Farmers' Variety Naming and Crop Varietal Diversity of Two Cereal and Three Legume Species in the Moroccan High Atlas, Using DATAR

Article *in* Sustainability · July 2023

DOI: 10.3390/su151310411

8 authors, including:

Agnès Bernis-Fonteneau
Sapienza University of Rome

Meryem Aakairi
University Ibn Zohr - Agadir

Giandaniele Castangia

Paolo Colangelo
Italian National Research Council

sustainability

MDPI

Article

Farmers' Variety Naming and Crop Varietal Diversity of Two Cereals and Three Legume Species in the Moroccan High Atlas, Using DATAR

Agnès Bernis-Fonteneau [1,2,*], Meryem Aakairi [3], Omar Saadani-Hassani [3], Giandaniele Castangia [4], Rachid Ait Babahmad [3], Paolo Colangelo [5], Ugo D'Ambrosio [4,6,†] and Devra I. Jarvis [2,7,8,†]

1 Department of Environmental Biology, Sapienza University of Rome, 00185 Rome, Italy
2 Platform for Agrobiodiversity Research (PAR), The Raffaella Foundation, Twisp, WA 98856, USA; d.jarvis@agrobiodiversitypar.org
3 Moroccan Biodiversity and Livelihoods Association, Av. Sidi Abad 1, N° 280, Marrakech 40000, Morocco
4 Global Diversity Foundation (GDF), 37 St. Margaret's Street, Canterbury CT1 2TU, UK; gcastangia83@gmail.com (G.C.); ugotopia@yahoo.com (U.D.)
5 National Research Council, Institute on Terrestrial Ecosystems, Via Salaria km 29,300, Montelibretti, 00015 Rome, Italy; paolo.colangelo@cnr.it
6 Etnobiofic Research Group, Institut Botànic de Barcelona (IBB-CSIC-ICUB), Universitat de Barcelona, Passeig del Migdia, s/n, 08038 Barcelona, Spain
7 Department of Crop and Soil Sciences, Washington State University, Pullman, WA 99164, USA
8 Bioversity International, Via di S. Domenico 1, 00153 Roma, Italy
* Correspondence: agnes.bernisfonteneau@uniroma1.it
† These authors contributed equally to this work.

Abstract: Local agrobiodiversity in remote areas such as the Moroccan High Atlas is poorly studied, despite being of great importance for the sustainability and resilience of mountainous populations. This includes important species such as wheat (*Triticum* spp.), barley (*Hordeum vulgare*), fava beans (*Vicia faba*), peas (*Pisum sativum*), and alfalfa (*Medicago sativa*). This study aimed to better understand varietal naming by farmers and the traits they use for assessing the current diversity of the five species, in 22 locations, distributed across three hubs of the High Atlas. The data were provided by 282 Amazigh informants during focus-group discussions, household surveys, and market surveys, with the support of the Diversity Assessment Tool for Agrobiodiversity and Resilience (DATAR). The use of local terminology for variety names and systematically collected morphological, ecological, and use descriptors appears to be a valuable way to assess local intraspecific diversity, and further comparisons with genomic results are recommended. Furthermore, the results also indicate low diversity at the household level, which contrasts with the greater diversity at the community level. Larger areas are still planted with landraces compared to areas planted with modern varieties, although the levels of richness (number) of both landraces and modern varieties are equivalent overall. Many factors influence this diversity: the biophysical characteristics of the sites, the socio-economic and management practices of farmers, and the availability of varietal diversity and of modern varieties or landraces. Although selection processes have reduced the local diversity available for economically important crops, we found that farmers still rely greatly on landraces, which present traits and variability that allow them to adapt to local conditions.

Keywords: agrobiodiversity; agroecology; Amazigh; ethnotaxonomy; barley; wheat; fava bean; pea; alfalfa

check for updates

Citation: Bernis-Fonteneau, A.; Aakairi, M.; Saadani-Hassani, O.; Castangia, G.; Ait Babahmad, R.; Colangelo, P.; D'Ambrosio, U.; Jarvis, D.I. Farmers' Variety Naming and Crop Varietal Diversity of Two Cereals and Three Legume Species in the Moroccan High Atlas, Using DATAR. *Sustainability* **2023**, *15*, 10411. https://doi.org/10.3390/su151310411

Academic Editor: Dario Donno

Received: 19 April 2023
Revised: 15 June 2023
Accepted: 28 June 2023
Published: 1 July 2023

1. Introduction

The world's reservoir of genetically diverse crop varieties allows farmers to adopt a risk-management strategy [1–8]. With this diversity, farmers can achieve more stable productivity and ensure the resilience of their production systems in multiple and changing environments [9–11]. The sustainability of agroecosystems, supported by the agrobiodiversity they contain, is crucial in a climate-change context [12–14]. This pool of genetic material is also the main source for future breeding activities [15–19]. The farm-based conservation of crop varietal diversity, through its sustainable use by farming communities, is therefore essential to ensure healthy and resilient agricultural production systems for the future [6,17,20–25].

Local traditional varieties are still maintained, adapted, and managed in farmers' fields [10,14,16,26–30]. This is the case in Morocco [31–36], despite the major sociodemographic and economic changes that have occurred in its rural and mountainous areas over the past decades through the overall social and economic development of the country. The abandonment of traditional practices and landraces takes place while moving from a predominantly rural population to a chiefly urban population, and as youths migrate to the city [37]. The landrace diversity of barley (*Hordeum vulgare* L.), wheat (*Triticum* spp., particularly hard wheat, *T. durum* Desf.), fava beans (*Vicia faba* L.), peas (*Pisum sativum* L.), and alfalfa (*Medicago sativa* L.) was the subject of past research [31–36,38–61].

It has been demonstrated that this crop-variety diversity allows farmers to adapt to various conditions and abiotic and biotic stresses, and it has been at the heart of management options, particularly in extreme environments, mostly for small-scale farmers [9–14,62–64]. However, at the same time, this crucial intraspecific diversity continues to be eroded by unsustainable management practices and the introduction of improved varieties, coupled with agricultural inputs [16,65–70]. A better understanding of this diversity in farmers' production systems is necessary for the implementation of adapted interventions to ensure the conversation of this heritage for the benefits of the farmers themselves.

In this article, we assess the crop varietal diversity still found in the fields in the High Atlas region for five major food crops in Morocco. We studied the varietal naming by local farming communities of these species, and the amount and distribution of this diversity across their production systems. The following crop species were selected for their importance in the production and livelihoods of smallholder Amazigh farmers: barley (*Hordeum vulgare* L.), wheat (*Triticum* spp., focusing on hard wheat, *T. durum* Desf.), fava beans (*Vicia faba* L.), peas (*Pisum sativum* L.), and alfalfa (*Medicago sativa* L.) [59,65,70–73]. We also examined socio-economic and ecological factors to better understand their impact on this diversity and its distribution. This gives an additional perspective on crop-variety diversity, as little research has been conducted on the ways in which Amazigh communities label and classify animal and plant agrobiodiversity [74,75].

This research was part of the project, "Conserving High Atlas agrobiodiversity to improve Amazigh livelihoods in Morocco," funded by the Darwin initiative for a duration of three years, from 2020 to 2023, and carried out by the Global Diversity Foundation (GDF) and the Moroccan Biodiversity and Livelihoods Association (MBLA). The data, including the seed samples, were collected in 22 different locations in the Moroccan High Atlas (Al Haouz and Azilal provinces). We first used an ethnographic approach [76], to characterize the crops' intraspecific diversity and then calculated for the different sites the diversity indicators and area statistics [77] based on data collected using DATAR, the Diversity Assessment Tool for Agrobiodiversity and Resilience (www.datar-par.org, accessed on 27 June 2023) developed by ®Icity, Marco Frangella, for the Platform for Agrobiodiversity Research (PAR)), with contributions from local Amazigh communities.

2. Materials and Methods

The High Atlas Mountains cover a surface of 59,184 km^2, stretching around 650 km in length and between 50 and 100 km in width. They cover south-eastern Morocco from the Atlantic Ocean in the west to the Algerian border in the east and are delimited to the north by the valleys of the rivers Moulouya and Oum Er-Rbia and to the south by the geological feature known as the 'South Atlas Fault' [78]. Inhabited mostly by small-scale subsistence and transhumant farmers of Amazigh descent (speakers of Tashelhit to the west and Tamazight to the east), these mountains include multiple key biodiversity areas in the Mediterranean basin hotspot [79].

Fieldwork sites in the High Atlas were divided into three 'hubs': Al Haouz to the west (roughly corresponding to the municipalities of Aghouatim, Amizmiz, Asni, Imegdal, Ouirgane, Oukaimeden, Ourika, Tahannaout, and Talat N'Yaaqoub), Demnate in the center (municipalities of Ait Abbas, Ait Blal, Ait Boualli, Ait Oumdiss, Sidi Boulkhalf, Tabant, and Tifni), and Azilal to the east (municipalities of Ait M'hamed, Tamda Noumercid, and Zaouiat Ahansal). Differences in climate, altitude, soil type, and other parameters were identified between the three areas (see Table S1 in the Supplementary Materials). Locations of the study sites and surveys are presented in Figure 1.

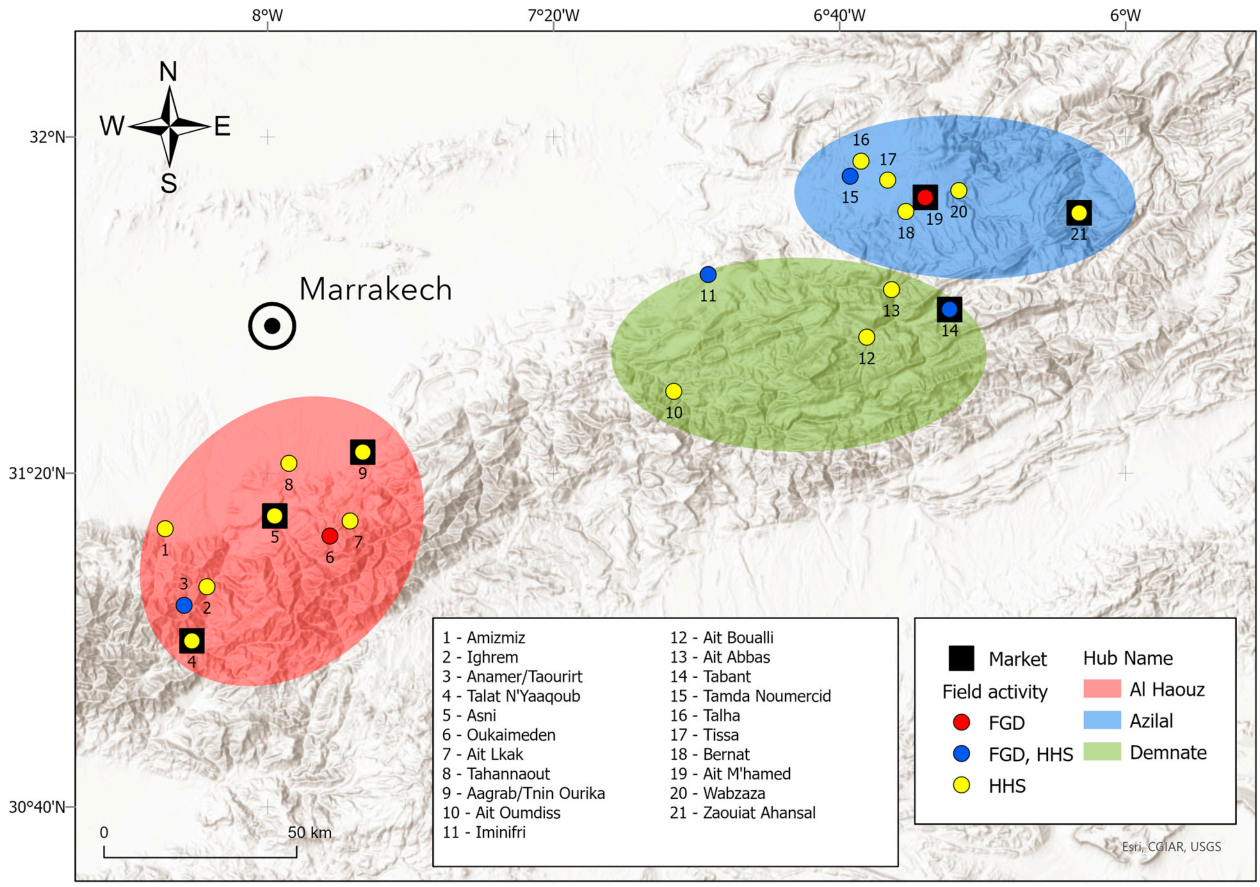

Figure 1. Central High Atlas map with locations of study sites and surveys.

Central High Atlas is characterized by temperatures ranging from 1.2 and 19.6 °C, with a mean of 13.7 °C. Rainfall varies from 118 to 773 mm per year, with an average value of 341 mm. Hubs are characterized by access to local markets, water from rivers and water sources, depending on the context and natural environment of each site. The climatic region of the High Atlas is subdivided into two climatic categories: one part features a cold semi-arid climate (BSk), and the other features a hot semi-arid climate (BSh) [80].

The local communities' economies in this region consist of small-scale agriculture (cereals, pulses, fruit trees, and others), extensive pastoralism (chiefly small ruminants), revenues from services such as tourism, and outmigration to Moroccan cities or abroad [37].

Hubs were chosen to link to previous work in the area and for logistical purposes, with reference to the FAO global agroecological zones (GAEZ) [81]. Table 1 presents the main biophysical and socio-economic characteristics of the different sites with names of *douars* (hamlets) and sites, names of tribes, numbers of surveys realized, elevation, rainfall, temperature and soil type, accessibility of the *douar*, distance to local markets, and, finally, the main economic activities and overall estimates of economic conditions. A more detailed description of the *douars* and hubs is available in Table S1 of the Supplementary Materials.

Table 1. Biophysical and socio-economic characteristics of field sites (FGD—focus-group discussions; HHS—household surveys).

Name of *Douar*/Hamlet (Hub)	Amazigh Tribe [1]	N° FGD	N° HHS	Elevation [2] (m)	Rainfall [3] (mm)	Temperature [3] (°C)	Soil Type [4]	Accessibility by Road [5]	Distance Local Market [5]	Main Economic Activities [5]	Economic Conditions [5]
Asni * (Al Haouz)	Rhirhaya	0	45	1183	453	15	Calcic Xerosols	Medium	Medium	Tourism, agriculture, livestock, trade	Good
Talat N'Yaaqoub * (Al Haouz)	Goundafa	0	15	1186	438	15	Lithosols	Low	Near	Agriculture, livestock	Low
Oukaimeden (Al Haouz)	Rhirhaya	1	0	2599	581	9	Lithosols	Medium	Far	Tourism, livestock, agriculture	Medium
Amizmiz (Al Haouz)	Kdamoute	0	5	931	438	16	Calcic Xerosols	High	Near	Trade, agriculture, livestock	Good
Anamer-Taourirt (Al Haouz)	Goundafa	2	90	1633	509	12	Lithosols	Low	Far	Agriculture, livestock	Low
Ighrem (Al Haouz)	Goundafa	0	5	1057	442	15	Lithosols	Low	Far	Agriculture, livestock	Low
Aagrab-Tnin Ourika * (Al Haouz)	Ourika	0	35	850	365	17	Calcic Xerosols	High	Near	Tourism, agriculture, trade, livestock	Good
Ait Lkak (Al Haouz)	Ourika	0	65	1901	543	11	Lithosols	Medium	Far	Agriculture, livestock	Medium
Tahannaout (Al Haouz)	Rhirhaya	0	25	935	400	17	Calcic Xerosols	High	Near	Trade, tourism, agriculture, livestock	Good
Tabant * (Demnate)	Ait Bougmez	2	70	1860	334	12	Rendzinas	Medium	Near	Trade, tourism, agriculture, livestock	Good
Ait Abbas (Demnate)	Ait Abbas	0	85	1464	369	14	Rendzinas	Low	Medium	Agriculture, livestock	Medium
Iminifri (Demnate)	Oultana	2	55	1005	474	16	Calcic Xerosols	High	Near	Tourism, agriculture	Good
Ait Boualli (Demnate)	Ftouaka	0	15	1685	364	12	Rendzinas	Low	Far	Livestock, agriculture, tourism	Low
Ait Oumdiss (Demnate)	Ftouaka	0	39	1286	437	16	Lithosols	Low	Far	Agriculture, livestock	Low
Zaouiat Ahansal * (Azilal)	Ihanesalen	0	55	1563	309	12	Rendzinas	Medium	Medium	Tourism, livestock	Low
Bernat (Azilal)	Ait Messat & Ait Attab	0	60	1651	406	13	Rendzinas	High	Near	Agriculture, livestock	Medium
Tamda Noumercid (Azilal)	Ait Messat & Ait Attab	2	35	1279	468	15	Rendzinas	High	Near	Agriculture, livestock, trade	Medium
Ait M'hamed * (Azilal)	Ait Messat & Ait Attab	2	0	1704	401	13	Rendzinas	High	Near	Agriculture, livestock, trade	Good
Wabzaza (Azilal)	Ait Messat & Ait Attab	0	30	1599	390	14	Rendzinas	Low	Far	Livestock	Low
Talha (Azilal)	Ait Messat & Ait Attab	0	50	1272	470	16	Rendzinas	High	Near	Agriculture, livestock, trade	Medium
Tissa (Azilal)	Ait Messat & Ait Attab	0	25	1598	440	13	Rendzinas	Medium	Medium	Agriculture, livestock	Good

[1] Amazigh tribes taken from the portal "Tribus du Maroc" (http://tribusdumaroc.free.fr/ accessed 27 June 2023); [2] elevation values were extracted from the SRTM DEM and are available through NASA Earthdata at https://dwtkns.com/srtm30m accessed 27 June 2023)/; [3] rainfall and average yearly temperature data were extracted from the WordClim historical datasets, period 1970–2000 (www.worldclim.org); [4] soil types refer to the FAO Digital Soil Map of the World Version 3.6, January 2003; [5] digital maps and community researchers' and farmers' expertise; * indicates location where local market (*souk*) inventories were carried out. *Souks* occur on a weekly basis at each of the 6 locations.

The research took place from late 2020 to early 2022, and the data collection itself was conducted from October 2021 to February 2022. The study started with a local market (*souk*) prospection of the five species. In a second phase, focus groups were carried out in six locations in the region of study with 100 farmers, focusing on two of the five species in greater detail, according to the diversity of the species in that region identified in Phase 1 and previous knowledge of the region. In a final phase, household surveys were carried out in 19 locations, and 157 farmers were interviewed for the five species (at the start of the project, COVID-19 pandemic emerged, which significantly affected the start of fieldwork and the data collection itself). During the multiple visits in all phases of field work, samples were collected for the different accessions and stored at the seedbank of the School of Sciences at Cadi Ayyad University in Marrakech.

Three different types of survey were conducted for the five target species to collect information on varieties, their description, and their distribution. Market surveys, focus-group discussions (FGD), and household surveys (HHS) were used to identify named varieties. A total of 282 informants were interviewed, including 246 Amazigh farmers for FGD and HHS and 36 seed sellers for market surveys. Numbers and methods of selection of farmers for the three types of survey are detailed below. Nine farmers took part in both FGD and HHS. All interviewed farmers signed free prior informed consent before sharing their knowledge.

To better understand regional seed availability and exchange, from May to September 2021, six local markets were inventoried, including interviews with 36 seed vendors. Vendors were randomly selected, starting with an informal discussion and followed by a short, structured interview.

Focus-group discussions were carried out with an average of 12 to 18 farmers each, totalling 99 farmers across the project sites. The FGD discussions followed the methodology of Jarvis and Campilan [82]), with a repeatable set of guiding questions using direct questions, participatory diagramming and visualization, scoring, and specimen descriptions brought to the FGD [83,84]. Farmers described the varieties they grew, indicated their main management practices, the sources of their seeds/planting materials, and the goals they aimed to achieve with their diversity. A total of 11 FGD sessions were conducted, hosted in the six municipalities of Ait M'hamed, Anamer-Taourirt, Iminifri, Oukaimeden, Tabant, and Tamda Noumercid, distributed across the three hubs, with two sessions per village. The total number of participants in the FGDs was 99, all of whom were Amazigh, of whom 55 (55%) were male and 44 (45%) were female, with an age between 18 and 90, from a total of 37 villages distributed across the area.

Surveys were conducted at 19 sites, representing different farmers' communities, for the five target crops (alfalfa, barley, fava beans, peas, and wheat). Households at each site were selected using a randomly stratified design (by village) to ensure geographic representation across the target villages within each agro-ecological site, followed by snowball sampling until a representative sample was achieved, totaling 156 households. After data cleaning, we retained a total of 795 observations. Only households with farmers growing one or several of the target species were included. For each household, information was collected on all varieties of the target crops grown by that household, in each management space (i.e., field or home garden [85,86]), together with associated management practices and sources of planting materials for the varieties identified.

Crops' intraspecific diversity indicators, richness, evenness, and divergence, were calculated from the data collected during the household surveys [77]. Average household richness was calculated based on the mean number of varieties per crop in households within each community. Community richness was calculated as the total number of varieties present in a site. Household and community evenness were calculated using the Simpson index, estimated using the frequency of the varieties of each crop at household and community levels, respectively. In order to compare how farmers used the agrobiodiversity available in their own communities, we compared community richness and evenness with the average household richness and the average household evenness. Finally, to estimate the extent to which households belonging to the same community show different compositions from the available portfolio of varieties in the community, we estimated the divergence using the formula described by Jarvis et al. [77]:

$$\text{Divergence} = (\text{Community Evenness} - \text{Average household evenness})/\text{Community Evenness}$$

The FGD and HHS were conducted with the support of the Diversity Assessment Tool for Agrobiodiversity and Resilience (DATAR, which was in its pilot phase during data collection; therefore, many adaptations and fine-tuning occurred during the study, making the tool more user-friendly and bug-free). DATAR is an innovative IT tool built to assess agrobiodiversity and support decision-making for agricultural development. It is intended to enhance the resilience of production systems and improve productivity using diversity of plants grown and animals kept [87]. Furthermore, it is a free open-source tool and, therefore, accessible to all. The DATAR tool was built to bridge the gap between crop- and livestock-agrobiodiversity assessment from the household level, through the agroecological zone level to the project level. Farmers are at the core of DATAR, which includes social and economic aspects. Descriptors and values used in DATAR are harmonized to allow a comprehensive analysis covering different species and even different varieties across landscapes and agroecological zones.

3. Results

3.1. Varietal Naming: Ethnosemantics and Ethnotaxonomy

Using data collected during the three types of survey, FGD, HHS, and market surveys, a total of 111 crop-variety names were found. For these 111 crop-variety names identified from the five selected species, the local ethnotaxa naming in Amazigh was usually composed of two or three words (excluding prepositions). Predominantly, the first word referred to the name of the crop, followed by one or two attributes defining the variety in question. A few exceptions were found, such as *tachairine* (small-sized barley) and *rwiza* (modern barley), composed of one word, and a couple of ethnotaxa names with four words (*ibawn n'Azaghar idalan iqhwayn* and *ibawn n'Azaghar iwraghen iqhwayn*). In the latter case, an additional attribute was added after the second, as detailed in Table S2 in the Supplementary Materials. As is common in other languages, several ethnotaxa may be used for highly similar varieties while, in other cases, the same ethnotaxon is used for significantly different varieties [88,89].

Regarding the species' names (acting as nouns), several were borrowed from Moroccan Arabic (locally known as Darija) (Table S2). In some cases, such as barley and green pea, a Darija name is used for more modern varieties (e.g., *rwiza* and *jelbana*), while Amazigh terms are used for older varietis (e.g., *tomzin* and *tanift*). For alfalfa, the Amazigh terms, *ikffis* and *tilfzt* [90], were fully substituted by the Darija name, *fessa*. A completely different fodder species is also referred to as a kind of "alfalfa" (*fessa*), named *fessa n-sif* (alfalfa of the summer), which corresponds to *Trifolium alexandrinum* L. This species was not included in this study.

Concerning the varietal attributes (acting as modifiers) (Table S2), these usually refer to perceived indigeneity/foreignity, the color of the fruit, the size of the plant or the seed, the shape of the seed, or the geographical origin, amongst others. Several adjectives are borrowed from Darija. One of the main attributes is linked to perceived indigeneity/foreignity and is the very common Maghrebian distinction between *beldi* (from the land) and *roumi* (foreign, from abroad). This was the most common attribute in our data, present in almost half of the ethnotaxa (46%). The *beldi/roumi* distinction, borrowed from Darija, moves beyond the origin of any variety or its historical introduction. Literally, it refers to that which comes from the land (indigenous) (*bled* is "the land," and *beldi* is "from the land") and from what is foreign (from the "west") [91]. In many cases, beldi is associated with the concepts of traditional (*taqlidi*), natural (*tabi'iya*) or healthy (*sih'hi*), especially in urban and peri-urban contexts [92].

Other relevant varietal attributes relate to the colors of seeds, appearing in almost one-third of the ethnotaxa collected (30%), as well as the geographical origins of the seeds, either national or international, which appear in about one-sixth of the ethnotaxa (16%). Less relevant indicators, appearing in fewer than 10% of the terms, relate to perceived historical antiquity, preferred altitudinal location and irrigation conditions, preferred uses, the characteristics of the plant, the characteristics of the seeds, commercial names, and anthroponyms (Table S2). In the Tamazight language, the feminine gender (nouns and adjectives) is marked by a circumfix ('*t(a)* ... *t*' for singular and '*t(i)* ... *in/t*' for plural. The same circumfix is used to denote smaller sizes (e.g., *tachairine* or small *chair*, and *tibawin* or small *ibawn*). Prepositions are also included in certain ethnotaxa, usually ″*n*″, corresponding to "of/from" (*n'adrar* or "of/from the mountain").

Our results show that the farmers' terminology tends to underestimate the units of diversity they use for cereals, barley and durum wheat, while it overestimates it for fava beans. This is similar to the findings of earlier studies carried out on these species [77,88,93,94]. For alfalfa and peas, is the findings are less clear. When underestimated, multiple units of diversity are clumped into a general term referring to perceived indigeneity/foreignity, while, when overestimated, additional morphological and geographical attributes are given, which often vary across regions and informants.

3.2. Crop-Variety Diversity and Distribution per Species and Across Hubs

For the data collected the during HHS alone, a total of 55 varieties were observed for each crop, of which nine were for barley, 11 were for wheat, 14 were for fava beans, nine were for peas, and 12 were for alfalfa. During the HHS, the data were collected on the varietal diversity grown on the farms with details of the areas planted. From these data, a total of 55 varieties were identified: nine for barley, 11 for wheat, 14 for fava beans, nine for peas, and 12 for alfalfa. The diversity indicators were calculated for the five target species at hub and household level, as well as the area planted with each crop and the percentages of landraces. These are presented in Table 2. More detailed results for the diversity indicators for each target crop and each hamlet (*douar*) are available in Table S3 of the Supplementary Materials.

Table 2. Hub, village, and household (HH)-area statistics and estimates of diversity.

Crop	Hub	n° Hamlets	n° HH	Total Area (ha)	% Area Landrace	Mean Crop Area HH	Community Richness	% Landrace	Community Evenness	Divergence	Average HH Richness	Average HH Evenness
Barley	Al Haouz	8	48	164.79	87.65	3.43	4	50.00	0.4995	0.96	1.04	0.02
	Azilal	6	44	194.10	99.95	4.41	3	66.67	0.0051	- *	1.05	0.01
	Demnate	5	46	672.78	99.99	14.63	2	50.00	0.0001	1.00	1.00	0.00
	All Hubs	**19**	**138**	**1031.67**	**97.85**	**7.48**	**9**	**55.56**	**0.5268**	**0.85**	**1.47**	**0.08**
Wheat	Al Haouz	4	12	71.87	11.30	5.99	3	33.33	0.3685	1.00	1.00	0.00
	Azilal	6	43	128.90	76.49	3.00	5	60.00	0.5103	0.94	1.07	0.03
	Demnate	5	33	211.67	71.90	6.41	3	33.33	0.4401	0.94	1.06	0.02
	All Hubs	**15**	**88**	**412.44**	**62.78**	**4.69**	**11**	**45.45**	**0.7855**	**0.65**	**2.27**	**0.28**
Fava bean	Al Haouz	7	44	2.85	98.68	0.06	10	80.00	0.4612	0.40	1.75	0.28
	Azilal	2	9	3.18	84.25	0.35	3	66.67	0.5977	0.91	1.11	0.06
	Demnate	1	1	0.01	100.00	0.01	1	100.00	0.0000	- *	1.00	0.00
	All Hubs	**10**	**54**	**6.04**	**91.10**	**0.11**	**14**	**78.57**	**0.7685**	**0.49**	**2.90**	**0.39**
Pea	Al Haouz	7	44	0.72	43.18	0.02	6	50.00	0.7303	0.97	1.05	0.02
	Azilal	4	16	7.70	34.36	0.48	4	25.00	0.5358	0.83	1.19	0.09
	All Hubs	**11**	**60**	**8.42**	**35.12**	**0.14**	**9**	**44.44**	**0.5699**	**0.52**	**2.00**	**0.27**
Alfalfa	Al Haouz	6	37	4.90	69.08	0.13	8	50.00	0.7739	0.95	1.08	0.04
	Azilal	6	26	100.47	99.98	3.86	2	50.00	0.0004	- *	1.08	0.03
	Demnate	4	23	35.42	96.44	1.54	2	50.00	0.0686	0.68	1.04	0.02
	All Hubs	**16**	**86**	**140.79**	**98.01**	**1.64**	**12**	**50.00**	**0.4317**	**0.65**	**1.81**	**0.15**

* When the community evenness and average HH evenness are close to 0, divergence results are not relevant.

Table 2 shows the number of hamlets, number of households interviewed, total area covered by crop, percent area covered only by landraces for each crop, and the diversity indicators of richness, evenness, and divergence for each target crop in the different hubs in the study. We found that the two cereals are grown on large surfaces for the households sampled, followed by the legume-forage crop. Compared to the areas that comprise hundreds of hectares, the legume crops for human consumption only cover less than 10 ha of the sampled areas, respectively. Overall, the Al Haouz hub shows higher levels of richness for all the crops except for wheat, of which one out of three varieties is a landrace and is only planted in 11% of the area sampled. It should be noted that since one of the pea varieties was found in two different sites, the total number of varieties, with all the hubs added, is not the addition of the number of varieties for each site, but the addition of the total number of distinct varieties from each site.

The farms' level of varietal diversity obtained with the average HH richness is low, at very close to 1 for all the crops, with the majority of households growing only one variety.

However, at the hub level, the variety richness shows higher results. For barley, the results show a community richness reaching as high as 4 in Al Haouz and lower in the other two hubs, but with the average household richness remaining very close or equal to 1 in all the hubs. The results for wheat show, on average, higher community richness than the barley in the three hubs, at 3 in Al Haouz and Demnate and 5 in Azilal. As with barley, the average household richness remains almost equal to 1 for durum wheat. The fava-bean community-richness results were only available for two hubs as the health situation due to the COVID-19 pandemic limited the number of households surveyed in Demnate to one. Fava beans shows the highest levels of household richness overall, with an average of 1.75 in Al Haouz, and its community richness reached 10 in Al Haouz hub and 3 in Azilal. The pea results were only available for two hubs. In the Al Haouz hub, the community richness was 6 and the average household richness was close to 1, while in Azilal, the values were 4 and almost 1.2, respectively. For alfalfa, the average household richness was very close to 1 for the three hubs, but the community richness reached 8 in Al Haouz, and it was only 2 in Azilal and Demnate.

Overall, landraces cover 88% of the area studied, although only 53% of the varieties are landraces. For barley, landraces are 56% of all the varieties and cover 96% of the area; for wheat, we found 42% of the landraces among the varieties covering 61% of the area; for fava beans, 92% of the area is planted with landraces, which comprise 73% of the total varieties; for peas, is the values are 54% of the area for 39% of the landraces, and, finally, for alfalfa, 39% of the varieties are landraces, and they cover 89% of the studied area.

A correlation analysis was conducted comparing the variety-richness indicators of the five species with an index calculated based on the characteristics of the studied sites. The indexes were attributed to each site by summing the scores for the agroecological zones, soil quality, accessibility by road, distance to the local market, size of the nearest market, economic situation, and water availability for irrigation. The scores ranked from 1 to 4, with the higher scores representing the best scenarios. The details of the scoring are available in Table S4 of the Supplementary Materials. A summary of the indexes and richness indicators for each site is available in Table S5 of the Supplementary Materials. Results of this correlation analysis are presented in Table 3.

Table 3. Pearson correlation indexes of crop-variety richness versus economic and ecological characteristics of the hubs.

	Pearson—Al Haouz	**Pearson—Azilal**	**Pearson—Demnate**
INDEX-Barley	−0.0829	−0.2608	-
INDEX-Wheat	0.6764	0.6728	0.5916
INDEX-Fava bean	−0.1745	0.2570	0.6325
INDEX-Pea	−0.0473	0.5984	-
INDEX-Alfalfa	0.5700	0.4614	0.6325
INDEX-TOT	0.1894	0.5827	0.8497

A correlation is acknowledged when indexes are close to |1|.

This statistical test did not show evidence of correlations between the socio-economic and ecological factors and the varietal diversity, except in the Demnate hub, when all the species were considered.

4. Discussion

Taking into consideration farmers' traditional knowledge, management practices, and the and sources of the seeds of the crop varieties they grow is crucial for successful conservation and development programs [95–100]. Farmers' variety naming was shown to provide information on the period of use of varieties by famers and on the flow of materials between villages [101]. In Morocco, previous research showed that the terminology given by farmers for the varietal diversity of three of the five species under consideration either underestimates the units that farmers use to manage diversity, or it both overestimates them for some varieties (in that the same variety has different names) and underestimates them for others (in that different varieties are given the same name). The first situation occurs with the cereals, barley [88,102,103] and durum wheat [88,102,104], while the second situation occurs for fava beans [88,93,102,105]. This is coherent with our findings.

The identification by farmers of their varieties is not always accurate [73,88,89,102,106–112]. The comparison of DNA analyses with farmers' assessment of sorghum, wheat, cassava, beans, and potatoes has shown very variable degrees of accuracy, sometimes with high levels of misidentification [28,89,106,110,113–116]. However, it is the named and described crop varietal units that farmers manage as named recognizable populations. Therefore, the belief of a farmer or a community that a named variety has particular properties and identity is likely to mean that they will continue to reinforce the separate identities of these named varieties through their management practices. This creates a powerful selection practice that is able to maintain the preferred traits in specific populations linked to farmers' needs (Brown and Brubaker, 2002 [117,118].

From our calculated diversity indicators, it can be seen that, on average, farmers grow only one variety of a given crop in their fields and that limited levels of community richness were found for all the crops studied. The results obtained can be explained by several factors. The choice of a limited number of varieties at the community level may be driven by economic and cultural choices; it could also be linked to the number and type of varieties available and the impact of selection and genetic improvement programs, which tend to reduce diversity [65]. In Morocco, two distinct seed systems coexist in space and time. On one hand, there is the informal seed sector, which is maintained by a seed supply resourced either from farms and the exchange between farmers, or from local weekly markets (*souks*). On the other hand, in the formal sector, seed companies (national or international, public or private) are authorized to supply certified seeds after approval. Important developments occurred during the last quarter of the 20th century, accelerating the changes in both systems. These included the dissemination of texts adapted to international legislation, the breeding through national programs of highly productive varieties, the foundation of the national company for seed trade (known as SONACOS), and the significant increase in the registration of commercial seeds, especially from private breeders in Europe, the USA, Australia, North Africa, and, to a lesser extent, national breeders, both public and private [119]. According to governmental sources (ONSSA), the commercial varieties inscribed in the official catalogue for the five species under investigation includes 62 for barley, 91 for hard wheat, 25 for fava, 90 for peas, and 116 for alfalfa, with most of the inscriptions starting in the 1980s. For fava and peas (varieties for human consumption), most of the inscriptions were developed in the 1980s, while for barley, hard wheat, and fodder peas, they arose in the 1990s and, for alfalfa, the inscriptions were developed in the 2000s and 2010s, showing the more recent interest in this species compared to the other four [120]. The registered commercial varieties are predominantly from private international breeders, especially for peas and alfalfa, while they are more balanced between private and public breeders (national and international) for cereals and fava beans [119]. Compared to these seed catalogues, our results suggest that for the most part, the terminology farmers use to name and describe diversity underestimates genotypic differences, especially for cereals and alfalfa, whose different hybrids are clustered using the same names.

Another reason for the relatively low figure for varietal richness at the farm level could be the choice of varieties that are particularly well adapted to local and climatic conditions. Landraces may offer farmers great adaptability through their innate genetic variability. Previous studies showed that barley, wheat, fava beans, and alfalfa landraces have population structures [77,88] and often embed high levels of genetic variability within their populations [38,40,49,58,70,121–124]. For fava beans in Morocco, studies have shown that farmers sometimes emphasize traits that distinguish populations within varieties rather than traits that distinguish different varieties. Landrace populations continue to evolve and adapt over time to local conditions [27,102,125–127] and can prove very competitive in low-input systems [7,9,10,128–130]. Moreover, farmers make management choices regarding diversity as a strategy to self-adapt their production systems. Farmers make selection choices in landrace populations for their preferred traits, and this leads to a self-sustaining system [77]. As demonstrated by Bonneuil et al. [131], when studying intraspecific diversity, not only does the varietal richness matter, but the within-variety diversity and the level of spatial evenness are also important. Seed samples were collected during the project and further investigations will be possible once a genomic analysis can be conducted. This analysis would allow the confirmation of the variety naming by farmers and would also allow the measurement of the internal genetic variability. The complementarity of the agro-morphological and in-the-field performance descriptions by famers and of the genetic analysis could prove very useful for future breeding activities [94,132–134].

The economic conditions, accessibility, and biotic and abiotic stresses in the different hubs may have also shaped the results, as documented in earlier studies in Morocco [102]. However, the results of this study regarding the possible correlation between varietal richness and the economic and ecological characteristics of the hubs were not significant, except for the Denmate hub, when all the target crops were taken into consideration. The Al Haouz hub showed higher levels of richness for all the crops except for wheat, which could have resulted from the orographic isolation of Al Haouz, where agriculture is mainly based on self-subsistence. The Demnate and Azilal hubs showed more production of agricultural surpluses overall, and are better connected with surrounding areas for trade. The further study of the correlation between richness of the crops and the geophysical characteristics of the sites would be valuable.

As Samberg et al. have shown, with barley in other African mountainous regions, such as Ethiopia, the distribution of the genetic diversity of numerous species can be more effectively determined by social factors, such as farmers' management and exchange systems, than by solely the biology of the crop under investigation or the physical environment [135]. Similar results were found in Nepal, where genetic variation was predominantly due to intra-population diversity within a farmer-named variety, and was independent of agroclimatic zones, variety names, and altitude [94]. In contrast, Demissie and Bjørnstad [136] and Teshome [137] found that the phenotypic traits in Ethiopian barley arid sorghum were strongly related to the altitudinal range. A similar phenomenon seems to be occurring in the Moroccan High Atlas.

As in other parts of Morocco, especially where subsistence agriculture is still practiced, local landraces' seed-exchange networks are crucial to crop supply and diversity. Nonetheless, these networks are highly vulnerable to farming unpredictability, since they are more or less easily replaced by seeds purchased from outside sources. As a result, the diversity and evolution of local landraces, along with the traditional knowledge associated with them, is significantly impoverished, if not lost. This is especially significant when, in consecutive years, the harvest is affected by detrimental biophysical factors [138].

5. Conclusions

This study deepens our knowledge of how the Amazigh perceive varietal diversity in five highly relevant species in the High Atlas, and how they are distributed geographically in an east-to-west gradient. The understanding of this diversity, and the ways in which it is perceived by farmers, is a complex, yet essential process in order to know and protect more effectively the landraces of essential crops that might be endangered and better adapted to local environmental conditions. It is also an opportunity to introduce a possible new way of addressing a research question in the field of varietal diversity in the High Atlas by including the *beldi–roumi* distinction, using ethnotaxonomy, and linking them to phenotypic and genotypic diversity.

As our research suggests, the local terminology used for variety names and the traits used to describe these varieties either overestimate or, more generally, underestimate local agrobiodiversity, with a large variation in naming both at the regional level and according to the source of information (producers vs. sellers). The systematic assessment of local knowledge remains, however, a valuable way to assess intra-specific diversity and to better understand how local communities distinguish, categorize, and value the diversity within their production systems. A comparison with the genomic analysis results for the specific use traits desired by the local communities would be the next step to support crop improvement in these communities.

The diversity indicators show that the varietal diversity is low at smaller scales, i.e., hamlets, while it increases at the larger levels, i.e., hubs. Except for the fava beans in the Al Haouz hub, the farmers usually grow only one variety of each crop at the farm level, a rather low figure. Landraces are still widely planted by farmers and cover extensive areas, while their number is similar to those of modern varieties. This is particularly true for barley and alfalfa. Genetic variability within landraces and their adaptability over time allows farmers to make management and selection choices for the sustainability of their production. Based on this research, participatory approaches could be used to better characterize landraces and support farmers in their selection of landraces to meet their needs and expectations.

The specific characteristics of each hub, including biophysical and socio-economic conditions and practices, also influence the diversity used, although these are difficult to elucidate. It is important to note that COVID-19 affected the quality of the data collection by limiting the sampling because of sanitary restrictions, with a consequent impact on the field-work timing, locations, and interactions.

The implications of this study include the considerable genetic erosion of current traditional genotypes, especially alfalfa, followed by cereals, which grow in greater areas and have been more heavily affected by national programs and seed companies, followed by peas and favas, which have much smaller surfaces of production. Maintaining and documenting local genetic resources and their associated traditional ecological knowledge (TEK) is essential for their conservation and sustainable use. The next steps will include, for the five species, the performance of a genetic analysis on the agrobiodiversity observed and described by farmers, the establishment of a better understanding of the ways in which locals classify crop diversity, and an examination of the relations between genetic units and local designations.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su151310411/s1, Table S1. Detailed biophysical and socio-economic characteristics of field sites (FGD—focus-group discussions; HHS—household surveys); Table S2. Amazigh nouns and modifiers used to describe the observed diversity of the 5 species collected in local markets, focus-group discussions, and household surveys; Table S3. Diversity-index estimates from HHS. Community richness and evenness, average HH richness and evenness, divergence, and number of households surveyed are reported for each crop at each site; Table S4. Scoring from 1 to 4 (higher score for best scenarios) of the different characteristics of sites; Table S5. Scores of each hub and varietal richness for each of the target species.

Author Contributions: Conceptualization, A.B.-F., M.A., U.D. and D.I.J.; Methodology, A.B.-F., M.A., O.S.-H., G.C., R.A.B., P.C., U.D. and D.I.J.; Validation, A.B.-F., M.A., U.D. and D.I.J.; Formal analysis, A.B.-F., G.C., P.C., U.D. and D.I.J.; Resources, M.A., O.S.-H. and R.A.B.; Data curation, G.C., P.C. and U.D.; Writing—original draft, A.B.-F., M.A. and U.D.; Writing—review & editing, A.B.-F., M.A., O.S.-H., G.C., R.A.B., P.C., U.D. and D.I.J.; Visualization, A.B.-F., M.A., G.C., P.C. and U.D.; Supervision, A.B.-F., U.D. and D.I.J.; Project administration, R.A.B., U.D. and D.I.J. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by DEFRA—UK Darwin Initiative—under the project "Conserving High Atlas agrobiodiversity to improve Amazigh livelihoods in Morocco" (grant number 27-001), with support from The Raffaella Foundation. The development of the DATAR web portal and app was supported by the Global Environmental Facility (GEF)—International Fund for Agricultural Development (IFAD), and the United National Environmental Program (UNEP): Cross-cutting capacity building, knowledge services and coordination project for the Food Security Integrated Approach Pilot Program—GEF project 9140.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data are available from the senior author on reasonable request.

Acknowledgments: We would like to acknowledge the local communities and authorities for their collaboration, the local community researchers for their support in the field operations, the GDF and MBLA teams, Sapienza University, and the Alliance of Bioversity International and CIAT for their administrative and technical support, Fabio Attorre, Fatima Ezzhara, and Elisabetta Rossetti, for their intellectual support, and the anonymous reviewers for their careful evaluation of our manuscript and their insightful comments and suggestions.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

References

1. Mulumba, J.W.; Nankya, R.; Adokorach, J.; Kiwuka, C.; Fadda, C.; de Santis, P.; Jarvis, D.I. A risk-minimizing argument for traditional crop varietal diversity use to reduce pest and disease damage in agricultural ecosystems of Uganda. *Agric. Ecosyst. Environ.* **2012**, *157*, 70–86. [CrossRef]
2. Jarvis, D.I.; Hodgkin, T.; Sthapit, B.R.; Fadda, C.; Lopez-Noriega, I. An Heuristic Framework for Identifying Multiple Ways of Supporting the Conservation and Use of Traditional Crop Varieties within the Agricultural Production System. *Crit. Rev. Plant Sci.* **2011**, *30*, 125–176. [CrossRef]
3. Sawadogo, M.; Ouedraogo, J.; Belem, M.; Balma, D.; Dossou, B.; Jarvis, D.I. Components of the ecosystem as instruments of cultural practices in the in situ conservation of agricultural biodiversity. *Plant Genet. Resour. Newsl.* **2005**, *141*, 19–25.
4. Bhandari, B. Summer Rainfall Variability and the Use of Rice (*Oryza sativa* L.) Varietal Diversity for Adaptation: Farmers' Perceptions and Responses in Nepal. Master's Thesis, CBM Swedish Biodiversity Centre, Uppasala, Sweden, 2009.
5. Thurston, H.D.; Salick, J.; Smith, M.E.; Trutmann, P.; Pham, J.L.; McDowell, R. Traditional management of agrobiodiversity. In *Agrobiodiversity. Characterization, Utilization and Management*; Wood, D., Lenn´e, J.M., Eds.; CABI Publishing: Wallingford, UK, 1999; pp. 211–243.
6. Zhu, Y.; Chen, H.; Fan, J.; Wang, Y.; Li, Y.; Chen, J.; Fan, J.X.; Yang, S.; Hu, L.; Leung, H.; et al. Genetic diversity and disease control in rice. *Nature* **2000**, *406*, 718–722. [CrossRef] [PubMed]
7. Trutmann, P.; Voss, J.; Fairhead, J. Indigenous knowledge and farmer perception of common bean disease in the central African highlands. *Agric. Hum. Values* **1996**, *13*, 64–70. [CrossRef]
8. Finckh, M.R. Ecological benefits of diversification. In *Rice Science: Innovations and Impact for Livelihood*; Mew, T.W., Brar, D., Peng, S., Dawe, D., Hardy, B., Eds.; International Rice Research Institute: Los Baños, Philippines, 2003; pp. 549–564.
9. Barry, M.B.; Pham, J.L.; Noyer, J.L.; Courtois, B.; Billot, C.; Ahmadi, N. Implications for in situ genetic resource conservation from the ecogeographical distribution of rice genetic diversity in Maritime Guinea. *Plant Genet. Resour.* **2007**, *5*, 45–54. [CrossRef]
10. Bisht, I.S.; Mehta, P.S.; Bhandari, D.C. Traditional crop diversity and its conservation on-farm for sustainable agricultural production in Kumaon Himalaya of Uttaranchal state: A case study. *Genet. Resour. Crop Evol.* **2007**, *54*, 345–357. [CrossRef]
11. Duc, G.; Bao, S.; Baum, M.; Redden, B.; Sadiki, M.; Suso, M.J.; Vishniakova, M.; Zong, X. Diversity maintenance and use of *Vicia faba* L. genetic resources. *Field Crop. Res.* **2010**, *115*, 270–278. [CrossRef]
12. Food and Agriculture Organization (FAO). *Coping with Climate Change—The Roles of Genetic Resources for Food and Agriculture*; FAO: Rome, Italy, 2015.
13. Platform for Agrobiodiversity Research (PAR). *The Use of Agrobiodiversity by Indigenous and Traditional Agricultural Communities in: Adapting to Climate Change*; Synthesis paper; PAR, Bioversity International: Rome, Italy, 2010.
14. Bezancon, G.; Pham, J.L.; Deu, M.; Vigouroux, Y.; Sagnard, F.; Mariac, C.; Kapran, I.; Mamadou, A.; G´erard, B.; Ndjeunga, J.; et al. Changes in the diversity and geographic distribution of cultivated millet (*Pennisetum glaucum* (L.) R. Br.) and sorghum (*Sorghum bicolor* (L.) Moench) varieties in Niger between 1976 and 2003. *Genet. Resour. Crop. Evol.* **2009**, *56*, 223–236. [CrossRef]
15. Frison, E.A.; Cherfas, J.; Hodgkin, T. Agricultural Biodiversity Is Essential for a Sustainable Improvement in Food and Nutrition Security. *Sustainability* **2011**, *3*, 238–253. [CrossRef]
16. Food and Agriculture Organization (FAO). *The Second Report on the State of the World's Plant Genetic Resources for Food and Agriculture*; FAO: Rome, Italy, 2010; ISBN 978-92-5-106534-1.
17. Hajjar, R.; Jarvis, D.I.; Gemmill-Herren, B. The Utility of Crop Genetic Diversity in Maintaining Ecosystem Services. *Agric. Ecosyst. Environ.* **2008**, *123*, 261–270. [CrossRef]
18. Frankel, O.H.; Brown, A.H.D.; Burdon, J.J. *The Conservation of Plant Biodiversity*; Cambridge University Press: Cambridge, UK, 1995; 299p.
19. Thomas, M.; Dawson, J.C.; Goldringer, I.; Bonneuil, C. Seed exchanges, a key to analyze crop diversity dynamics in farmer-led on-farm conservation. *Genet. Resour. Crop Evol.* **2011**, *58*, 321–338. [CrossRef]
20. Jarvis, D.I.; Hodgkin, T.; Brown, A.H.D.; Tuxill, J.; Lopez Noriega, I.; Smale, M.; Sthapit, B. *Crop Genetic Diversity in the Field and on the Farm*; Principles and Applications in Research Practices; Yale University Press: New Haven, CT, USA, 2016.

21. Sthapit, B.; Gauchan, D.; Sthapit, S.; Ghimire, K.H.; Joshi, B.K.; De Santis, P.; Jarvis, D.I. Sourcing and Deploying New Crop Varieties in Mountain Production Systems. In *Farmers and Plant Breeding: Current Approaches and Perspectives*; Taylor and Francis: Abingdon, VA, USA, 2019; pp. 196–216. ISBN 9780429507335.
22. Hunter, D.; Fanzo, J. Agricultural biodiversity, diverse diets and improving nutrition. In *Diversifying Food and Diets: Using Agricultural Biodiversity to Improve Nutrition and Health*; Fanzo, J., Hunter, D., Borelli, T., Mattei, F., Eds.; Earthscan by Routledge: Abingdon, UK, 2013; pp. 1–13.
23. Hunter, D.; Guarino, L.; Spillane, C.; McKeown, P.C. (Eds.) *Routledge Handbook of Agricultural Biodiversity*, 1st ed.; Routledge: Abingdon, VA, USA, 2017.
24. Aguilar-Støen, M.; Moe, S.R.; Camargo-Ricalde, S.L. Home gardens sustain crop diversity and improve farm resilience in Candelaria Loxicha, Oaxaca, Mexico. *J. Hum. Ecol.* **2009**, *37*, 55–77. [CrossRef]
25. Johns, T.; Sthapit, B.R. Biocultural diversity in the sustainability of developing country food systems. *Food Nutr. Bull.* **2004**, *25*, 143–155. [CrossRef]
26. Bellon, M.R.; Pham, J.L.; Jackson, M.T. Genetic conservation: A role for rice farmers. In *Plant Conservation: The In Situ Approach*; Hawkes, J.G., Ed.; Chapman & Hall: London, UK, 1997.
27. Brush, S.B. *Farmers' Bounty: Locating Crop Diversity in the Contemporary World*; Yale University Press: New Haven, CT, USA, 2004.
28. Brush, S.; Kesselli, R.; Ortega, R.; Cisneros, P.; Zimmerer, K.; Quiros, C. Potato diversity in the Andean center of crop domestication. *Conserv. Biol.* **1995**, *9*, 1189–1198. [CrossRef]
29. Jarvis, D.I.; Zoes, V.; Nares, D.; Hodgkin, T. On-farm management of crop genetic diversity and the convention on biological diversity's programme of work on agricultural biodiversity. *Plant Genet. Resour. Newsl.* **2004**, *138*, 5–17.
30. Guzman, F.A.; Ayala, H.; Azurdia, C.; Duque, M.C.; Vicente, M.C. AFLP assessment of genetic diversity of Capsicum genetic resources in Guatemala: Home gardens as an option for conservation. *Crop. Sci.* **2005**, *45*, 363–370. [CrossRef]
31. Jarvis, D.I.; Fadda, C.; de Santis, P.; Thompson, J. (Eds.) Damage, Diversity and Genetic Vulnerability: The Role of Crop Genetic Diversity in the Agricultural Production System to Reduce Pest and Disease Damage. In Proceedings of the International Symposium, Rabat, Morocco, 15–17 February 2011; Bioversity International: Rome, Italy, 2011; p. 349.
32. Sadiki Arbaoui, M.; Ghaouti, L.; Jarvis, D.I. Seed Exchange and Supply Systems and On-Farm Maintenance of Crop Genetic Diversity. In Proceedings of the Seed systems and crop genetic diversity on-farm, Proceedings of a Workshop, Pucallpa, Peru, 16–20 September 2003; Jarvis, D.I., Sevilla-Panizo, R., Chávez-Servia, J.L., Hodgkin, T., Eds.; IPGRI: Rome, Italy, 2003; pp. 83–87.
33. Chentoufi, L.; Sahri, A.; Arbaoui, M.; Belqadi, L.; Birouk, A.; Roumet, P.; Muller, M.H. Anchoring Durum Wheat Diversity in the Reality of Traditional Agricultural Systems: Varieties, Seed Management, and Farmers' Perception in Two Moroccan Regions. *J. Ethnobiol. Ethnomed* **2014**, *10*, 1–16. [CrossRef]
34. Sahri, A.; Chentoufi, L.; Arbaoui, M.; Ardisson, M.; Belqadi, L.; Birouk, A.; Roumet, P.; Muller, M.H. Towards a Comprehensive Characterization of Durum Wheat Landraces in Moroccan Traditional Agrosystems: Analysing Genetic Diversity in the Light of Geography, Farmers' Taxonomy and Tetraploid Wheat Domestication History. *BMC Evol. Biol.* **2014**, *14*, 264. [CrossRef]
35. Zarkti, H.; Ouabbou, H.; Udupa, S.M.; Gaboun, F.; Hilali, A. Agro-Morphological Variability in Durum Wheat Landraces of Morocco. *Aust. J. Crop. Sci.* **2012**, *6*, 1172–1178.
36. Ouafi, L.; Alane, F.; Rahal-Bouziane, H.; Abdelguerfi, A. Agro-Morphological Diversity within Field Pea (*Pisum sativum* L.) Genotypes. *Afr. J. Agric. Res.* **2016**, *11*, 4039–4047. [CrossRef]
37. Crawford, D. Ethnography and Demography: Moroccan Households and Cultural Change. *Hesperis Tamuda* **2020**, *55*, 469–491.
38. Orabi, J.; Jahoor, A.; Backes, G. Genetic diversity and population structure of wild and cultivated barley from West Asia and North Africa. *Plant Breed.* **2009**, *128*, 606–614. [CrossRef]
39. Bajracharya, J.; Brown, A.H.D.; Joshi, B.K.; Panday, D.; Baniya, B.K.; Sthapit, B.R.; Jarvis, D.I. Traditional seed management and genetic diversity in barley varieties in high-hill agro-ecosystems of Nepal. *Genet. Resour. Crop. Evol.* **2011**, *59*, 389–398. [CrossRef]
40. Pasam, R.K.; Sharma, R.; Walther, A.; Özkan, H.; Graner, A.; Kilian, B. Genetic Diversity and Population Structure in a Legacy Collection of Spring Barley Landraces Adapted to a Wide Range of Climates. *PLoS ONE* **2014**, *9*, e116164. [CrossRef] [PubMed]
41. Swanston, J.S.; Newton, A.C. Mixtures of UK wheat as an efficient and environmentally friendly source for bioethanol. *J. Ind. Ecol.* **2005**, *9*, 109–126. [CrossRef]
42. Reynolds, M.; Dreccer, F.; Trethowan, R. Drought-adaptive traits derived from wheat wild relatives and landraces. *J. Exp. Bot.* **2007**, *58*, 177–186. [CrossRef]
43. Finckh, M.R. Stripe rust, yield, and plant competition in wheat cultivar mixtures. *Phytopathology* **1992**, *82*, 905–913. [CrossRef]
44. Reif, J.; Zhang, P.; Dreisigacker, S. Wheat genetic diversity trends during domestication and breeding. *Appl. Genet.* **2005**, *110*, 859–864. [CrossRef]
45. van Frank, G.; Rivière, P.; Pin, S.; Baltassat, R.; Berthellot, J.-F.; Caizergues, F.; Dalmasso, C.; Gascuel, J.-S.; Hyacinthe, A.; Mercier, F.; et al. Genetic Diversity and Stability of Performance of Wheat Population Varieties Developed by Participatory Breeding. *Sustainability* **2020**, *12*, 384. [CrossRef]
46. Raman, H.; Stodart, B.J.; Cavanagh, C.; Mackay, M.; Morell, M.; Milgate, A.; Martin, P.; Raman, H.; Stodart, B.J.; Cavanagh, C.; et al. Molecular diversity and genetic structure of modern and traditional landrace cultivars of wheat (*Triticum aestivum* L.). *Crop. Pasture Sci.* **2010**, *61*, 222–229. [CrossRef]
47. Basheer-Salimia, R.; Shtaya, M.; Awad, M.; Abdallah, J.; Hamdan, Y. Genetic diversity of Palestine landraces of faba bean (*Vicia faba*) based on RAPD markers. *Genet. Mol. Res.* **2013**, *12*, 3314–3323. [CrossRef]

48. Kehel, Z.; Garcia-Ferrer, A.; Nachit, M.M. Using Bayesian and Eigen approaches to study spatial genetic structure of Moroccan and Syrian durum wheat landraces. *Am. J. Mol. Biol.* **2013**, *3*, 17–31. [CrossRef]
49. Terzopoulos, P.J.; Bebeli, P.J. Genetic diversity analysis of Mediterranean faba bean (*Vicia faba* L.) with ISSR markers. *Field Crop. Res.* **2008**, *108*, 39–44. [CrossRef]
50. Göl, Ş.; Doğanlar, S.; Frary, A. Relationship between geographical origin, seed size and genetic diversity in faba bean (*Vicia faba* L.) as revealed by SSR markers. *Mol. Genet. Genom.* **2017**, *292*, 991–999. [CrossRef] [PubMed]
51. Ghafoor, A.; Ahmad, Z.; Ahmad, Z. Genetic diversity in *Pisum sativum* and a strategy for indigenous biodiversity conservation. *Pak. J. Bot.* **2005**, *37*, 71–77.
52. Cupic, T.; Tucak, M.; Popovic, S.; Bolaric, S.; Grljusic, S.; Kozumplik, V. Genetic diversity of pea (*Pisum sativum* L.) genotypes assessed by pedigree, morphological and molecular data. *J. Food Agric. Environ.* **2009**, *7*, 343–348.
53. Gixhari, B.; Pavelková, M.; Ismaili, H.; Vrapi, H.; Jaupi, A.; Smýkal, P. Genetic diversity of Albanian pea (*Pisum sativum* L.) landraces assessed by morphological traits and molecular markers. *Czech. J. Genet. Plant* **2014**, *50*, 177–184. [CrossRef]
54. Javaid, A.; Ghafoor, A.; Rabbani, M.A. Analysis of genetic diversity among local and exotic *Pisum sativum* genotypes through RAPD and SSR markers. *Pak. J. Bot.* **2022**, *54*, 903–909. [CrossRef] [PubMed]
55. Touil, L.; Guesmi, F.; Fares, K.; Zagrouba, C.; Ferchichi, A. Genetic diversity of some Mediterranean populations of the cultivated alfalfa (*Medicago sativa* L.) using SSR markers. *Pak. J. Biol. Sci.* **2008**, *11*, 1923–1928. [CrossRef]
56. Benabderrahim, M.A.; Hamza, H.; Mansour, H.; Ferchichi, A. A comparison of performance among exotic and local alfalfa (*Medicago sativa* L.) ecotypes under Tunisian conditions. *Rom. Agric. Res.* **2015**, *32*, 43–51.
57. Bouizgaren, A.; Farissi, M.; Ghoulam, C.; Kallida, R.; Faghire, M.; Barakate, M.; al Feddy, M.N. Assessment of summer drought tolerance variability in Mediterranean alfalfa (*Medicago sativa* L.) cultivars under Moroccan fields conditions. *Arch. Acker Pfl. Boden.* **2013**, *59*, 147–160. [CrossRef]
58. Prosperi, J.M.; Jenczewski, E.; Muller, M.H.; Fourtier, S.; Sampoux, J.P.; Ronfort, J. Alfalfa domestication history, genetic diversity and genetic resources. *Legume Perspect.* **2014**, *4*, 13–14.
59. Bouizgaren, A.; Birouk, A.; Kerfal, S.; Hmama, H.; Jarvis, D. *On-farm Conservation of Alfalfa Farmer's Units of Diversity (FUD) in Morocco*; International Symposium on Managing Biodiversity in Agricultural Ecosystems: Montreal, QC, Canada, 2011.
60. Noeparvar, S.; Valizadeh, M.; Monirifar, H.; Haghighi, A.; Darbani, B. Genetic diversity among and within alfalfa populations native to Azerbaijan based on RAPD analysis. *J. Biol. Res.-Thessal.* **2008**, *10*, 159–169.
61. Al-Farsi, S.M.; Nadaf, S.K.; Al-Sadi, A.M.; Ullah, A.; Farooq, M. Evaluation of indigenous Omani alfalfa landraces for morphology and forage yield under different levels of salt stress. *Physiol. Mol. Biol. Plants* **2020**, *26*, 1763–1772. [CrossRef]
62. IAASTD. Agriculture at a Crossroads. In *International Assessment of Agricultural Knowledge, Science and Technology for Development*; McIntyre, B.D., Herren, H.R., Wakhungu, J., Watson, R.T., Eds.; Island Press: Washington, DC, USA, 2009.
63. Keleman, A.; Garcia Rano, H.; Hellin, J. Maize diversity, poverty, and market access: Lessons from Mexico. *Dev. Pract.* **2009**, *19*, 187–199. [CrossRef]
64. Kontoleon, A.; Pascual, U.; Smale, M. Introduction: Agrobiodiversity for economic development: What do we know? Agrobiodiversity conservation and economic development. In *Environmental Economics*; Kontoleon, A., Pascual, U., Smale, M., Eds.; Routledge: Oxfordshire, UK, 2009; pp. 1–24.
65. Walters, S.A.; Bouharroud, R.; Mimouni, A.; Wifaya, A. The Deterioration of Morocco's Vegetable Crop Genetic Diversity: An Analysis of the Souss-Massa Region. *Agriculture* **2018**, *8*, 49. [CrossRef]
66. Henkrar, F.; El-Haddoury, J.; Ouabbou, H.; Nsarellah, N.; Iraqi, D.; Bendaou, N.; Udupa, S.M. Genetic Diversity Reduction in Improved Durum Wheat Cultivars of Morocco as Revealed by Microsatellite Markers. *Sci. Agric.* **2016**, *73*, 134–141. [CrossRef]
67. Kesavan, P.C.; Swaminathan, M.S. Strategies and models for agricultural sustainability in developing Asian countries. *Philos. Trans. R. Soc. B Biol. Sci.* **2008**, *363*, 877–891. [CrossRef]
68. De Boef, W.S.; Dempewolf, H.; Byakwell, J.M.; Engles, J.M.M. Integrating genetic resource conservation and sustainable development into strategies to increase the robustness of seed systems. *J. Sustain. Agric.* **2010**, *34*, 1–28. [CrossRef]
69. Oude, L.A.; Carpentier, A. Damage Control Productivity: An input damage abatement approach. *J. Agric. Econ.* **2001**, *52*, 11–22.
70. Bouizgaren, A.; Birouk, A.; Kerfal, S.; Hmama, H.; Jarvis, D. Conservation in Situ de La Biodiversité Des Populations Noyaux de Luzerne Locale Au Maroc. In *La conservation In Situ de la Biodiversité Agricole: Un Défi Pour une Agriculture Durable*; IPGRI: Rome, Italy, 2002.
71. Chentoufi, L.; Sahri, A.; Roumet, P.; Muller, M.H. Diversité Agro-Morphologique et Gestion Variétale Par Les Agriculteurs Du Blé Dur (*Triticum turgidum* ssp. *durum) Dans Le Pré-Rif Marocain. Rev. Maroc. Des Sci. Agron. Et Vétérinaires* **2014**, *2*, 30–38.
72. FAO GIEWS. *Country Brief Morocco—Global Information and Early Warning System on Food and Agriculture*; FAO: Rome, Italy, 2022.
73. Sadiki, M.; Belqadi, L.; Mahdi, M.; Jarvis, D. Diversity of Farmer-Named Faba Bean (*Vicia faba* L.) Varieties in Morocco: A Scientific Basis for in Situ Conservation on-Farm in Local Ecosystems. In Proceedings of the CBD-IPGRI International Symposium on Managing Biodiversity in Agricultural Ecosystems, Montreal, QC, Canada, 8–10 November 2001.
74. Hmimsa, Y.; Aumeeruddy-Thomas, Y.; Ater, M. Vernacular Taxonomy, Classification and Varietal Diversity of Fig (*Ficus carica* L.) among Jbala Cultivators in Northern Morocco. *Hum. Ecol.* **2012**, *40*, 301–313. [CrossRef]
75. Masski, H.; Ait Hammou, A. Fish Names Variability Traces the Geo-Historical Dynamics of Moroccan Fishermen Communities. *J. Ecol. Anthropol.* **2016**, *18*, 8. [CrossRef]
76. Martin, G.J. *Ethnobotany: A Methods Manual, 2nd edition*; Routledge: Abingdon, USA, 2004; 292p.

77. Jarvis, D.I.; Brown, A.H.D.; Cuong, P.H.; Collado-Panduro, L.; Latournerie-Moreno, L.; Gyawali, S.; Tanto, T.; Sawadogo, M.; Mar, I.; Sadiki, M.; et al. A global perspective of the richness and evenness of traditional crop-variety diversity maintained by farming communities. *Proc. Natl. Acad. Sci. USA* **2008**, *105*, 5326–5331. [CrossRef]
78. Global Diversity Foundation (GDF). *GIS-Based Analysis of the Agdals of Igourdane (Ait Mhammed) and Oukaimeden (Oukaimeden) in the Moroccan High Atlas*; Internal Report; Global Diversity Foundation: Canterbury, UK, 2021.
79. BirdLife International. *Mediterranean Basin Biodiversity Hotspot: Ecosystem Profile*; Critical Ecosystem Partnership Fund: Arlington, VA, USA, 2017; 339p.
80. Beck, H.E.; Zimmermann, N.E.; McVicar, T.R.; Vergopolan, N.; Berg, A.; Wood, E.F. Present and Future Köppen-Geiger Climate Classification Maps at 1-Km Resolution. *Sci. Data* **2018**, *5*, 180214. [CrossRef]
81. Fischer, G.; Nachtergaele, F.O.; van Velthuizen, H.T.; Chiozza, F.; Franceschini, G.; Henry, M.; Muchoney, D.; Tramberend, S. *Global Agro-Ecological Zone V4—Model Documentation*; FAO: Rome, Italy, 2021; ISBN 978-92-5-134426-2.
82. Jarvis, D.I.; Campilan, D.M. *Crop Genetic Diversity to Reduce Pests and Diseases On-Farm: Participatory Diagnosis Guidelines. Version I*; Bioversity Technical Bulletin n.12; Bioversity International: Rome, Italy, 2006; p. 101.
83. Barahona, C.; Levy, S. *How to Generate Statistics and Influence Policy Using Participatory Methods in Research: Reflections on Work in Malawi 1999–2002*; Working Paper 212; IDS: Brighton, UK, 2003.
84. Chambers, R. *Relaxed and Participatory Appraisal: Notes on Practical Approaches and Methods for Participants in PRA/PLA-related Familiarization Workshops*; IDS Participation Group: Brighton, UK, 2002.
85. Lope, D. Gender Relations as a Basis for Varietal Selection in Production Spaces in Yucatan, Mexico. Master's Thesis, Wageningen University, Wageningen, The Netherlands, 2004.
86. Eyzaguirre, P.B.; Linares, O.F. (Eds.) *Home Gardens and Agrobiodiversity*; Smithsonian Books: Washington, DC, USA, 2004; 296p, ISBN 158834-112-7.
87. Jarvis, D.I.; Fonteneau, A.; Nankya, R.; Turdieva, M.K.; Gauchan, D.; Tempelmann, K.; López Noriega, I. Diversity assessment tool for agrobiodiversity and resilience (DATAR)-Integrate intra-specific diversity of crop, livestock and aquatic resources in to agricultural development decision making. In Proceedings of the International Scientific and Practical Conference «Innovation in Use of Agrobiodiversity for Sustainable Agriculture Development», Tashkent, Uzbekistan, 25–26 September 2019.
88. Sadiki, M.; Jarvis, D.; Rijal, D.; Bajracharya, J.; Hue, N.N.; Camacho, T.C.; Burgos-May, L.A.; Sawadogo, M.; Balma, D.; Lope, D.; et al. Variety names: An entry point to crop genetic diversity and distribution in agroecosystems? In *Managing Biodiversity in Agricultural Ecosystems*; Jarvis, D.I., Padoch, C., Cooper, D., Eds.; Columbia University Press: New York, NY, USA, 2007; pp. 34–76.
89. Quiros, C.F.; Brush, S.B.; Douches, D.S.; Zimmerer, K.S.; Huestis, G. Biochemical and folk assessment of variability of Andean cultivated potatoes. *Econ. Bot.* **1990**, *44*, 254–266. [CrossRef]
90. Múrcia, C.; Zenia, S. *Diccionari Català-Amazic/Amazic-Català*; Llibres de l'Índex: Barcelona, Spain, 2016; ISBN 9788494491108.
91. Jabiot, I. "Beldi-Roumi": Hétérogénéité d'une Qualification Ordinaire. *Les Études Essais Du Cent. Jacques Berque* **2015**, *25*, 3–15.
92. Zirari, H. Entre alimentation (*makla*) et nutrition (*taghdia*): Arbitrages et réinvention au quotidien des pratiques alimentaires en contexte urbain. *Hesperis Tamuda* **2020**, *LV*, 385–407.
93. Belqadi, L. Diversité et Ressources Génétiques de *Vicia faba* L. Au Maroc: Variabilité, Conservation Ex Situ et in Situ et Valorisation. Ph.D. Thesis, Institut Agronomique et Vétérinaire Hassan II, Rabat, Morocco, 2003.
94. Bajracharya, J.; Rana, R.B.; Gauchan, D.; Sthapit, B.R.; Jarvis, D.I.; Witcombe, J.R. Rice landrace diversity in Nepal. Socio-economic and ecological factors determining rice landrace diversity in three agro-ecozones of Nepal based on farm surveys. *Genet. Resour. Crop. Evol.* **2010**, *57*, 1013–1022. [CrossRef]
95. Nugroho, H.Y.S.H.; Sallata, M.K.; Allo, M.K.; Wahyuningrum, N.; Supangat, A.B.; Setiawan, O.; Njurumana, G.N.; Isnan, W.; Auliyani, D.; Ansari, F.; et al. Incorporating Traditional Knowledge into Science-Based Sociotechnical Measures in Upper Watershed Management: Theoretical Framework, Existing Practices and the Way Forward. *Sustainability* **2023**, *15*, 3502. [CrossRef]
96. Liu, Y.; Ren, X.; Lu, F. Research Status and Trends of Agrobiodiversity and Traditional Knowledge Based on Bibliometric Analysis (1992–Mid-2022). *Diversity* **2022**, *14*, 950. [CrossRef]
97. Peano, C.; Caron, S.; Mahfoudhi, M.; Zammel, K.; Zaidi, H.; Sottile, F. A Participatory Agrobiodiversity Conservation Approach in the Oases: Community Actions for the Promotion of Sustainable Development in Fragile Areas. *Diversity* **2021**, *13*, 253. [CrossRef]
98. Molnár, Z.; Babai, D. Inviting Ecologists to Delve Deeper into Traditional Ecological Knowledge. *Trends Ecol. Evol.* **2021**, *36*, 679–690. [CrossRef]
99. Vigouroux, Y.; Barnaud, A.; Scarcelli, N.; Thuillet, A.C. Biodiversity, adaptation, and evolution of cultivated crops. *CR Biol.* **2011**, *334*, 450–457. [CrossRef]
100. Chakanda, R.; van Treuren, R.; Visser, B.; Berg, R.V.D. Analysis of genetic diversity in farmers' rice varieties in Sierra Leone using morphological and AFLP®markers. *Genet. Resour. Crop. Evol.* **2012**, *60*, 1237–1250. [CrossRef]
101. Nuijten, E.; Almekinders, C.J.M. Mechanisms Explaining Variety Naming by Farmers and Name Consistency of Rice Varieties in The Gambia. *Econ. Bot.* **2008**, *62*, 148–160. [CrossRef]
102. Sadiki, M.; Birouk, A.; Bouizgaren, A.; Belqadi, L.; Rh'rrib, K.; Taghouti, M.; Kerfal, S.; Lahbhili, M.; Bouhya, H.; Douiden, R.; et al. La Diversité Génétique in Situ Du Blé Dur, de l'orge, de La Luzerne et de La Fève: Options de Stratégie Pour Sa Conservation. In *La Conservation In Situ de la Biodiversité Agricole: Un Défi Pour une Agriculture Durable*; Birouk, A., Sadiki, M., Nassif, F., Saidi, S., Mellas, H., Bammoune, A., Jarvis, D., Eds.; IPGRI: Rome, Italy, 2002; pp. 37–117.

103. Rh'rib, K.; Amri, A.; Sadiki, M. Caracterisation Agro Morphologique Des Populations Locales d'orge Des Sutes Tanant et Taounate. In *La Conservation In Situ de la Biodiversité Agricole: Un Défi Pour une Agriculture Durable*; Birouk, A., Sadiki, M., Nassif, F., Saidi, S., Mellas, H., Bammoune, A., Jarvis, D., Eds.; IPGRI: Rome, Italy, 2002; pp. 286–294.
104. Taghouti, M.; Saidi, S. Perception et Désignation Des Entités de Blé Dur Gérées Par Les Agriculteurs. In *La Conservation In Situ de la Biodiversité Agricole: Un Défi Pour une Agriculture Durable*; Birouk, A., Sadiki, M., Nassif, F., Saidi, S., Mellas, H., Bammoune, A., Jarvis, D., Eds.; IPGRI: Rome, Italy, 2002; pp. 275–279.
105. Benchekchou, Z. Analyse de La Structure de La Diversité Génétique de La Fève in Situ En Relation Avec Sa Gestion à La Ferme: Contribution Au Développement Des Bases Scientifiques Pour La Conservation in Situ de La Fève Au Maroc. In *Mémoire de 3ème Cycle du Diplôme D'ingénieur D'état en Agronomie*; Institut Agronomique et Vétérinaire Hassan II: Rabat, Morocco, 2004.
106. Sagnard, F.; Barnaud, A.; Deu, M.; Barro, C.; Luce, C.; Billot, C.; Rami, J.F.; Bouchet, S.; Dembele, D.; Pomies, V.; et al. Multi-scale analysis of sorghum genetic diversity: Understanding the evolutionary processes for in situ conservation. (Special issue: Agrobiodiversites). *Cah. Agric.* **2008**, *17*, 114–121.
107. Chakauya, E.; Tongoona, P.; Matibiri, E.A.; Grum, M. Genetic diversity assessment of sorghum landraces in Zimbabwe usingmicrosatellites and indigenous local names. *Int. J. Bot.* **2006**, *2*, 29–35. [CrossRef]
108. Kizito, E.B.; Chiwona-Karltun, L.; Egwang, T.; Fregene, M.; Westerbergh, A. Genetic diversity and variety composition of cassava on small scale farms in Uganda: An interdisciplinary study using genetic markers and farmer interviews. *Genetica* **2007**, *130*, 301–318. [CrossRef]
109. Mujaju, C.; Chakauya, E. Morphological variation of sorghum landrace accessions on-farm in semi-arid areas of Zimbabwe. ANSInet, Asian Network for Scientific Information, Faisalabad, Pakistan. *Int. J. Bot.* **2008**, *4*, 376–382. [CrossRef]
110. Boster, J.S. Selection for Perceptual Distinctiveness: Evidence from Aguaruna cultivars of *Manihot esculenta*. *Econ. Bot.* **1985**, *39*, 310–325. [CrossRef]
111. Busso, C.S.; Devos, K.M.; Ross, G.; Mortimore, M.; Adams, W.M.; Ambrose, M.J.; Alldrick, S.; Gale, M.D. Genetic diversity within and among landraces of pearl millet (*Pennisetum glaucum*) under farmer management in West Africa. *Genet. Resour. Crop Evol.* **2000**, *47*, 561–568. [CrossRef]
112. Soleri, D.; Cleveland, D.A. Farmers' genetic perceptions regarding their crop populations: An example with maize in the central valleys of Oaxaca, Mexico. *Econ. Bot.* **2001**, *55*, 106–128. [CrossRef]
113. Zimmerer, K.S.; Douches, D.S. Geographical approaches to native crop research and conservation: The partitioning of allelic diversity in Andean potatoes. *Econ. Bot.* **1991**, *45*, 176–189. [CrossRef]
114. Jaleta, M.; Tesfaye, K.; Kilian, A.; Yirga, C.; Habte, E.; Beyene, H.; Abeyo, B.; Badebo, A.; Erenstein, O. Misidentification by farmers of the crop varieties they grow: Lessons from DNA fingerprinting of wheat in Ethiopia. *PLoS ONE* **2020**, *15*, e0235484. [CrossRef] [PubMed]
115. Maredia, M.K.; Reyes, B.A.; Manu-Aduening, J.; Dankyi, A.; Hamazakaza, P.; Muimui, K.; Rabbi, I.Y.; Kulakow, P.A.; Parkes, E.; Abdoulaye, T.; et al. *Testing Alternative Methods of Varietal Identification Using DNA Fingerprinting: Results of Pilot Studies in Ghana and Zambia*; (No. 1096-2016-88478); Michigan State University: East Lansing, MI, USA, 2016.
116. Salick, J.; Cellinese, N.; Knapp, S. Indigenous diversity of Cassava: Generation, maintenance, use and loss among the Amuesha, Peruvian upper Amazon. *Econ. Bot.* **1997**, *51*, 6–19. [CrossRef]
117. Casañas, F.; Simó, J.; Casals, J.; Prohens, J. Toward an Evolved Concept of Landrace. *Front. Plant Sci.* **2017**, *8*, 145. [CrossRef]
118. Brown, A.H.D.; Brubaker, C. Indicators for sustainable management of plant genetic resources: How well are we doing. In *Managing Plant Genetic Diversity*; Engles, J.M.M., Rao, V.R., Brown, A.H.D., Jackson, M.T., Eds.; International Plant Genetic Resources Institute: Rome, Italy; CABI Publishing: Wallingford, UK, 2002; pp. 249–262.
119. Tahiri, A. Seed Systems in Morocco. In Proceedings of the Seed Systems and Crop Genetic Diversity On-Farm, Pucallpa, Peru, 16–20 September 2003; Jarvis, D., Sevilla-Panizo, R., Chávez-Servia, J.L., Hodgkin, T., Eds.; IPGRI: Rome, Italy, 2005.
120. ONSSA (Office National de Sécurité Sanitaire des Produits Alimentaires). Homologation of Varieties. Available online: https://www.onssa.gov.ma/seed-and-seedlinds/varietys-homologation/?lang=en (accessed on 6 April 2023).
121. Oliveira, H.R.; Campana, M.G.; Jones, H.; Hunt, H.V.; Leigh, F.; Redhouse, D.I.; Lister, D.L.; Jones, M.K. Tetraploid Wheat Landraces in the Mediterranean Basin: Taxonomy, Evolution and Genetic Diversity. *PLoS ONE* **2012**, *7*, e37063. [CrossRef]
122. Hadado, T.T.; Rau, D.; Bitocchi, E.; Papa, R. Genetic Diversity of Barley (*Hordeum vulgare* L.) Landraces from the Central Highlands of Ethiopia: Comparison between the Belg and Meher Growing Seasons Using Morphological Traits. *Genet. Resour. Crop. Evol.* **2009**, *56*, 1131–1148. [CrossRef]
123. Rhouma, H.B.; Taski-Ajdukovic, K.; Zitouna, N.; Sdouga, D.; Milic, D.; Trifi-Farah, N. Assessment of the Genetic Variation in Alfalfa Genotypes Using SRAP Markers for Breeding Purposes. *Chil. J. Agric. Res.* **2017**, *77*, 332–339. [CrossRef]
124. Alghamdi, S.S.; Al-Faifi, S.A.; Migdadi, H.M.; Khan, M.A.; El-Harty, E.H.; Ammar, M.H. Molecular Diversity Assessment Using Sequence Related Amplified Polymorphism (SRAP) Markers in *Vicia faba* L. *Int. J. Mol. Sci.* **2012**, *13*, 16457–16471. [CrossRef] [PubMed]
125. Jackson, L.; van Noordwijk, M.; Bengtsson, J.; Foster, W.; Lipper, L.; Pulleman, M.; Said, M.; Snaddon, J.; Vodouhe, R. Biodiversity and agricultural sustainagility: From assessment to adaptive management. *Curr. Opin. Environ. Sustain.* **2010**, *2*, 80–87. [CrossRef]
126. Jackson, L.E.; Pascual, U.; Hodgkin, T. Utilizing and conserving agrobiodiversity in agricultural landscapes. *Agric. Ecosyst. Environ.* **2007**, *121*, 196–210. [CrossRef]

127. Barnaud, A.; Trigueros, G.; McKey, D.; Joly, H.I. High outcrossing rates in fields with mixed sorghum landraces: How are landraces maintained? *Heredity* **2008**, *101*, 445–452. [CrossRef]
128. Gollin, D.; Smale, M. *Valuing Genetic Diversity: Crop Plants and Agroecosystems. Biodiversity in Agroecosystems*; CRC Press: London, UK, 1999.
129. Gepts, P. Plant genetic resources conservation and utilization: The accomplishments and future of a societal insurance policy. *Crop. Sci.* **2006**, *46*, 2278–2292. [CrossRef]
130. Mavromatis, A.G.; Arvanitoyannis, I.S.; Chatzitheodorou, V.A.; Khan, E.M.; Korkovelos, A.E.; Goulas, C.K. Landraces versus commercial common bean cultivars under organic growing conditions: A comparative study based on agronomic performance and physiochemical traits. *Eur. J. Hortic. Sci.* **2007**, *72*, 214–219.
131. Bonneuil, C.; Goffaux, R.; Bonnin, I.; Montalent, P.; Hamon, C.; Balfourier, F.; Goldringer, I. A new integrative indicator to assess crop genetic diversity. *Ecol. Indic.* **2012**, *23*, 280–289. [CrossRef]
132. Zarkti, H.; Ouabbou, H.; Hilali, A.; Udupa, S.M. Detection of genetic diversity in Moroccan durum wheat accessions using agro-morphological traits and microsatellite markers. *Afr. J. Agric. Res.* **2010**, *5*, 1837–1844.
133. Amezrou, R.; Gyawali, S.; Belqadi, L.; Chao, S.; Arbaoui, M.; Mamidi, S.; Rehman, S.; Sreedasyam, A.; Verma, R.P.S. Molecular and phenotypic diversity of ICARDA spring barley (*Hordeum vulgare* L.) collection. *Genet. Resour. Crop. Evol.* **2018**, *65*, 255–269. [CrossRef]
134. Pressoir, G.; Berthaud, J. Patterns of population structure in maize landraces from the Central Valleys of Oaxaca in Mexico. *Heredity* **2004**, *92*, 88–94. [CrossRef] [PubMed]
135. Samberg, L.H.; Fishman, L.; Allendorf, F.W. Population genetic structure in a social landscape: Barley in a traditional Ethiopian agricultural system. *Evol. Appl.* **2013**, *6*, 1133–1145. [CrossRef] [PubMed]
136. Demissie, A.; Bjørnstad, A. Phenotypic diversity of Ethiopian barleys in relation to geographical regions, altitudinal range, and agro-ecological zones: As an aid to germplasm collection and conservation strategy. *Hereditas* **2004**, *124*, 17–29. [CrossRef]
137. Teshome, A.; Brown, A.H.D.; Hodgkin, T. Diversity in landraces of cereal and legume crops. *Plant Breed. Rev.* **2001**, *21*, 221–261.
138. Jensen, H.R.; Belqadi, L.; de Santis, P.; Sadiki, M.; Jarvis, D.I.; Schoen, D.J. A case study of seed exchange networks and gene flow for barley (*Hordeum vulgare* subsp. *vulgare*) in Morocco. *Genet. Resour. Crop. Evol.* **2013**, *60*, 1119–1138. [CrossRef]