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Exploring the Potential of Neglected Local Endemic Plants of Three Mediterranean Regions in the Ornamental Sector: Value Chain Feasibility and Readiness Timescale for Their Sustainable Exploitation

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Abstract: The neglected and underutilized plants (NUPs) have never been mainstreamed by researchers, politicians and stakeholders for sustainable exploitation in the ornamental-horticultural sector. This study focused on 399 local endemic plants of three Mediterranean regions (Crete, Mediterranean coast-Rif of Morocco, Tunisia), with the aim to develop a new scheme for their multifaceted ornamental-horticultural evaluation facilitating their sustainable exploitation. The methodological scheme was developed within three multidisciplinary co-creative workshops by experts and was adjusted by end-users. The developed scheme uses point and weighted scoring of several attributes relevant to biological and ornamental-horticultural characteristics and concerns three ranking levels: (i) ornamental-horticultural potential (general or subsector-specific; 20 attributes), (ii) sustainable exploitation feasibility (12 attributes) and (iii) readiness timescale (after gap and SWOT analyses) in creating value chains in short-, medium- or long-term. The analysis of the data illustrated two example-cases of already achieved sustainable exploitation with established value chains; outlined the prospects for sustainable exploitation of 18 and 23 local endemic NUPs in short-term and medium-term, respectively; and identified 86 taxa with reachable possibilities in the long-term. The proposed multifaceted evaluation scheme can be applied for the valorisation of NUPs in other areas and may help to define priorities and to identify opportunities and gaps for their sustainable exploitation.

Keywords: biodiversity; phytogenetic resources; plant propagation-cultivation; methodological scheme; Crete–Greece; Morocco; Tunisia

1. Introduction

The Mediterranean Basin is generally considered as an important cultural and biodiversity hotspot famous for ancient civilizations, monuments, traditions, food diversity, wild edible greens, commercially appreciated ornamental species and valuable aromatic-medicinal plants [1–3]. Many regions within the Mediterranean Basin such as archipelagos, islands, peninsulas and mountain ranges or combinations thereof are outlined as major hotspots of biodiversity and include numerous range-restricted endemic species [4]. Notwithstanding the overall appreciation, most of the huge Mediterranean plant diversity includes neglected and underutilised species [5], and only a small fraction of these resources is currently used in the agricultural sector and the ornamental-horticultural industry due to weak documentation of their potential and lack of coordinated actions [4,6]. Despite the fact that neglected and underutilised plants (NUPs) may prove to be a promising alternative for the future in various sectors or source of added value products [7], their incorporation into agricultural systems is still very limited. Among them, the single-country or single-region endemic species may offer unique opportunities for local economies, especially when associated with exclusive business branding and sovereign rights regulating the Access and Benefit Sharing policies in the frame of the provisions of the Nagoya Protocol and the European Directive 511/2014. Such unique resources, being often wild-growing in marginal areas, are naturally selected to withstand stress conditions and therefore may contribute to low-input sustainable production systems [7].

The ornamental-horticultural nursery and landscape industry introduces yearly to the USA alone over 50,000 of ornamental species and many more globally, most of which are exotic to the regions where they are introduced [8,9]. Global exports of this economic sector have increased over the last decade by more than 10% annually [10]. Worldwide the multi-billion-dollar ornamental-horticultural industry is continuously in search of new crops (often of exotic origin) with exciting characteristics (e.g., uniqueness), adaptability to diverse conditions and low maintenance costs [2,11,12]. The maintenance of the ornamental-horticultural market dynamics vastly depends on new crops, innovation and varietal renewal [13,14]. Even in widely appreciated ornamentals around the world such as the South American *Anthurium* spp. [9,15], there are many species with attractive features that are not currently under cultivation, being neglected and unexploited due to lack of coordinated research and development of production systems [16]. Domestication of wild-growing plants with interesting properties and plant rarity/endemism are important factors that are extremely appreciated by the ornamental-horticultural sector sourcing for unique new crops [6,17]. Previous studies on the commercial value of the Greek native endemic plants (single-country endemics) over the internet have illustrated a robust international market related with 145 traded taxa (species and subspecies) purchased by 76 nurseries in seven countries [3].

Previous projects and research activities related with sustainable plant utilisation in the Mediterranean region such as the MEDUSA [1] or RUBIA projects [18] have focused almost exclusively to common plant species of the Mediterranean Region and have examined them basically from an ethnobotanical viewpoint. The same applies for relevant studies at local scales, e.g., [6,19–21]. Such attempts have never focused on single-country endemic plants and their ornamental-horticultural value. Unfortunately, NUPs and especially local endemic NUPs are rarely addressed by valorisation initiatives and usually only scarce, fragmented and scattered information exist on their domestication potential [5,7]. Previous studies on the ex situ conservation of local endemic plants (indicating also their pilot domestication in man-made environments) showed that less than half of the Greek endemics are to be found in botanic gardens and/or seed banks [22], while no Tunisian endemic and only few Moroccan endemic (Mediterranean coast-Rif) plants are to be found under ex situ conservation worldwide [21].

Studies related to the ornamental-horticultural value of new crops are generally related with plant habit and features (e.g., morphological and phenological characteristics, growth-development etc.), ecological preferences (tolerance to various factors), aesthetic

interferences (e.g., remarkable quality aspects, beauty, attractiveness, florists' acceptance) and cultivation regimes including agro-processing (e.g., variability, durability, post-harvest longevity, spacing, plant management), and fertilization regimes [23]. Landscape applications and gardening may often focus on some categories of attributes, while other subsectors of the ornamental-horticultural industry may focus on others [23–25]. Depending on studying profile and research focus, the selected attributes are often assessed or scored in various ways (point or weight scoring with different scaling, using metrics, estimations, quantitative and/or qualitative data), and frequently, the attributes are used as necessary conditions or criteria that should be met or fulfilled, respectively. To date, the research on how to evaluate comprehensively new crops from ornamental-horticultural viewpoint remains limited and strongly compromised [25], reflecting the perceptions of individual studies. Consequently, this situation undermines the ornamental-horticultural evaluation of NUPs, including local endemic species.

The availability and critical appraisal of existing knowledge on NUPs including single-country or single-region floristic elements have the potential to contribute towards mitigating important barriers for the sustainable exploitation of unique resources at local scales and beyond [26]. In this framework, our study (outcome of the research programme Multi-Val-End, ARIMNet2) brings research focus on NUPs, and especially unique floristic elements (single-country or single-region endemic plants) of three Mediterranean regions (Crete, Greece; Mediterranean coast-Rif of Morocco; Tunisia). Mainstreaming the sustainable use of these unique NUPs for the ornamental-horticultural industry primarily means to document and evaluate interesting features and properties; to be able to propagate and know how to cultivate them; to improve their production systems; and to establish effective linkages allowing value chains' creation. In this context, the aim of our research was to review all available data and experience regarding the focal endemic NUPs, to document and explore their potential in the ornamental-horticultural sector and to develop a new methodological scheme for their multifaceted evaluation. Furthermore, our investigation assessed the feasibility of creating value chains for these unique NUPs and estimated the readiness timescale in which such endeavours can be achieved. The following questions were explored in this study:

(1) What is the potential of local endemic NUPs of Crete, Mediterranean coast-Rif of Morocco and Tunisia in the ornamental-horticultural sector, and how this potential can be documented?
(2) What are the main challenges associated with the sustainable exploitation of the focal NUPs, and for which of them there is enough experience to achieve it?
(3) What are the prospects of these unique plants in the ornamental-horticultural sector in terms of value chain creation? What opportunities or main barriers exist?
(4) Which local endemic NUPs can be exploited sustainably at local scales in short-term, medium-term and long-term?

2. Materials and Methods

2.1. Single Country Endemic Plants of the Targeted Regions

The 223 single-island local endemic plant taxa (species and subspecies) of Crete were retrieved from Menteli et al. [27]. The 94 single-region endemic taxa of Rif and the Mediterranean coast of Morocco as well as the 82 single-country endemic taxa of Tunisia were retrieved from Libiad et al. [21]. This resulted to a floristic catalogue including 399 taxa.

The evaluation procedure of the focal taxa was conducted gradually at three different levels (Figure 1).

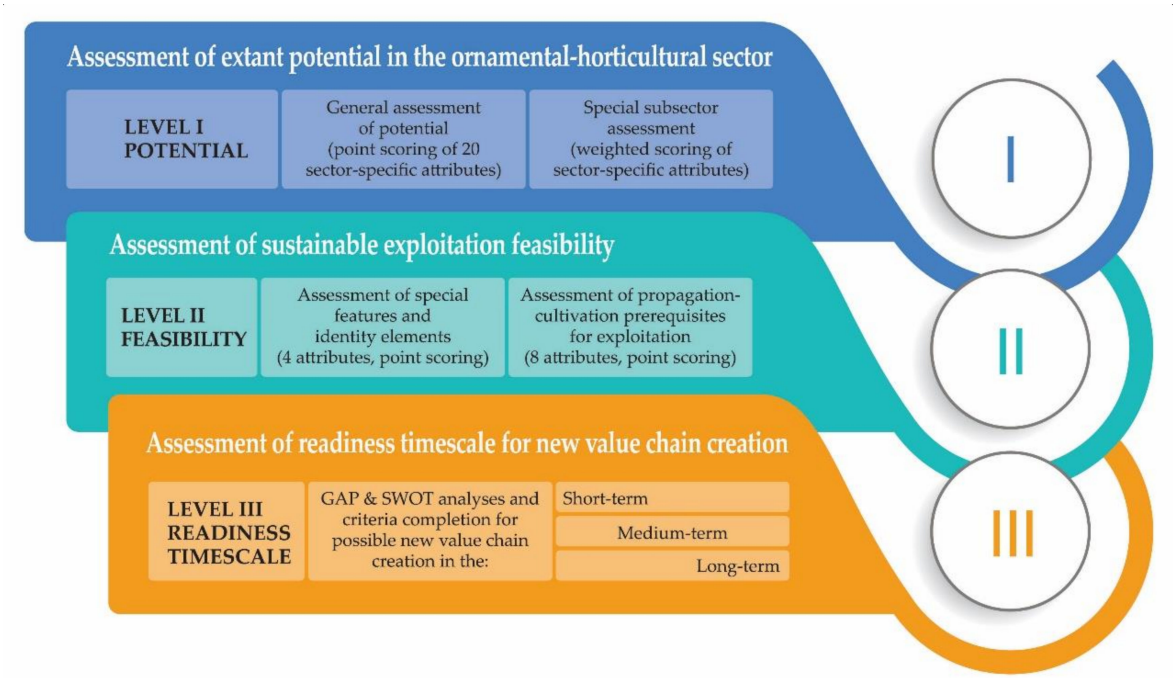


Figure 1. Simplified overview of the multifaceted scheme used for the evaluation of the local endemic plants of Crete (Greece), Mediterranean coast-Rif of Morocco and Tunisia in the ornamental-horticultural sector. For attribute types, individual attributes and scores applied in Levels I and II, see Table 1. For Level III evaluation, see conditions that should be met in Table 2, after SWOT and GAP analyses (Figure 2; Figure 3, respectively).

2.2. Development of Methodological Scheme

In the frame of the MULTI-VAL-END project (ARIMNet2), a new methodology was developed for the evaluation of NUPs in the ornamental-horticultural sector which was applied to the focal taxa of the present study, viz. single-country endemic taxa of Crete (Greece), Mediterranean coast-Rif of Morocco and Tunisia. The methodological scheme was established during three workshops (in total, 14 days) in Thessaloniki (Greece), Taza (Morocco) and Tunisia (webinar due to COVID-19). In these workshops, 13 research scientists with complementary expertise (plant taxonomy, conservation biology, biodiversity, phytogenetic resources, ethnobotany, insect biology and conservation, horticulture, floriculture, agronomy, biotechnology, plant propagation, natural resources evaluation, phytochemistry, plant ecology, phytosociology, landscape architecture) from three countries (authors of this study and associates) worked through a participatory process adopting co-creation principles [28]. This process involved short oral presentations, case-studies, brainstorming, problem-solving, directed dialogue, thematic debates and voting. These methodological tools were used accordingly, until the co-creators reached consensus regarding the following issues:

i. Selection of individual attributes: After preliminary surveys, every researcher proposed potential attributes for the evaluation of the taxa in the ornamental-horticultural sector. After detailed presentation and analysis of each attribute during the workshops, the co-creation procedure facilitated in-depth examination of the potential advantages and disadvantages related to scoring of each attribute. Finally, the experts voted separately for each attribute to be adopted (co-decision). This procedure defined the final set of attributes (n = 32, Table 1) to be used for the evaluation of the targeted single-country endemic taxa (n = 399).
ii. Definition of attributes types: Among the 32 selected attributes (Table 1), 20 were assessed by the experts as sector-specific, reflecting explicit interest concerning the potential of the target taxa in the ornamental/horticultural sector. In total, 12 attributes (Table 1) were employed as prerequisites of common interest across various economic

sectors (e.g., agro-alimentary, medicinal, cosmetics etc.) facilitating the sustainable exploitation of the target-taxa. These were either related to taxon's special features, i.e., rarity, protection status and endemism, or related to the taxon's achieved or foreseen propagation and cultivation success.

iii. Selection of data sources: One to four types of data sources per attribute were prioritised for the evaluation, i.e., literature survey, best expert judgment, survey over internet sources, and examination of available photographic material (Table I in S1). In three cases of attributes (height, compactness of form, blooming period) all four types of sources were used for the evaluation of taxa, while in eight cases of attributes three of them were consulted to score each taxon. In total, 15 attributes were based on a single data source, while in six cases of attributes, two of the data sources were used. Two different data sources were on average used per attribute; the most common data source used was literature survey; the commonest combination of data sources was best expert judgment and survey on the Internet. The team of experts in each country reviewed and prepared in advance all the selected data sources per attribute. This facilitated at later stages the end-users during the evaluation of the local endemic taxa of the targeted regions (see vi below).

iv. Scaling of the selected attributes: Through co-creation to reach consensus, the scaling for each attribute was defined (two-fold to seven-fold), and the relevant scoring was based on the basic possible clusters of information that could be outlined per attribute. The selection of scaling for each attribute considered the quality and quantity of extant information for every taxon and the concomitant possible characterisations that could be designated for each score value. Therefore, three of the attributes were binary with only two possible scores (yes/no); four attributes allowed a three-grade scale (3 possible scores); eight attributes were four-grade scale; eight attributes allowed five (5) possible scores; and nine attributes were seven-grade scale (Table 1).

v. Directionality of attribute scaling and scoring values: The directionality of the scaling in each attribute and the relevant score values were designated through co-creation procedures favouring the most desired, strong or interesting characteristics, metrics and/or estimations per attribute. Individual scores and distance between different scores were established to represent the relative escalation of interest regarding the specific plant characteristics according to best expert judgment. In this way, lower attribute score was always assigned to cases of taxa with absence of data, weak or undesired characteristics, metrics and/or estimations. On the other hand, comparatively higher score was assigned to cases of taxa with desired characteristics, metrics and/or estimations or extant data and strong interest (Table 1; see also examples on scoring of taxa in S1).

vi. Validation by end-users and data consistency: The pilot application and validation of the above-described methodology for the evaluation of the local endemic taxa was performed in each country by three end-users with academic education (Bachelor and Master of Science) who were assisted upon request by the project's experts. These end-users were recruited from the local academic environments in each country in order to apply the developed methodology; they consulted the relevant information per attribute provided to them by the coordinators; they followed the guidelines given to them, and they scored independently the target-taxa of the three regions. The scoring procedure was completed in repetitive detached sessions, considering only one or few related attributes at a time. In this way, all attributes were progressively scored regarding the focal taxa of all three target regions. Upon scoring completion per country, the datasets created were checked in terms of consistency and misspellings or errors were revised by the project's experts.

vii. Suitability formulas related to special potential in ornamental-horticultural subsectors: In order to estimate the special suitability of each target taxon as pot/patio plant or for home gardening, landscaping and xeroscaping applications, every sector-specific attribute (L1, Table 1) was examined regarding its special relevance to these subsectors

of the ornamental-horticultural industry. In total, four attributes were excluded as of general interest (non-specific to subsectors), i.e., existing prices in e-trade, possibility for breeding, attraction for botanical holidays, collections in the wild. For the rest of the attributes, a relative weight was assigned to each one according to best experts' judgment, thus indicating either stronger (0.75 or 0.60) or weaker (0.25 or 0.40) special subsector interest. Therefore, the following distinct formulas were calculated for all the target-taxa, accordingly, including different number of attributes (see below, in parenthesis):

(a) Suitability as pot/patio plant (9 attributes) = 0.75 * ($A + B + C + D$) + 0.25 * ($E + F + G + H + I$), where A is the score for impressive flowers; B, the score for blooming period; C, the score for plant symmetry; D, the score for leaf colour; E, the score for attractiveness of leaf shape; F, the score for height; G, the score for compactness of form; H, the score for seasonal phenotypic changes; I, the score for existing prices in the electronic trade.

(b) Suitability for home gardening (13 attributes) = 0.60 * ($A + B + C + D + F + G + H + I$) + 0.40 * ($J + K + L + M$), where A is the score for blooming period; B, the score for compactness of form; C, the score for plant symmetry; D, the score for seasonal phenotypic changes; E, the score for attractiveness of leaf shape; F, is the score of shade preference^{-1}; G, the score for frost hardiness; H, is the score for altitudinal range; I, the score for environmental tolerance; J, the score for impressive flowers; K, the score for leaf colour; L, the score for height; M, is the score for existing prices in the electronic trade.

(c) Suitability for landscaping (13 attributes) = 0.75 * ($A + B + C + D + E + F + G + H$) + 0.25 * ($I + J + K + L$), where A is the score for blooming period; B, the score for compactness of form; C, the score for plant symmetry; D, the score for height; E, the score for seasonal phenotypic changes; F, the score for frost hardiness; G, the score for altitudinal range; G, the score for environmental tolerance; H, the score for water demand; I, the score for impressive flowers; J, the score for attractiveness of leaf shape; K, the score for leaf colour; L, the score for existing prices in the electronic trade.

(d) Suitability for xeroscaping (12 attributes) = 0.75 * ($A + B + C + D + F$) + 0.25 * ($G + H + I + J + K + L$), where A is the score for water demand; B, the score for frost hardiness; C, the score for altitudinal range; D, the score for environmental tolerance; E, the score for compactness of form; F, the score of height^{-1}; G, the score for impressive flowers; H, the score for blooming period; I, the score for seasonal phenotypic changes; J, the score for attractiveness of leaf shape; K, the score for leaf colour; L, the score for existing prices in the electronic trade.

Note on formulas: High shrubs and trees can be calculated in formula a (collapse of plants may occur due to indoor or patio humidity and temperatures). For the rest of the formulas, collapse of plants may occur due to outdoor conditions. In formula b, toxic/poisonous plants were not calculated. In formula c, trees, high shrubs and toxic/poisonous plants were also calculated with this formula. In formula d, toxic/poisonous plants were calculated, while trees or high shrubs were not calculated.

Table 1. Ornamental-horticultural potential (Level I evaluation, L-I) of the local endemic plants of Crete (Greece), Rif-Mediterranean coast of Morocco and Tunisia based on 20 sector-specific attributes as well as feasibility evaluation (Level II, L-II) for the sustainable exploitation of the taxa (species and subspecies) based on 12 attributes considered as prerequisite for any such attempt. Description and guidelines are provided for every attribute along with the scaling and directionality for each one. The respective scores that can be applied in each case (2 to 7 possible scores) are also indicated, accordingly. For data sources used, explanations and scoring examples per attribute see S1.

Level and Attribute Name	Short Description	SCORE 0	SCORE 1	SCORE 2	SCORE 3	SCORE 4	SCORE 5	SCORE 6	Choices
L-I Height	Maximum stem height	1–10 cm	11–20 cm	21–30 cm	31–40 cm	41–50 cm	51–60 cm	>61 cm	0 to 6
L-I Compactness of form	Plant form in respect to cushion–forming habit	Very loose	Loose	–	Moderate	–	Dense	Very dense	0, 1, 3, 5 or 6
L-I Blooming Period	Duration of flowering	No data	1–2 weeks	2–4 weeks	1–2 months	2–4 months	4–6 months	>6 months	0 to 6
L-I Altitudinal range	Altitudinal classes (min to max)	0–100 m	>100–500 m	–	500–1000 m	–	>1000–1500 m	>2000 m	0, 1, 4, 5 or 6
L-I Environmental Tolerance	Different habitat types	No data	–	–	1	2	3	4 or more	0, 2, 3, 4, 5 or 6
L-I Seasonal Phenotypic Changes	Seasonal colouring or variation in flowers and/or leaves	No data/No change	–	Possibly	–	–	–	YES	0, 2 or 6
L-I Existing Prices in e–trade	Trade documentation	No data	–	–	Possible	–	–	YES	0, 3 or 6
L-I Possibility for Breeding	Useful for congeners	NO	–	–	–	–	–	YES	0 or 6
L-I Eligibility as Foliage Plant	Attractive leaves	No data/No opinion	Uncertain/Ambiguous	–	–	Suspected	Possible	YES	0, 1, 4, 5 or 6
L-I Attraction for Botanical Holidays	Trade documentation	NO	–	–	–	–	–	YES	0 or 6
L-I Wild Collections	Pressure on wild populations	No data	Uncertain/Ambiguous	–	–	Suspected	Reported	Documented	0, 1, 3, 5 or 6
L-I Impressive Flowers	Attractive and uncommon flowers and/or inflorescences	Not impressive	–	–	Rather impressive	–	–	Very impressive	0, 3 or 6
L-I Eligibility for Cut Flower	Flowering stem length	<10 cm	11–20 cm	21–30 cm	31–40 cm	41–50 cm	51–60 cm	>60 cm	0, 1, 3, 5 or 6
L-I Shining of Leaf Texture	Glossy effect of leaf texture	Not shiny at all	–	–	Rather shiny	–	–	Very shiny	0, 3 or 6
L-I Attractiveness of Leaf Shape	Attractiveness and uncommonness of perceived leaf shape	Plain and not attractive	Unusual and strange	–	Common & not very attractive	–	–	Distinct & very attractive	0, 1, 3 or 6

Table 1. *Cont.*

Level and Attribute Name	Short Description	SCORE 0	SCORE 1	SCORE 2	SCORE 3	SCORE 4	SCORE 5	SCORE 6	Choices
L-I Plant Symmetry	Perceived plant habit in terms of symmetrical growth (mirror–like symmetry)	Very asymmetrical	–	Asymmetrical	–	Almost symmetrical	–	Very symmetrical	0, 1, 3 or 6
L-I Leaf Colour	Vividness of leaf colour (commercially appreciated)	No leaves (cactus or parasitic)	Not uniform and/or pale green	–	Uniform, flat green	Uniform, glaucous	–	Uniform, dark green or other	0, 1, 3 or 6
L-I Shade Preference	Estimation according to habitats, promoting light preference (basic habitat categories)	No data	High (forest)	–	Intermediate (bushy, shrub)	–	–	Low (open, shiny)	0, 1, 3 or 6
L-I Salt Tolerance Estimation	Proximity of wild habitat to coastal areas	>10 km	>1–10 km	–	Up to 1000 m	–	101–500 m	0–100 m	0, 1, 3, 5 or 6
L-I Shade Preference	Estimated shade tolerance (basic habitat categories, promoting light preference)	No data	High (forest)	–	Intermediate (bushy, shrub)	–	–	Low (open, shiny)	0, 1, 3 or 6
L-I Frost Hardiness	Hardiness estimation based on plants' altitudinal preferences (natural altitudinal range)	No data	Not hardy (0–300 m)	–	Rather hardy (>300–850 m)	–	–	Hardy (>850 m)	0, 1, 3 or 6
L-II Existing Cultivations	Extant documentation	No	–	–	–	–	–	Yes	0 or 6
L-II Threat Category	Extinction risk status based on IUCN criteria	Not evaluated	Data deficient	Declining/Rare	Near Threatened	Vulnerable	Endangered	Critically endangered	0 to 6
L-II Protection Status	Sum of legal instruments in which the taxon is included	Not included	–	–	–	Included in 1	Included in 2	Included in >3	0, 4, 5 or 6
L-II Ex situ Conservation	Taxon's ex situ conservation effectiveness (accessibility and availability of plant material)	No	Low	Very low	Ineffective	Inter–mediate	Almost effective	Very effective	0 to 6
L-II Distribution	Occurrence in number of national phytogeographic regions (range within the country)	7 or more regions	6	5	4	3	2	1	0 to 6

Table 1. *Cont.*

Level and Attribute Name	Short Description	SCORE 0	SCORE 1	SCORE 2	SCORE 3	SCORE 4	SCORE 5	SCORE 6	Choices
L-II Commercial Products	Sum of commercial products marketed (after species-specific internet survey)	No data	1	2	3	4	5	>6	0 to 6
L-II Known Propagation	Species-specific propagation methods and/or techniques	No data	–	–	Under investigation	Possible	Guidelines	Protocols	0, 3, 5 or 6
L-II Vegetative Propagation Success	Classes for vegetative propagation success according to literature or known studies in process	No data	1–15%	16–30%	31–45%	45–60%	61–75%	>75%	0 to 6
L-II Seed Germination Success	Classes for seed germination success according to literature or known studies in process	No data	1–15%	15–30%	31–45%	45–60%	61–75%	>75%	0 to 6
L-II Cultivation Needs	Documentation of taxon's needs in man-made environments	No data	–	–	Under investigation	Experiential	–	Guidelines	0, 3, 5 or 6
L-II Existing Cultivation Protocols	Guidelines, experience, studies in progress or pilot cultivations (<5 years), ex situ cultivation	No data	Failure	Ex situ maintenance	Pilot cultivation	Preliminary	Basic	Full	0 to 6
L-II Water Demand	Basic water needs of wild–growing populations, promoting low demands (basic habitat types)	No Data	High (mesic, humid, forest)	–	Intermediate	–	–	Low (xeric, arid, rocky)	0, 1, 3 or 6

2.3. Multifaceted Evaluation Procedure and Data Elaboration

The multifaceted evaluation of the focal taxa includes the combination of at three different levels (Figure 1), namely:

Level I

At the first level, the general ornamental-horticultural potential of each local endemic taxon was evaluated using a point scoring system with 20 sector-specific attributes (Table 1; see examples of scoring in S1). The sum of scorings for all attributes was calculated, and it was expressed as relative percentage (%) of the maximum possible score that could be generated. i.e., sum of maximum scores for all attributes. Then, lists of hierarchically ranked taxa per country were produced, illustrating the most interesting taxa per country for the ornamental-horticultural industry (see S2). The target taxa were further assessed using a weighted scoring and special formulas according to their special interest for the ornamental-horticultural industry, i.e., their suitability as pot/patio plants or for home gardening, landscaping and xeroscaping. All values were expressed as relative percentages (%) of the maximum possible scores that could be generated in each subsector. Furthermore, respective hierarchical lists were generated, outlining the most interesting taxa per subsector and reflecting their special interest to ornamental-horticultural subsectors (see S2).

Level II

The second level assessed the sustainable exploitation feasibility of the focal taxa in the ornamental-horticultural sector by employing the partial scoring of 12 attributes of common interest across various economic sectors (see examples of scoring in S1). Eight of these attributes represented the pre-conditions that should be met (prerequisites) prior to any sustainable exploitation of the target taxa in any economic sector (also in the ornamental-horticultural sector), i.e., available initial plant material for propagation, species-specific propagation and cultivation techniques. The rest four attributes outlined the special plant features and identity elements that could be exploited in product branding and marketing, thus facilitating trade exclusiveness, i.e., taxon's endemism or uniqueness, rarity, extinction risk and protection statuses. The sum of scorings for all these attributes was calculated and this was expressed as relative percentage (%) of the maximum possible score that could be created, i.e., sum of maximum scores for all attributes. Hereafter, lists of hierarchically ranked taxa per country were produced, outlining the most feasible cases for sustainable exploitation of taxa in the ornamental-horticultural sector and its subsectors (see S2).

Level III

Prior to the evaluation of the taxa at the third level, a general SWOT analysis was performed, focusing on the extant strengths, weaknesses, opportunities and possible threats (or barriers) to achieve sustainable exploitation of the focal taxa (Figure 2). Furthermore, a general gap analysis was performed assessing the current state and the aimed future state with regards to the value chains' creation of the evaluated focal taxa (Figure 3). This procedure was part of the 3rd level of evaluation and resulted to the necessary conditions that should be met for defining the sustainable exploitation of the focal taxa in probable reality (Table 2).

At the third level of evaluation, the above-mentioned prerequisites or necessary conditions were taken into account to designate the readiness timescale for sustainable exploitation of the evaluated focal taxa. This allowed determining if the sustainable exploitation has already been achieved in some cases of taxa, whether this is indeterminable or achievable for others in short-term, medium-term and long-term. The above-mentioned criteria were applied in all cases of the focal taxa, and in each case, a single characterisation was designated (Table S2, see S2).

Figure 2. SWOT analysis concerning the readiness for sustainable exploitation of the local endemic plants of Crete (Greece), Mediterranean coast-Rif of Morocco and Tunisia in the ornamental-horticultural sector, indicating strengths, weaknesses, opportunities, and threats related to the creation of possible value chains.

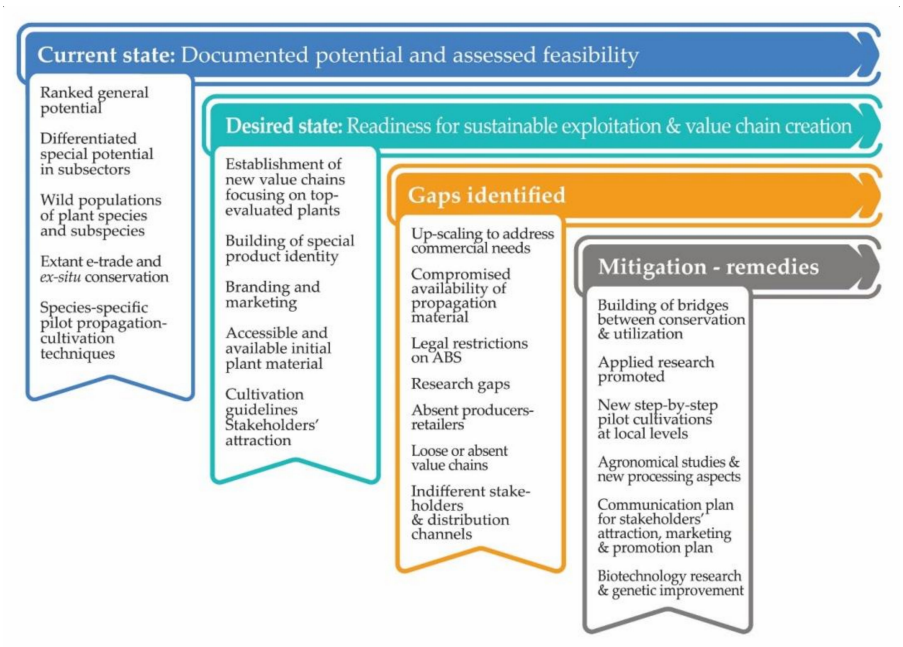


Figure 3. Gap analysis concerning the sustainable exploitation of the local endemic plants of Crete (Greece), Mediterranean coast-Rif of Morocco and Tunisia with regards to value chains' creation in the ornamental-horticultural sector, indicating the current state after the evaluations performed for the taxa (Level I: evaluation of general and special potential; Level II: evaluation of feasibility for sustainable exploitation), the desired state (Readiness timescale; Level III), the respective gaps identified and the mitigation-remedies that should be envisaged.

Table 2. Designated readiness timescale (Level III evaluation) regarding the sustainable exploitation of the local endemic plants of Crete (Greece), Rif-Mediterranean coast of Morocco and Tunisia with prerequisites or necessary conditions that should be met accordingly in cases of already achieved exploitation or achievable exploitation in short-term, medium-term or long-term or indeterminable exploitation. For sustainable exploitation feasibility attributes and calculated scores (Level II), see Table 1 and Methods.

Readiness Timescale	Sustainable Exploitation Feasibility Ranking Class (score)	Up-Scaling to address Commercial Demand	Availability of Propagation Material	Possibility to overcome Legal Restrictions on ABS (in Relation to Interest)	Overview of extant Research (Research Gaps)	Estimated Attraction of New Producers -Retailers	Estimated Difficulty for Value Chain Creation	Estimated Exploitation of Distribution Channels
Already Achieved	Highest (>70%)	Upon request	Available	No restriction (strong)	Advanced (no)	Extant	Extant	Extant
Achievable in Short-Term	Above-average to high (>55–70%)	Easy	Potentially easy	Feasible (increased)	Adequate (hardly any)	Easy	Need for enhancement	Easy
Achievable in Medium-Term	Average (>50–55%)	Possible	Probable	Rather feasible (extant)	Not sufficient (few)	Possible	Reachable	Possible
Achievable in Long-Term	Lower to average (>35–50%)	Currently limited	Currently limited	Rather difficult (low)	Limited (several)	Difficult	Difficult to create	Limited
Indeterminable	Very low to lowest (<35%)	Uncertain	Very limited	Very difficult (very limited)	Very limited (many)	Very difficult	Very difficult to create	Very limited

2.4. Statistical-Numerical Analysis

To explore correlations between plant attributes, we performed correlation analysis for each study region at $p < 0.001$ for all possible pairs of Level I as well as Level II attributes.

To further explore how the different Level I attributes and focal taxa are grouped in each study region, we performed complete linkage hierarchical cluster analyses with 1- Pearson r distance measure. Specifically: (i) for focal taxa based on the scoring for each of the attributes (223 taxa of Crete; 94 taxa of the Mediterranean coast-Rif of Morocco; 82 taxa of Tunisia) and (ii) for 19 out of 20 attributes for Crete and the Mediterranean coast-Rif of Morocco and for 18 out of 20 attributes for Tunisia (attributes excluded from the analysis were those with either no data or those with the same score for all species).

3. Results

3.1. Correlations of Level I and Level II Attributes from Ornamental-Horticultural Viewpoint

Correlation analysis among the Level I attributes for Cretan endemics (Table A1 in S3) showed that the most important significant ones were the positive correlation among plant height and eligibility for cut flower (0.93) and the negative one among frost hardiness and salt tolerance (−0.68). As regards the Level II attributes (the attribute distribution in national phytogeographical regions was excluded due to maximum scores for all taxa) correlation analysis showed (Table A2 in S3) that the most significant correlations were positive ones between identified commercial products on market and existing cultivations (0.91) and between altitudinal range and frost hardiness (0.62).

In the case of Moroccan (Mediterranean coast-Rif) endemics, correlation analysis among the Level I attributes showed (Table B1 in S3) that the most important correlations were the positive ones between frost hardiness and altitudinal range (0.97) as well as between collections in the wild and attraction of botanical holidays (0.78), while the most prominent negative correlation was between altitudinal range and estimation of salt tolerance (−0.67). As regards the Level II attributes (the attributes vegetative propagation success, protection status and existing cultivations were excluded due to absence of scoring in all cases) correlation analysis showed (Table B1 in S3) that the most important significant correlations were the positive ones between seed germination and existing cultivations (0.95) as well as number of identified commercial products on market and ex situ cultivation (0.70).

In the case of Tunisian endemics, correlation analysis among the Level I attributes (the attributes seasonal phenotypic changes and existing prices in electronic trade over the internet were excluded due to absence of scoring for all taxa) showed that the most important correlations (Table C1 in S3) were the positive correlation between frost hardiness and altitudinal range (0.73).

As regards the Level II attributes (the attributes existing cultivations, protection status, ex situ conservation in institutions, commercial products on market and vegetative propagation success were excluded due absence of scoring for all taxa) the most prominent significant correlation found was the negative one (−0.69) between national phytogeographical zones (Level II attribute) and environmental tolerance (Level I attribute).

3.2. Cluster Analyses of Level I Attributes and of Focal Taxa

The results of the hierarchical cluster analyses of Level I attributes (Figure 4) discerned the following:

(i) In the case of the Cretan endemic plants (Figure 4a), three clearly differentiated clusters of attributes were differentiated: Cluster A with most of the attributes related to plant habit (frost hardiness, altitudinal range, blooming period, environmental tolerance, compactness of form, plant symmetry) and two groups with attributes related to perceived value from human viewpoint, i.e., cluster B (collections in the wild, electronic trade over the internet and promotion for botanical holidays, eligibility as foliage plant, impressive flowers, seasonal phenotypic changes, attractiveness of

leaf shape, shining of leaf texture) and cluster C (shade tolerance, estimation of salt tolerance, leaf colour, height, eligibility for cut flower, possibility for breeding).

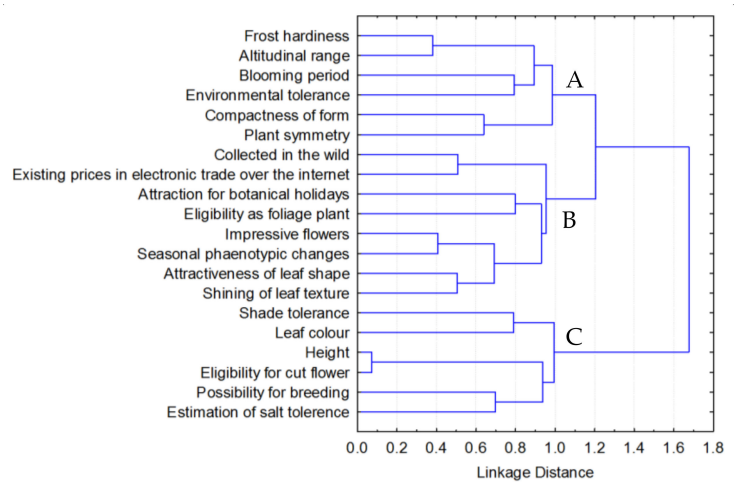
(ii) In the case of Moroccan (Mediterranean coast-Rif) endemic plants (Figure 4b), three basic clusters were differentiated: Cluster A with some plant habit-related attributes (plant symmetry, environmental tolerance, blooming period) grouped together with some others related to perceived value from human viewpoint (height, eligibility for cut flower, estimation of salt tolerance, impressive flowers, shining of leaf texture), cluster B with the rest of the plant habit-related attributes (compactness of form, altitudinal range, frost hardiness) and cluster C with five attributes which are related to perceived value from human viewpoint (n = 5).

(iii) In the case of Tunisian endemic plants, four basic clusters were discerned (Figure 4c), with cluster A including four attributes related to perceived value from human viewpoint (height, possibility for breeding, estimation of salt tolerance and shade tolerance) and clusters B, C and D with attributes of both types.

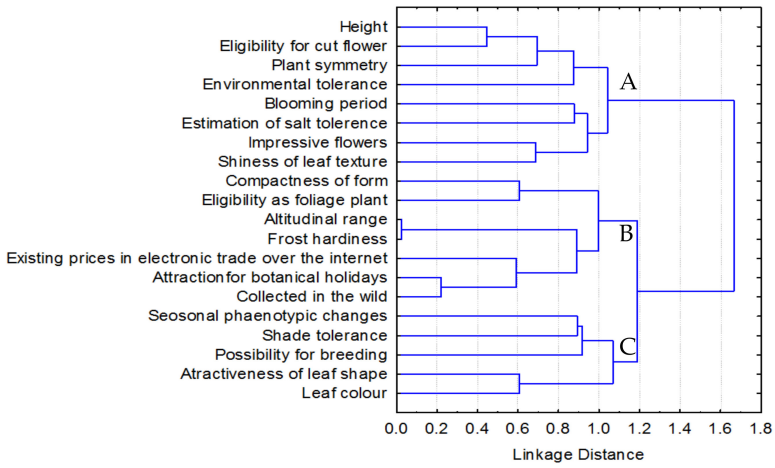
From ornamental-horticultural viewpoint, the 223 distinct and unique biological entities (local endemic taxa) of Crete are clustered into two basic clusters (S4; the attribute distribution in national phytogeographical zones was excluded due to maximum scores for all taxa), i.e., cluster A (groups 1–6) which is discerned from B (groups 7, 8). Cluster A (163 taxa) included among others the local endemic grasses and some bulbous plants of the genera *Gagea* and *Geocarym*, while all other local endemic bulbous plants (e.g., members in genera *Allium, Crocus, Bellevalia, Muscari, Ornithogalum, Prospero, Scilla*) were clustered with other taxa into cluster B (in total, 60 taxa). Within the subclusters A1, A2 and A3, individual groups are discerned (groups 1–6). At least 20 genera with more than one Cretan endemics are restricted into one of these groups (e.g., *Limonium* spp. in group 7) whereas another 24 genera with their endemic taxa are clustered into different groups (e.g., *Campanula* spp., *Centaurea* spp.)

In the case of the 94 distinct and unique biological entities (local endemic taxa) of Morocco (Mediterranean coast-Rif), the analysis showed (S4) two basic clusters (A and B). Cluster A is divided into two subclusters, one incorporating the only tree species (*Abies marocana*) and bulbous plants of genera *Acis* and *Narcissus* (in total 3 taxa) while the other included 21 taxa of various families. Within cluster B, two subclusters are discerned, one with 14 taxa of various families and another with three different groups (3, 4, 5:56 taxa in total). Most of the genera (11) with more than one Moroccan endemics of Mediterranean coast-Rif are restricted into one of these groups (e.g., *Centaurea* spp., *Marrubium* spp., *Sideritis* spp., *Sonchus* spp. etc.) whereas another seven genera with their endemic taxa are clustered into different groups (e.g., *Silene* spp., *Saxifraga* spp., *Teucrium* spp.).

In the case of the 82 distinct and unique biological entities (local endemic taxa) of Tunisia, the analysis (S4; the attributes seasonal phenotypic changes and existing prices in electronic trade over the internet were excluded due to absence of scoring for all taxa) showed two basic clusters (A and B). Cluster A is divided into two subclusters, one (A1) incorporating two groups (group 1 and group 2 including most of the numerous *Limonium* spp.), while within the A2 subcluster four different groups of taxa of various families are discerned (groups 3–6). In cluster B, two subclusters are discerned (groups 7 and 8). Many different genera of grasses are grouped together (group 8) but members of bulbous plants are distributed in five groups, i.e., *Bellevalia dolichophylla* in group 2; *B. galitensis* in group 4; *Hyacyntoides kroumiriensis* in group 6, *Ophrys* spp. and *Oncostema maireana* in group 7 and *Serapias* X *debelainii* in group 8. The latter applies also for members of the genus *Limonium* which are dispersed in four different groups (2, 3, 5, 6). Most of the genera with more than one Tunisian endemic taxon are clustered into different groups (e.g., *Bellevalia* spp., *Limonium* spp., *Linaria* spp., *Sixalix* spp., *Teucrium* spp.), while members of four genera with more than one endemic taxon are restricted into one of these groups (e.g., *Dianthus* spp., *Galium* spp., *Helianthemum* spp., *Ophrys* spp.).



(**a**)



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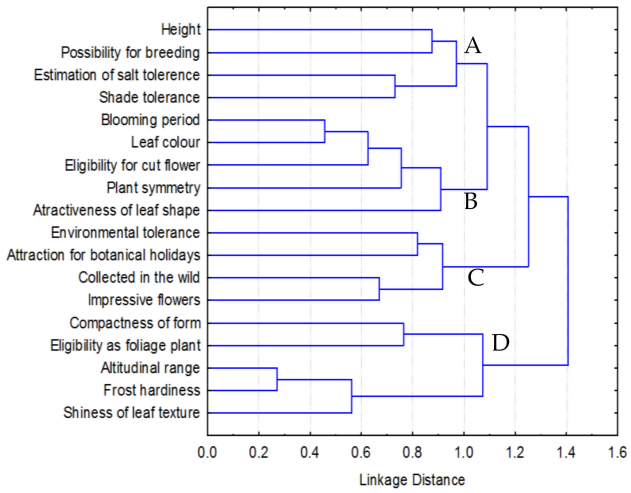


(**c**)

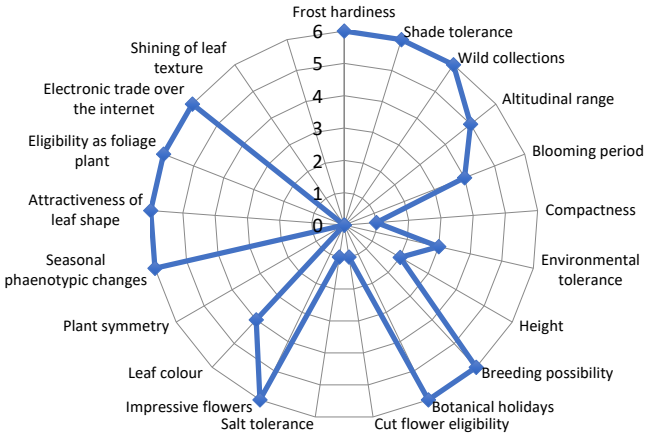
Figure 4. Graph of hierarchical clustering of Level I attributes (complete linkage, 1-Pearson r distance) based on the score values of the local endemic plants of (**a**) Crete, (**b**) Mediterranean coast-Rif of Morocco and (**c**) Tunisia.

3.3. Focal Plants' General and Special Ornamental-Horticultural Interest

The evaluation of the general potential and special potential of the focal endemic taxa in the ornamental-horticultural sector and its subsectors (Level I) is shown in S2 as percentages of the maximum possible scores, accordingly.

3.3.1. Local endemic plants of Crete

Among the Cretan endemics, the highest-evaluated taxon was *Arum idaeum* (70.83%) showing a very interesting general potential. The scoring of *Origanum dictamnus* (67.5%) is illustrated in Figure 5. In total, 8 taxa (hierarchically, *O. dictamnus*, *Tulipa cretica*, *Ebenus cretica*, *Muscari spreitzenhoferi*, *Fritillaria messanensis* subsp. *sphaciotica*, *Acantholimon androsaceum*, *Tulipa bakeri* and *Lomelosia minoana* subsp. *asterusica*) ranked in above-average to high positions with scores >56.7–67.5%. Overall, 14 taxa ranked average with scores 50.8–53.3%, and 83 taxa ranked in lower to average positions with scores 35.8–50%. For 117 taxa, the scores ranked comparatively very low (<35%), and the lowest one was assigned to *Micromeria sphaciotica* (18.33%).



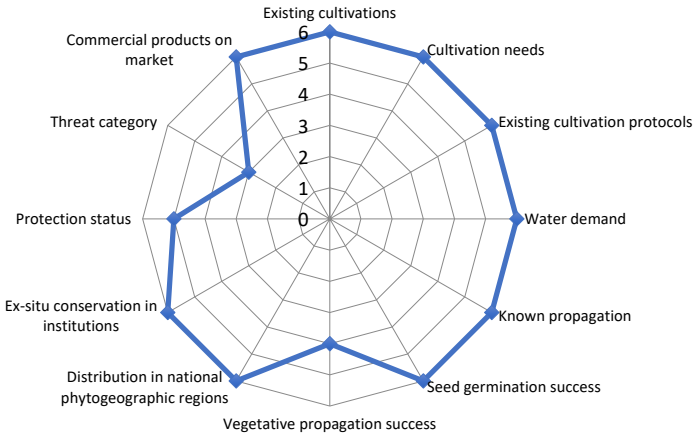


Figure 5. Evaluation example of *Origanum dictamnus* (Cretan endemic) scored for 20 attributes (above; Level I: evaluation of potential) and 12 attributes (below; Level II: evaluation of sustainable exploitation feasibility), reaching 67.5% and 91.67% of the optimum possible scores, accordingly. This example is hierarchically ranked in the above-average to high class of Level I and the highest class of Level II. The latter ranking illustrates the case of already achieved sustainable exploitation (see Readiness timescale, Level III). For attributes and scoring, see Table 1.

The highest suitability for pot/patio plant was assessed for *Arum idaeum* (80.2%), *A. androsaceum* (79.2%), *Tulipa cretica* and *Biarum tenuifolium* subsp. *idomenaeum* (both 72.9%). In total, 19 taxa ranked in above-average to high positions with scores 55.2 to 67.7%. There were another 12 taxa with average scores (51–54.2%), while 52 taxa ranked with lower to average scores >35–50%. A total of 136 taxa were scored very low (<35%), and the lowest one was recorded for the parasitic plant *Cuscuta atrans* (10.4%). The highest suitability for home gardening was found in *Acantholimon androsaceum* (79.2%), *Arum idaeum* (77.1%) and *Tulipa cretica* (73.0%). In total, 21 taxa ranked in above-average to high positions with scores 55.3–68.8% (hierarchically: *Draba cretica, Muscari spreitzenhoferi, Origanum dictamnus, Biarum tenuifolium* subsp. *idomenaeum*, *Cyclamen graecum* subsp. *candicum*, *Lomelosia albocincta*, *L. minoana* subsp. *asterusica*, *L. minoana* subsp. *minoana*, *Anchusa cespitosa*, *Serapias cordigera* subsp. *cretica*, *Tulipa bakeri*, *Ebenus cretica*, *Cephalanthera cucullata*, *Cyclamen confusum*, *Silene variegata*, *Euphorbia rechingeri*, *Centranthus sieberi*, *Fritillaria messanensis* subsp. *sphaciotica*, *Inula candida* subsp. *decalvans*, *Epipactis cretica*, *Tulipa doerfleri*). In addition, 14 taxa with average scores 50.1–54.8% and another 108 taxa with lower to average scores 35.1–49.9%. The scores for 77 taxa were very low, with the lowest score assigned to *Hypericum aciferum* (16.4%).

The highest suitability for landscaping was found in *Acantholimon androsaceum* (72.6%), *Tulipa cretica*, *Muscari spreitzenhoferi* and *Lomelosia albocincta* (each 71.0%). In total, 23 taxa ranked above-average to high with scores 56.5–69.9%. There were another 36 taxa with average scores 50.5–56.5%. In total, 116 taxa ranked in lower to average positions with scores 35.5–50%. For another 44 taxa, the scores were very low (<35%), and the lowest one was assigned to *Ranunculus veronicae* (24.2%).

The highest suitability for xeroscaping was found in *Draba cretica* (85.4%), and another 13 taxa ranked close in the top positions with scores 70.8–81.4%. In total, 86 taxa ranked in above-average to high positions with scores 55.1–69.2%, with more prominent among them (>65–70%) hierarchically: *Acantholimon androsaceum*, *Tulipa cretica*, *Muscari spreitzenhoferi*, *Anchusa cespitosa*, *Origanum dictamnus*, *Arum idaeum*, *Lomelosia albocincta*, *Astragalus creticus* subsp. *creticus*, *Centranthus sieberi*, *Lomelosia minoana* subsp. *asterusica*, *Crocus oreocreticus*, *Lomelosia minoana* subsp. *minoana* and *Euphorbia rechingeri*. There were another 34 taxa ranked in average positions with scores 50.2–54.9% and 69 taxa ranked in lower to average positions (35.6–49.6%). Additionally, 20 taxa were scored very low, with the lowest ones in two subspecies of *Dianthus fruticosus* (subsp. *creticus* and subsp. *sitiacus*: 28.1%).

3.3.2. Local Endemic Plants of the Mediterranean Coast-Rif of Morocco

The highest-evaluated taxon was *Abies marocana* (72.5%) showing a very interesting general potential. In total, 3 taxa (*Salvia interrupta* subsp. *paui, Acis tingitana, Rhodanthemum hosmariense*) ranked in above-average to high positions with scores > 55–70%. Overall, 44 taxa ranked in lower to average positions with scores 35.8–50%. For 46 taxa, the scores ranked comparatively very low (<35%), and the lowest were assigned to *Mantisalca amberboides* and *Marrubium fontianum* (16.67%).

The highest suitability for pot/patio plant was assessed for *Salvia interrupta* subsp. *paui* (73.96%), *Rhodanthemum hosmariense* (72.9%) and *Abies marocana* (71.9%). In total, 15 taxa ranked in above-average to high positions with scores 55.2 to 68.8% (hierarchically: *Xiphion rutherfordii, Santolina adscensionis, Acis tingitana, Centaurium barrelieroides, C. erythraea* subsp. *bifrons, Cytisus grandiflorus* subsp. *haplophyllus, Ferula bolivari, F. fontqueri, Stachys fontqueri, Malva vidalii, Narcissus albimarginatus, Fumana fontqueri, Fumaria macrosepala* subsp. *megasepala, Genista osmariensis, Teucrium gypsophilum*). There were another 12 taxa with average scores (51–54.2%), while 47 taxa ranked with lower to average scores >35–50%. In addition, 17 taxa were scored were very low (<35%), and *Marrubium fontianum* ranked at the lowest position (10.4%).

None of the Moroccan taxa entered to the highest class of scores for home gardening (>70%). In total, 8 taxa ranked in above-average to high positions with scores between 56.1–68.8% (hierarchically: *Abies marocana, Salvia interrupta* subsp. *paui, Rhodanthemum*

hosmariense, Stachys fontqueri, Acis tingitana, Genista osmariensis, Narcissus albimarginatus, Scrophularia fontqueri). There were 14 taxa with average scores 50.1–53.5% and another 52 taxa with lower to average scores (35.1–49.9%). The scores for 20 taxa were very low, with the lowest score assigned to *Mantisaca amberboides* (23.38%).

Salvia interrupta subsp. *paui* was identified as best for landscaping (70.97%). In total, 12 taxa ranked to above-average to high positions with scores 55.4–69.9% (hierarchically: *Rhodanthemum hosmariense, Abies marocana, Genista osmariensis, Anthyllis vulneraria* subsp. *fatmae, Malva vidalii, Stachys fontqueri, Scrophularia fontqueri, Santolina adscensionis, Teucrium gypsophilum, Ferula bolivari, Bromus erectus* subsp. *microchaetus, Sideritis arborescens* subsp. *maireana*). There were another 12 taxa in average positions with scores 51.6–54.8%. In total, 51 taxa ranked in lower to average positions with scores 35.5–50%. Additionally, 18 taxa were scored very low (<35%), with the lowest positions assigned to *Lathyrus coerulescens* and *Mantisalca amberboides* (17.7%).

The highest suitability for xeroscaping was found in *Rhodanthemum hosmariense* (77.1%) and *Salvia. interrupta* subsp. *paui* (74.7). In total, 28 taxa ranked in above-average to high positions with scores 55.1–65.6% (15 taxa > 60%: *Anthyllis vulneraria* subsp. *fatmae, Stachys fontqueri, Linum austriacum* subsp. *gomaricum, Saxifraga tricrenata, Sideritis romoi, Iberis grosmiquelii, Genista osmariensis, G. oxycedrina, Moehringia glochidisperma, Saxifraga werneri, Armeria alpinifolia, Malva vidalii, Teucrium huotii, Fumana fontqueri, Santolina adscensionis*). There were another 15 taxa ranked in average positions with scores 50.2–54.94% and 35 taxa ranked in lower to average positions with scores 35.2–49.8%. For 14 taxa, the scores were very low and the lowest one was in *Lathyrys coerulescens* and *Mantisalca amberboides* (16.6%).

3.3.3. Local Endemic Plants of Tunisia

None of the Tunisian taxa was ranked in the highest or average positions regarding the general potential in the ornamental/horticultural sector. Overall, 30 taxa ranked in lower to average positions with scores 35.8–47.5%. For 52 taxa, the scores ranked comparatively very low (<35%), and the lowest one was assigned to *Poa lehoueroui* (13.3%).

No taxon achieved the highest suitability for pot/patio plant (>70%). In total, 9 taxa ranked in above-average to high positions with scores 55.2 to 59.4% (hierarchically: *Limonium byzacium*, *Linaria multicaulis* subsp. *multicaulis*, *Limonium lacertosum*, *Marrubium aschersonii*, *Delphinium sylvaticum* subsp. *ichkeulianum*, *Dianthus cintranus* subsp. *byzacenus*, *D. rupicola* subsp. *hermaeensis*, *Teucrium luteum* subsp. *gabesianum*, *Calendula suffruticosa* subsp. *suffruticosa*). There were another 16 taxa with average scores (51.04–54.7%), while 45 taxa ranked with lower to average scores >35–50%. For 12 taxa, the scores were very low (<35%), and the lowest one was recorded for *Poa lehoueroui* (19.8%).

No taxon ranked in the highest suitability positions for home gardening. In total, *Erinacea schoenenbergeri* and *Sideritis tunetana* ranked in above-average to high positions both with score 51.4%. There were another 42 taxa with lower to average scores 35.1–48.8%. The scores for 38 taxa were very low, with the lowest score assigned to *P. lehoueroui* (13.8%).

No taxon ranked in the highest suitability positions for landscaping. *Erinacea schoenenbergeri* and *Sideritis tunetana* ranked again above-average to high with 58.1% and *Teucrium radicans* with 50.5%. There were another 56 taxa with lower to average positions with scores 35.5–48.4%. For another 23 taxa, the scores were very low (<35%), and the lowest one was assigned to *P. lehoueroui* (22.6%)

Among Tunisian endemics, *Erinacea schoenenbergeri* was evaluated as best for xeroscaping (64.8%), while *Sideritis tunetana, Teucrium radicans* and *Arabis tunetana* ranked in the high positions with scores between 55.3–60.7%. In total, 3 taxa (*Teucrium alopecurus, Helianthemum virgatum* subsp. *africanum, Linaria duflexa* subsp. *dumetii*) ranked in average positions with scores 50.99–53.75%, and 50 taxa ranked in lower to average positions with scores 35.6–49.8%. For 25 taxa, the scores were very low, and the lowest one was assigned to *Trifolium tunetanum* (17.9%).

3.4. Sustainable Exploitation Feasibility

The evaluation of sustainable exploitation feasibility (Level II) for the focal taxa of the studied regions/countries is demonstrated in S2 as percentages of the maximum possible scores per region/country and per taxon.

Among Cretan endemics, *Origanum dictamnus* achieved the highest score (91.67%, Figure 5). In total, 18 taxa ranked in above-average to high positions with scores >55.6–69.4% (hierarchically: *Calamintha cretica*, *Sideritis syriaca* subsp. *syriaca*, *Teucrium cuneifolium*, *Bellevalia brevipedicellata*, *Anthemis glaberrima*, *Nepeta sphaciotica*, *Centaurea poculatoris*, *Helichrysum heldreichii*, *Campanula saxatilis* subsp. *saxatilis*, *Convolvulus argyrothamnos*, *Bupleurum kakiskalae*, *Carlina diae*, *Crepis auriculifolia*, *Campanula hierapetrae*, *Dianthus xylorrhizus*, *Hypericum jovis*, *Sesleria doerfleri*, *Thymbra calostachya*). Another 23 taxa ranked in average positions with scores >50–54.17%, and 78 taxa ranked lower in average positions with scores 36.11% to 48.61%. For 103 taxa, the scores were very low (<35%), and the lowest one was recorded in the case of *Prospero batagliae* (15.28%).

Among Moroccan (Mediterranean coast-Rif) endemics, no taxon achieved highest (>70%) or above-average to high positions (>55–70%). In total, 7 taxa ranked lower in low to average positions (>35–50%), and 87 taxa were scored very low (<35%). The lowest scores were recorded in the cases of *Ammiopsis daucoides*, *Festuca embergeri* and *Mantisalca amberboides* (8.3%).

Among Tunisian endemics, no taxon achieved highest (>70%), above-average to high positions (>55–70%) or average positions (>50–55%). *Artemisia campestris* subsp. *cinerea* ranked in average positioning with 50% and *Calendula suffruticosa* subsp. *suffruticosa* ranked lower with 36.11%. In total, for 80 taxa, the scores were very low (<35%) and the lowest one was recorded in the cases of *Bituminaria tunetana* and *Crepis juvenalis* (5.6%).

3.5. SWOT and Gap Analyses

The procedure of SWOT and gap analyses (Figures 2 and 3, respectively) allowed the identification of specific gaps related to the sustainable exploitation of the focal evaluated taxa in the ornamental-horticultural sector and its subsectors. For these gaps, specific remedies and actions were outlined in an attempt to bridge them and mitigate the barriers (Figure 3). The analysis indicated that in order to devise or to create a new value chain in the ornamental-horticultural sector for NUPs (such as the local endemic taxa of this study), five general conditions should be first accomplished as necessary prerequisites: (a) extant high ornamental-horticultural potential (see Level I evaluation); (b) outline of unique product identity (see Level II evaluation); (c) availability of propagation material or material that can be easily produced (Level II evaluation) with Access and Benefit-Sharing (ABS) mechanisms already in place (Nagoya Protocol, EU Directive 511/2014); (d) propagation and cultivation techniques in place (at least in pilot scale) and adequate research already conducted (Level II evaluation); (e) incorporated commercial interest (or triggered interest by a, b, c, d) able to attract stakeholders and extant distribution channels.

3.6. Readiness Timescale for Sustainable Exploitation of the Focal Plants

The readiness timescale for sustainable exploitation of the focal taxa of the studied regions/countries in the ornamental-horticultural sector is shown in S2. Among the local endemics of all regions/countries evaluated (n = 399 taxa) at Level III (Table 2; Table 3), the readiness timescale for sustainable exploitation was indeterminable in 67.67% of the cases (280 taxa) and determinable for 119 taxa (29.82%). Among the latter, the readiness timescale was assessed as "already achieved" only in the case of *Origanum dictamnus* (Lamiaceae), a local Cretan endemic. This was based on full completion of all the necessary conditions mentioned in Table 2. For 18 and 23 Cretan taxa, the relevant readiness timescale was designated as achievable in the short-term and medium-term, respectively. In total, the readiness timescale for 78 Cretan taxa, 7 Moroccan (Mediterranean coast-Rif) and the Tunisian *Artemisia campestris* subsp. *cinerea* was designated as "achievable in the long-term".

Table 3. Overview of the local endemic taxa (species and subspecies) of Crete (Greece), Rif-Mediterranean coast of Morocco and Tunisia with respect to the readiness timescale designated for their sustainable exploitation in the ornamental-horticultural sector.

Designated Readiness Timescale	Number of Cretan Endemic taxa (Percentage %; n = 223)	Number of Moroccan Endemic Taxa of the Rif-Mediterranean Coast (Percentage %; n = 94)	Number of Tunisian endemic Taxa (Percentage %; n = 82)
Already Achieved	1 (0.44)	0 (0)	0 (0)
Achievable in Short-Term	18 (8.01)	0 (0)	0 (0)
Achievable in Medium-Term	23 (10.31)	0 (0)	0 (0)
Achievable in Long-Term	78 (34.97)	7 (7.44)	1 (1.22)
Indeterminable	103 (46.19)	87 (92.55)	81 (98.78)

4. Discussion

4.1. Evaluation of Neglected and Underutilized Plants from Ornamental-Horticultural Viewpoint

In general, from a conservational viewpoint, there are rule-based systems and scoring systems used for the evaluation or prioritisation of various plant groups with different focus, e.g., [29–31]. The rule-based systems apply specific rules and criteria resulting in explicit characterizations (e.g., IUCN extinction risk categories) while the scoring systems use different variables which are scored resulting in hierarchical ranking [31]. However, research on how to evaluate comprehensively new ornamental-horticultural crops or how to set priorities for their sustainable exploitation still remains compromised, fragmented and scattered. To date, only a limited number of studies are available about the principles of plant selection for special landscape applications in different countries and areas [25], and therefore, no coherent evaluation scheme has attracted considerable attention, especially with regards to local endemic NUPs [32]. Landscape and gardening applications often focus on special attributes such as plant habit, vegetative and flowering period, flower diameter, plant type, germination capacity, reproduction rate, coverage, height, drought resistance, environmental tolerance, stain resistance and concomitant survival rates [25]. On the other hand, several characteristics have been selected in different subsectors of the ornamental-horticultural industry for the evaluation of new promising crops such as leaf length, metrics and shape, flower/inflorescence colour, size and concomitant metrics, stem rigidity and appearance, leaf, corolla and/or fruit colour and brightness, perceived aroma, leaf texture and shining, general originality compared to marketed or traditional products and vase life (for cut flowers), most of them with stronger of weaker aesthetic interferences [23]. Depending on studying profile and research focus, the number of characteristics varies, and these are often assessed with different scores (or are combined to produce more complex variables or indexes) or are finally used as necessary conditions met or criteria fulfilled. It is worth mentioning that all of these approaches are based on the received view, i.e., merely employing only scientists (and/or nurserymen in some cases) as proxies capturing needs for end-users (consumers).

The present study is fundamentally differentiated from any previous due to the adoption of principles of the co-creation view in the development of the new methodological scheme. This innovative co-creation viewpoint is aiming to actively involve stakeholders in the design, customisation, personalisation and invention of solutions [28]. This collaborative co-creation approach goes often well beyond the personal skills of the participants involved in the cooperation and requires contributors to faithfully work together and develop communication based on durable relationships with a view to pooling expertise or resources and standardising operations [28]. In this framework, the current investigation has co-creatively reviewed all the ornamental-horticultural features and attributes found in literature and combined these with attributes from conservation viewpoint [31] in order to outline the multidimensional evaluation of the local endemic NUPs studied herein. Finally, all the above variables were incorporated in a coherent, scalable and multifaceted

scoring system (Table 1) enabling multiple levels of evaluation. This methodology involved participatory tools that were used accordingly to reach consensus between co-creators for a number of critical issues (number and types of attributes, rules, score values, scaling of interest, concept of evaluation, directionality, validation, consistency, formulas, levels of evaluation).

4.2. Special Features of the New Methodological Scheme Developed

The numerous attributes used in the new methodology described herein (20 in Level I and 12 in Level II) are largely independent, since only limited correlations were found among them after the scoring of the focal taxa at Level I and II (see S3). Furthermore, the hierarchical classifications of the attributes discerned two or three groups of attributes related either to plant habit or perceived value (Figure 5). The hierarchical classifications of the taxa of the three regions/countries (see S4) showed that their local endemics are also well-separated at different linkage distances into basic clusters and subclusters with several distinct groups sharing analogous scorings. This analysis illustrates the discrimination ability of the applied method discerning clearly the different biological entities of the three studied regions based on their ornamental-horticultural values.

The special features of the new methodology developed herein for the ornamental evaluation of the focal local endemic NUPs can be outlined as follows:

1. The participation of scientists of different expertise and end-users in the process of developing the new methodological scheme (co-creative approach, multidisciplinary and participatory procedures, consensus on evaluation parameters and rules);
2. The high number of individual attributes evaluated with point scoring in Levels I and II, and their connection to Level III;
3. The number of different data sources used to evaluate each taxon per selected attribute (literature, internet survey, photo interpretation, best-expert-judgement);
4. The data-adaptive scaling used in each attribute (two to seven possible scores);
5. The escalation of interest in the score values of each attribute (higher scores for cases with many data or strong interest or highly desirable features/measurements/estimates, and lower scores in opposite cases);
6. The three clearly defined levels of evaluation, i.e., evaluation of potential (Level I), sustainable exploitation feasibility (Level II), and readiness timescale (Level III) with conditions to be met;
7. The discrimination of general (overall) potential and special potential in different subsectors of the ornamental-horticultural industry, i.e., suitability for pot plant, home gardening, landscaping and xeroscaping;
8. The use of special formulas with weighted scoring to calculate subsector-specific interest;
9. Potential of robust selection of taxa considering market needs and provision of all necessary features for improvement in demand based on the resulting score of every taxon per evaluation level (percentage of the possible maximum score);
10. The possibility of aggregating scores in ranking classes per level of evaluation and of generating hierarchical classification of taxa per level of evaluation, thus allowing comparisons.

4.3. General and Special Ornamental-Horticultural Potential of Local Endemic NUPs

Previous studies indicate that there is commercial interest for at least 28 local Cretan endemics traded by 14 nurseries of seven countries [27] and four Moroccan (Mediterranean coast-Rif) endemics traded over the internet by 18 nurseries worldwide [33].

Results of the current study indicated a great diversity of local endemic taxa, presenting a strong general ornamental-horticultural potential for commercialization and some examples of unique NUPs with great potential are shown in Figures 6 and 7. Some noteworthy cases across the regions/countries studied are the Moroccan (Rif) fir-tree (*Abies marocana*); aromatic-medicinal herbs and small shrubs such as dittany of Crete (*Origanum dictamnus*) and Moroccan sage (*Salvia interupta* subsp. *paui*); Cretan shrubby plants such

as *Acantholimon androsaceum, Ebenus cretica* and *Lomelosia minoana* subsp. *asterusica*; the Cretan aroid (*Arum idaeum*); as well as bulbous plants such as the Moroccan snowflake *Acis tingitana* and the Cretan endemics *Muscari spreitzenhoferi, Tulipa bakeri* and *Fritillaria messanensis* subsp. *sphaciotica*.

Figure 6. Examples of rock-dwelling Cretan local endemic plants with strong potential in different subsectors of the ornamental-horticultural industry photographed in their wild habitats on the island of Crete (Greece). **Above:** *Achusa cespitosa* (left photo: L. Dariotis) and *Acantholimon androsaceum* (right photo: F. Samaritakis) with high suitability for landscaping and xeroscaping applications. **Middle:** *Origanum dictamnus* (left photo: E. Kalpoutzakis) and *Tulipa cretica* (right photo: V. Papiomytoglou) highly suitable for pot/patio, home gardening and xeroscaping applications. **Bottom:** *Lomelosia minoana* subsp. *minoana* (left photo: P. Tsilikakis) and *Lomelosia albocinta* (right) with high suitability for landscaping and xeroscaping applications. All photos are reproduced with permission.

Figure 7. Examples of Moroccan (Mediterranean coast-Rif) local endemic plants with strong potential in different subsectors of the ornamental-horticultural industry (pot/patio, home gardening, landscaping and/or xeroscaping) photographed in wild habitats: *Abies marocana* (middle), *Acis tingitana* (top left photo: Nhu Nguyen, University of Hawaii), *Salvia interrupta* subsp. *paui* (top right, from gardenbreizh.org), *Rhodanthemum hosmariense* (bottom left photo: F. de la Porte), and *Stachys fontqueri* (bottom right photos). All photos are reproduced with permission.

High suitability for pot/patio plants was identified for the Cretan aroids *Arum idaeum, Biarum davisii* and *B. tenuifolium* subsp. *idomenaeum*; the Moroccan aromatic-medicinal herb *Salvia interrupta* subsp. *paui*; the Cretan *Acantholimon androsaceum, Fritillaria messanenis* subsp. *sphaciotica* and *Tulipa cretica;* and the Moroccan *Abies marocana, Acis tingitana, Rhodanthemum hosmariense*, *Santolina adscensionis* and *Xiphion rutherfordii.*

The Moroccan Abies marocana, Rhodanthemum hosmariense and Salvia interupta subsp. paui as well as the Cretan endemics Acantholimon androsaceum, Arum idaeum, Tulipa cretica, Draba cretica, Muscari spreitzenhoferi and Origanum dictamnus were evaluated as appropriate NUPs for home gardening (Figures 6 and 7).

Highly suitable for landscaping were scored the Cretan endemics (Figure 6) Acantholimon androsaceum, Tulipa cretica, Muscari spreitzenhoferi, Lomelosia albocincta, L. minoana subsp. asterusica, L. minoana subsp. minoana, Arum idaeum, and Draba cretica as well as the Moroccan endemics Abies marocana, Salvia interrupta subsp. paui and Rhodanthemum hosmariense (Figure 7).

Highly suitable for xeroscaping were the Cretan endemics (Figure 6) Draba cretica, Acantholimon androsaceum, Tulipa cretica, Muscari spreitzenhoferi, Anchusa cespitosa, Origanum dictamnus, Lomelosia albocincta, Arum idaeum, Astragalus creticus subsp. creticus, Centranthus sieberi, Lomelosia minoana subsp. asterusica, L. minoana subsp. minoana, L. sphaciotica subsp. decalvans, L. sphaciotica subsp. sphaciotica, Crocus oreocreticus, Euphorbia rechingeri, Inula candida subsp. decalvans and Asperula idaea; the Moroccan (Mediterranean coast-Rif) endemics (Figure 7) Rhodanthemum hosmariense, Salvia interrupta subsp. paui, Stachys fontqueri and Anthyllis vulneraria subsp. fatmae as well as the Tunisian endemic Erinacea schoenenbergeri.

4.4. Local Endemic NUPs: Sustainable Exploitation Feasibility and Readiness Timescale

NUPs are usually unknown plant species which have rarely attracted the major attention of researchers, politicians and stakeholders [4,7]. The fundamental steppingstone for any sustainable exploitation of NUPs is the development of effective propagation and cultivation protocols, which are associated with important agronomical aspects and agro-processing [6]. It is known that the limited knowledge on products' shelf life, ambient conditions and longevity during preservation under storage and processing may undermine the commercialization potential of crops and NUPs [26]. Furthermore, information and storytelling on value-added products with unique identity and commercial prospect are absolutely necessary to attract consumers, stakeholders, producers, wholesalers and retailers. Hence, a multidisciplinary research approach is required in conjunction with necessary political preference and coherent policy awareness for the sustainable exploitation of NUPs [26].

Among the local endemic plants of Crete, *Origanum dictamnus* (Lamiaceae, Figure 6) represents an example-case of sustainable exploitation that has already been achieved at national level [34]. The dittany of Crete scored highest (91.67% with regards to the maximum possible score, Figure 5) in the feasibility evaluation (Level II) and comparatively ranked first among all the local endemic plants evaluated in the current study (n = 399). The market need for this plant in Crete was traditionally covered by harvesting wild-growing populations [34], thus leading progressively to population decline and local extinction events. To date, *O. dictamnus* is nationally threatened with extinction, i.e., assessed as Vulnerable [35] or Near Threatened [36] and is protected nationally (Greek Presidential Decree 67/1981) and internationally (Bern Convention, Annexes II and IV of the European Directive 92/43/EEC). Due to strong mythological background and ancient traditional uses still surviving in modern times in Crete combined with decline in the wild and currently approved medicinal activities and therapeutic properties [37], the cultivation of *O. dictamnus* in Crete started as early as the 1920s [34]. Therefore, the commercial production of *O. dictamnus* was considerably increased after the 1950s, while to date, approximately 80% of the current production is exported (mainly to Central European countries and Japan), and the rest is locally marketed in Greece (mainly in traditional or

modern shops with local products and open-air market stalls) [38–41]. Despite the facts that dittany of Crete is known in several countries, the marketed dried products seem to be unavailable outside Greece [37]. However, there are several processed products in the market which include its extracts and these are exported from Greece to the global markets. Dittany is also a popular aromatic-medicinal plant for ornamental-horticultural purposes for landscaping and gardening usage with high demand especially in Crete, and therefore, commercially propagated material is readily available in many local nurseries throughout the year. The above-mentioned actually fulfil all the necessary conditions mentioned in Table 2 and designate a paradigm of "already achieved sustainable exploitation" of a local endemic plant of the Mediterranean region.

Furthermore, the Cretan calamint (*Calamintha cretica*) and the Cretan mountain tea or "Malotira" (*Sideritis syriaca* subsp. *syriaca*) scored 69.44% and 66.67%, respectively, could potentially be exploited in the short-term, despite the fact that these do not actually rank in the highest class of sustainable exploitation feasibility (>70%). It is worth mentioning that *S. syriaca* subsp. *syriaca* has been recently proposed as a new industrial crop almost ready to be exploited [42]. In the same line (NUPs scored above-average to high), there are another 15 cases of Cretan taxa that can be exploited in the short-term as they fulfil all the necessary criteria mentioned in Table 3. Up-scaling in cultivation can be easily achieved for these taxa, due to already established propagation techniques and pilot cultivation protocols. For example, *Carlina diae* has been recently proposed as a new crop with ornamental value [17]; *Convolvulus argyrothamnos* has been cultivated successfully in pilot scale for many years in Crete as an ornamental plant (Z. Kypriotakis, pers. comm.); *Lomelosia minoana* subsp. *minoana* and *Scutellaria hirta* have been lately promoted for landscaping and gardening [43]; and *Bupleurum kakiskalae* has already been cultivated successfully at the entrance of the Management Authority of the Samaria National Park in Crete (https://www.samaria.gr/en/home-2-2/, (accessed on 18 February 2021)). Ex situ conservation actions in place are very important for the availability of propagation material for these plants, in order to facilitate the massive propagation of certified plants for commercialization. This can also alleviate possible legal restrictions related to Access and Benefit-Sharing (ABS) policies. The commercial demand and up-scaling of these taxa could be accomplished with the already propagation protocols developed and extant pilot cultivation results in place, e.g., [44,45]. With hardly any or some easily bridged research gaps (e.g., agro-processing), the attraction of stakeholders, producers and retailers can be easy for these taxa, and the possible facilitation by extant distribution channels can be likely reasonable. Consequently, the value chains for these taxa can be considered as reachable in the short-term.

The application of the criteria mentioned in Table 2 resulted in 23 Cretan endemic taxa that can be sustainably exploited in the medium-term. The availability of propagation material for these plants can be probable either due to some ex situ conservation actions in place or accessibility of wild-growing populations which may facilitate the production of documented material. Legal restrictions related to ABS policies may impose some risks in accessing wild populations, but these can be overcome due to commercial interest after prior informed consent. Most probably local forest authorities may authorise collections of initial propagation material for further commercialisation in the frame of the EU Directive 511/2014. The upscaling of existing pilot attempts to address commercial demand for these new taxa is deemed as possible on the basis of successful rapid propagation techniques and pilot cultivations already examined, e.g., [44,45]. If some research gaps (e.g., agro-processing, cultivation practices, fertilisation regimes, agronomical aspects etc.) are bridged carefully, the attraction of stakeholders, producers, retailers and distribution channels can be well-thought-out as possible. Consequently, the value chains for these taxa can be considered as reachable in the medium-term.

The application of the relevant criteria mentioned in Table 2 resulted to 86 taxa that can be exploited in the long-term, which include 78 Cretan endemics, *Artemisia campestris* subsp. *cinerea* from Tunisia, and the Moroccan taxa *Abies marocana*, *Centaurium erythraea* subsp.

bifrons, *Anthyllis vulneraria* subsp. *fatmae*, *Bromus erectus* subsp. *microchaetus*, *Rhodanthemum hosmariense*, *Sonchus masguindalii* and *Xiphion rutherfordii*. The limited availability of propagation material for these plants can be likely sourced from scattered ex situ conservation actions [21] and extant e-commerce in some cases [33]. Legal restrictions related to ABS policies and mechanisms may also impose some considerable barriers in accessing wild-populations due to compromised commercial interest and discrepancies in implementation of the Nagoya Protocol in different countries. The absence of propagation methods and cultivation protocols may limit the upscaling of these taxa for commercialization. With almost absence of knowledge about these taxa, appropriate applied research is needed to bridge several existing gaps (e.g., propagation, cultivation, agro-processing, cultivation practices, fertilisation regimes, agronomical aspects etc.). Consequently, intense efforts are required to attract stakeholders and distribution channels. Therefore, the value chains for these taxa can be considered as difficult to create and consequently this can only be achieved in long-term.

The basic differences related to the designated timescale (short-term, medium-term or long-term) for achievable sustainable exploitation of the local endemic plants of Crete (Greece), Mediterranean coast-Rif of Morocco and Tunisia in the ornamental-horticultural sector are illustrated in Figure 8.

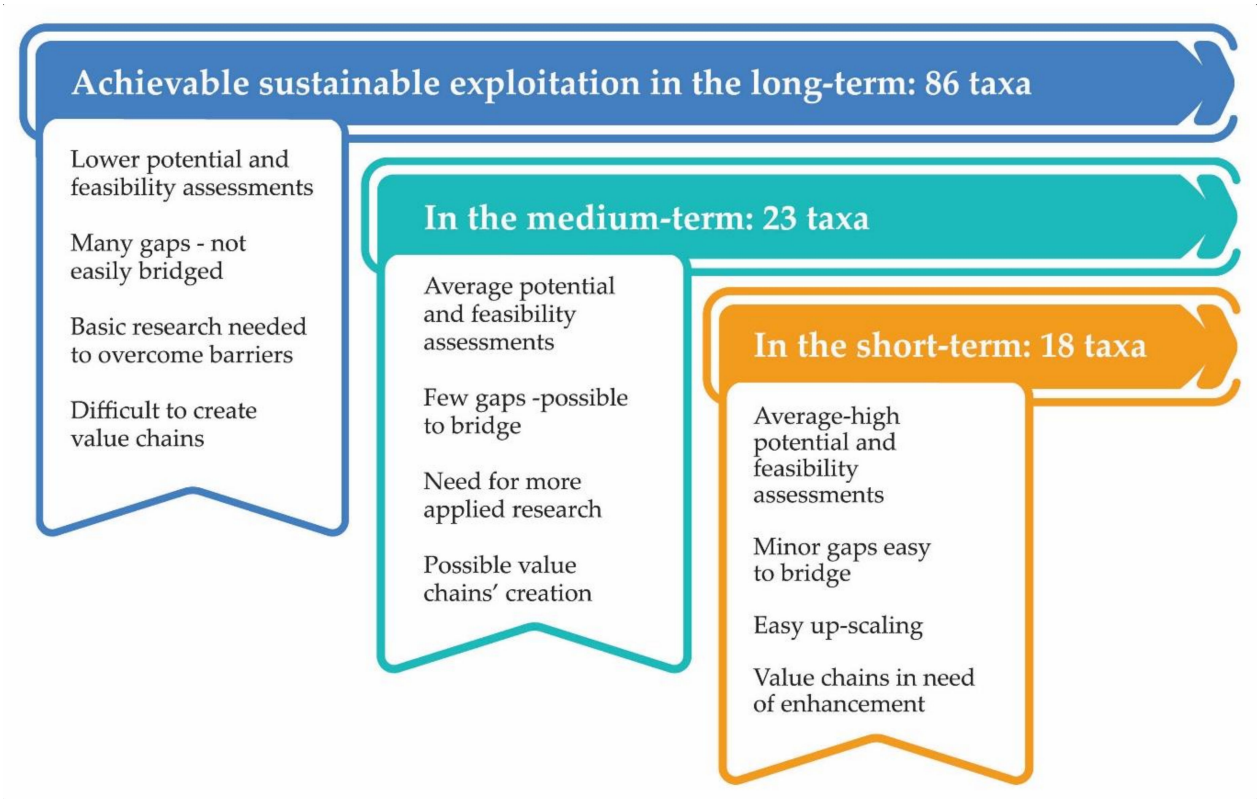


Figure 8. Basic differences related to the designated timescale (short-term, medium-term or long-term) for achievable sustainable exploitation of the local endemic plants of Crete (Greece), Mediterranean coast-Rif of Morocco and Tunisia in the ornamental-horticultural sector.

Due to increased uncertainty, discrepancies and high difficulty in fulfilling the relevant criteria of Table 2, the readiness timescale remains indeterminable for the majority of the local endemic NUPs of the regions/countries studied, i.e., Cretan endemics (103 taxa), Moroccan (87) and Tunisian ones (81). The compromised evaluation results in the case of the Tunisian taxa reflects basic knowledge gaps, limited red listing and absence of legal plant protection status, as discussed in previous studies [21,33].

5. Conclusions

The current research proposed a new methodological scheme for the multifaceted ornamental-horticultural evaluation of NUPs at three levels, focusing on unique floristic elements (single-country or single-region endemic plants) of three regions of Mediterranean countries (Crete, Greece; Mediterranean coast-Rif of Morocco; Tunisia). Being wild-growing in nature and thriving often in marginal areas, these unique phytogenetic resources are naturally selected to withstand stress conditions and are therefore able to contribute to low-input sustainable production systems. When sustainably managed and marketed for added value products, such unique resources may offer new opportunities for local economies and exclusive business branding. In this context, this study revealed that the case of dittany of Crete (*Origanum dictamnus*) and the Cretan mountain tea (*Sideritis syriaca* subsp. *syriaca*) represent successful examples of already achieved sustainable exploitation of local endemic NUPs with commercial products currently available on the market. According to the results of this research, there are very good opportunities for sustainable exploitation of at least 18 and 23 local endemic NUPs in the short-term and medium-term, respectively. In addition, another 86 local endemic NUPs can be sustainably exploited only in the long-term.

In any case, effective value chains are needed to unlock the full potential of the focal unique NUPs of Crete, Tunisia and Morocco (Mediterranean coast-Rif) in the ornamental-horticultural sector, accomplishing all critical activities from nature to the market. The applied research on the development of species-specific propagation cultivation, pre-harvest, and post-harvest protocols will rapidly enhance the production of local endemic NUPs for commercial consumption.

Overall, the successful implementation of sustainable exploitation of native, wild-growing, unique (endemic) phytogenetic resources requires multidisciplinary research that covers fields and expertise ranging from artificial selection and breeding, propagation-cultivation to agronomical aspects. On the other hand, there is also need for appropriate socio-economic and marketing policies and sufficient investments by national governments and local authorities, non-governmental organizations, and other relevant stakeholders. If these are be in place in the near future, the sustainable exploitation of some dozens of local endemic taxa of Crete with highly promising possibilities can be achieved in short-term or medium-term.

Supplementary Materials: The four appendices (S1, S2, S3, S4) are available online at https://www.mdpi.com/2071-1050/13/5/2539/s1. S1: Level I and Level II attributes used for the ornamental-horticultural evaluation of the focal endemic NUPs of Crete (223 taxa), northern Morocco (94) and Tunisia (82) with data sources, guidelines-explanations and scoring examples per attribute. S2: Percentage (%) of the maximum possible scores achieved per evaluation level regarding the local endemic plants (alphabetically) of Crete, Tunisia and Mediterranean coast-Rif of Morocco. Level I: Evaluation of general potential in the ornamental-horticultural sector and evaluation of special interest in its subsectors (pot/patio plants, home gardening, landscaping, xeroscaping); Level II: Evaluation of sustainable exploitation feasibility. Level III: Readiness timescale for sustainable exploitation. Blue cell cases: >70%; green cell cases: >55–70%; yellow cell cases: >50–55%. S3: Correlations among attributes used in different evaluation levels. S4: Complete linkage hierarchical clusterings (1-Pearson r distance) of focal taxa.

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