested plants of Morocco: checklist and priorities for conservation

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Abstract The rich floristic diversity of Morocco, which encompasses approximately 5784 taxa, includes a significant proportion of Crop Wild Relatives (CWR) and Wild Harvested Plants (WHP), which holds immense potential for biodiversity conservation and food security. This study presents a comprehensive inventory of CWR and WHP, developed from the latest floristic data and biodiversity assessments. Taxa were prioritized on multiple criteria, including economic value, potential for crop improvement, conservation status, endemism, inclusion in the International Treaty on Plant Genetic Resources for Food and Agriculture, and contributions to national diets through dietary energy supply. A systematic scoring framework categorizes taxa into four priority levels to guide conservation efforts. The analysis revealed that 4682 specific and infraspecific taxa (81% of the Moroccan flora), belonging to 152 families and 789 genera,

were identified as CWR and/or WHP. They include 3547 taxa classified solely as CWR, 115 as WHP, and 1135 as both. Conservation prioritization highlighted 4596 CWR (98% of total CWR taxa) and 1208 WHP, with high-priority categories encompassing 252 CWR and 36 WHP taxa. These taxa are particularly notable for their adaptive traits to extreme climatic conditions such as drought and salinity, making them invaluable for crop improvement under climate change scenarios. Morocco has emerged as a Mediterranean biodiversity hotspot for CWR and WHP, underscoring its critical role in global genetic resource conservation. The findings advocate for an integrated national conservation strategy, balancing in situ and ex situ approaches to mitigate genetic erosion and habitat degradation. This work supports Morocco's commitments to international biodiversity and food security frameworks, emphasizing the urgency of preserving

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plant genetic resources for sustainable agriculture and resilience to environmental changes.

Keywords Biodiversity conservation · Genetic resources · Endemism · Food security · North Africa

Introduction

Plant genetic resources, including Crop Wild Relatives (CWRs) and Wild Harvested Plants (WHPs), are essential assets to address global challenges related to food security, agricultural system resilience, and ecological sustainability (Reeves et al. 2016). These resources represent a vital reservoir of genetic diversity, offering innovative solutions to enhance agricultural productivity and increase crop adaptability to both biotic and abiotic stresses (Mammadov et al. 2018). In the context of climate change, these wild and cultivated plants play a strategic role in ensuring global food security and sustainability in agricultural systems (FAO 2006, 2019).

In particular, CWRs are invaluable resources for strengthening crop resistance to diseases, extreme climatic conditions (such as drought, heat, and salinity), and pests (FAO 2009, 2019; Hajjar and Hodgkin 2007). They are wild species closely related to cultivated crops and provide a foundational source of genetic diversity crucial for crop improvement (Maxted et al. 2006, 2010). These wild species can contribute resistance genes against various environmental pressures, including diseases, drought, and salinity, and possess nutritional quality traits critical for crops adaptation to climate change (Maxted et al. 2010). For example, the genus *Aegilops* L., specifically *Aegilops tauschii* Coss., the wild ancestor of durum wheat *Triticum durum* Desf., has been incorporated into breeding programs to enhance wheat resistance to diseases such as stem rust *Puccinia graminis* f. sp. *tritici* and improve water stress tolerance (Vincent et al. 2013; Hajjar and Hodgkin 2007). Other CWRs, such as *Olea europaea* L. (olive) and *Daucus carota* L. (wild carrot), exhibit drought-resistant traits and high adaptability, especially valuable for arid regions such as Morocco (Maxted et al. 2006; FAO 2011).

WHPs, on the other hand, consist of non-domesticated plants harvested for food, medicinal, and economic resources, particularly within rural communities where they sustain essential traditional practices

(Hajjar and Hodgkin 2007). These wild-harvested plants play crucial roles in ecosystems, biodiversity, and human societies, especially in Mediterranean and semi-arid regions such as Morocco, where they have been gathered for millennia for diverse uses. These non-domesticated plants are traditionally exploited for their nutritional, medicinal, and artisanal value, remaining an essential complement to diet and medicine in numerous rural and urban communities (Maxted and Vincent 2021). According to the World Health Organization (WHO), approximately 65% of the global population relies on plant-derived products for healthcare (Fabricant and Farnsworth 2001), and more than 6,000 plant species are used for medicinal purposes (Lavania 2005). From an economic perspective, an important part of WHPs consists of medicinal and aromatic plants (PAM), providing a valuable supplementary income source for rural communities. Morocco is in fact the 12th exporter of PAMs (Lamrani-Alaoui et al. 2015) and their transformed products are sold abroad every year with an estimated total value of approximately 300 million MAD¹. A substantial number of native or naturalized species with direct economic importance for Morocco are officially recognized, these include around 800 plant taxa of medicinal and aromatic value, (Taleb 2017) with 40 endemics (Jamaledine et al. 2017).

Furthermore, WHPs present significant potential in enhancing food security and nutrition for communities residing in challenging conditions. They can aid in broadening diets by providing crucial nutritional resources, especially in areas influenced by climatic and environmental limitations. A notable example is *Sideroxylon spinosum* L., the argan tree, a species endemic to Morocco and Algeria whose oil is widely used for culinary, medicinal, and cosmetic purposes. This oil is highly valued for its antioxidant, moisturizing, and antiaging properties, and represents an important economic resource for rural communities, particularly in the southwest of the country (Bellakhdar 1997; Lybbert et al. 2011). However, this plant faces increasing overexploitation, compromising its long-term sustainability and threatening local biodiversity. Deforestation and overuse of the argan tree, alongside numerous other wild plants, endanger not

¹ Centre de Recherche Forestière, Plantes Aromatiques et Médicinales du Maroc, 2011.

only the species itself but also the traditional knowledge and sustainable agricultural systems associated with its use (Schippmann et al. 2006).

Morocco, with its unique geographic position between the Mediterranean and the Sahara, is a major center of plant biodiversity. The country hosts approximately 5211 plant species and subspecies (Fennane and Ibn Tattou 2012; Benabid 2000), giving it considerable floristic richness and making it a global biodiversity hotspot (Médail and Quézel 1999). This plant diversity spans a range of habitats, from the Mediterranean and Atlantic coastal plains to the Atlas Mountains and extends into the arid deserts of the Sahara. Morocco is a significant repository of CWRs and WHPs, harboring numerous wild species closely related to essential agricultural crops such as wheat *Triticum* sp. pl., barley *Hordeum vulgare* L., and olive *Olea europaea*, as well as medicinal and nutritional plants such as the carob tree *Ceratonia siliqua* L., the lavender *Lavandula angustifolia* Mill., and the thyme *Thymus vulgaris* L. This wealth positions Morocco as a key player in the conservation of Mediterranean and semi-arid phyto-genetic resources (Fennane et al. 1999, 2007, 2014).

This exceptional biodiversity currently faces multiple threats. Agricultural intensification, deforestation, and natural resources overuse, combined with the impacts of climate change, disrupt the ecological balance (Cardinale et al. 2012). These environmental pressures, notably rising temperatures, prolonged drought periods, and soil salinization, contribute to the loss of genetic diversity and the erosion of natural ecosystems. For example, several CWR and WHP populations, particularly in the arid regions of eastern Morocco and the High Atlas Mountains, are experiencing rapid declines, endangering not only the species themselves but also the ecosystem services they provide, such as water regulation and soil fertility (Dempewolf et al. 2017; Hajjar and Hodgkin 2007; FAO 2011).

In addition, the official Red Book of Moroccan Vascular Flora (Fennane et al. 2021) underscores the heightened conservation concerns for certain wild taxa of economic, ecological, or cultural significance. At present, there are almost 1000 threatened species (Vulnerable, Endangered and Critically Endangered) and 24 extinct or presumed extinct for Morocco (Fennane et al. 2021). Species such as *Sideroxylon spinosum* (argan) or *Origanum elongatum* (Bonnet)

Emb. & Maire are endemic species legally protected due to habitat loss and overharvesting. This protection status further highlights the urgency of establishing robust conservation and management strategies that safeguard Morocco's unique plant heritage.

In response to these challenges, international initiatives have been established, including the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) (FAO 2009) and the Second Global Plan of Action for Plant Genetic Resources (FAO 2011). These agreements aim to promote the conservation and sustainable use of plant genetic resources by integrating CWRs and WHPs into national management strategies. Morocco, a signatory of these conventions, has implemented in situ and ex situ conservation programs to protect its unique plant biodiversity. However, despite the existence of official listings of economically valuable and protected species, there remains no unified, updated, and prioritized inventory that can guide national strategies effectively. Therefore, developing a national inventory of CWRs and WHPs to identify the most vulnerable species and those with high potential for sustainable agriculture and biodiversity preservation constitutes the fundamental component of a successful conservation strategy (Kell et al. 2007).

In this context, given the growing threats to these resources, the urgency for a thorough documentation, prioritization, and effective conservation planning can be addressed by, first of all, the development of national inventories of CWRs and WHPs as a basis for planning effective conservation strategies (Maxted et al. 1997; Kell et al. 2007; Ferreira de Souza Dias et al. 2015; FAO 2017). The Mediterranean basin is one of the three primary global CWR diversity hotspots, alongside West Asia and China (Vincent et al. 2013). However, while conserving all CWRs/WHPs is crucial, applying a broad concept of CWR (Maxted et al. 2006) may encompass an excessive number of taxa, rendering active conservation impractical due to limited resources. For instance, in Europe, 83% of the total flora can be classified as CWR in a broad sense (Kell et al. 2007), making comprehensive management of all these species unfeasible. Prioritizing taxa in conservation planning is, therefore, critical (Ford-Lloyd et al. 2007; Maxted and Kell 2009; Kell et al. 2017). According to (Maxted et al. 2013), inventories help to complete lists and annotated lists by providing detailed information on species, such as their genetic

relationships with crops, their threat according to the IUCN Red List (IUCN 2023), and other essential criteria for the sustainable management of phylogenetic resources.

In light of the above, this study aims to create a prioritized inventory of Moroccan CWRs and WHPs, on the basis of recent data on Moroccan flora and employing prioritization criteria established in the scientific literature.

Accordingly, we hypothesize that compiling and prioritizing a comprehensive list of Morocco's CWRs and WHPs, taking into account their crop relatedness, threat status, socio-economic importance, and ecological value, will uncover critical gaps in conservation efforts, highlight taxa essential for agricultural and economic resilience, and provide a robust framework for further policy recommendations.

From an economic perspective, the identification of priority species important for Morocco's agricultural economy can serve as an important contribution to stimulate crop improvement programs, diversification of the production, and sustainable rural livelihood. Ultimately, this inventory can serve as a foundation for developing sustainable conservation strategies, both in situ and ex situ, to ensure the resilience of Moroccan agricultural systems in the face of climate change pressures and hinder natural ecosystem degradation.

Materials and methods

Compilation of reference list of Moroccan crop wild relatives and wild harvested plants

A comprehensive reference list of CWRs and WHPs of Moroccan flora was compiled by integrating both regional and international databases to ensure a complete and accurate inventory of taxa present in Morocco. The Flora of Morocco served as the primary reference (Fennane et al. 1999, 2007, 2014), which was further enriched, validated and corrected with data from the African Plant Database² (version 4.0.0) and Euro+Med Plantbase.³ Starting from this integrated checklist, CWR taxa (i.e. all taxa within the same genus as a crop) were identified, and classified

according to Gene Pool (Harlan and de Wet 1971a) and Taxon Groups concepts (Maxted et al. 2006), using data from Germplasm Resources Information Network (USDA 2023), the CWR inventory by Harlan and de Wet (Vincent et al. 2013) and previous papers on the north African region (Lala et al. 2018; El Mokni et al. 2022). This methodology is aligned with international standards for identifying CWR, as utilized in similar research (Kell et al. 2015; Contre-ras Toledo et al. 2018; Rahman et al. 2019). Regarding the compilation of data on WHP taxa, they were identified by the analysis of several bibliographic sources as better detailed in subsection 2.4.

Taxonomic nomenclature harmonization

Taxonomic precision is essential for comparative analysis. Species nomenclature was harmonized using internationally recognized databases: the International Plant Name Index (IPNI 2024) and Plants of the World Online (POWO 2024). This process ensured the use of names that adhere to global standards, minimizing discrepancies due to local variations or nomenclatural updates.

Auxiliary data compilation

Auxiliary data for each taxon were compiled according to (Thormann et al. 2018) to ensure comprehensive and consistent documentation. The information collected for each taxon included: family, genus, species, taxonomic rank, status (native, introduced, invasive), endemism, Red List status, associated crop common and scientific names, relationship type and degree with the associated crop, and local cultivation status. Additionally, specific data for each taxon, such as the gross production value of associated crops, synonyms, and usage categories (e.g., medicinal, edible), were integrated, providing a solid foundation for subsequent analyses.

Identification of wild harvested plants: ethnobotanical approach

The identification of WHP relied on a documentary analysis of traditional plant uses in Morocco. Although this study did not include direct ethnobotanical surveys, it incorporated existing data from regional publications, including (Bellakhdar 1997)

² <https://africanplantdatabase.ch/>

³ <http://ww2.bgbm.org/EuroPlusMed>

and other researchers who have documented ethnobotanical uses in various regions of Morocco (Charnot 1945; El Oualidi et al. 2004; Fakchich and Mostafa 2014; Ouhaddou et al. 2015; El Alami et al. 2016; Najem et al. 2019; Fakchich and Mostafa 2020; Kharchoufa et al. 2021; Alami Merrouni et al. 2021; Jeddi et al. 2021; Belhaj et al. 2021; Chaachouay et al. 2021; Labrighli et al. 2024). Local plant uses were classified into categories such as: beverages, environmental, ethnobotanical, forage, food, food additive, fuel, material, medicinal, ornamental, and social uses. In addition, information on taxa known for toxicity or honey production relevance was included to provide a detailed overview of the roles of WHP in local practices.

Prioritization methodology

The prioritization of identified CWR and WHP taxa was conducted using criteria from (Maxted and Kell 2009), with adaptations from (Brehm et al. 2010, 2018), (Kell et al. 2015, 2017), and (Lala et al. 2018). Six criteria (a-f) have been chosen to evaluate the priority level of each taxon in the inventory. These criteria enabled an objective evaluation of taxa based on socio-economic, genetic, and ecological importance (Table 1).

Criterion (a), *economic value of associated crop*, was based on the economic value of crops associated with the CWR, derived from FAOSTAT data for Moroccan gross agricultural production (FAO 2023) for the period 2016–2020. Classification followed the FAOSTAT product nomenclature, allowing standardization of taxa economic value based on their contribution to the agricultural economy. Taxa with high economic value received higher scores, highlighting their direct impact on national livelihood and economy.

Criterion (b), *degree of genetic relatedness*, was determined using the Gene Pool (GP) (Harlan and de Wet 1971b) and Taxon Group (TG) (Maxted et al. 2006) concepts. Categories included: GP1b: wild forms of the crop, with easy crossbreeding and fertile hybrids; GP2: secondary relatives, with more difficult crossbreeding; GP3: tertiary relatives, where genetic transfer is complex or requires advanced techniques. In cases lacking crossbreeding data, the taxon group concept was applied: TG1b: same species as the crop; TG2: same series or section; TG3:

Table 1 Scoring system adopted for prioritization of Crops Wild Relatives (CWR) and Wild Harvested Plants (WHP) taxa

Criteria	Score										
	0	1	2	3	4	5	6	7	8	9	10
a) Economic Value in Morocco (000 \$ per year)		< 1	1–10	> 10–100	> 100–200	> 200–400	> 400–500	> 500–600	> 600–1,000	> 1,000–2,000	> 2,000
b) Degree of CWR–crop a relatedness		TG5	GP3		TG3, TG4		GP2, TG2			GP1b, TG1b	
c) Threat status			LC, DD	NT			EN			CR	
d) Endemicity					VU					Endemic	
e) Nutritional Value										0 > Kcal/capita/day	
f) ITPGRFA Annex I										Included	

same subgenus; TG4: same genus; TG5: same tribe. When a CWR was associated with multiple crops, the closest genetic link was prioritized. If ties occurred, the economically most significant crop was retained, ensuring that the taxa with the highest impact were emphasized.

Criterion (c), *threat status*, was obtained from the IUCN Red List (IUCN 2023) and the Red Book of Moroccan Vascular Flora (Fennane et al. 2021). Taxa categorized as LC (Least Concern), NT (Near Threatened), VU (Vulnerable), EN (Endangered), and CR (Critically Endangered) were scored according to Table 1. The scores increased with increasing extinction risk, ensuring that the most threatened taxa received priority attention.

Criterion (d), *endemism*, was determined using the Checklist of Endemic and Type Specimens of the North African Vascular Flora (El Oualidi et al. 2012), Flore Pratique du Maroc (Fennane et al. 1999, 2007, 2014), and the African Plant Database. Endemic species received higher weight than non-endemic ones (score 10/10), reflecting their critical role in regional biodiversity. These taxa, often confined to specific ecosystems, require increased conservation efforts because of their vulnerability to environmental disturbances.

Criteria (e) and (f), *nutritional value* and *ITPGRFA Annex I inclusion*, which reflect the importance of the associated crop for food security, were established by combining information on inclusion in Annex I of ITPGRFA (FAO 2009) and the average nutritional contribution of associated crops (kcal/capita/day) for the North African region according to FAOSTAT data for food balances, period 2016–2020 (FAO 2023).

The CWR taxa were firstly identified as belonging to the same genus as a crop, with adjustments for taxa having updated names. For the calculation of priority levels, scores for each of the six criteria were assigned on a 0 to 10 scale to each taxon, and a final score (FS) was calculated as the average of these scores. Finally, four priority levels were then obtained:

- High priority: $FS \geq 5$;
- Medium priority: $2 \leq FS < 5$;
- Low priority: $0 < FS < 2$;
- No priority: $FS = 0$.

Exclusively cultivated species (GP1a and TG1a) and invasive species were excluded from prioritization. Economic and food importance criteria do not apply to WHPs, which were evaluated solely on the basis of criteria c and d.

Limitations of data sources and potential gaps

Although this study relies on the most up-to-date floristic data and biodiversity assessments available for Morocco, several limitations should be considered:

- **Incomplete geographic coverage:** Some areas, particularly remote regions such as mountainous and Saharan zones, are under-sampled, potentially leading to biases in reported species distributions.
- **Potentially overlooked taxa:** Certain rare, cryptic, or poorly studied species may not be adequately documented in existing inventories. Taxonomically complex groups requiring genetic analyses for precise identification may also be underrepresented.
- **Reliance on secondary data sources:** The inventory is based on compiled databases and previous scientific publications, which may contain identification errors or outdated information.
- **Bias in data collection efforts:** Some species are better studied due to their economic or medicinal importance, while others, particularly those with no immediate human use, may be under-sampled.

Results and discussion

Checklist description

The comprehensive checklist of the flora of Morocco comprises a total of 5784 taxa, encompassing species, subspecies, varieties, and botanical hybrids. Among these, 4682 taxa (approximately 81% of the total) are classified as Crop Wild Relatives and/or Wild Harvested Plants, distributed across 152 families, 789 genera, and 3316 species. This proportion is aligned with findings from other regions where CWRs are broadly defined, including all taxa within the same genus as cultivated crops, without excluding introduced, invasive, or cultivated species (Kell et al. 2007, 2015).

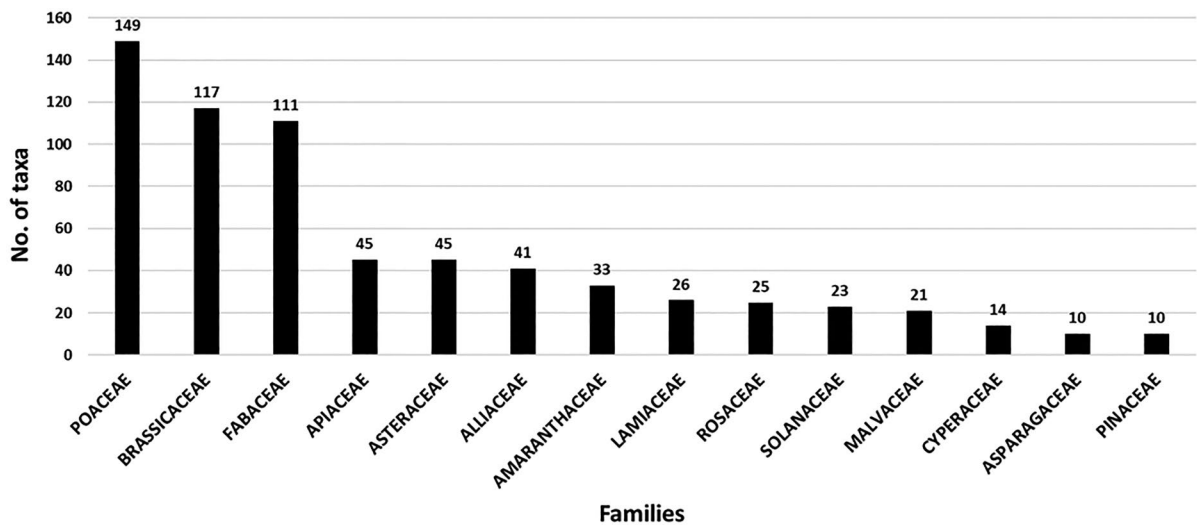


Fig. 1 Number of taxa belonging to the most represented Crop Wild Relatives (CWR) families in Morocco

Among the identified CWR and/or WHP taxa, approximately 97% (4534 taxa) are native to Morocco, 222 are introduced or naturalized, 113 are cultivated, and 35 are classified as invasive. The checklist includes 4682 CWR specific and infraspecific taxa belonging to 3316 species, 789 genera, and 152 families. Additionally, 1250 taxa are WHPs, and are included in 491 genera and 121 families. A total of 1135 taxa belong to both CWR and WHP groups, whereas 3547 are exclusively CWRs and 115 are exclusively WHPs.

The ten most represented CWR families in the checklist include Poaceae (149 taxa), Brassicaceae (117), Fabaceae (111), Apiaceae and Asteraceae (45), Alliaceae (41), Amaranthaceae (33), Lamiaceae (26), Rosaceae (25) and Solanaceae (23) (in order of importance). These families encompass 615 taxa, accounting for approximately 17% of the total CWRs (Fig. 1). The most abundant CWR genera are *Vicia* L. (46 taxa related to broad bean and vetch), *Allium* L. (41 taxa related to onion, leek and garlic), *Thymus* L. (26 taxa related to Thyme), *Carthamus* L. (23 taxa related to safflower), *Diplotaxis* DC. (23 taxa related to Brassicas), *Lathyrus* L. (23 taxa related to pea vine), *Avena* L. (21 taxa related to oat), *Brassica* L. (19 taxa related to cauliflowers and broccoli), *Daucus* L. (19 taxa related to carrot), *Malva* L. (19 taxa related to common mallow). Among these, there are several crops belonging to 656 taxa of significant

socio-economic importance on the basis of criteria *a*, *e* and *f* (Fig. 2).

The identified CWR species for Morocco account for approximately 18% of the crops and CWRs of Europe and the Mediterranean area, according to Kell et al. (2005, 2008), and for approximately 11% of the total Euro-Mediterranean flora (40783 taxa; Raab-Straube et al. 2016). These figures are consistent with Morocco's position as one of the most biodiverse countries in the region, with its flora including approximately 4534 CWR taxa. This number is higher than those of previous reports, such as (Benabid 2000), likely due to differences in methodologies, updates to the genus list used to define CWR taxa (El Mokni et al. 2022), and improvements in taxonomic and distributional data.

Compared with other national CWR checklists, Morocco, with its 446,550 km² of not desert territory (approximately 710,850 km² including Western Sahara), has a larger number of CWR taxa than countries such as Portugal (2262 taxa; 92,212 km²; (Brehm et al. 2007, 2010)) and the United Kingdom (2109 taxa; 242,495 km²; (Fielder et al. 2012)). It is also similar to countries like Italy and Greece (Kell 2005; Kell et al. 2007; Ciancaleoni et al. 2021). However, Morocco's CWR diversity notably exceeds that of other North African countries, largely due to its extensive range of bioclimatic zones, from

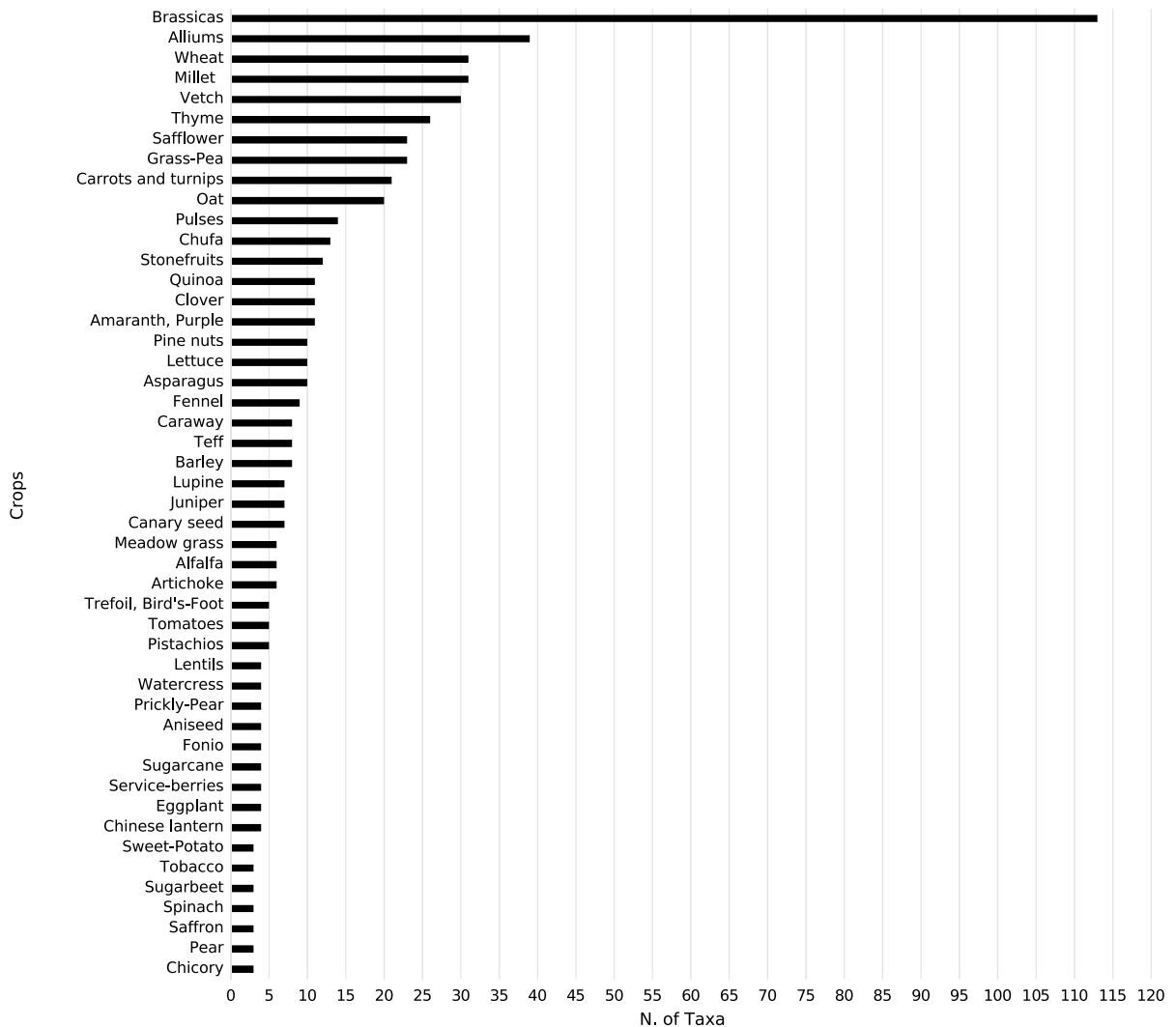


Fig. 2 Number of taxa belonging to the most socio-economically important crops

Mediterranean forests in the north to arid deserts in the south, which foster high ecological and species diversity.

This richness reinforces Morocco's role as a critical component of the North African hotspot of CWR diversity within the Mediterranean region (Vincent et al. 2013; Maxted and Vincent 2021). Its strategic position as a meeting point for the Mediterranean, Atlantic, and Saharan influences highlights the country's potential contribution to global food security and genetic resource conservation.

Spain and Italy, like Morocco, exhibit high CWR diversity, particularly within Poaceae, Fabaceae, and

Brassicaceae, but Italy's fragmented landscapes foster a greater proportion of narrowly endemic taxa (Ciancaleoni et al. 2021). In contrast, Greece and Turkey, major centers of crop domestication, harbor a rich diversity of CWR linked to cereals, legumes, and fruit crops, supported by well-established gene banks and in situ conservation programs (Vincent et al. 2013; Kell et al. 2017).

Morocco distinguishes itself with a high proportion of drought- and salinity-tolerant CWR, such as *Aegilops*, *Olea*, and *Daucus*, which are crucial for breeding climate-resilient crops (Heywood 2011; Kell et al. 2015). Additionally, Morocco's endemic WHP

diversity surpasses that of neighboring North African countries, reflecting its varied bioclimatic zones and the longstanding role of WHP in local food and medicinal traditions (Fennane et al. 2014; El Oualidi et al. 2012).

Given these patterns, stronger regional collaboration is essential. Initiatives such as transboundary conservation programs, gene exchange networks, and harmonized conservation policies could bolster the resilience of Mediterranean plant genetic resources, benefiting biodiversity and food security alike (Kell et al. 2017).

The ten most numerous WHP families in Morocco, which account for 57% of the total WHP taxa, are Fabaceae (152 taxa), Asteraceae (133), Lamiaceae (94), Apiaceae (63), Poaceae (63), Brassicaceae (54), Caryophyllaceae (42), Euphorbiaceae (41), Rosaceae (33), and Cistaceae (32) (in order of importance) (Fig. 3). This list is aligned with findings from research in other Mediterranean areas such as Andalusia, Sicily, Crete, Cyprus and Tunisia (Nassif and Tanji 2013; Lentini and Venza 2007; El Mokni et al. 2022), underscoring not only floristic similarities but also the interplay between biodiversity and cultural heritage.

Euphorbia L. (36 taxa), *Astragalus* L. (31), *Diplo-taxis* DC. (23), *Thymus* L. (23), *Helianthemum* Miller (20), *Paronychia* Miller (18), *Acacia* Miller (14) are the most represented genera, alongside *Allium* L.,

Eucalyptus L'Hér., *Rumex* L., and *Salvia* L. (each with 13) (Fig. 4). Together, these genera constitute 17.5% of the total WHP taxa. These results highlight the ecological diversity of Morocco and its integration into the broader agrobiodiversity patterns of the Mediterranean Basin, particularly as a center for traditional plant uses related to both diet and medicine.

The majority (88%) of WHPs in Morocco are also CWRs. The 1250 WHP taxa in Morocco represent about 27% of the integrated floristic checklist and approximately 3% of the total Euro-Mediterranean flora (Raab-Straube et al. 2016). In Morocco, the numerical consistency of WHPs with respect to the integrated checklist (27%) is lower than that observed in Tunisia, where 847 WHP taxa constitute 34% of the integrated checklist (El Mokni et al. 2022) and higher than that of Portugal (17%; (Brehm et al. 2007) and Italy (22%; (Ciancaleoni et al. 2021). Several factors may explain this, such as the remarkable diversity of medicinal and aromatic plants in Africa (Farnsworth 1985), the widespread use of wild-gathered food plants in diets, particularly in rural areas (Hadjichambis et al. 2008), and the crucial role of WHP in supporting rural livelihoods through additional income (Borelli et al. 2020). This difference could also be due to methodological variations, regional biodiversity disparities, or ecological differences between countries.

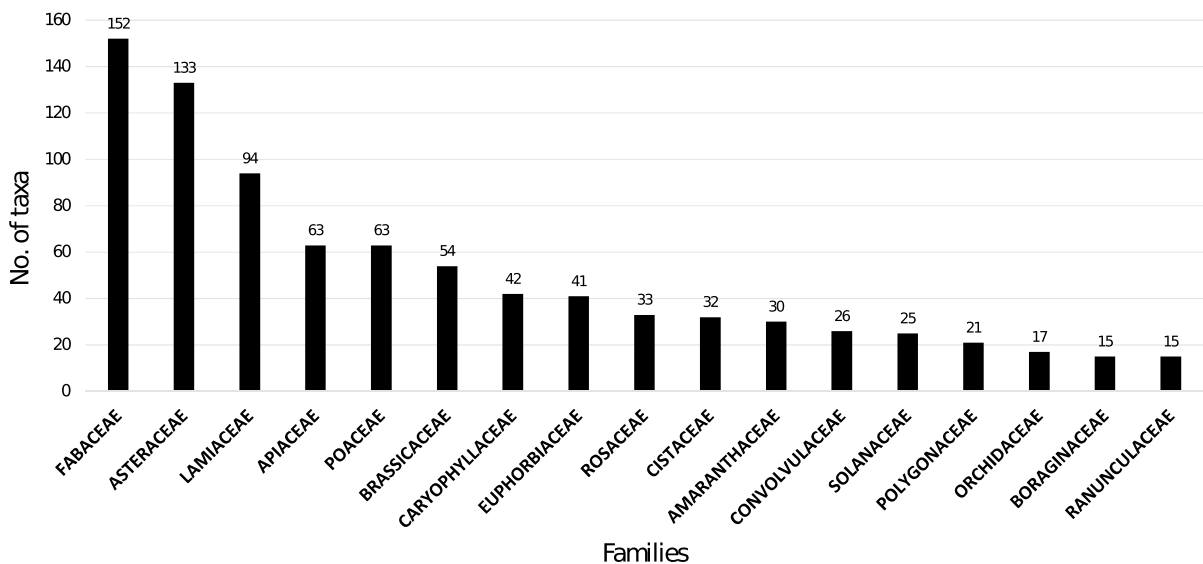


Fig. 3 Number of taxa belonging to the most represented families of Wild Harvested Plants (WHP) in Morocco

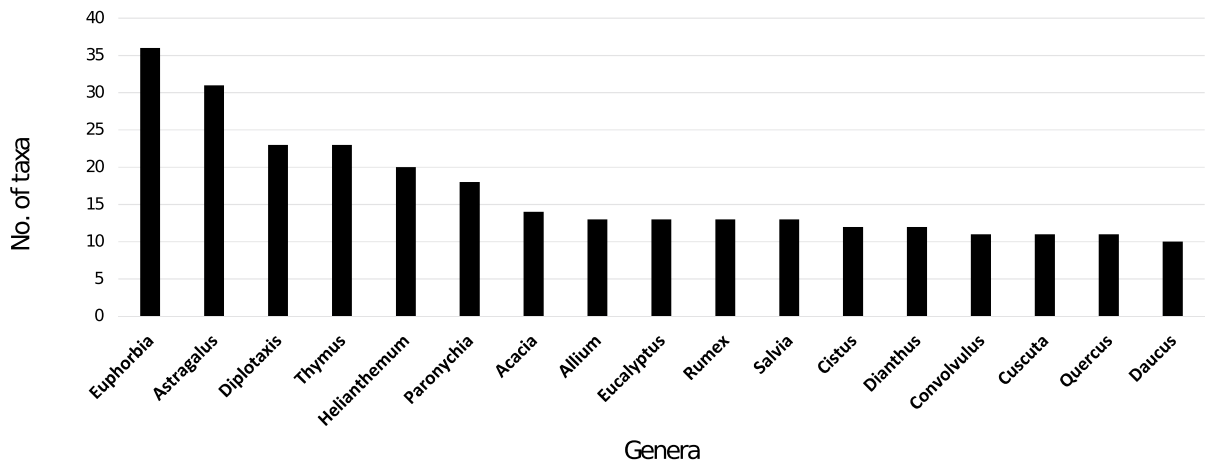


Fig. 4 Number of taxa belonging to the most represented genera of Wild Harvested Plants (WHP) in Morocco

We found that 815 taxa (65% of the total WHPs) are medicinal, 250 (20%) are used as human food 219 (18%) are fodder, 185 (15%) are poisonous. The “Material” category is represented by 135 taxa (11%), 120 (10%) are used as food additives, 120 (10%) are ornamentals, 110 (9%) are aromatic, 108 (9%) have a social use, 90 taxa (7%) have some generic ethnobotanical use, 64 taxa (5%) for beverages, 48 (4%) are used for environmental purposes (Fig. 5). Additionally, only 42 taxa (3%) are used for honey production and 2 taxa are used for fuel production.

Interestingly, more than half of the Moroccan WHP taxa have multiple uses. Among the 1250 WHP taxa, 329 were classified into more than one use category, 137 into more than two, 99 into more than three, 26 into more than four, 39 into more than five, eight into more than six use categories. *Sideroxylon spinosum* and *Juglans regia* L. fall into 8 use categories. The most frequent use combinations include medicinal, food, fodder, food additive, social and ethnobotanical use.

The most abundant use category (medicinal) included several major taxa that are also CWR. This

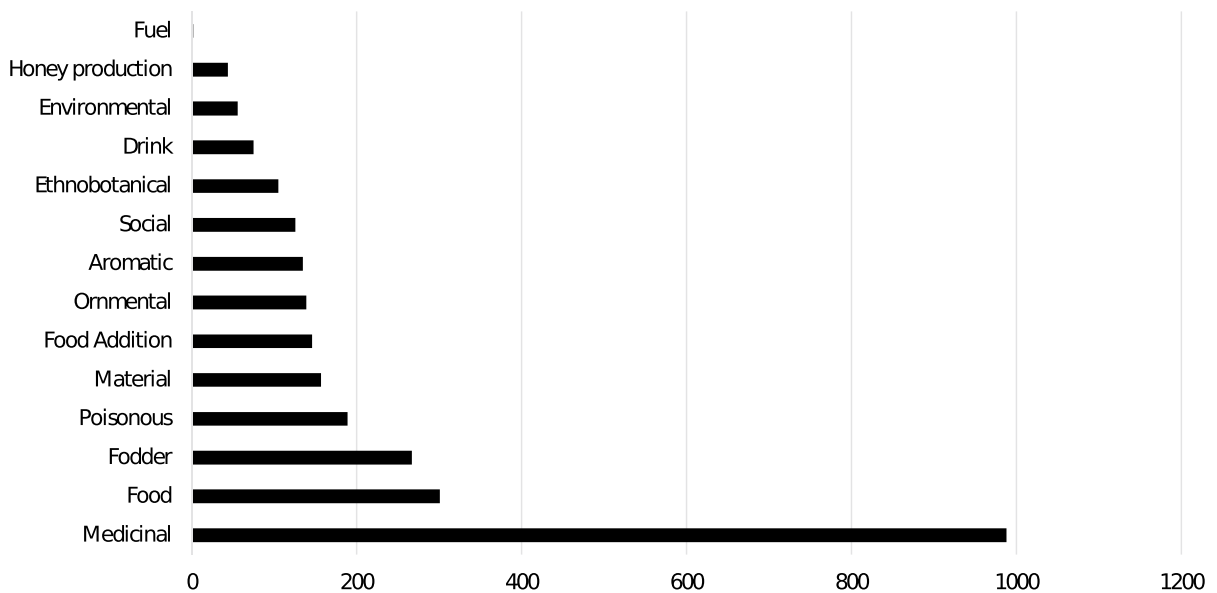


Fig. 5 Number of taxa according to Wild Harvested Plants (WHP) use categories

is consistent with ethnobotanical knowledge from other regions in the Mediterranean, where plants play a central role in traditional healthcare. The rich diversity of medicinal plants of Morocco is vital, as these species not only contribute to cultural practices but also serve as important sources of healthcare, especially in rural areas where modern medical infrastructure might be limited (Hadjichambis et al. 2008). The heavy reliance on medicinal plants also reflects a wider trend across the Mediterranean and North African regions, where plant-based remedies have been integral to local healing practices for centuries (Farnsworth 1985).

Beyond their economic and genetic importance, CWRs and WHPs deliver essential ecosystem services and underpin local livelihoods. Leguminous species such as *Vicia* and *Lathyrus* enhance soil fertility through nitrogen fixation (Graham and Vance 2003), while nectar producing plants support pollinator populations vital for biodiversity and agriculture (Potts et al. 2003). Moreover, many species contribute to habitat stability in arid regions by preventing soil erosion (Maxted et al. 2013). In addition to their ecological roles, WHP hold significant cultural and economic value in Morocco. For instance, species like *Origanum compactum* Benth. and *Thymus sat-ureioides* Coss. are widely used in traditional medicine (Bellakhdar 1997), and *Argania spinosa* (argan) is central to handicrafts, local cuisine, and rural economics (Lybbert et al. 2011). The collection, processing, and commercialization of these medicinal and aromatic plants provide critical income and employment opportunities for smallholder farmers and cooperatives. Integrating these ecological, ethnobotanical, and economic dimensions into conservation planning not only strengthens the prioritization framework but also promotes long-term biodiversity conservation while enhancing socio-economic resilience and food security (Maxted and Vincent 2021).

On the other hand, this situation underscores the urgent need for a conservation strategy aimed at preserving WHP and CWR to prevent overexploitation. In Morocco, as (Lamrani-Alaoui and Hassikou 2018) noted, certain species are at risk of overharvesting and require immediate attention in conservation efforts. Among these species, those belonging to genera such as *Lavandula* L. sp. pl., *Origanum* L. sp. pl., *Salvia* L. sp. pl., and *Thymus* L. sp. pl. are particularly vulnerable. These plants, commonly used

for their aromatic, medicinal, and culinary properties, are being increasingly collected in the wild, which could lead to population declines if not carefully managed. Within the category of WHP used for food, the most represented genera in Morocco include *Capparis* L., *Portulaca* L., *Diploaxis* DC., *Rosa* L., *Calamintha* Mill., *Centaurea* L., and *Pinus* L. These plants not only are integral to the local diet but also play significant roles in traditional culinary and medicinal practices. However, overharvesting could threaten their sustainability, emphasizing the need for effective conservation policies to protect these species, and ensuring that they continue to provide vital resources for future generations while maintaining ecological balance. The situation in Morocco, with its unique diversity of wild plants, mirrors challenges faced by other Mediterranean and North African countries, highlighting the importance of region-specific conservation strategies that prioritize both the preservation of biodiversity and the sustainable use of these valuable resources (Borelli et al. 2020; Zrira 2013).

Prioritization criteria application

The application of the above-mentioned methodology to the integrated checklist led to the selection of 4711 CWR taxa and/or WHP (4596 CWR and 1208 WHP taxa) native or introduced taxa suitable for prioritization by the application of the criteria. Invasive species were excluded from the analysis, as long as taxa only occurring in cultivation.

Economic value of the related crop

On the whole 360 CWR taxa (8% of the total CWR) resulted important from the economic point of view because they are related to a valuable crop for the country, according to FAO (2023). Brassicas, Alliums, Wheat and Vetch are the most represented FAO crop groups, accounting for more than 50% (196 taxa) of the taxa related to economically important crops for the country. The most represented families resulted: Brassicaceae (96 taxa), Fabaceae (74 taxa), Poaceae (67 taxa), Alliaceae (39 taxa), Rosaceae (23 taxa), Apiaceae (21 taxa), Solanaceae (13 taxa), Asparagaceae (10 taxa), Asteraceae (7 taxa), Amaranthaceae (3 taxa). From an economic perspective,

the most profitable crops are Wheat, Olives, Potatoes, Barley, Apples and others (Fig. 6).

Degree of relatedness

Among the 4596 CWR taxa that were used as base for prioritization, 149 were assessed as TG5, 151 as GP3, 4100 as TG3 or TG4, 64 as GP2 or TG2, 131 as GP1b or TG1b (Fig. 7).

Threat status

A total of 3554 taxa of CWR/WHP (75% of the total) have been evaluated through national or global Red List assessments, comprising 3451 CWR and 960 WHP. Of these, 23 taxa have been assessed exclusively at the global level by the IUCN, whereas the National Red List of Morocco (Fennane et al. 2021) has evaluated 3118 taxa. Additionally, 406 taxa were assessed by both the IUCN and the National Red List, ensuring broader coverage of their conservation status.

The threat categories for these taxa are illustrated in Fig. 8, highlighting the distribution across various levels of risk, such as Critically Endangered, Endangered, and Vulnerable. These assessments emphasize the pressing need for targeted conservation strategies to protect these vital taxa, which play a key role in Morocco's agrobiodiversity and ecological balance.

Endemicity

A total of 1250 CWR and/or WHP taxa (26.5% of the total CWR/WHP) are endemic to Morocco and North Africa, according to (El Oualidi et al. 2012). This group includes 1233 CWR taxa and 162 WHP taxa, demonstrating Morocco's significant contribution to the regional biodiversity of these species. Among these, 77 taxa are directly related to crops of national economic importance, as highlighted by FAOSTAT (FAO 2023), and 60 taxa are recognized as globally important under the ITPGRFA (FAO 2009).

Some noteworthy taxa include *Sideroxylon spinosum*, a species globally recognized for its ecological and economic value, particularly in the production of argan oil, and *Phoenix dactylifera* L., which supports Morocco's date palm industry. Other significant examples are *Ceratonia siliqua* L., which is critical for its role in food and fodder production, and *Punica*

granatum L., which is widely valued for its nutritional and medicinal properties.

Relevance for food security and nutrition

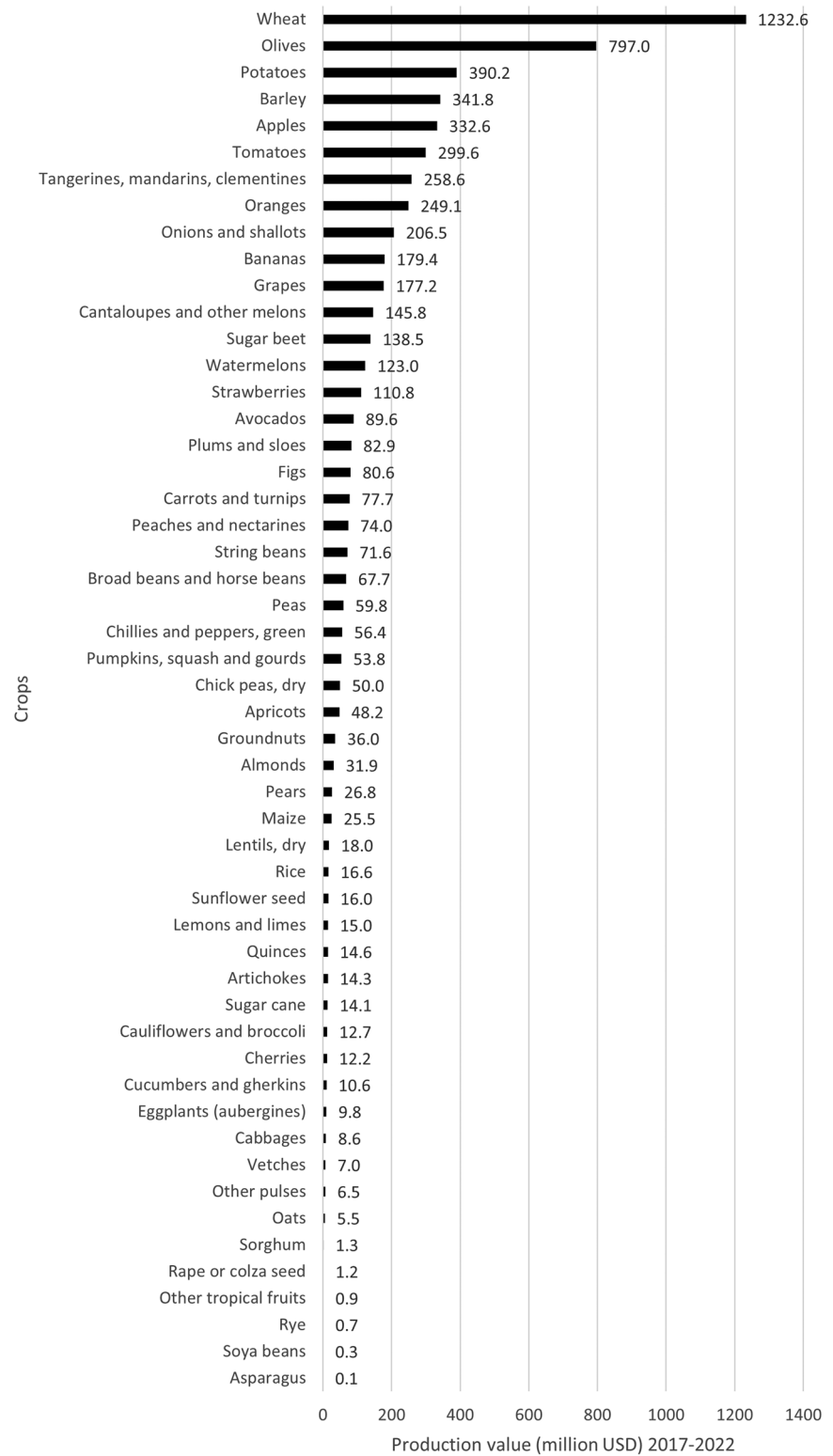
Six hundred and seventy-six CWR taxa (13.4%) are related to crops included in Annex I of the ITPGRFA (277 taxa) (FAO 2009) and/or contribute to the annual dietary energy per capita per day (608 taxa) (Kcal/capita/day; (FAO 2023)) (Fig. 9). Among these, approximately 5% (374 taxa) are related to crops of socio-economic importance for the country, such as cabbages, garlic, onion, carrot, barley, and wheat. The crops of high regional importance for food security in Morocco (i.e., those providing more than 3% of the daily energy supply) that also have wild relatives in the country include *Triticum durum* Desf., *Triticum aestivum*, *Triticum dicoccum* Schubl., *Sorghum bicolor* L. Moench, *Vicia sativa* L., *Olea europaea*, *Phoenix canariensis* Chabaud, and *P. dactylifera* L. Wheat provides the highest daily energy supply (40%) among these crops, as indicated by the "Wheat & products" category (FBS code: 2511).

Priority taxa

The prioritization process identified a total of 1208 WHP taxa, including 115 taxa classified exclusively as WHP. Among these, 979 taxa were prioritized for conservation, and were distributed as follows: 36 high-priority taxa (Table 2), 222 medium-priority taxa, and 721 low-priority taxa. The remaining 229 taxa were categorized as non-priority for conservation. Among the 115 WHP-only taxa, 103 were prioritized, consisting of 2 high-priority taxa, 20 medium-priority taxa, and 85 low-priority taxa. The two high-priority WHP-only taxa, *Paronychia aretioides* DC. and *Paronychia velata* (Maire) Chaudhri (Caryophyllaceae), are notable for their reported medicinal uses.

At the family level, the most represented groups among the priority WHP taxa are Fabaceae (111 taxa), Asteraceae (110 taxa), Lamiaceae (66 taxa), Apiaceae (54 taxa), Brassicaceae (52 taxa), Poaceae (49 taxa), Caryophyllaceae (40 taxa), Euphorbiaceae (32 taxa), Cistaceae (31 taxa), and Amaranthaceae (26 taxa). The most abundant genera are *Euphorbia* L. (29 taxa), *Diploaxis* DC. (23 taxa),

Fig. 6 Crops/crop groups of economic importance in Morocco, showing their average gross production values (2017–2022)



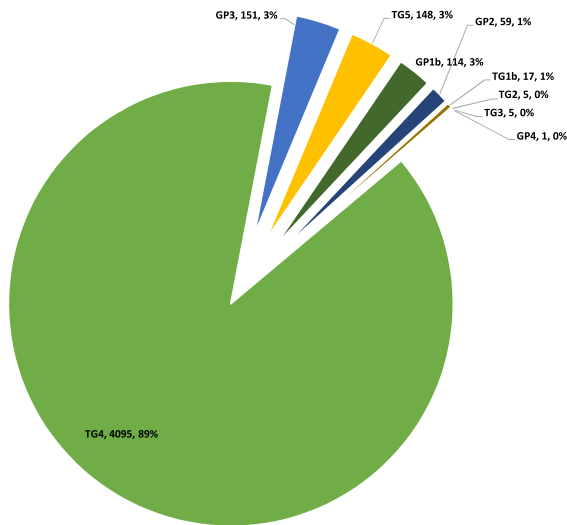


Fig. 7 Percentage distribution of prioritized taxa in the Gene Pool and Taxon Group categories

Helianthemum Mill. (19 taxa), *Astragalus* L. (17 taxa), *Paronychia* Miller (17 taxa), *Thymus* L. (17 taxa), *Rumex* L. (13 taxa), *Cistus* L. (12 taxa), *Dianthus* L. (12 taxa), and *Convolvulus* L. (11 taxa). High-priority taxa are concentrated in genera such as *Diplotaxis* DC. (8 taxa), *Astragalus* L. (3 taxa), *Phlomis* L. (3 taxa), *Brassica* L. (2 taxa),

Helichrysum Mill. (2 taxa), and *Paronychia* Mill. (2 taxa).

A closer examination reveals that the prioritization process led to the identification of key WHP taxa with significant ecological, nutritional, and economic importance. For instance, two endemic high-priority aromatic plants, *Origanum elongatum* (Bonnet) Emb. & Maire and *Thymus riatarum* Humbert & Maire are valued for their essential oils with recognized medicinal applications (Zouari et al. 2012; Sobeh et al. 2020). Similarly, *Paronychia aretioides* and *Paronychia velata*, both high-priority taxa within Caryophyllaceae, are widely recognized for their medicinal properties and ethnobotanical relevance. These plants represent not only genetic resources for conservation but also economic assets for rural populations through their potential use in pharmaceuticals, nutraceuticals, and other value-added products.

Furthermore, WHP taxa play an essential role in supporting rural livelihoods. Their wild harvesting can provide an additional source of nutrition and economic income for local communities, especially in regions where agriculture and formal employment are limited (FAO 2019). These plants may also contribute to the development of new marketable foods, active pharmaceutical compounds, and other secondary products, further stimulating local economies. The list of priority CWR in Morocco includes 4596 taxa,

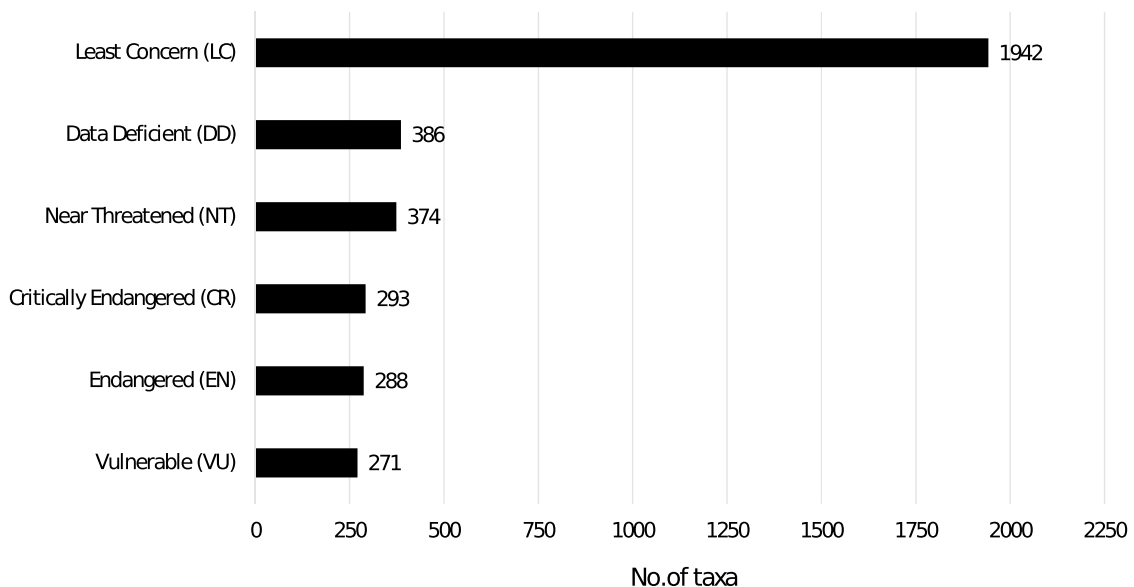


Fig. 8 The threat status of prioritized taxa in Morocco

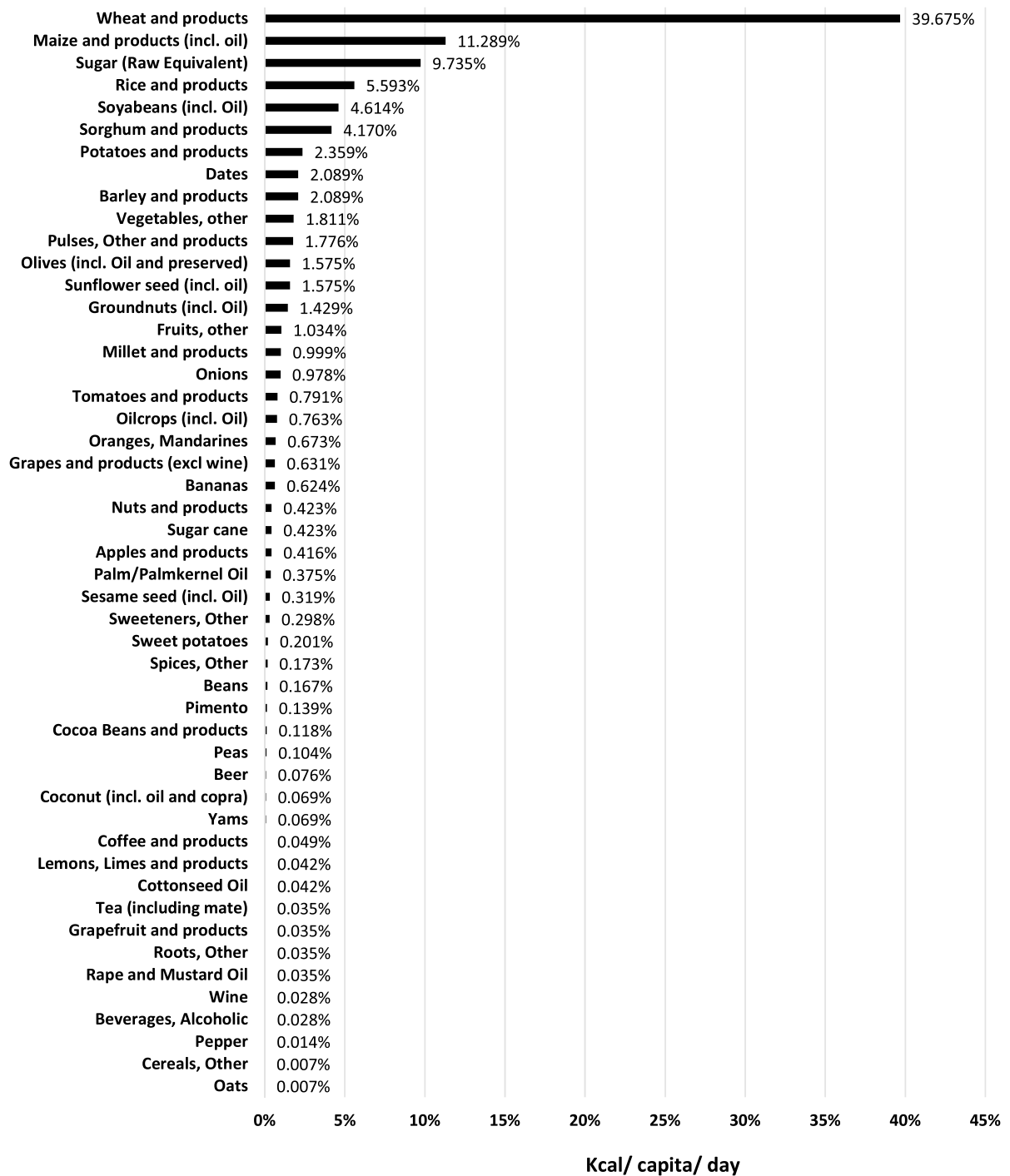


Fig. 9 Average annual contributions of crops/crop groups for North Africa to dietary energy (kilocalories) per capita per day of 0.1% or more over the period (2017–2022)

Table 2 High priority Wild Harvested Plants assessment

Family	Taxon	Rank	CWR	WHP	Energy supply ITPGRFA priority	Conservation priority	Endemic priority	FPS	Priority
Pinaceae	<i>Abies marocana</i> Trab.	species	CWR	WHP	0	6	10	5,3	High
Malvaceae	<i>Abutilon albidum</i> (Willd.) Sweet	species	CWR	WHP	0	6	10	5,3	High
Asparagaceae	<i>Asparagus altissimus</i> Munby	species	CWR	WHP	10	2	10	7,3	High
Fabaceae	<i>Astragalus maroccanus</i> Braun-Blanq. & Maire	species	CWR	WHP	0	6	10	5,3	High
Fabaceae	<i>Astragalus maurus</i> (Humbert & Maire) Pau	species	CWR	WHP	0	6	10	5,3	High
Fabaceae	<i>Astragalus tetuanensis</i> Podlech.	species	CWR	WHP	0	10	10	6,7	High
Brassicaceae	<i>Brassica fruticulosa</i> subsp. <i>cossoniana</i> (Boiss. & Reu- ter) Maire	subsp.	CWR	WHP	10	2	10	7,3	High
Brassicaceae	<i>Brassica fruticulosa</i> subsp. <i>radicata</i> (Desf.) Batt.	subsp.	CWR	WHP	10	2	10	7,3	High
Apiaceae	<i>Bupleurum canescens</i> Schousboe	species	CWR	WHP	0	6	10	5,3	High
Orobanchaceae	<i>Cistanche mauritanica</i> (Coss. & Durieu) G. Beck	species	CWR	WHP	0	10	10	6,7	High
Fabaceae	<i>Crotalaria vialattei</i> Batt.	species	CWR	WHP	0	6	10	5,3	High
Cupressaceae	<i>Cupressus atlantica</i> Gaussen	species	CWR	WHP	0	6	10	5,3	High
Brassicaceae	<i>Diplotaxis assurgens</i> (Delile) Thell. subsp. <i>assurgens</i>	subsp.	CWR	WHP	10	4	10	8,0	High
Brassicaceae	<i>Diplotaxis assurgens</i> subsp. <i>tetragona</i> (Maire) Nègre	subsp.	CWR	WHP	10	4	10	8,0	High
Brassicaceae	<i>Diplotaxis berthautii</i> Braun- Blanq. & Maire	species	CWR	WHP	10	4	10	8,0	High
Brassicaceae	<i>Diplotaxis ollivieri</i> Maire	species	CWR	WHP	10	3	10	7,7	High
Brassicaceae	<i>Diplotaxis pitardiana</i> Maire	species	CWR	WHP	10	3	10	7,7	High
Brassicaceae	<i>Diplotaxis siettiana</i> Maire	species	CWR	WHP	10	0	10	6,7	High
Brassicaceae	<i>Diplotaxis siifolia</i> subsp. <i>bipinnatifida</i> (Coss.) Mart.- Laborde	subsp.	CWR	WHP	10	2	10	7,3	High
Brassicaceae	<i>Diplotaxis virgata</i> subsp. <i>brachycarpa</i> (Godr.) Nègre	subsp.	CWR	WHP	10	2	10	7,3	High
Oleaceae	<i>Fraxinus dimorpha</i> Coss. & Durieu	species	CWR	WHP	0	6	10	5,3	High
Cistaceae	<i>Helianthemum neopiliferum</i> Muñoz Garm. & Navarro	species	CWR	WHP	0	6	10	5,3	High
Asteraceae	<i>Helichrysum italicum</i> subsp. <i>picardii</i> (Boiss. & Reuter) Franco	subsp.	CWR	WHP	0	6	10	5,3	High
Asteraceae	<i>Helichrysum pendulum</i> (C. Presl) C. Presl	species	CWR	WHP	0	6	10	5,3	High
Lauraceae	<i>Laurus azorica</i> (Seub.) Franco	species	CWR	WHP	0	10	10	6,7	High
Fabaceae	<i>Lens nigricans</i> (M. Bieb.) Godr.	species	CWR	WHP	10	2	10	7,3	High

Table 2 (continued)

Family	Taxon	Rank	CWR	WHP	Energy supply ITPGRFA priority	Conservation priority	Endemic priority	FPS	Priority
Lamiaceae	<i>Micromeria peltieri</i> (Maire) R. Morales	species	CWR	WHP	0	10	10	6,7	High
Lamiaceae	<i>Origanum elongatum</i> (Bon- net) Emb. & Maire	species	CWR	WHP	0	6	10	5,3	High
Caryophyllaceae	<i>Paronychia aretioides</i> DC.	species		WHP	0	10	10	6,7	High
Caryophyllaceae	<i>Paronychia velata</i> (Maire) Chaudhri	species		WHP	0	6	10	5,3	High
Lamiaceae	<i>Phlomis bovei</i> subsp. <i>maroc- cana</i> Maire	subsp.	CWR	WHP	0	6	10	5,3	High
Lamiaceae	<i>Phlomis purpurea</i> L. subsp. <i>purpurea</i>	subsp.	CWR	WHP	0	6	10	5,3	High
Lamiaceae	<i>Phlomis purpurea</i> subsp. <i>caballeri</i> (Pau) Rivas- Martinez	subsp.	CWR	WHP	0	6	10	5,3	High
Rosaceae	<i>Pyrus bourgaeana</i> Decne	species	CWR	WHP	0	6	10	5,3	High
Asteraceae	<i>Taraxacum getulum</i> Pomel	species	CWR	WHP	0	6	10	5,3	High
Lamiaceae	<i>Thymus riatarum</i> Humbert & Maire	species	CWR	WHP	0	6	10	5,3	High

with 252 taxa (5.4% of the total CWR prioritized) classified as high priority for conservation, 1617 taxa (35.2%) as medium priority, and 2727 taxa (59.3%) as low priority. Among the high-priority taxa, 85 taxa are endemic to Morocco, highlighting the country's unique biodiversity and its global importance in genetic resources conservation. Seventy-seven taxa scored above 7.0 points in the evaluation and 147 taxa above 6.0 points, making them the top priority for conservation (Table 3). These include relatives of major crops such as wheat, barley, oat, olive, carrot, cabbage, pea, and pear, with considerable socio-economic and agricultural relevance.

Among the 147 high-priority taxa, 41% belong to GP1b, TG1b, or GP2, which makes them easier to use in breeding programs. For example, species within these groups present valuable traits such as disease resistance, abiotic stress tolerance, and enhanced nutritional qualities.

The top ten CWR priority families in Morocco are Brassicaceae (80 taxa), Fabaceae (60), Poaceae (35), Apiaceae (25), Alliaceae (10), Rosaceae (10), Solanaceae (10), Asteraceae (9), Asparagaceae (3), and Amaranthaceae and Oleaceae (2 taxa each). The most abundant priority genera are *Vicia* L. (44 taxa), *Diplotaxis* DC. (23), *Avena* L. (20), *Brassica* L. (19),

Daucus L. (18), *Allium* L. (10), *Solanum* L. (10), *Lathyrus* L. (7), *Carthamus* L. (6), *Eruca* Miller (6), and *Erucastrum* C. Presl (6).

The priority taxa closely related to economically significant crops in Morocco include *Avena magna* H.C. Murphy & Terrell and *Avena murphyi* Ladiz., secondary gene pool relatives of oat, which are valuable for their agronomic and biotic traits (Loskutov and Rines 2011). These species are, however, under threat due to agricultural intensification and overgrazing. Similarly, *Pyrus mamorensis* Trab., a secondary gene pool of pear, is recognized for its tolerance to acidic soils (Hancock and Lobos 2008). Another example is *Olea europaea* subsp. *maroccana* (Greuter & Burdet) Vargas & al., an endemic subspecies of olive, which plays a crucial role in the olive oil industry—a vital sector of the Moroccan economy.

High-priority genera such as Brassica (19 taxa) include species such as *Brassica maurorum* Durieu, which is closely related to cultivated cabbages and offers potential traits for disease resistance and stress adaptation. Similarly, *Daucus* taxa, including 13 high-priority and 5 medium-priority species, are key wild relatives of carrot, an economically significant crop in Morocco. Species like *Daucus aureus* Desf. and *Daucus carota* subsp. *maximus* (GP1b) are

Table 3 High priority crop wild relatives assessment

Family	Taxon	Rank	CWR	WHP	CROP name	GenePool/ Taxon-Group	Relative degree	Energy Supply/ ITPGRFA priority	Conservation priority	Endemic priority	FPS	Priority
Poaceae	<i>Agropyron cristatum</i> subsp. <i>brachyatherum</i> (Maire) Dobignard	subsp.	CWR		Wheat	GenePool	3	10	2	10	7,3	High
Alliaceae	<i>Allium antitlanticum</i> Emb. & Maire	species	CWR		Garlic/Onion	TaxonGroup	4	0	2	10	6,0	High
Alliaceae	<i>Allium fontanexii</i> J. Gay	species	CWR		Garlic/Onion	TaxonGroup	4	0	6	10	6,7	High
Alliaceae	<i>Allium mauritanicum</i> Brullo, Pavone & Salmeri	species	CWR		Garlic/Onion	TaxonGroup	4	0	4	10	6,3	High
Alliaceae	<i>Allium tingitanum</i> Brullo, Pavone & Salmeri	species	CWR		Garlic/Onion	TaxonGroup	4	0	2	10	6,0	High
Alliaceae	<i>Allium trichocnemis</i> J. Gay	species	CWR		Garlic/Onion	TaxonGroup	4	0	10	10	7,3	High
Alliaceae	<i>Allium valdecallosum</i> Maire & Weiller	species	CWR		Garlic/Onion	TaxonGroup	4	0	10	10	7,3	High
Asparagaceae	<i>Asparagus altissimus</i> Munby	species	CWR	WHP	Asparagus	TaxonGroup	4	10	2	10	6,5	High
Asparagaceae	<i>Asparagus pastorianus</i> Webb & Berthel.	species	CWR		Asparagus	TaxonGroup	4	10	3	10	6,7	High
Poaceae	<i>Avena agadirana</i> Baum & Fedak	species	CWR		Oat	GenePool	2	10	6	10	8,7	High
Poaceae	<i>Avena atlantica</i> Baum & Fedak	species	CWR		Oat	GenePool	3	10	6	10	8,0	High
Poaceae	<i>Avena canariensis</i> B.R. Baum, Rajhathy & Sampson	species	CWR		Oat	GenePool	3	10	0	10	7,0	High
Poaceae	<i>Avena fatua</i> L. subsp. <i>fatua</i>	subsp.	CWR		Oat	GenePool	1b	10	3	0	7,2	High
Poaceae	<i>Avena magna</i> Murphy & Terrel	species	CWR		Oat	GenePool	2	10	6	10	8,7	High

Table 3 (continued)

Family	Taxon	Rank	CWR	WHP	CROP name	GenePool/ Taxon-Group	Relative degree	Energy Supply/ ITPGRFA priority	Conservation priority	Endemic priority	FPS	Priority
Poaceae	<i>Avena murphyi</i> Ladiz.	species	CWR		Oat	GenePool	2	10	10	10	9,3	High
Poaceae	<i>Avena prostrata</i> Ladiz.	species	CWR		Oat	GenePool	3	10	0	10	7,0	High
Poaceae	<i>Avena sterilis</i> L. subsp. <i>sterilis</i>	subsp.	CWR		Oat	GenePool	1b	10	2	0	7,0	High
Poaceae	<i>Avena sterilis</i> subsp. <i>ludoviciana</i> (Dur.) Gillet & Magne	subsp.	CWR		Oat	TaxonGroup	1b	10	2	0	7,0	High
Poaceae	<i>Avena sterilis</i> subsp. <i>trichophylla</i> (K. Koch) Malzev	subsp.	CWR		Oat	TaxonGroup	1b	10	2	0	7,0	High
Brassicaceae	<i>Barbarea intermedia</i> Boreau	species	CWR		Brassicas	TaxonGroup	4	10	6	0	6,7	High
Brassicaceae	<i>Brassica barrellieri</i> (L.) Janka	species	CWR		Turnip	GenePool	2	10	0	0	6,0	High
Brassicaceae	<i>Brassica desnottesii</i> Emb. & Maire	species	CWR		Cabbage/ Kale	GenePool	3	10	6	10	8,0	High
Brassicaceae	<i>Brassica elongata</i> subsp. <i>indhasiana</i> Quézel	subsp.	CWR		Cabbage/ Kale	GenePool	2	10	10	10	9,3	High
Brassicaceae	<i>Brassica elongata</i> subsp. <i>subscaposa</i> (Maire & Weiller) Maire	subsp.	CWR		Cabbage/Kale	GenePool	2	10	10	10	9,3	High
Brassicaceae	<i>Brassica fruticulosa</i> subsp. <i>cossoniana</i> (Boiss. & Reuter) Maire	subsp.	CWR	WHP	Cabbage/ Kale	GenePool	3	10	2	10	7,3	High
Brassicaceae	<i>Brassica fruticulosa</i> subsp. <i>radicata</i> (Desf.) Batt.	subsp.	CWR	WHP	Cabbage/ Kale	GenePool	3	10	2	10	7,3	High
Brassicaceae	<i>Brassica maurorum</i> Durieu	species	CWR		Mustard, Black	GenePool	2	10	10	10	9,3	High
Brassicaceae	<i>Brassica napus</i> L	species	CWR	WHP	Rape	GenePool	1b	10	0	0	6,7	High

Table 3 (continued)

Family	Taxon	Rank	CWR	WHP	CROP name	GenePool/ Taxon-Group	Relative degree	Energy Supply/ ITPGRFA priority	Conservation priority	Endemic priority	FPS	Priority
Brassicaceae	<i>Brassica nigra</i> (L.) Koch	species	CWR	WHP	Mustard, Black	GenePool	1b	10	0	0	6,7	High
Brassicaceae	<i>Brassica oleracea</i> L.	species	CWR	WHP	Cabbage/ Kale	GenePool	1b	10	0	0	6,7	High
Brassicaceae	<i>Brassica oxyrrhina</i> Coss	species	CWR		Cabbage/ Kale	GenePool	3	10	6	10	8,0	High
Brassicaceae	<i>Brassica rapa</i> subsp. <i>campestris</i> (L.) Clapham	subsp.	CWR	WHP	Summer turnip rape	GenePool	1b	10	0	0	6,7	High
Brassicaceae	<i>Brassica repanda</i> subsp. <i>africana</i> (Maire) Greuter & Burdet	subsp.	CWR		Cabbage/ Kale	TaxonGroup	4	10	2	0	6,0	High
Brassicaceae	<i>Brassica repanda</i> subsp. <i>blancoana</i> (Boiss.) Heywood	subsp.	CWR		Cabbage/ Kale	TaxonGroup	4	10	2	10	7,7	High
Brassicaceae	<i>Brassica repanda</i> subsp. <i>confusa</i> (Emb. & Maire) Heywood	subsp.	CWR		Cabbage/ Kale	TaxonGroup	4	10	2	10	7,7	High
Brassicaceae	<i>Brassica repanda</i> subsp. <i>latifolia</i> (Boiss. & Reut.) Heywood	subsp.	CWR		Cabbage/ Kale	TaxonGroup	4	10	2	0	6,0	High
Brassicaceae	<i>Brassica repanda</i> subsp. <i>silenifolia</i> (Emb.) Greuter & Burdet	subsp.	CWR		Cabbage/ Kale	TaxonGroup	4	10	2	10	7,7	High
Brassicaceae	<i>Brassica tournefortii</i> Gouan	species	CWR	WHP	Cabbage/ Kale	GenePool	2	10	2	0	6,3	High
Brassicaceae	<i>Camelina microcarpa</i> DC.	species	CWR		Cabbage, Abyssinian	TaxonGroup	4	10	2	0	6,0	High
Fabaceae	<i>Cicer atlanticum</i> Maire	species	CWR		Chickpea	GenePool	3	10	6	10	8,0	High
Brassicaceae	<i>Crambe filiformis</i> Jacq.	species	CWR		Crambe	GenePool	2	10	2	0	6,3	High

Table 3 (continued)

Family	Taxon	Rank	CWR	WHP	CROP name	GenePool/ Taxon-Group	Relative degree	Energy Supply/ ITPGRFA priority	Conservation priority	Endemic priority	FPS	Priority
Brassicaceae	<i>Crambe hispanica</i> L.	species	CWR		Crambe	GenePool	1b	10	2	0	7,0	High
Brassicaceae	<i>Crambe kralikii</i> Coss.	species	CWR		Crambe	GenePool	3	10	2	10	7,3	High
Asteraceae	<i>Cynara tournefortii</i> Boiss. & Reuter	species	CWR		Artichoke	GenePool	2	0	0	10	6,0	High
Apiaceae	<i>Daucus carota</i> L. subsp. <i>carota</i>	subsp.	CWR	WHP	Carrot	GenePool	1b	10	2	0	7,0	High
Apiaceae	<i>Daucus carota</i> subsp. <i>commutatus</i> (Paol.) Thell.	subsp.	CWR	WHP	Carrot	GenePool	1b	10	2	0	7,0	High
Apiaceae	<i>Daucus carota</i> subsp. <i>fontanesii</i> Thell.	subsp.	CWR	WHP	Carrot	GenePool	1b	10	2	0	7,0	High
Apiaceae	<i>Daucus carota</i> subsp. <i>gummifer</i> (Syme) Hook. f.	subsp.	CWR	WHP	Carrot	GenePool	1b	10	2	0	7,0	High
Apiaceae	<i>Daucus carota</i> subsp. <i>halophilus</i> (Brot.) A.Pujadas	subsp.	CWR	WHP	Carrot	GenePool	1b	10	2	0	7,0	High
Apiaceae	<i>Daucus carota</i> subsp. <i>hispanicus</i> (Gouan) Thell.	subsp.	CWR	WHP	Carrot	GenePool	1b	10	2	0	7,0	High
Apiaceae	<i>Daucus carota</i> subsp. <i>maritimus</i> (Lam.) Batt.	subsp.	CWR	WHP	Carrot	GenePool	1b	10	2	0	7,0	High
Apiaceae	<i>Daucus carota</i> subsp. <i>maximus</i> (Desf.) Ball.	subsp.	CWR	WHP	Carrot	GenePool	1b	10	2	0	7,0	High
Apiaceae	<i>Daucus durieu</i> Lange	species	CWR		Carrot	TaxonGroup	4	10	2	0	6,0	High
Apiaceae	<i>Daucus gracilis</i> Steinh.	species	CWR		Carrot	GenePool	2	10	2	0	6,3	High
Apiaceae	<i>Daucus sahariensis</i> Murb.	species	CWR		Carrot	GenePool	2	10	2	0	6,3	High

Table 3 (continued)

Family	Taxon	Rank	CWR	WHP	CROP name	GenePool/ Taxon-Group	Relative degree	Energy Supply/ ITPGRFA priority	Conservation priority	Endemic priority	FPS	Priority
Apiaceae	<i>Daucus setifolius</i> subsp. <i>tangerinus</i> Sauvage	subsp.	CWR		Carrot	TaxonGroup	4	10	2	10	7,7	High
Apiaceae	<i>Daucus tenuisectus</i> Coss. ex Batt.	species	CWR		Carrot	GenePool	3	10	3	10	7,5	High
Brassicaceae	<i>Diplotaxis assurgens</i> (Delile) Thell. subsp. <i>assurgens</i>	subsp.	CWR	WHP	Cabbage, Abyssinian	GenePool	3	10	4	10	7,7	High
Brassicaceae	<i>Diplotaxis assurgens</i> subsp. <i>tetragona</i> (Maire) Nègre	subsp.	CWR	WHP	Cabbage, Abyssinian	TaxonGroup	4	10	4	10	8,0	High
Brassicaceae	<i>Diplotaxis berthautii</i> Braun-Blanq. & Maire	species	CWR	WHP	Mustard	GenePool	3	10	4	10	7,7	High
Brassicaceae	<i>Diplotaxis erucoides</i> subsp. <i>longisiliqua</i> (Coss.) Gomez-Campo	subsp.	CWR	WHP	Mustard	TaxonGroup	4	10	2	0	6,0	High
Brassicaceae	<i>Diplotaxis harra</i> subsp. <i>crassifolia</i> (Raf.) Maire	subsp.	CWR	WHP	Mustard	TaxonGroup	4	10	2	0	6,0	High
Brassicaceae	<i>Diplotaxis olivieri</i> Maire	species	CWR	WHP	Cabbage/ Kale	TaxonGroup	4	10	3	10	7,8	High
Brassicaceae	<i>Diplotaxis pitardiana</i> Maire	species	CWR	WHP	Cabbage/ Kale	TaxonGroup	4	10	3	10	7,8	High
Brassicaceae	<i>Diplotaxis siettiana</i> Maire	species	CWR	WHP	Cabbage/ Kale	TaxonGroup	4	10	0	10	7,3	High
Brassicaceae	<i>Diplotaxis siifolia</i> subsp. <i>bipinnatifida</i> (Coss.) Mart.-Laborde	subsp.	CWR	WHP	Mustard	TaxonGroup	4	10	2	10	7,7	High
Brassicaceae	<i>Diplotaxis tenuifolia</i> (L.) DC.	species	CWR	WHP	Arugula	GenePool	2	10	0	0	6,0	High

Table 3 (continued)

Family	Taxon	Rank	CWR	WHP	CROP name	GenePool/ Taxon-Group	Relative degree	Energy Supply/ ITPGRFA priority	Conservation priority	Endemic priority	FPS	Priority
Brassicaceae	<i>Diplotaxis tenuisiliqua</i> subsp. <i>rupestris</i> (Ball) Mart.-Laborde	subsp.	CWR	WHP	Cabbage, Abyssinian	TaxonGroup	4	10	2	0	6,0	High
Brassicaceae	<i>Diplotaxis viminea</i> (L.) DC.	species	CWR	WHP	Rape	GenePool	3	10	4	0	6,0	High
Brassicaceae	<i>Diplotaxis virgata</i> subsp. <i>brachycarpa</i> (Godr.) Nègre	subsp.	CWR	WHP	Turnip	TaxonGroup	4	10	2	10	7,7	High
Brassicaceae	<i>Diplotaxis virgata</i> subsp. <i>tenuirostris</i> (Maire) Mart.-Laborde	subsp.	CWR	WHP	Turnip	TaxonGroup	4	10	2	0	6,0	High
Brassicaceae	<i>Eruca foleyii</i> (Batt.) Lorite, Perfectti & al.	species	CWR		Arugula	TaxonGroup	4	10	6	10	8,3	High
Brassicaceae	<i>Eruca pinnatifida</i> (Desf.) Pomel	species	CWR		Arugula	TaxonGroup	1b	10	0	0	6,7	High
Brassicaceae	<i>Eruca setulosa</i> Boiss. & Reuter	species	CWR		Arugula	TaxonGroup	4	10	6	10	8,3	High
Brassicaceae	<i>Eruca vesicaria</i> (L.) Cav. subsp. <i>vesicaria</i>	subsp.	CWR		Arugula	GenePool	1b	10	2	0	7,0	High
Brassicaceae	<i>Eruca vesicaria</i> subsp. <i>sativa</i> (Mill.) Thell.	subsp.	CWR		Arugula	GenePool	1b	10	2	0	7,0	High
Brassicaceae	<i>Erucastrum brevirostre</i> (Maire) Gomez-Campo	species	CWR		Mustard	TaxonGroup	4	0	3	10	6,2	High
Brassicaceae	<i>Erucastrum elatum</i> (Ball) O. E. Schulz	species	CWR		Mustard	TaxonGroup	4	0	2	10	6,0	High
Brassicaceae	<i>Erucastrum ifniense</i> Gomez-Campo	species	CWR		Mustard	TaxonGroup	4	0	6	10	6,7	High

Table 3 (continued)

Family	Taxon	Rank	CWR	WHP	CROP name	GenePool/ Taxon-Group	Relative degree	Energy Supply/ ITPGRFA priority	Conservation priority	Endemic priority	FPS	Priority
Brassicaceae	<i>Erucastrum leucanthum</i> Coss. & Durieu	species	CWR		Mustard	TaxonGroup	4	0	2	10	6,0	High
Brassicaceae	<i>Erucastrum rufanum</i> (Emb. & Maire) Gomez-Campo	species	CWR		Mustard	TaxonGroup	4	0	3	10	6,2	High
Brassicaceae	<i>Erucastrum varium</i> (Durieu)	species	CWR		Mustard	TaxonGroup	4	0	2	10	6,0	High
Rosaceae	<i>Fragaria vesca</i> L.	species	CWR	WHP	Strawberry	GenePool	1b	10	0	0	6,7	High
Asteraceae	<i>Helianthus annuus</i> L.	species	CWR	WHP	Sunflower	GenePool	1b	10	0	0	6,7	High
Poaceae	<i>Hordeum vulgare</i> L.	species	CWR	WHP	Barley	GenePool	1b	10	0	0	6,7	High
Brassicaceae	<i>Isatis djurdjurae</i> Coss. & Durieu	species	CWR		Radish	TaxonGroup	5	10	3	10	7,3	High
Fabaceae	<i>Lathyrus cicera</i> L.	species	CWR	WHP	Grass-Pea	GenePool	2	10	2	0	6,3	High
Fabaceae	<i>Lathyrus pulcher</i> J. Gay	species	CWR		Grass-Pea	GenePool	2	0	0	10	6,0	High
Fabaceae	<i>Lathyrus sativus</i> L.	species	CWR	WHP	Grass-Pea	GenePool	1b	10	0	0	6,7	High
Fabaceae	<i>Lathyrus zalahensis</i> Andr.	species	CWR		Grass-Pea	TaxonGroup	4	0	10	10	7,3	High
Fabaceae	<i>Lens culinaris</i> Medik.	species	CWR	WHP	Lentil	GenePool	1b	10	0	0	6,7	High
Fabaceae	<i>Lens lamottei</i> Czefr	species	CWR		Lentil	GenePool	2	10	2	0	6,3	High
Fabaceae	<i>Lens nigricans</i> (M. Bieb.) Godr.	species	CWR	WHP	Lentil	GenePool	3	10	2	10	7,3	High
Rosaceae	<i>Malus pumila</i> Mill.	species	CWR	WHP	Apple	GenePool	2	10	0	0	6,0	High
Fabaceae	<i>Pisum sativum</i> L. subsp. <i>sativum</i>	subsp.	CWR	WHP	Pea	GenePool	1b	10	2	0	7,0	High
Fabaceae	<i>Pisum sativum</i> subsp. <i>elatius</i> (M. Bieb.) Ascherson & Graebner	subsp.	CWR		Pea	GenePool	1b	10	2	0	7,0	High

Table 3 (continued)

Family	Taxon	Rank	CWR	WHP	CROP name	GenePool/ Taxon-Group	Relative degree	Energy Supply/ ITPGRFA priority	Conservation priority	Endemic priority	FPS	Priority
Apiaceae	<i>Pseudorhiza biseriata</i> (Murb.) Sáenz de Rivas	species	CWR		Carrot	GenePool	3	10	2	10	7,3	High
Poaceae	<i>Secale montanum</i> Guss.	species	CWR		Wheat	TaxonGroup	4	10	2	0	6,0	High
Rosaceae	<i>Pyrus bourgaeana</i> Decne	species	CWR	WHP	Pear	GenePool	2	0	6	10	7,0	High
Brassicaceae	<i>Raphanus raphanistrum</i> L. subsp. <i>raphanistrum</i>	subsp.	CWR	WHP	Radish	GenePool	1b	10	2	0	7,0	High
Brassicaceae	<i>Raphanus raphanistrum</i> subsp. <i>landra</i> (DC.) Bonnier & Layens	subsp.	CWR		Radish	GenePool	1b	10	2	0	7,0	High
Brassicaceae	<i>Roripella atlantica</i> (Ball) Maire	species	CWR		Rape	TaxonGroup	5	10	4	10	7,5	High
Brassicaceae	<i>Rorippa hayanica</i> Maire	species	CWR		Rape	TaxonGroup	5	10	4	10	7,5	High
Brassicaceae	<i>Sinapis arvensis</i> L. subsp. <i>arvensis</i>	subsp.	CWR		Mustard, Black	GenePool	2	10	2	0	6,3	High
Brassicaceae	<i>Sinapis flexuosa</i> Poir.	species	CWR		Mustard, White	GenePool	1b	10	0	10	8,3	High
Solanaceae	<i>Solanum dulcamara</i> L.	species	CWR	WHP	Tomato/ Eggplant	TaxonGroup	4	10	2	0	6,0	High
Solanaceae	<i>Solanum herculeum</i> Bohs	species	CWR		Tomato/ Eggplant	TaxonGroup	4	10	2	0	6,0	High
Solanaceae	<i>Solanum limaeanum</i> Hepper & P.-M. L. Jaeger	species	CWR		Eggplant	GenePool	2	10	0	0	6,0	High
Solanaceae	<i>Solanum villosum</i> Mill.	species	CWR		Tomato/ Eggplant	TaxonGroup	4	10	2	0	6,0	High
Poaceae	<i>Sorghum halepense</i> (L.) Pers.	species	CWR	WHP	Sorghum	GenePool	2	10	2	0	6,2	High
Fabaceae	<i>Vicia altissima</i> Desf.	species	CWR		Faba-Bean	TaxonGroup	4	10	4	0	6,3	High

Table 3 (continued)

Family	Taxon	Rank	CWR	WHP	CROP name	GenePool/ Taxon-Group	Relative degree	Energy Supply/ ITPGRFA priority	Conservation priority	Endemic priority	FPS	Priority
Fabaceae	<i>Vicia benghalensis</i> L. subsp. <i>benghalensis</i>	subsp.	CWR		Faba-Bean	TaxonGroup	4	10	2	0	6,0	High
Fabaceae	<i>Vicia benghalensis</i> subsp. <i>heterocalyx</i> (Maire & Weiller) Hormat	subsp.	CWR		Faba-Bean	TaxonGroup	4	10	2	10	7,7	High
Fabaceae	<i>Vicia cedretorum</i> Font Quer	species	CWR		Faba-Bean	TaxonGroup	4	10	6	10	8,3	High
Fabaceae	<i>Vicia disperma</i> DC.	species	CWR		Faba-Bean	TaxonGroup	4	10	2	10	7,7	High
Fabaceae	<i>Vicia ervilia</i> (L.) Willd.	species	CWR	WHP	Vetch, Bitter	GenePool	1b	10	0	0	6,7	High
Fabaceae	<i>Vicia fairchildiana</i> Maire	species	CWR		Faba-Bean	TaxonGroup	4	10	10	10	9,0	High
Fabaceae	<i>Vicia glauca</i> C. Presl	species	CWR		Faba-Bean	TaxonGroup	4	10	2	0	6,0	High
Fabaceae	<i>Vicia hirsuta</i> (L.) S.F. Gray	species	CWR		Vetch, One-Flower	GenePool	2	10	2	0	6,3	High
Fabaceae	<i>Vicia lecontei</i> Humbert & Maire	species	CWR		Vetch, Hungarian	TaxonGroup	4	10	3	10	7,8	High
Fabaceae	<i>Vicia leucantha</i> Biv.	species	CWR		Vetch, Hungarian	TaxonGroup	4	10	10	0	7,3	High
Fabaceae	<i>Vicia lutea</i> subsp. <i>cavanillesii</i> (Mart. Mart.) Romero Zarco	subsp.	CWR		Vetch, Hungarian	TaxonGroup	4	10	2	0	6,0	High
Fabaceae	<i>Vicia lutea</i> subsp. <i>vestita</i> (Boiss.) Rouy	subsp.	CWR		Vetch, Hungarian	TaxonGroup	4	10	2	0	6,0	High
Fabaceae	<i>Vicia monantha</i> Retz. subsp. <i>monantha</i>	subsp.	CWR		Vetch, Hungarian	TaxonGroup	4	10	2	0	6,0	High
Fabaceae	<i>Vicia monantha</i> subsp. <i>biflora</i> (Desf.) Maire	subsp.	CWR		Vetch, Hungarian	TaxonGroup	4	10	2	0	6,0	High

Table 3 (continued)

Family	Taxon	Rank	CWR	WHP	CROP name	GenePool/ Taxon-Group	Relative degree	Energy Supply/ ITPGRFA priority	Conservation priority	Endemic priority	FPS	Priority
Fabaceae	<i>Vicia monantha</i> subsp. <i>calcarata</i> (Desf.) Romero Zarco	subsp.	CWR		Vetch, Hungarian	TaxonGroup	4	10	2	0	6,0	High
Fabaceae	<i>Vicia murbeckii</i> Maire	species	CWR		Vetch, Hungarian	TaxonGroup	4	10	6	10	8,3	High
Fabaceae	<i>Vicia narbonensis</i> L.	species	CWR		Vetch, Narbon	GenePool	1b	10	2	0	7,0	High
Fabaceae	<i>Vicia onobrychioides</i> L.	species	CWR		Vetch, Hungarian	TaxonGroup	4	10	2	10	7,7	High
Fabaceae	<i>Vicia parviflora</i> Cav.	species	CWR		Vetch, Hungarian	TaxonGroup	4	10	2	0	6,0	High
Fabaceae	<i>Vicia peregrina</i> L.	species	CWR		Vetch, Hungarian	TaxonGroup	4	10	2	0	6,0	High
Fabaceae	<i>Vicia pubescens</i> (DC.) Link	species	CWR		Vetch, Hungarian	TaxonGroup	4	10	2	0	6,0	High
Fabaceae	<i>Vicia sativa</i> L. subsp. <i>sativa</i>	subsp.	CWR	WHP	Vetch, Common	GenePool	1b	10	2	0	7,0	High
Fabaceae	<i>Vicia sativa</i> subsp. <i>amphicarpa</i> (Dorthes) Batt.	subsp.	CWR	WHP	Vetch, Common	GenePool	1b	10	2	0	7,0	High
Fabaceae	<i>Vicia sativa</i> subsp. <i>cordata</i> (Hoppe) Batt.	subsp.	CWR		Vetch, Common	GenePool	1b	10	2	0	7,0	High
Fabaceae	<i>Vicia sativa</i> subsp. <i>macrocarpa</i> (Moris) Arcangeli	subsp.	CWR	WHP	Vetch, Common	GenePool	1b	10	2	0	7,0	High
Fabaceae	<i>Vicia sativa</i> subsp. <i>nigra</i> (L.) Ehrh.	subsp.	CWR	WHP	Vetch, Common	GenePool	1b	10	2	0	7,0	High
Fabaceae	<i>Vicia sicula</i> (Raf.) Guss.	species	CWR		Vetch, Common	TaxonGroup	4	10	2	0	6,0	High
Fabaceae	<i>Vicia tenuifolia</i> Roth subsp. <i>tenuifolia</i>	subsp.	CWR		Vetch, Common	TaxonGroup	4	10	2	0	6,0	High
Fabaceae	<i>Vicia tenuifolia</i> subsp. <i>delmasii</i> (Emb. & Maire) Dobignard	subsp.	CWR		Vetch, Common	TaxonGroup	4	10	2	10	7,7	High

Table 3 (continued)

Family	Taxon	Rank	CWR	WHP	CROP name	GenePool/ Taxon-Group	Relative degree	Energy Supply/ ITPGRFA priority	Conservation priority	Endemic priority	FPS	Priority
Fabaceae	<i>Vicia tenuifolia</i> subsp. <i>villosa</i> (Batt.) Greuter	subsp.	CWR		Vetch, Common	TaxonGroup	4	10	2	10	7,7	High
Fabaceae	<i>Vicia tetrasperma</i> (L.) Schreber	species	CWR		Vetch, Common	TaxonGroup	4	10	2	0	6,0	High
Fabaceae	<i>Vicia vicioides</i> (Desf.) Coutinho	species	CWR		Vetch, Common	TaxonGroup	4	10	2	0	6,0	High
Fabaceae	<i>Vicia villosa</i> subsp. <i>garbiensis</i> (Font Quer & Pau) Maire	subsp.	CWR		Vetch, Common	TaxonGroup	4	10	2	10	7,7	High
Fabaceae	<i>Vicia villosa</i> subsp. <i>pseudocracca</i> (Bertol.) Rouy	subsp.	CWR		Vetch, Common	TaxonGroup	4	10	2	0	6,0	High
Fabaceae	<i>Vicia villosa</i> subsp. <i>varia</i> (Host) Corb.	subsp.	CWR		Vetch, Common	TaxonGroup	4	10	2	0	6,0	High
Oleaceae	<i>Olea europaea</i> subsp. <i>maroccana</i> (Greuter & Burdet) Vargas & al.	subsp.	CWR	WHP	Olive	GenePool	2	0	2	10	6,3	High
Vitaceae	<i>Vitis vinifera</i> subsp. <i>sylvestris</i> (C.C. Gmel.) Hegi	subsp.	CWR	WHP	Grape, Wine	GenePool	1b	0	0	0	5,0	High

particularly notable for their breeding potential and adaptation to arid environments.

The Moroccan wheat and barley sectors, which are essential for national food security, also benefit from high-priority CWR such as *Aegilops* sp. pl. (GP2) and *Triticum* sp. pl. (GP1b). These relatives provide genetic material for improving yield, drought tolerance, and resistance to diseases like rusts. Barley, a staple crop for Moroccan livestock, is supported by tertiary gene pool relatives that contribute resilience traits.

In addition, Morocco hosts high-priority CWR for other critical crops such as watermelon *Citrullus colocynthis* (L.) Schrad., pea *Pisum sativum* subsp. *elatius*, and onion (*Allium* sp. pl.) These species are valuable not only for their agronomic traits but also for their use as food, spices, and medicinal plants.

Underscoring the importance of Morocco's key crop wild relatives is essential particularly for olive (*Olea europaea* subsp. *maroccana* and *Sideroxylon spinosum* which are endemic taxa emblematic of the nation's agricultural and ecological landscape. Morocco is among the largest olive producer in Africa, contributing substantially to the global olive oil market (IOC 2024). Olive oil represents a vital economic sector, with an average annual production of 140,000 tonnes, generating over 200 million US dollars and employing more than 500,000 people, particularly in rural areas (ONSSA 2021). In addition to its economic importance, olive oil constitutes a significant dietary staple, providing essential fatty acids and antioxidants to the Moroccan population.

The wild olive, oleaster, (*Olea europaea* subsp. *maroccana*, GP1b), is distributed across various regions of Morocco, including the Rif, Middle Atlas, and Anti-Atlas Mountains. It is classified as a high-priority CWR due to its ecological and genetic significance. The wild olive is still extensively used as rootstock for olive cultivars in traditional and marginal areas, offering traits such as drought tolerance, pest resistance, and adaptation to poor soils (Besnard et al. 2013; Loumou and Giourga 2003). Furthermore, oleaster represents a critical genetic reservoir for improving olive yield and oil quality, particularly under conditions of climate change. Conservation strategies should focus on in situ protection in biodiversity hotspots, such as the Souss-Massa and Tazekka regions, as well as ex situ efforts in national genebanks.

Another standout species is *Sideroxylon spinosum*, commonly known as the argan tree, which is an endemic and iconic plant of southwestern Morocco. Spanning approximately 2.5 million hectares, the argan forest is a UNESCO-designated biosphere reserve due to its environmental, social, and economic importance (UNESCO 1999). The argan tree provides an array of ecosystem services, including combating desertification, enhancing soil fertility, and supporting biodiversity. Its oil, which is highly valued for its nutritional, medicinal, and cosmetic properties, generates significant income, particularly through women's cooperatives, with an annual export value exceeding 100 million US dollars (Charrouf and Guillaume 2009; Nouaim et al. 2007).

Genetically, *Sideroxylon spinosum* is a vital resource for breeding programs aimed at improving resilience to climatic extremes such as drought and high temperatures. Recent investigations have highlighted its unique adaptations to arid conditions, including a deep root system and mechanisms for conserving water and nutrients (Tahrouch et al. 2011). However, this species faces threats from overgrazing, land conversion, and climate change, necessitating urgent conservation actions. Both in situ conservation through reforestation programs and ex situ measures, such as seed banking, are imperative to ensure long-term sustainability.

In addition to olives and argan, Morocco is home to a rich diversity of CWRs related to cereals, legumes, and vegetables. For example, wild relatives of wheat (*Triticum* sp. pl.) and barley (*Hordeum vulgare*) are critical for breeding programs addressing drought and heat stress—two significant challenges for Moroccan agriculture. Wild *Aegilops* species, closely related to wheat, have shown potential to enhance yield stability and resistance to pests and diseases under arid conditions (Araus and Cairns 2013; Benbella and Paulsen 1998).

Vegetable crops such as carrot (*Daucus carota*), onion (*Allium cepa*), and cabbage (*Brassica oleracea*) are also well-represented by wild relatives in Morocco. Wild *Daucus* species, for example, offer genetic traits for disease resistance and adaptation to saline soils, which are increasingly relevant as agricultural lands face salinization due to climate change (Simon et al. 2021). Similarly, wild *Allium* species, including high-priority relatives, have the potential to

increase pest resistance and stress tolerance in cultivated onions and leeks.

Morocco's unique biodiversity extends to legumes, with wild relatives of lentil (*Lens* sp. pl.), chickpea (*Cicer* sp. pl.), and pea (*Pisum sativum*) playing a critical role in breeding programs aimed at improving nutritional quality and resistance to biotic stresses (Maxted et al. 2010). Wild *Vicia* species, such as *Vicia narbonensis* L., are particularly noteworthy for their potential to enhance drought resistance in cultivated vetches and other legumes used for fodder and human consumption (Abd El Moneim 1992).

From an ecological perspective, the conservation of Moroccan CWRs is essential not only for safeguarding biodiversity but also for ensuring the sustainability of agricultural systems. Morocco's population, estimated over 37 million continues to grow and its territories are increasingly urbanizing. Despite this trend, agriculture remains a major employer, engaging almost 30% of the total country workforce (ILO 2024). This demographic context, together with the environmental pressures deriving from climate change, puts a strong emphasis on the needs of addressing future increasing nutritional demands while at the same time ensuring environmental protection. In this context, the taxa here identified as related to crops important for food security and nutrition and those related to economically valuable taxa could assume a key role in supporting nutritional and livelihood demands of households. These genetic resources are integral to developing cultivars that can withstand the challenges posed by climate change, including water scarcity, soil degradation, and extreme weather events. This is the case, as previously mentioned, of wheat and barley wild relatives. These two crops, for instance, resulted being strong contributors to the population daily energy supply. The importance of conserving their wild relatives and support future breeding programs emerges especially in light of the country's growing population. For example, wild genes from *Triticum* and *Hordeum* could significantly improve cereal yields under Morocco's highly variable rainfall conditions (Araus and Cairns 2013). Additionally, wild harvested plants could play an important role in differentiating nutritional and economic income especially for rural communities.

Implementation of an integrated conservation strategy

The effective implementation of a national conservation strategy for Crop Wild Relatives (CWR) and Wild Harvested Plants (WHP) in Morocco requires coordinated action among government agencies, research institutions, and local communities.

At the institutional level, the Ministry of Agriculture, the National Institute for Agronomic Research (INRA), and the National Herbarium of Scientific Institute, Mohammed V University play a key role in cataloging, monitoring, and preserving plant genetic resources. Strengthening ex situ conservation through national seed banks and botanical gardens will ensure the long-term preservation of priority taxa.

For in situ conservation, local communities and farmers should be actively involved in managing CWR populations in their natural habitats. Initiatives such as community-protected areas, participatory breeding programs, and sustainable harvesting guidelines could enhance conservation while ensuring economic benefits for local populations.

At the international level, Morocco can leverage partnerships with organizations like the European Cooperative Programme for Plant Genetic Resources (ECPGR) and the Global Strategy for Plant Conservation (GSPC) to access funding, technical expertise, and conservation strategies aligned with global standards.

A multi-stakeholder, integrated approach combining policy support, research, and community engagement is essential to securing Morocco's plant biodiversity for future generations.

Ensuring the effectiveness of conservation strategies requires a structured monitoring framework integrating in situ and ex situ approaches. In situ, periodic field surveys and remote sensing will track population trends, habitat conditions, and environmental threats, with community involvement ensuring sustainable management. Ex situ, genetic assessments of seed bank accessions will evaluate diversity retention and viability for potential reintroductions.

Success will be measured through species persistence, population recovery, and genetic stability, with data centralized in a national conservation database. This adaptive approach will optimize conservation efforts and safeguard Morocco's plant genetic resources for future resilience.

Conclusion

Morocco is globally acknowledged as a significant center of biodiversity, particularly within the Mediterranean Basin. It stands out as a significant reservoir of plant genetic resources, harboring a remarkably diverse flora that includes both crop wild relatives (CWRs) and wild harvested plants (WHPs). In this study, we identified a substantial portion of Morocco's flora, approximately 40%, as potentially useful for crop improvement or direct utilization in food, medicinal, and other ethnobotanical reported applications. Our results align with findings from global research on Crop Wild Relatives and Wild Harvested Plants, confirming Morocco's role as a hotspot of CWR diversity. This diversity is especially critical given the global need for resilience against climate change, environmental degradation, and food insecurity.

Our prioritization process identified 252 taxa as high conservation priorities, encompassing critical genetic resources for addressing challenges such as pests, diseases, and climatic extremes. This priority list includes wild relatives of wheat, barley, oats, olive, and argan, underscoring their value for breeding programs aimed at enhancing yield, resilience and nutritional quality.

Our findings demonstrate the national importance of these genetic resources for agricultural and socio-economic resilience, especially given Morocco's demographic trends. In fact, with a population exceeding 37 million and agriculture employing a significant share of the workforce, the pressure on staple foods to ensure food security and rural livelihoods is vast.

Priority species such as *Sideroxylon spinosum*, the argan tree, *Olea europaea* subsp. *maroccana*, wild olive with significant breeding potential, and *Avena magna*, an oat-relative with agronomically valuable traits, exemplify the ecological and socio-economic significance of Morocco's endemic flora. Each of them can, currently or potentially, support vital rural sectors through high-value products while at the same time offering crucial ecosystem services in ecologically sensible semi-arid areas.

Despite all that, mounting threats from overgrazing, urbanization, habitat loss, and the effects of climate change are raising concerns about genetic erosion and the long term sustainability of key agricultural systems. For example, many endemic priority

species adapted to extreme environments are not yet fully integrated into conservation frameworks, jeopardizing their survival.

By providing a comprehensive inventory and identifying priority taxa for targeted conservation, this study offers a practical framework to guide future in situ and ex situ actions. Integrating these measures into national development strategies, while also collaborating closely with local communities and policymakers, will be critical to safeguarding Morocco's plant diversity. Protected areas can serve as natural reservoirs for priority taxa, ensuring their continued evolution in native ecosystems. Similarly, the Moroccan National Gene Bank can play a crucial role in preserving germplasm and supporting its utilization in research and breeding programs. In so doing, the country can preserve and harness these invaluable CWR and WHP resources for climate resilience, economic development, and the ongoing challenge of feeding a growing population.

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Data availability Input files created for this study are included in this article and its supplementary files or are available from the corresponding authors on reasonable request.

Declarations

Conflict of interest The authors declare no Conflict of interest.

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References

- Abd El Moneim AM (1992) Narbon vetch (*Vicia narbonensis* L.): a potential feed legume crop for dry areas in West Asia. *J Agron Crop Sci* 169(5):347–353. <https://doi.org/10.1111/j.1439-037X.1992.tb01046.x>
- Alami Merrouni I, Kharchoufa L, Bencheikh N et al (2021) Ethnobotanical profile of medicinal plants used by people of north-eastern Morocco: cross-cultural and historical approach. *Ethnobotany Res Appl*. <https://doi.org/10.32859/era.21.34.1-45>
- Araus J, Cairns J (2013) Field high-throughput phenotyping: the new crop breeding frontier. *Trends Plant Sci*. <https://doi.org/10.1016/j.tplants.2013.09.008>
- Belhaj S, Chaachouay N, Zidane L et al (2021) Ethnobotanical and toxicology study of medicinal plants used for the treatment of diabetes in the high atlas central of Morocco. *J Pharm Pharmacognosy Res* 9:619–662. https://doi.org/10.56499/jppres21.1014_9.5.619
- Bellakhdar J (1997) La pharmacopée marocaine traditionnelle, Médecine arabe ancienne et savoirs populaires. Ibis pres, 2 Saint-Etienne
- Benabid A (2000) Flore et écosystèmes du Maroc : Evaluation et préservation de la biodiversité. Ibis Press. Paris, Librairie et éd. Kalila Wa Dimna. Rabat
- Benbella M, Paulsen GM (1998) Efficacy of treatments for delaying senescence of wheat leaves: II. senescence and grain yield under field conditions. *Agron J* 90(3):332–338. <https://doi.org/10.2134/agronj1998.00021962009000030004x>
- Besnard G, Khadari B, de Navascués M et al (2013) The complex history of the olive tree: from late quaternary diversification of mediterranean lineages to primary domestication in the northern levant. *Proceed Biol Sci/R Soc* 280:20122833. <https://doi.org/10.1098/rspb.2012.2833>
- Borelli T, Hunter D, Powell B et al (2020) Born to eat wild: an integrated conservation approach to secure wild food plants for food security and nutrition. *Plants*. <https://doi.org/10.3390/plants9101299>
- Brehm J, Maxted N, Ford-Lloyd B et al (2007) National inventories of crop wild relatives and wild harvested plants: case-study for Portugal. *Genet Resour Crop Evol* 55:779–796. <https://doi.org/10.1007/s10722-007-9283-9>
- Brehm J, Maxted N, Martins-Loução MA et al (2010) New approaches for establishing conservation priorities for socio-economically important plant species. *Biodivers Conserv* 19:2715–2740. <https://doi.org/10.1007/s10531-010-9871-4>
- Brehm J, Kell S, Thormann I et al (2018) Interactive toolkit for crop wild relative conservation planning - version 1. <https://doi.org/10.7910/DVN/SYUSY8>
- Cardinale B, Duffy J, Gonzalez A et al (2012) Biodiversity loss and its impact on humanity. *Nature* 486:59–67. <https://doi.org/10.1038/nature11148>
- Chaachouay N, Benkhiguel O, Douira A et al (2021) Poisonous medicinal plants used in the popular pharmacopoeia of the rif, Northern Morocco. *Toxicon* 189:24–32. <https://doi.org/10.1016/j.toxicon.2020.10.028>
- Charnot A (1945) La toxicologie au Maroc. Mémoires de la Société des sciences naturelles du Maroc (XLVII)
- Charrouf Z, Guillaume D (2009) Sustainable development in Northern Africa: the argan forest case. *Games* 1:1–10. <https://doi.org/10.3390/su1041012>
- Ciancaleoni S, Raggi L, Barone G et al (2021) A new list and prioritization of wild plants of socioeconomic interest in Italy: toward a conservation strategy. *Agroecol Sustain Food Syst* 45:1–27. <https://doi.org/10.1080/21683565.2021.1917469>
- Contreras Toledo A, Cortes-Cruz M, Costich D et al (2018) A crop wild relative inventory for Mexico. *Crop Sci* 58:1292. <https://doi.org/10.2135/cropsci2017.07.0452>
- Dempewolf H, Baute G, Anderson J et al (2017) Past and future use of wild relatives in crop breeding. *Crop Sci*. <https://doi.org/10.2135/cropsci2016.10.0885>
- El Alami A, Loubna F, Abderrahman C (2016) Etude ethnobotanique sur les plantes médicinales spontanées poussant dans le versant nord de l'atlas d'azilal (maroc). *Algerian J Nat Prod* 4:271–282
- El Mokni R, Barone G, Maxted N et al (2022) A prioritised inventory of crop wild relatives and wild harvested plants of Tunisia. *Genet Resour Crop Evol*. <https://doi.org/10.1007/s10722-021-01340-z>
- El Oualidi J, Taleb A, Ater M (2004) Conception, essai et évaluation des meilleures pratiques de conservation in-situ d'espèces végétales sauvages d'importance économique, Rapport du projet régional EP/INT/204/GEF de la FAO
- El Oualidi J, Khamar H, Fennane M et al (2012) Checklist des endémiques et spécimens types de la flore vasculaire de l'Afrique du nord. Documents de l'Institut Scientifique (25)
- Fabricant D, Farnsworth N (2001) The value of plants used in traditional medicine for drug discovery. *Environ Health Perspect* 109(Suppl 1):69–75. <https://doi.org/10.2307/3434847>
- Fakchich J, Mostafa E (2014) Ethnobotanical survey of medicinal plants used by people in oriental Morocco to manage various ailments. *J Ethnopharmacol*. <https://doi.org/10.1016/j.jep.2014.03.016>
- Fakchich J, Mostafa E (2020) An overview on ethnobotanico-pharmacological studies carried out in Morocco, from 1991 to 2015: systematic review (part 1). *J Ethnopharmacol* 267:113200. <https://doi.org/10.1016/j.jep.2020.113200>
- FAO (2006) Food Security. https://www.fao.org/fileadmin/templates/faoitally/documents/pdf/pdf_Food_Security_Coept_Note.pdf, [Online; Accessed 16 Dec 2024]
- FAO (2009) International treaty on plant genetic resources for food and agriculture. <https://www.fao.org/4/i0510e/i0510e.pdf>, [Online; Accessed 16 Dec 2024]
- FAO (2011) Second global plan of action for the conservation and sustainable utilization of plant genetic resources for food and agriculture. <https://www.fao.org/4/i2624e/i2624e00.pdf>, [Online; Accessed 16 Dec 2024]
- FAO (2017) Voluntary guidelines for the conservation and sustainable use of crop wild relatives and wild food plants. <https://openknowledge.fao.org/server/api/core/bitstreams/7329d2d1-cb38-49c7-bf1b-e422c1871593/content>, [Online; Accessed 16 Dec 2024]
- FAO (2019) The state of the world's biodiversity for food and agriculture. <https://openknowledge.fao.org/server/api/>

- core/bitstreams/50b79369-9249-4486-ac07-9098d07df60a/content, [Online; accessed 16-December-2024]
- FAO (2023) FAOSTAT statistical database. <https://www.fao.org/faostat/en/#data>, [Online; accessed 16-January-2025]
- Farnsworth NR (1985) Medicinal plants and traditional medicine in Africa. *J Pharm Sci* 74(3):364–364. <https://doi.org/10.1002/jps.2600740339>
- Fennane M, Ibn Tattou M (2012) Statistiques et commentaires sur l'inventaire actuel de la flore vasculaire du maroc. *Bulletin de l'Institut Scientifique, section Sciences de la Vie* 34
- Fennane M, Ibn Tattou M, Mathez J, et al (1999) Flore pratique du Maroc: manuel de détermination des plantes vasculaires, vol. I
- Fennane M, Ibn Tattou M, Ouyahya A et al (2007) Flore pratique du Maroc: manuel de détermination des plantes vasculaires, vol. II
- Fennane M, Ibn Tattou M, El Oualidi J (2014) Flore pratique du Maroc: manuel de détermination des plantes vasculaires, vol. III
- Fennane M, Ibn Tattou (coll.) M, El Oualidi (coll.) J (2021) Livre rouge de la flore vasculaire du Maroc. Travaux de l'Institut Scientifique
- Fielder H, Hopkins J, Smith C et al (2012) Uk wild species to underpin global food security: species selection, genetic reserves and targeted collection. *Crop wild relative* 8:24–27
- Ford-Lloyd B, Kell S, Maxted N (2007) Establishing conservation priorities for crop wild relatives. *Crop Wild Relative Conservation and Use* pp 110–119
- Graham P, Vance C (2003) Legumes: Importance and constraints to greater use. *Plant Physiol* 131:872–7. <https://doi.org/10.1104/pp.017004>
- Hadjichambis A, Paraskeva-Hadjichambi D, Della A et al (2008) Wild and semi-domesticated food plant consumption in seven circum-mediterranean areas. *Int J Food Sci Nutr* 59:383–414. <https://doi.org/10.1080/09637480701566495>
- Hajjar R, Hodgkin T (2007) The use of wild relatives in crop improvement: a survey of developments over the last 20 years. *Euphytica* 156:1–13. <https://doi.org/10.1007/s10681-007-9363-0>
- Hancock J, Lobos G (2008) Pears, pp 299–336. https://doi.org/10.1007/978-1-4020-6907-9_10
- Harlan JR, de Wet MJM (1971) Toward a rational classification of cultivated plants. *Taxon* 20(4):509–517. <https://doi.org/10.2307/1218252>
- Harlan JR, de Wet MJM (1971) Toward a rational classification of cultivated plants. *Taxon* 20(4):509–517. <https://doi.org/10.2307/1218252>
- Heywood VH (2011) Ethnopharmacology, food production, nutrition and biodiversity conservation: towards a sustainable future for indigenous peoples. *J Ethnopharmacol* 137(1):1–15. <https://doi.org/10.1016/j.jep.2011.05.027>
- ILO (2024) International labour organization. “ilo modelled estimates database” ilo.stat. <https://databank.worldbank.org/source/world-development-indicators/>, [Online; Accessed 10 Feb 2025]
- IOC (2024) (International Olive Council) . <https://www.internationaloliveoil.org>, [Online; Accessed 16 Dec 2024]
- IPNI (2024) The royal botanic gardens, kew, harvard university herbaria and libraries and australian national botanic gardens. <https://www.ipni.org/>, [Online; Accessed 16 Dec 2024]
- IUCN (2023) The IUCN red list of threatened species. <https://www.iucnredlist.org/>, [Online; Accessed 16 Jan 2025]
- Jamaledine M, Oualidi JE, Taleb MS et al (2017) Inventaire et état de conservation des plantes aromatiques et médicinales (pam) au Maroc. *Phytothérapie* 15:114–122. URL <https://api.semanticscholar.org/CorpusID:13322602>
- Jeddi M, Ouaritini Z, Fikri Benbrahim K (2021) Ethnobotanical study of medicinal plants in Northern Morocco (taouante): case of mernissa. *Ethnobotany Res Appl*. <https://doi.org/10.32859/era.21.35.1-23>
- Kell S (2005) The CWR Catalogue For Europe and the Mediterranean. https://pgrsecure.bham.ac.uk/sites/default/files/meetings/palanga/WG1_02_CWR_Catalogue_Kell.pdf, [Online; Accessed 16 Dec 2024]
- Kell S, Knüpfer H, Jury S et al (2007) Crops and wild relatives of the Euro-Mediterranean region: making and using a conservation catalogue., pp 69–109. <https://doi.org/10.1079/9781845930998.0069>
- Kell S, Qin H, Chen B et al (2015) China's crop wild relatives: diversity for agriculture and food security. *Agri Ecosyst Environ*. <https://doi.org/10.1016/j.agee.2015.02.012>
- Kell S, Ford-Lloyd B, Brehm J et al (2017) Broadening the base, narrowing the task: prioritizing crop wild relative taxa for conservation action. *Crop Sci* 57:1042–1058. <https://doi.org/10.2135/cropsci2016.10.0873>
- Kharchoufa L, Bouhrim M, Bencheikh N et al (2021) Potential toxicity of medicinal plants inventoried in northeastern Morocco: an ethnobotanical approach. *Plants* 10:1108. <https://doi.org/10.3390/plants10061108>
- Labrihli K, Moujahdi C, Rhazi L et al (2024) Raising awareness of toxic spontaneous plants in Morocco: a comprehensive checklists. *Flora Mediterranea* 34:143–158. <https://doi.org/10.7320/FlMedit34.143>
- Lala S, Amri A, Maxted N (2018) Towards the conservation of crop wild relative diversity in North Africa: checklist, prioritisation and inventory. *Genet Resour Crop Evol*. <https://doi.org/10.1007/s10722-017-0513-5>
- 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>
- Lamrani-Alaoui M, Benabid A, R H (2015) Étude relative à l'élaboration du plan d'action pour la conservation, la gestion durable et la valorisation des plantes aromatiques et médicinales du Maroc ; phase 1 : identification des 20 espèces de PAM spontanées prioritaires et des espèces exploitées à risque, Projet PAM, centre de recherche forestière, Rabat
- Lavania U (2005) Genomic and ploidy manipulation for enhanced production of phyto-pharmaceuticals. *Plant Genet Resour* 3(2):170–177. <https://doi.org/10.1079/PGR200576>
- Lentini F, Venza F (2007) Wild food plant of popular use in sicily. *J Ethnobiol Ethnomed* 3:15. <https://doi.org/10.1186/1746-4269-3-15>

- Loskutov IG, Rines HW (2011) *Avena*, Springer Berlin Heidelberg, Berlin, Heidelberg, pp 109–183. https://doi.org/10.1007/978-3-642-14228-4_3
- Loumou A, Giourga C (2003) Olive groves: “the life and identity of the mediterranean”. *Agric Hum Values* 20:87–95. <https://doi.org/10.1023/A:1022444005336>
- Lybbert T, Aboudrare A, Chaloud D et al (2011) Booming markets for Moroccan argan oil appear to benefit some rural households while threatening the endemic argan forest. *Proc Natl Acad Sci USA* 108:13963–8. <https://doi.org/10.1073/pnas.1106382108>
- Mammadov J, Buyyarapu R, Guttikonda SK et al (2018) Wild relatives of maize, rice, cotton, and soybean: treasure troves for tolerance to biotic and abiotic stresses. *Front Plant Sci*. <https://doi.org/10.3389/fpls.2018.00886>
- Maxted N, Kell S (2009) Establishment of a Global Network for the In Situ Conservation of Crop Wild Relatives: Status and Needs. https://www.fao.org/fileadmin/templates/agphome/documents/PGR/SoW2/CropWildRelatives_2011_final.pdf, [Online; Accessed 16 Dec 2024]
- Maxted N, Vincent H (2021) Review of congruence between global crop wild relative hotspots and centres of crop origin/diversity. *Genet Resour Crop Evol*. <https://doi.org/10.1007/s10722-021-01114-7>
- Maxted N, Hawkes JG, Guarino L et al (1997) Towards the selection of taxa for plant genetic conservation. *Genet Resour Crop Evol* 44:337–348. <https://doi.org/10.2135/cropsci2016.10.0885>
- Maxted N, Ford-Lloyd B, Jury S et al (2006) Towards a definition of a crop wild relative. *Biodivers Conserv* 15:2673–2685. <https://doi.org/10.1007/s10531-005-5409-6>
- Maxted N, Kell S, Toledo A et al (2010) A global approach to crop wild relative conservation: securing the gene pool for food and agriculture. *Kew Bull* 65:561–576. <https://doi.org/10.1007/s12225-011-9253-4>
- Maxted N, Brehm JM, Kell S (2013) Resource Book for the Preparation of National Plans for Conservation of Crop Wild Relatives and Landraces. https://www.fao.org/fileadmin/templates/agphome/documents/PGR/PGR-ResourceBook/TEXT_ALL_2511.pdf, [Online; Accessed 16 Dec 2024]
- Médail F, Quézel P (1999) Biodiversity hotspots in the mediterranean basin: setting global conservation priorities. *Conserv Biol* 13(6):1510–1513. <https://doi.org/10.1046/j.1523-1739.1999.98467.x>
- Najem M, Daoudi A, Ibijbjen J et al (2019) Biodiversity of poisonous medicinal plants solicited in the traditional phytotherapy of the central middle atlas -Morocco-. *Ethnobot Res Appl* 18:1–22. <https://doi.org/10.32859/era.18.19.1-22>
- Nassif F, Tanji A (2013) Gathered food plants in Morocco: the long- forgotten species in ethnobotanical research. *Life Sci Leaflets* 3(3):17
- Nouaim R, Echairi A, Kaaya M et al (2007) Contribution to the domestication of the argan tree for oil production purposes. *Cahiers Agri* 16:199–204. <https://doi.org/10.1684/agr.2007.0098>
- ONSSA (2021) (Rapport annuel sur l’agriculture au Maroc) . <https://conseil-concurrence.ma/wp-content/uploads/2023/10/Rapport-Annuel-CC-2021-Fr.pdf>, [Online; Accessed 16 Dec 2024]
- Ouhaddou H, Boubaker H, Msanda F et al (2015) An ethnobotanical study of medicinal plants of the agadir ida ou tanane province (Southwest Morocco). *J Appl Biosci* 84:7707–7722
- Potts S, Vulliamy B, Dafni A et al (2003) Linking bees and flowers: how do floral communities structure pollinator communities? *Ecology* 84:2628–2642. <https://doi.org/10.1890/02-0136>
- POWO (2024) Facilitated by the Royal Botanic Gardens, Kew. <https://powo.science.kew.org/>, [Online; Accessed 16 Dec 2024]
- Raab-Straube Ev, Henning T, Berendsohn W et al (2016) Sisyphe close to the mountain top: Euro+med plant-base is nearing its completion. <https://doi.org/10.13140/RG.2.1.4121.8803>
- Rahman W, Brehm JM, Maxted N (2019) Setting conservation priorities for the wild relatives of food crops in Indonesia. *Genet Resour Crop Evol* 66:809–824. <https://doi.org/10.1007/s10722-019-00761-1>
- Reeves T, Thomas G, Ramsay G (2016) Save and Grow in practice. Maize, rice, wheat: A guide to sustainable cereal production. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy
- Schippmann U, Leaman D, Cunningham A (2006) A comparison of cultivation and wild collection of medicinal and aromatic plants under sustainability aspects. *Med Aromat Plants*. https://doi.org/10.1007/1-4020-5449-1_6
- Simon PW, Rolling WR, Senalik D et al (2021) Wild carrot diversity for new sources of abiotic stress tolerance to strengthen vegetable breeding in Bangladesh and Pakistan. *Crop Sci* 61(1):163–176. <https://doi.org/10.1002/csc2.20333>
- Sobeh M, Rezaq S, Cheurfa M et al (2020) *Thymus algeriensis* and *Thymus fontanesii*: Chemical composition, in vivo anti-inflammatory, pain killing and antipyretic activities: a comprehensive comparison. *Biomolecules*. <https://doi.org/10.3390/biom10040599>
- Ferreira de Souza Dias B, Bhatti S, Tutwiller A et al (2015) Strengthening the in situ conservation of plant genetic resources for food and agriculture through incorporation of crop wild relatives under areas important for biodiversity
- Tahrouch S, Hatimi A, Rapior S et al (2011) Narbon vetch (*vicia narbonensis* L.): a potential feed legume crop for dry areas in West Asia. *Online J Sci Technol* 1(4):17–23
- Taleb MS (2017) Aromatic and medicinal plants in Morocco: diversity and socio-economic role. *Int J Agric Biosyst Eng* 11(12):812
- Thormann I, Kell S, Brehm J, et al (2018) Cwr checklist and inventory data template v.1. <https://doi.org/10.7910/DVN/B8YOQL>
- UNESCO (1999) International co-ordinating council of the programme on man and the biosphere (mab). <https://unesdoc.unesco.org/ark:/48223/pf00000117692>, [Online; Accessed 10 Feb 2024]
- USDA (2023) A multi-year plan to strengthen U.S. Genebank Management of Plant Germplasm. <https://npgsweb.ars-grin.gov/gringlobal/taxon/taxonomysearchcwr>, [Online; Accessed 16 Dec 2024]

- Vincent H, Wiersema J, Kell S et al (2013) A prioritized crop wild relative inventory to help underpin global food security. *Biol Cons* 167:265–275. <https://doi.org/10.1016/j.biocon.2013.08.011>
- Zouari N, Ayadi I, Fakhfakh N, et al (2012) Variation of chemical composition of essential oils in wild populations of *Thymus algeriensis* Boiss. et Reut., a North African endemic species. *Lipids in health and disease* 11:28. <https://doi.org/10.1186/1476-511X-11-28>
- Zrira S (2013) The value chain of aromatic and medicinal plants in the maghreb. *Acta Horticulturae*. <https://doi.org/10.17660/ActaHortic.2013.997.36>

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