Chapter 12
Conservation of Wild Food Plants and Crop Wild Relatives: Planning, Strategies, Priorities, and Legal Frameworks

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Abstract Wild food plants (WFPs) are nutritionally rich and are consumed by the indigenous communities whereas crop wild relatives (CWRs) are the wild relatives of the domesticated crops with huge role in crop improvement. These plants are not only a source of macro and micronutrients, but also carry important traits which can be utilized for crop improvement programs. WFPs and CWRs have higher levels of environmental stress tolerance as compared to their cultivated relatives. CWRs can act as a donor of various abiotic and biotic stress tolerant genes and some of them are superior in micro and macro nutrients. The effective utilization of WFPs for crop improvement can revolutionize crop breeding research. WFPs are locally important as they provide nutritional security to consumers since they can grow in harsh ecological and environmental conditions. For these reasons, the potential of WFPs and CWRs is increasingly realised. At the same time, WFPs and CWRs face various threats due to anthropogenic and environmental stresses. Several studies have reported the loss of CWRs which is not good for the planet. Therefore, loss in their biodiversity should be arrested and their conservation deserves utmost importance. The habitats of WFPs are also endangered due to several anthropogenic and climate associated changes. This chapter mainly focuses on the importance of the protection of WFPs and CWRs at the global, national, local, and regional levels by effective planning, employing suitable strategies, and framing priorities based on multiple criteria. Priority-based conservation strategies and legal frameworks to ensure their protection are also briefly discussed in this chapter. The preference for the conservation of WFPs is based on their socio-economic value and potential uses. Protection is mainly through in-situ and ex-situ methods. Coordination between

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different in-situ and ex-situ conservation methods, and modifying legal frameworks based on regional requirements with proper utilization of WFPs would be the most sustainable way to meet global food demands.

Keywords Wild food plants · Crop wild relatives · In-situ and ex-situ conservation · Conservation planning · Conservation strategies · Botanic gardens

12.1 Introduction

Wild food plants (WFPs) are plant species that bear immense potential as a significant source of genetic diversity for crop improvement (von Wettberg et al. 2020). Crop wild relatives (CWRs) are the wild counterparts considered as the progenitors of domesticated crops (Ford-Lloyd et al. 2011). The importance of CWRs is well acknowledged for prospecting new genetic sources of variation for domesticated crops (Zhang et al. 2017). The Russian botanist N. I Vavilov was the first person to put forward the prospective use of CWR in plant breeding (Vavilov 1951). Later, Harlan and Wet (1971) conceptualized the importance of CWRs with the aid of their gene pool concept, where CWR can be categorized into primary and secondary gene pools (Choudhary et al. 2017). Gene flow occurs easily between the CWR and domesticated varieties, which increases the significance of CWRs in plant breeding, which denotes the genetic similarity between cultivated crops and CWRs (Maxted et al. 2006). Immense genetic diversity, adaptation to the local environment, and changing climatic conditions further signify their role in crop improvement (Mammadov et al. 2018). Moreover, WFPs are utilized by rural and tribal communities for their nutritional, medicinal, and economic services (Ahmad and Pieroni 2016; Mishra et al. 2021). Thus, the role of WFPs to ensure global food security is notable as they provide food and income for the rural populations while being a genetic resource for crop improvement. It means that wild relatives of the cultivated crops are crucial for the crop improvement programs. Some of the WFPs eaten by the indigenous communities are also wild relatives of some of the crops suggesting an overlap between the CWRs and WFPs. Therefore, strategies that aims to conserve the CWRs are equally applicable to the WFPs.

Modern food system practices that are based on the cultivation of a few selected crops, increase the vulnerability of monocultures to diseases, pest attacks and various abiotic stresses (Altieri 2019). As a measure to improve crop productivity, the availability of CWRs is highly crucial, considering the need for the identification and sourcing of genes related to nutritional traits, stress, and disease tolerance (Hanson 1952). For example, wild relatives of wheat such as emmer wheat are nutritionally rich and stress-tolerant (El Haddad et al. 2021). *Physalis*, a wild relative of tomato is highly nutritional and it has been widely used as a WFP in various parts of the world especially in South America (Zamora-Tavares et al. 2015). The plant may be used as a source of important genes that can be transformed into tomatoes or other related crops. WFP such as *Eleusine africana* Kenn.-O'Byrne is a CWR of finger millet and it is a endowed with some good traits that can be utilized for the improvement of cultivated finger millet (Dida and Devos 2006). The biotic stress tolerance of the CWRs can be effectively explored to improve pathogen-resistance in the cultivated crops. For example, *Brassica insularis* Moris, a wild variety native to the Mediterranean region, is tolerant to the fungus *Leptosphaeria maculans* (El Mokni et al. 2022). CWR of wheat, *Triticum turgidum* L. is notable for its resistance to fungal pathogens (Gnanesh et al. 2014). There are many more such examples of WFPs and CWRs that are superior and carry important traits crucial for their role in crop improvements. In fact, some of the CWRs are consumed by the indigenous communities as WFPs by collecting from the wild or through limited cultivation in their vicinity. There are many examples of WFPs which are consumed across the globe and have high nutritional value. However, recent studies have shown decline in the consumption of the WFPs by the current generation. This decline in the consumption of the WFPs has been attributed to several factors such as unavailability of the wild plants, change of life styles, and lack of knowledge of their value (Pawera et al. 2020). The marketing of commercially profitable crops on a large scale is also the major reason behind the negligence of WFPs. Several WFPs face conservation issues due to negligence and lack of documentation. It is important to conserve the WFPs and CWRs considering their potential use as a genetic resources. Moreover, climate change, along with issues such as habitat loss, industrialization, anthropogenic threats, and biopiracy, pose serious survival threats to the plants (Siddiqui and Shukla 2015). The present chapter briefly discusses about planning, strategies, and prioritization of important activities for the conservation of WFPs and CWRs.

12.2 Relevance of Crop Wild Relatives and Wild Food Plants

The CWRs are one of the best sources of plant genetic diversity. They represent an important resource for improvement of agricultural production around the world (Brozynska et al. 2016). CWRs are an important source of genetic diversity that can be harnessed for plant breeding and helps to improve agricultural production around the world (Bohra et al. 2022). They grow in a variety of habitats including harsh environmental conditions and are hence important for plant breeding initiatives (Crop Wild Relatives Global Portal 2021). CWRs are rich in genetic diversity as compared to their domesticated counterparts (Zhang et al. 2017). Our current food systems are highly homogenized. Diversification of the food crops is crucial to feed the burgeoning population, ensure their nutritional security and curb hunger (Sarkar et al. 2019). The current conditions demand the diversification of food systems according to the consumer perception and productivity. To fulfill the human calorie requirements, more stress-tolerant and nutritionally superior crops should be developed with CWRs (Brozynska et al. 2016). For example, consider the case of tomato plants, its wild relatives showed superiority in various attributes such as sugar content, yield and a higher proportion of soluble solids (Robertson and Labate 2006). The majority of the WFPs and CWRs are distributed in wild habitats, indigenous communities or forest dwellers depend on these plants as a major source of their diet (Borelli et al. 2020). It is also a boon to the non-indigenous population as an income generator and acts as a means of supplementary feeding to these people (Nyakoojo and Tugume 2020). Customary and traditional knowledge of the local communities about the WFPs pertaining to their use as food signifies the essential nutritional aspects and the feeding diversity of wild relatives in ensuring local food security (Ahmad and Pieroni 2016). Domesticated varieties demand the most optimum conditions in the context of abiotic and biotic factors and many of them have turned susceptible to various stresses which significantly affect their agronomic performance (Edmeades et al. 2001).

In contrast, WFPs can sustain adverse environmental conditions to a greater extent and thus ensure strong support to the global food systems in times of unfavorable conditions (Ladio and Lozada 2004). The presence of a high quantity of micronutrients suggests their potential for subsequent utilization in development of improved agronomic crop varieties (Sánchez-Mata et al. 2016). WFPs have gained paramount importance in providing a balanced diet to a seemingly increased health-concerned population and thus ensure healthy means of food consumption (Ju et al. 2013). Homogenized food systems and extensive competition in the global market create a greater probability for the underprivileged people of the society to face malnutrition and hunger (Schanbacher 2010). These traditional WFPs offer boundless possibilities in relieving the pressure of inequitable food access to several indigenous communities of West Sumatra, Indonesia (Pawera et al. 2020). WFPs with richness in bioactive compounds and micronutrients can sustain a larger vulnerable population by strengthening their bodily requirements and improving their immunity to combat various ailments (El-Ramady et al. 2022). A study by Mutie et al. (2020) in the drylands of Kitui county of Kenya shows that WFPs complement the food system of the population to thrive during unpredicted climatic alterations. The rural people of Kitui, market the products from WFPs such as gums and resins after processing them properly by applying their traditional knowledge (Mutie et al. 2020). The status of WFPs as an ecosystem service corresponding to their functional importance in the anthropological context was elucidated by Schulp et al. (2014). They provided information regarding spatial distribution, and interconnections between benefits, demand and supply of WFPs widely utilized in the European Union. The study reported that a large number of European citizens consume WFPs regularly.

The relevance of CWRs was better elucidated by Bohra et al. (2022), and stated that emerging nations should utilize their resources for crop improvement. The gene pool of CWRs is rich in certain disease resistance genes and abiotic stress tolerant genes, which can be utilized for improvement of the climatic change susceptible staple crops (Porch et al. 2013). CWRs have been considered paramount to crop improvement for humankind since the green revolution. A noteworthy example is the pivotal role of introgression breeding in conferring resistance to *Puccinia graminis* from the *Aegilops tauschii*, a type of wild wheat, to curb the stem rust and advancement in cereal production (Bohra et al. 2022). CWRs of industrially valuable crops utilized for fuel and aesthetic beauty also find their place in the need to be conserved for a sustainable healthy economy (Maxted et al. 2010). Judicious manipulation of the CWRs in plant breeding approaches directs more diversity in the genetic level of the cultivated crop varieties. Ziska (2021) reviewed the selection efforts by nature and breeders that are better adapted to increased CO_2 level in the atmosphere. They reported CWRs had better adaptation to increasing CO_2 conditions than the domesticated counterparts. In this context, attempts to identify the genetic loci conferring the adaptable traits were widely studied to produce elite cultivated varieties. In the study done by El Haddad et al. (2021), an evaluation of the performance of three critical dryland crops (durum wheat, barley, and lentil) developed by incorporating CWR in their pedigrees in the context of yield potential, yield stability across different environments were conducted. The results showed that the accessions derived from CWRs had better yields across all the varied conditions. For example, three accessions of wheat developed from *Triticum araraticum* and *T. urartu* were enriched with Zn content and barley accessions produced from *Hordeum spontaneum* were rich in proteins. The CWR-derived elites even had better food performances, further substantiating the utility of these wild alleles in crop improvement.

WFPs are important parts of local markets and are very important for associated communities, especially the women and young population. This remains valid in the current scenario of COVID-19 fractured world. As the COVID-19 disrupted the transport and cargo and also led to widespread disruptions in the food supply chains that involved long distance travels, people started relying on the local foods including the WFPs as they are locally obtained and involve short supply chains which are least affected due to COVID-19 (Borelli et al. 2020). This suggests the role and relevance of the WFPs in the future if we face a situation similar to COVID-19 or other natural disasters or wars. The relevance of CWRs in crop breeding and providing food security is required to be explored more and benefits of advanced molecular techniques such as genetic modification and gene editing should be reaped for improving the crops. Through the successful establishment of gene editing tools, rapid-domestication of CWRs can be achieved according to the breeders designs (Lemmon et al. 2018; Zhu and Zhu 2021; Yu et al. 2021). Figure. 12.1 represents various important aspects of these wild plants (CWRs and WFPs) that are beneficial for in plant breeding.

12.3 Status of Crop Wild Relatives and Wild Food Plants at the Global, National, Regional and Local Levels

For thousands of years, humans have relied on wild plants for their diets, and several people still rely on these species to satisfy their nutritional requirements (Turner et al. 2011). Wild edible plants are components of the cultural and genetic heritage of

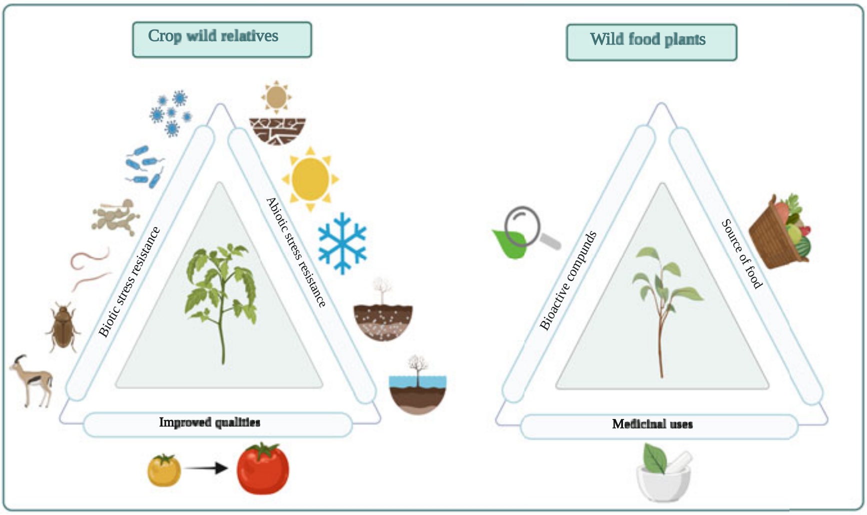

Fig. 12.1 Importance of CWRs and WFPs (Created with BioRender.com). CWRs possess various abiotic and biotic stress tolerant traits and the crop breeding methods can be applied for their improvement. WFPs are rich in bioactive compounds and hence they are used for various medicinal purposes besides their food value

different parts of the world and have aided rural and sub-urban communities during severe famine and scarcity (Pinela et al. 2017). An increase in the interest in WFPs is observed among modern societies that resulted in the accumulation of extensive ethnobotanical knowledge (Tardío et al. 2006). Research has shown decline in the wild species diversity due to several reasons such as socio-economic changes, industrialization of the diets, expansion of food markets, changes in land usage patterns and unsustainable harvesting practices (Bharucha and Pretty 2010). Kidane and Kejela (2021) have attributed this decline to agricultural expansion, poor management, overgrazing, and loss of indigenous knowledge. Only around 150 of the estimated 30,000 edible plant species are cultivated by humans, with only 30 species accounting for the majority of our dietary requirements (Shelef et al. 2017). Despite the fact that we produce optimum food to feed a significant proportion of the human population, nutrient-rich food is still out of reach for more than 1.5 billion people, and the food system needs to be transformed to ensure nutritional security for consumers (FAO 2020a). The relevance of agro-biodiversity and WFPs in risk management and establishment of resilient and sustainable food systems is increasingly recognized worldwide (Kahane et al. 2013; Boedecker et al. 2014). As a result, more research should be encouraged on documentation of WFP diversity, uses, and conservation strategies, as well as re-establishment of traditional knowledge for the sustainable usage of WFPs in a rapidly changing world. CWRs on the other hand, aided in crop domestication for thousands of years (Perrino and Perrino 2020) and are widely used in breeding experiments and crop improvement programs for enhancement of plant performance (Zhang et al. 2017; Bohra et al. 2022). The in-situ and ex-situ strategies are critical for the long-term conservation of forest genetic resources in the context of changing societal requirements and climate change (FAO 2020b). CWR conservation and utilization are becoming increasingly popular in international food security policy and research (Smýkal et al. 2017). However, there is a lack of coordination in the crop research community to convey developments, best practices, constraints, and opportunities for adoption of CWRs. Attempts aimed at systematically assessing the utility and diversity of CWR species are infrequent (Dempewolf et al. 2017). To avoid the extinction of CWRs and WFPs diversity and to optimize their availability, particularly for crop development, proper conservation, and sustainable usage must be ensured at the global, regional, national, and local levels.

Assessment of the existing state of CWRs and WFPs conservation and utilization can help uncover gaps in their conservation and aid in the planning priorities. In many situations, such an evaluation is already available, either as part of a country report, research program, or as a separate study (FAO 2017). An attempt to assess genetic resources of crop plants, livestock and forest trees on a global level was initiated by the Food and Agricultural Organization (FAO) of the United States through the program "The State of the World's Biodiversity for Food and Agriculture" and WFPs were also included in this report (FAO 2019). A total of 91 countries submitted a report and among them, only 69 countries provided a detailed report. A total of 1995 WFPs were recognized combining all the reports besides other groups of wild species of mammals, birds, fungi, insects, fish, crustacea, molluscs, reptiles and amphibians (FAO 2019). Ulian et al. (2020), reviewed the global status of edible plants by a combined data from major projects and research with a focus on neglected and underutilized species (NUS), dividing them into three categories; wild, cultivated, and wild and cultivated species as well as mentioned edible parts, uses and distribution of NUS. Regarding CWRs, Milla (2020) undertook a global assessment of food crops, examining 866 food crop species and 901 wild progenitors, as well as their cultivation and domestication histories, geographical distribution, and a time-calibrated genetic phylogeny of food crops. Castañeda-Álvarez et al. (2016) utilized gene bank databases, herbariums, and biodiversity data to simulate the global distribution of 1076 taxa connected to 81 crops. They discovered that CWRs are underrepresented on gene banks, with no germplasm accessions for 313 (29.1% of total) taxa connected with 63 crops, and a further 257 (23.9%) taxa represented by less than ten accessions. Overall, global trends in the abundance of WFPs and CWR were reported to be decreasing (FAO 2019). Botanic gardens also play an important role in plant genetic resource conservation (Kumar 2021). Meyer and Barton (2019) outlined the reserves of CWRs in botanic gardens, they reported 28.6% of global priority CWR taxa and 75.4% of US priority CWR taxa in botanic gardens. Botanic gardens maintain 22 global priority and 108 US priority CWR taxa not reported by crop gene banks, based on a comparison with priority CWR holdings in crop gene banks. Several ethnobotanical studies have reported the usage and diversity of WFPs from different parts of the world (Al-Fatimi 2021; Guarrera and Savo 2016; Baldi et al. 2022; de Medeiros et al.

2021; Xu et al. 2020; Winstead and Jacobson 2022; Ding et al. 2021; Menendez-Baceta et al. 2017).

At the national level, a wide range of collaborators are involved in the conservation and sustainable use of CWRs and WFPs. In many cases, national governments have introduced National Plant Genetic Resources for Food and Agriculture (PGRFA) programs to drive efforts towards global PGRFA protection and sustainable usage (FAO 2017). Many nations report a lack of efficient information-sharing and collaboration systems among stakeholders, notably between those working in the food and agricultural sector and those working on environmental and wildlife matters (Pilling et al. 2020). While most nations have routinely established threatened species conservation strategies for the past three decades, the establishment of conservation efforts for CWRs at the national level is still in its budding stages (Iriondo et al. 2016). The same goes with WFPs, though the number of publications on the relevance of WFPs is rising, mostly at the local level, there is a lack of data and information at the national level, and conservation assessments are still inadequate; due to this, the contribution of WFPs to the national economy and their overall importance is under-evaluated (Borelli et al. 2020). It is very concerning that biodiversity for food and agriculture, as well as the ecosystem services it provides, is reportedly declining in so many production systems in several nations (FAO 2019). WFPs provide food and financial security at the local level and are a source of traditional medicines too (Uprety et al. 2012; Hickey et al. 2016; Asprilla-Perea and Díaz-Puente 2019; Ray et al. 2020; Punchay et al. 2020). For local communities, WFPs remain a preferred alternative to commercial food crops because they are easily accessible and economically feasible (Delang 2006a). Many ethnobotanical researches and surveys are being conducted at regional and local levels to better understand how human societies collect, manage, and interpret the local plants which they utilize as food and medicine (Pardo-de-Santayana and Macía 2015). Most such recent studies reveal a gradual decrease in traditional knowledge about wild plant usage and management among local communities (Singh and Bedi 2017; Luo et al. 2019; Yeşil et al. 2019; Thorn et al. 2020; Punchay et al. 2020; Aziz et al. 2021; Pascual-Mendoza et al. 2021; Ghanimi et al. 2022). According to a review by Schunko et al. (2022) regarding the change in perceptions of WFPs and mushrooms among local people, 92% of all reported changes in wild edibles are related to their decreased abundance, and fruits and vegetables account for 76% of the wild edibles with decreasing abundance, whereas CWRs account for 23%.

12.4 Threats to Wild Food Plants and Crop Wild Relatives

The existing agrobiodiversity is threatened mainly by the combined effects of anthropogenic activities and natural calamities (Chaudhary et al. 2020). The rise in human population is contributing significantly to the devastation of agrobiodiversity (Khumalo et al. 2012; Montenegro de Wit 2016) in different ways, such as uncontrolled and unsustainable practices of natural resources exploitation, urbanization, (Ebert and angels 2020) introduction of exotic species, and forest land usage for expanding agricultural operations (FAO 2017; Hunter 2012). Apart from these human interventions, unavoidable climate change, desertification, the spread of invasive species and natural disasters also contribute to the deterioration of the diversity of WFPs and CWRs (Fatima et al. 2020; Norton et al. 2017; FAO 2017; Gupta et al. 2020). The extinction risk analysis of wild varieties of some vital crop species in Mesoamerica, known for its agricultural significance as the center of crop origins and highly diverse CWRs, revealed that among 224 CWRs analyzed, 35% of them are under the risk of extinction (Goettsch et al. 2021). Land conversion for agriculture, as well as current agricultural techniques such as herbicide use and urban expansion, were some major threats to CWR species in Mesoamerica (Goettsch et al. 2021). Climate change causes biotic and abiotic stresses to WFPs through varying rainfall and temperature patterns, heat waves, weeds and pest outbreaks, and changes in sea level and atmospheric CO_2 concentrations (Raza et al. 2019). According to van Treuren et al. (2020), climate change has a significant influence on the distribution of red-listed CWRs in the Netherlands. Their findings indicate that the distribution areas of CWRs that are categorized as being critically endangered have been declining owing to changing climatic conditions. A similar study by Vincent et al. (2019) also points out the impact of climate change on CWRs distribution. They analyzed the number of CWRs under different crop types expected to lose 50% or more of their current ranges by 2070 due to climate change and found that the root, bulb, or tuberous vegetable CWRs are facing distribution loss, followed by cereals and leguminous CWRs. Some CWRs such as *Zea perennis* and *Vicia hyaeniscyamus* are expected to lose 100% of their distribution area by 2070. Jarvis et al. (2008) studied the influence of climate change on wild relatives of three crop plants, potato (*Solanum tuberosum*), peanut (*Arachis hypogaea*), and cowpea (*Vigna unguiculata*), and decline and fragmentation of distribution of area were observed together with increased extinction risk of some species. South African WFPs distribution patterns tend to vary under uncertain temperatures and the geographic range of certain traditional WFPs is changing due to rising temperature (Wessels et al. 2021). The nonavailability of optimal climatic conditions reduces the WFP species richness (Wessels et al. 2021), conversely the increasing temperature is predicted to influence some species positively by providing optimal growth conditions and lengthened growing season (Phillips et al. 2017).

The Green Revolution of the 1960s and 1970s popularized modern cultivars, which were widely adopted by farmers. It quickly displaced the genetically diverse traditional and wild landraces that had existed for centuries, making traditional diversity only to be found in gene banks or other conservation initiatives (Ford-Lloyd et al. 2011). As a result of plant breeding techniques, the agricultural diversity was decreased through the introduction of mono-cropping system with genetically uniform cultivars (Dwivedi et al. 2016). The plant breeding studies should utilise the potential of CWR diversity, but CWRs have been underrepresented in gene bank-like conservation programs (Castañeda-Álvarez et al. 2016). Besides that, the genetic pollution or the gene flow from exotic and invasive species along with genetically modified and conventional crops causes a significant threat to agrobiodiversity (Gepts and Papa 2003) and its in-situ conservation efforts. Traditionally, protected areas have not been designed by considering CWRs, and legislation is needed to encourage CWRs and WFPs protection in the same way that rare breeds of domestic animals are safeguarded (Bettencourt et al. 2007). Genetic erosion is the common threat to WFPs diversity in biotically disturbed ecosystems (Fu 2017), and conservation efforts in combination with information gathering about the plant features are vital for maintaining diversity (Pandey et al. 2005).

Uncontrolled use of wild resources and modification of the wild landscape can drastically reduce agrobiodiversity (Upreti and Upreti 2002). For example, due to human population pressure and agricultural expansion, frequent deforestation reduces the forest land area. In the case of Northwest Ethiopia, wildfires, fuelwood collection, overgrazing, and overharvesting were reported as a threat to WFP diversity (Berihun and Molla 2017). A similar study suggests that introduction of exotic species such as *Eucalyptus* and agricultural land expansion forced the WFPs to be grown in farmlands, farm boundaries, and watershed areas instead of their natural habitat (Kidane and Kejela 2021). Even in protected regions, the lack of strict legislation for the conservation of wild flora leads to unrestricted use. However, even when rules are very strictly enforced, the illegal harvesting of traded medicinal plants and timber is obeserved in from different parts (Khakurel et al. 2021). This shows that rules are not always effective but a community consciousness and awareness about the loss of biodiversity among the locals is also crucial for conserving the WFP biodiversity.

The traditional knowledge about WFPs is also under threat, and the younger generation abandons it. Traditional knowledge is passed down from generation to next generation (Yuan et al. 2014). The risk of losing traditional knowledge is increasing among the younger generation due to the death of older adults, increased deforestation of natural forests, monoculture of economic plants, reduction in the availability of WFPs (Cao et al. 2020), and socio-economic changes (Ju et al. 2013). A study by Reyes-García et al. (2013) on changes in traditional knowledge about WFPs among Amazonian indigenous people found that the usage of wild plant and knowledge regarding them have decreased. The loss of traditional knowledge can undoubtedly result in biodiversity loss, particularly WFP species. Therefore, preservation of local traditional knowledge is essential for safeguarding agrobiodiversity (Luo et al. 2019).

12.5 Conservation Priorities and Strategies

12.5.1 Conservation Priorities

CWRs have always been at the forefront in the improvment of the agronomic traits of the modern varieties, enabling resistance to adapt and survive to a multitude of stresses in their natural environment. Therefore, conservation of the CWRs is a prominent concern in the context of its importance in various aspects of cultivated plant species (Heywood et al. 2007). In an anthropological context, CWRs serve as an important resources to strengthen global food security. Medicinal, food, and ornamental value are some of the significant prioritization criteria (Ciancaleoni et al. 2021). The evaluation of habitat, climate and associated threat, anthropological impacts on the CWRs is essenial to outline the priorities for conservation (Castañeda-Álvarez et al. 2016). Besides that, the extent of utilisation of the gene pool of the CWR in plant breeding, socio-economic status of the cultivated crop, degree of threat exposed and endemicity of the wild relative are also considered (Idohou et al. 2013). The taxonomic and geographical information related to CWRs can help to refine the priority strategies (Castañeda-Álvarez et al. 2016). The geographic distribution of CWRs is an essential criterion in the formulation of conservation priorities as some CWR plants are native to two or more countries or to just one country which calls for better coordination among nations (Lala et al. 2018). By understanding the importance of CWRs in global food supply chain, production network and food security, the CWRs of some important crops are prioritized for conservation at global, national, regional and local level (Rahman et al. 2019). For example in Indonesia, out of 234 prioritized CWRs, 99 were crucial at global and national level such as the CWRs of banana, rice, mango, sorghum, sweet potato, citrus and coconut. 69 CWRs were important at national and regional level such as sugarcane and tropical fruits and 70 taxa including fig and yams were important only at global level (Rahman et al. 2019). The prioritization strategies at regional level are more focused on the production value, location, energy supply, nutrient content and threats faced by the plant (Zair et al. 2018).

The development of prioritization strategies for conservation helps to narrow down the checklist of CWR to be conserved and broadens the conservation activities which results in the effective conservation (Labokas et al. 2018). Maxted et al. (2007) discussed the role of national inventories in generation of conservation action plans of CWRs in United Kingdom. National CWR inventory serves an important function by describing the significant CWR crops for conservation by analysing their threat status, diversity, present conservation status, recognition of conservation sites, pattern of distribution and development of action plans (Maxted et al. 2007). They suggested that, the development of National CWR inventory, can easily prioritize the CWR taxa for conservation, which is easy to identify their threats through the genetic and ecogeographical investigation. The recognition of threats for the CWR can identify the gaps in conservation action plans and thereby effective in-situ and ex-situ conservation programs can be established (Maxted et al. 2007). The process of inclusion of CWR members into the prioritization list follows a highly selective methodology where the major focus is on the endemicity of the wild variety, and its socioeconomic importance to the country's economic status (Rahman et al. 2019).

Prioritization should be aimed at wild relatives with restricted distribution rather than CWR population with wider global existence (Perrino and Wagensommer 2021). According to Brehm et al. (2010), there is no stringent method for setting the criteria for prioritization; it largely depends on the aim of our conservation and the available information. Brehm et al. (2010) formulated nine prioritization criteria: habitat status, economic worth, ethnobotanical significance, worldwide distribution, country-wise distribution, ex-situ conservation status, in-situ conservation status, legal norms, and threat status and they used this criteria on the Portuguese CWRs. Ciancaleoni et al. (2021) suggested that prioritization of CWRs for their role in the functioning of the ecosystem is noted but focus on the species level is more worthy. Prioritization also considers the phylogenetic distance between the CWR and the cultivated variety (Viruel et al. 2021). The closer the links between CWRs and the related crops, the more ease with which gene donation from the wild relatives can occur (Maxted et al. 2010). Consideration of all the priority criteria is important to find appropriate in-situ and ex-situ conservation modes (Brehm et al. 2010). While prioritising conservation strategies, aspects such as threat status, closeness to the domesticated crop, traits of interest, distribution, status of conservation, availability and legal frameworks are important (Engels and Thormann 2020). The establishment of a priority list of CWRs at different geographic locations following different criteria serves as an index to aid in constructing sustainable policies for the preservation of high-priority CWRs (Castañeda-Álvarez et al. 2016). Categorization of taxa based on a final priority score (FPS) ranging from zero to ten, sets a base for collecting the wild relatives and increasing their representation in the gene banks (Castañeda-Álvarez et al. 2016). Khoury et al. (2013) prioritised 21 taxa from 69 genera of USA which are related to major food crops. Within the major categories formulated as part of the criteria, there are subcriteria to accommodate all the variants of CWRs with proper positions signifying their value. IUCN Red List Categories and Criteria represent the baseline for grouping the CWRs including Extinct in the Wild (EW), Critically Endangered (CR), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DE) and Not Evaluated (NE) (IUCN 2020). The commercialization potential and the current and future trade potential of the cultivated crops also serve as a baseline under economic status to prioritize the conservation of its CWR (Perrino and Perrino 2020). In this manner, prioritization baselines and strategies differ with regional, and international boundaries, where the value is based on the yield of CWR-related crops and the production quantity of the related food crops. A high priority is given for the CWRs that face threats due to the alteration of natural habitats within prescribed boundaries (Fitzgerald et al. 2013). It is also mandatory that assigning priority to conserve any taxon should necessarily correlate to its existing conservation initiatives (Brehm et al. 2010). After the establishment of conservation strategies, if the conserved CWR attains a significant population, they can be readily excluded from the current conservation priority list, and other CWRs can be considered for conservation (Nduche et al. 2021). In South Africa, Holness et al. (2019) reported that the identification and conservation of CWR endemics with narrower distribution were given priority. Those with broader distribution status were not targeted for conservation policies since they face a lesser rate of endangerment. As depicted in the study by Mponya et al. (2020), climate change adaptation is also a feature considered as a prioritization criterion. Maxted et al. (2010) provides an important 14 point strategy for the improvement of conservation of CWRs for the next 10 years. Some of these points include analysis of gaps, bioclimatic modelling, establishment of genetic reserves, monitoring and popularisation of the conserved species, development of

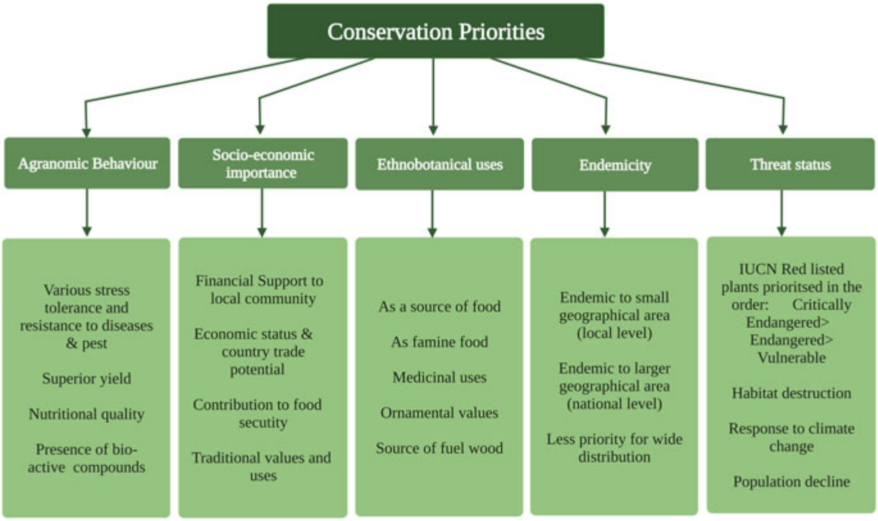

Fig. 12.2 Priorities for the conservation of WFPs and CWRs (Created with BioRender.com; see Sect. 12.5.1)

core collections and characterisation and evaluation of the CWRs for the beneficial traits (Maxted et al. 2010). But the utilisation of CWRs for breeding programs, consumption by consumers and popularity across the globe can provide actual results for the conservation policies. Ethnobotanical importance of the CWRs is also important for their conservation (Ciancaleoni et al. 2021). Ensuring the protection of the WFPs and CWRs should be prioritized for their sustainability and to strengthen the global food security (El Mokni et al. 2022). Figure 12.2 provides an outline of the priorities that act as a guide for the conservation of the CWRs and WFPs.

12.5.2 Conservation Strategies

For effecive conservation of the CWRs, estimation of the number of the CWR species is crucial (Maxted et al. 2012). Both ex-situ and in-situ conservation methods are important for the conservation of the CWRs, however most of the earlier conservation programs were focused on ex-situ conservation, which are found to be less effective (Maxted et al. 2012). Although ex-situ conservation methods were taken in the earlier instances, it is associated with several issues such as difficulty in collection, maintainence and propagation and costs associated with it (Meilleur and Hodgkin 2004). These issues including the research on natural introgressions between the crops and the CWRs led to increase in the interest in in-situ conservation (Meilleur and Hodgkin 2004). Meilleur and Hodgkin (2004) provides an extensive list of the examples of in-situ conserved CWRs from various countries. While focussing on in-situ conservation, it is also important to consider the other factors that influence the CWRs, for example the role of birds for the wild species of Chili (Tewksbury et al. 1999). Since CWRs grow in the wild, they carry adaptive traits that are absent from the domesticated crops, therefore CWRs from the wild are crucial for the introgressions and crop improvement (Warschefsky et al. 2014). The main challenge for in-situ modes is that the natural habitats of these wild plants are getting threatened and there is also profound negative effect of climate change. Therefore, in the present context, there is an immediate need for conserving CWRs by alternative methods as well (Meilleur and Hodgkin 2004). A vast majority of the CWR population existing in the biodiversity-protected areas remain unidentified, so recognition and proper representation of them along with significant moderation of in-situ management protocol of the reserved areas can lead to the conservation of the CWRs (Vincent et al. 2022). In-situ mode is a method of conservation that promotes sustenance of the CWRs in the wild which enables further diversification of wild characters by evolution (Rahman et al. 2019). As per Brown and Hodgkin (2015), incorporation of these diverse characters into the agriculture stream is important. As described by Heywood et al. (2007), various countries adopt diverse CWR prioritization factors with major emphasis on geographic surroundings for the adoption of a suitable mode of conservation method.

The ex-situ mode proceeds with efforts such as the collection of seeds of CWRs where educational societies and government collaborates are involved in the selection of seeds of significant CWRs (Zair et al. 2021). The role of botanical gardens in CWR conservation pertains to the protection of wild relatives of the staple crops. The botanical gardens also help in the dissemination of the information regarding CWRs to the general public which may trigger further conservation strategies (Kumar 2021). Seed banks store seeds of crops and wild relatives used for a variety of purposes and act as an important ex-situ conservation method, the seed banks act as important repositories of the crops (Hay and Probert 2013). However, seed banks depend on several important factors such as the seed germination, maturity and development (Hay and Probert 2013). It is important to note that conservation strategies are devised regionally and depend upon several factors including the availability of CWR diversity and threats associated with it.

A check list of the CWRs of Czech Republic was prepared and a conservation strategy was devised for their conservation (Taylor et al. 2017). Fielder et al. (2015) inventorised 148 priority CWRs of England and suggested in-situ and ex-situ conservation plants.

Cryopreservation can be used to conserve the seeds of CWR and WFPs which failed in ex-situ seed banks and this technique is particularly important for endangered species of CWRs (Pence et al. 2017). Plant tissue culture (PTC) has diverse applications including the storage of germplasm (Thorpe 2007). In-vitro culture is globally accepted as an efficient method for the germplasm storage and propagation, and for plants where seeds are not viable or seeds are not available, it is possible to apply in-vitro conservation techniques (Rajasekharan and Sahijram 2015). The PTC is widely applied as a tool for the conservation of endangered plants (Oseni et al.

2018). The major benefit of tissue culture is that it needs only a small space and a few plants for the initial culture (Oseni et al. 2018). Lauzer et al. (1992) developed clones of wild yams viz. *Dioscorea abyssinica* Hoch, and *D. mangenotiana* Miège through their nodal culture. Singh et al. (2019) developed an efficient protocol for the propagation of wild relative of chickpea (*Cicer arietinum* L.) viz. *Cicer microphyllum* Benth. from excised embryo. Hence, it is clear that in-vitro propagation can be successfully applied for the conservation of germplasm of CWRs and WFPs for long term and short term.

Conservation strategies including both ex-situ and in-situ modes should be analyzed so that the most efficient means of conservation can be targeted (Padulosi et al. 2011). An integrative strategy by utilising both modes of conservation can be applied to balance the difficulties and limitations of ex-situ and in-situ conservation (Meilleur and Hodgkin 2004). A major policy undertaken in Europe for the conservation of the CWR populations is to identify hotspots and their inclusion into Important CWR areas, which call for the immediate need for conserving this wild wealth (Maxted et al. 2015). Conservation of these valuable genetic resources from the wild is important. Protection of these plants ensure their sustainable presence even in the future. The involvement of various local communities in the conservation of the CWRs and WFPs is important to ensure their sustainable use (FAO 2017). International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) mandates that CWRs should be made publically available, which is important for the conservation of and research on the CWRs (Tyack et al. 2020). Since CWR are rich in nutrient composition, by focusing on this aspect, its utility as food and fodder, the farmer community and the animal husbandry sector would promote its cultivation and thereby conservation (Perrino and Wagensommer 2021).

Assessing and addressing anthropogenic harm inflicted upon the CWRs is a major strategy to reduce unsustainable utilization and thereby ensure the proper management of CWR resources (Engels and Thormann 2020). Those communities staying near the forests collect the WFPs from the forest and rely on their existence for livelihoods and other aspects, therefore, these communities promote the conservation of the wild species as their surivival is linked to the availability of the WFPs (Delang 2006b). Therefore, there is an intimate relationship between the communities and the WFP resources and the communities take interest in the usage, management and conservation of the WFPs (Evans 1993). This strategy should also be therefore combined with the conservation of WFP resources and CWRs. Formulation and implementation of appropriate conservation priorities and strategies at different levels is a vital step in establishing a proper CWR conservation frame (Rahman et al. 2019). Collaborative efforts between developing and developed nations is also important for the future conservation of the CWRs and WFPs. Considering all this, it is clear that regional, national and global strategies are crucial for the conservation of the wild genetic resources of a sustainable present and future, it is also important to identify the crucial CWRs and priorities should be devised to conserve them (Ford-Lloyd et al. 2011). On the basis of this small discussion, it can be stated that strategies for the conservation of the WFPs and CWRs depend upon their use value, locality, availability, threat and conservation status. It also depends

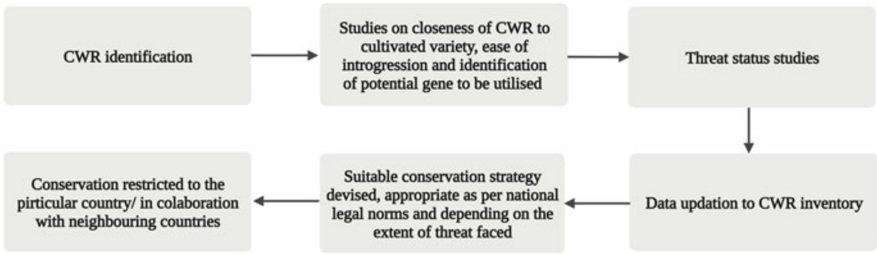

Fig. 12.3 An example of an appropriate and effective strategy for the conservation of WFPs and CWRs (Created with BioRender.com; see Sect. 12.5.2)

on the geographical location of the CWRs or WFPs and more importantly the local and national policies of a respective country are also crucial for the determination of the conservation strategy. Identification and inventorisation of the CWRs diversity and their hotspots are also very important to begin with any conservation strategy. Figure 12.3 provides an outline for the formulation of a conservation strategy for the conservation of the CWRs and WFPs.

12.6 Legal Frameworks for the Protection of CWRs and WFPs

Since CWRs and WFPs are collected from the wild in different countries, their conservation falls within the jurisdiction of a particular country (Montenegro de Wit 2017). The CWRs and WFPs from different countries are also different and plants may need different strategies for protection, therefore the legal frameworks of each country should be different. In the African countries, they focus on the multi-use regulatory framework by including access to the local people to utilize the WFPs for traditional uses, thereby ensuring coordination among the local population and the public institutions (Cunningham 2014). In 2010, Convention on Biological Diversity (CBD) formulated and presented a plan consisting of 20 targets known as the Aichi Biodiversity Targets which are spread across 5 strategic goals (CBD 2020; Garcia and Rice 2020). Target 13 emphasized the sustenance and conservation of the cultivated plants and animals including their wild relatives by 2020 (CBD 2020). It further aimed to ensure appropriate measures to protect the diverse gene pool of the wild relatives to arrest their genetic erosion (CBD 2020). With an aim to arrest the loss of plant biodiversity, CBD also established a Global Strategy for Plant Conservation (GSPC) program comprising of 16 targets (CBD 2011). The GPSC envisioned a symbiotic relationship between the plant genetic diversity and the humans with a major focus on the sustainable use of the plant resources for livelihoods and wellbeing while protecting the plant diversity including their habitats (CBD 2011). Target 9 of GPSC aimed to conserve 70% of crop diversity including their wild relatives with due respect towards indigenous knowledge and its protection. The International Treaty on Plant Genetic Resources for Food and Agriculture in Article 5 details about conservation, exploration, collection and evaluation of the plant genetic resources culminating in the maintenance and documentation of proper records of the plant genetic wealth (FAO 2001). Moreover, the treaty has a functional funding policy to extend support to developing countries to activate the efforts that fall under their idealized conservation protocol (Esquinas-Alcázar 2005). The Second Global Plan of Action for Plant Genetic Resources for Food and Agriculture, adopted by FAO member countries in 2011, signifies particular remarks on the broader aspects of conservation and suitable integrated approaches for its judicious utilization by the people (Mba et al. 2020). Legal frameworks are usually postulated within national borders, where effective strategies are formulated with the coordination of neighboring countries. As per CBD, the CWR protection falls under the country's jurisdiction. On a broader scale, developing countries have imposed national-level based restrictions on the unlimited access to plant genetic resources for food and agriculture (PGFRA; Esquinas-Alcázar 2005). Concerning in-situ conservation, the primary prerequisite is to have a solid national strategy, which gets further integrated with other countries, to widen the approach to a global base. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is an important agreement with the governments that ensures judicious global wildlife trade and ensures that there is no survival threat to the wild animals and plants (Fuchs 2008). In the present situation of increase in the illicit trade of wild plants, considering its demand and relevance in food security, this convention stands at the forefront to ensure the sustainable use and availability of wild plants in the market. It emphasizes trade, which should work as per the national legal norms (Lavorgna et al. 2018). ITPGRFA mandates that monetary benefits obtained through the commercialization of the seed banks should be used for the conservation and management of the crop genetic resources (Perrino and Perrino 2020). There is an illegal trade of some endangered plants that are highly important economically and medicinally. For the protection of WFPs, especially those which are endangered and critically endangered, laws of each country should be strengthened and international coordination should be established to tackle the illegal trade of the important wild plant resources (Reeve 2014). Pharmaceutical companies are also known to exploit wild plant resources without caring about their sustainability. There should be stringent laws globally to regulate the harvest of WFP resources for pharmaceutical purposes. National governments need to consider the international treaties and conventions to make their legislations that deal with the protection of the CWRs and WFPs. Several countries have evolved their own laws for the effective implementation of the international treaties and conventions. However, there may be certain locally important CWRs and WFPs and there may be local challenges to their conservation that needs local solutions. Therefore, while evolving a legislation, local needs, challenges and issues should also be considered.

12.7 Future Prospects of CWRs and WFPs

With an expected increase in population to nine billion by 2050, the future will revolve around finding answers to how this massive population can be fed (Godfray et al. 2010). Climate change is also posing great threat to the food security by reducing crop productions in various corners of the world. As the land resources are also declining and the current crops are susceptible to stresses, using CWRs for the improvement of the domesticated crops is an important area to enhance the food production and create resilient crops that can withstand vagaries of the environment. Plants are in a constant race to combat the pathogens which mutate faster, due to which cultivated varieties are always exposed to the biotic and stressful environment. The significant fact is that, CWRs possess resistance to these kinds of novel emerging pathogen strains, therefore, the future would constantly rely on the wild genetic resources (Hajjar and Hodgkin 2007). Plant breeding utilize the significant traits of the CWRs and incorporate them into the narrow genetic base of cultivated varieties (Tanksley and McCouch 1997). CWR accessions in Genbank are incomplete, which means this wild wealth's identity is still to be acknowledged. Therefore documentation of these wild resources would be a key in the future to utilize this genetic diversity in crop improvement programs and the medium that can be utilized would be well-formulated protocols and complementary taxonomic input (Dempewolf et al. 2017). CWR stands as an underutilized wild species whose worth increase in the future as the climate change threatens them and all other domesticated crops. The underutilised crops hold the key to the future, they will be helpful in the diversification of the crops and crop production systems (Padulosi et al. 2011). Considering all these insights on the importance of CWRs and on how things are going to be in the future, the core need is its sustainable utilization and a strong hand in its conservation.

12.8 Conclusions

This chapter focuses on the requirement for the conservation of CWR and WFPs detailing their significance. Taking the current trend of climate change and the subsequent consequences, the urge to protect wild genetic wealth is the need of the hour. Ensuring global food security needs multiple initiatives from different corners. Therefore, to feed the world with appropriate nutritional quality, increasing the yield of staple food crops by genetic enhancement need the existence of the wild progenitors of the crops with remarkable genetic superiority. All the conservation needs and appropriate priorities depend upon the proper action plans considering the threat status at global, national, regional, and local levels. The sustenance of wild genetic resources will be extremely vulnerable in the future if we do not make plans, strategies and take action appropriately. Anthropogenic activities are at the centre of the depletion of wild resources. In the context of the harm inflicted by man on natural resources, the possible way to counteract this is to value indigenous knowledge and support the local communities to earn economic benefits as well. The importance of a collaborative approach to club in-situ and ex-situ modes with local community participation is noteworthy. These underutilized wild relatives should be utilized sustainably and made available in the markets, vital scientific research should be complemented to monitor their population to avoid extinctions. Sustainable utilization along with conservation would be the most desirable framework to ensure that their diversity thrives in the wild. Considering all the facts, we conclude that, over time, things can't be changed, judiciously devised protocols for conservation and the urge to protect biodiversity and sustainable utilization would be the key.

References

Ahmad K, Pieroni A (2016) Folk knowledge of wild food plants among the tribal communities of Thakht-e-Sulaiman Hills, North-West Pakistan. J Ethnobiol Ethnomed 12:17. https://doi.org/10.1186/s13002-016-0090-2

Al-Fatimi M (2021) Wild edible plants traditionally collected and used in southern Yemen. J Ethnobiol Ethnomed 17(1):49. https://doi.org/10.1186/s13002-021-00475-8

Altieri MA (2019) Agroecology: principles and practices for diverse, resilient, and productive farming systems. In: Oxford research encyclopedia of environmental science. Oxford University Press

Asprilla-Perea J, Díaz-Puente JM (2019) Importance of wild foods to household food security in tropical forest areas. Food Secur 11(1):15–22. https://doi.org/10.1007/s12571-018-0846-8

Aziz MA, Ullah Z, Al-Fatimi M, De Chiara M, Sõukand R, Pieroni A (2021) On the trail of an ancient middle eastern ethnobotany: traditional wild food plants gathered by Ormuri speakers in Kaniguram, NW Pakistan. Biology 10(4):302. https://doi.org/10.3390/biology10040302

Baldi A, Bruschi P, Campeggi S, Egea T, Rivera D, Obón C, Lenzi A (2022) The renaissance of wild food plants: insights from Tuscany (Italy). Foods 11(3):300. https://doi.org/10.3390/foods11030300

Berihun T, Molla E (2017) Study on the diversity and use of wild edible plants in Bullen District Northwest Ethiopia. J Bot 2017:1–10. https://doi.org/10.1155/2017/8383468

Bettencourt E, Ford-Lloyd BV, Dias S (2007) Genetic erosion and genetic pollution of crop wild relatives: the PGR forum perspective and achievements. In: Maxted N, Ford-Lloyd BV, Kell SP, Iriondo JM, Dulloo ME, Turok J (eds) Crop wild relative conservation and use. CABI, Wallingford, pp 277–286

Bharucha Z, Pretty J (2010) The roles and values of wild foods in agricultural systems. Philos Trans R Soc B 365(1554):2913–2926. https://doi.org/10.1098/rstb.2010.0123

Boedecker J, Termote C, Assogbadjo AE et al (2014) Dietary contribution of Wild Edible Plants to women's diets in the buffer zone around the Lama forest, Benin—an underutilized potential. Food Secur 6:833–849. https://doi.org/10.1007/s12571-014-0396-7

Bohra A, Kilian B, Sivasankar S, Caccamo M, Mba C, McCouch SR, Varshney RK (2022) Reap the crop wild relatives for breeding future crops. Trends Biotechnol 40(4):412–431. https://doi.org/10.1016/j.tibtech.2021.08.009

Borelli T, Hunter D, Powell B, Ulian T, Mattana E, Termote C, Pawera L, Beltrame D, Penafiel D, Tan A, Taylor M, Engels J (2020) Born to eat wild: an integrated conservation approach to secure wild food plants for food security and nutrition. Plants 9(10):1299. https://doi.org/10.3390/plants9101299

Brehm JM, Maxted N, Martins-Loução MA, Ford-Lloyd BV (2010) New approaches for establishing conservation priorities for socio-economically important plant species. Biodivers Conserv 19(9):2715–2740. https://doi.org/10.1007/s10531-010-9871-4

Brown AHD, Hodgkin T (2015) Indicators of genetic diversity, genetic erosion, and genetic vulnerability for plant genetic resources. In: Ahuja MR, Jain SM (eds) Genetic diversity and erosion in plants: indicators and prevention. Springer International Publishing, Cham, pp 25–53

Brozynska M, Furtado A, Henry RJ (2016) Genomics of crop wild relatives: expanding the gene pool for crop improvement. Plant Biotechnol J 14(4):1070–1085. https://doi.org/10.1111/pbi.12454

Cao Y, Li R, Zhou S, Song L, Quan R, Hu H (2020) Ethnobotanical study on wild edible plants used by three trans-boundary ethnic groups in Jiangcheng County, Pu'er, Southwest China. J Ethnobiol Ethnomed 16(1):66. https://doi.org/10.1186/s13002-020-00420-1

Castañeda-Álvarez NP, Khoury CK, Achicanoy HA, Bernau V, Dempewolf H, Eastwood RJ, Guarino L, Harker RH, Jarvis A, Maxted N, Müller JV, Ramirez-Villegas J, Sosa CC, Struik PC, Vincent H, Toll J (2016) Global conservation priorities for crop wild relatives. Nat Plants 2(4):16022. https://doi.org/10.1038/nplants.2016.22

CBD (2020) Aichi biodiversity targets. https://www.cbd.int/sp/targets/. Accessed 11 Dec 2022

CBD (2011) Vision. https://www.cbd.int/gspc/vision.shtml. Accessed 11 Dec 2022

Chaudhary P, Bhatta S, Aryal K, Joshi BK, Gauchan D (2020) Threats, drivers, and conservation imperative of agrobiodiversity. J Agric Environ 21:44–61. https://doi.org/10.3126/aej.v21i0.38441

Choudhary M, Singh V, Muthusamy V, Wani SH (2017) Harnessing crop wild relatives for crop improvement. Int J Life Sci 6:73. https://doi.org/10.5958/2319-1198.2017.00009.4

Ciancaleoni S, Raggi L, Barone G, Donnini D, Gigante D, Domina G, Negri V (2021) A new list and prioritization of wild plants of socio economic interest in Italy: toward a conservation strategy. Agroecol Sustain Food Syst 45(9):1300–1326. https://doi.org/10.1080/21683565.2021.1917469

Crop Wild Relatives Global Portal (2021) Crop wild relatives: the importance of crop wild relatives. http://www.cropwildrelatives.org/resources/in-situ-conservation-manual/elearning-modules/elearning/the-importance-of-crop-wild-relatives/. Accessed 26 Jul 2022

Cunningham AB (ed) (2014) Applied ethnobotany, 1st edn. Routledge, London

de Medeiros PM, Figueiredo KF, Gonçalves PHS, Caetano RDA, Santos ÉMDC, dos Santos GMC, Barbosa DM, de Paula M, Mapeli AM (2021) Wild plants and the food-medicine continuum—an ethnobotanical survey in Chapada Diamantina (Northeastern Brazil). J Ethnobiol Ethnomed 17(1):37. https://doi.org/10.1186/s13002-021-00463-y

Delang CO (2006a) The role of wild food plants in poverty alleviation and biodiversity conservation in tropical countries. Prog Dev Stud 6(4):275–286. https://doi.org/10.1191/1464993406ps143oa

Delang CO (2006b) Not just minor forest products: the economic rationale for the consumption of wild food plants by subsistence farmers. Ecol Econ 59(1):64–73. https://doi.org/10.1016/j.ecolecon.2005.10.006

Dempewolf H, Baute G, Anderson J, Kilian B, Smith C, Guarino L (2017) Past and future use of wild relatives in crop breeding. Crop Sci 57(3):1070–1082. https://doi.org/10.2135/cropsci2016.10.0885

Dida MM, Devos KM (2006) Finger millet. In: Kole C (ed) Cereals and millets. Springer, Berlin, Heidelberg, pp 333–343

Ding X-Y, Zhang Y, Wang L, Zhuang H-F, Chen W-Y, Wang Y-H (2021) Collection calendar: the diversity and local knowledge of wild edible plants used by Chenthang Sherpa people to treat seasonal food shortages in Tibet, China. J Ethnobiol Ethnomed 17(1):40. https://doi.org/10.1186/s13002-021-00464-x

Dwivedi SL, Ceccarelli S, Blair MW, Upadhyaya HD, Are AK, Ortiz R (2016) Landrace germplasm for improving yield and abiotic stress adaptation. Trends Plant Sci 21(1):31–42. https://doi.org/10.1016/j.tplants.2015.10.012

Ebert AW, Engels JMM (2020) Plant biodiversity and genetic resources matter! Plants 9(12):1706. https://doi.org/10.3390/plants9121706
Edmeades GO, Cooper M, Lafitte R, Zinselmeier C, Ribaut JM, Habben JE, Löffler C, Bänziger M (2001) Abiotic stresses and staple crops. In: Nösberger J, Geiger HH, Struik PC (eds) Crop science: progress and prospects. Papers presented at the Third International Crop Science Congress, Hamburg, Germany, 17–22 August 2000. CABI, Wallingford, pp 137–154
El Haddad N, Sanchez-Garcia M, Visioni A, Jilal A, El Amil R, Sall AT, Lagesse W, Kumar S, Bassi FM (2021) Crop wild relatives crosses: multi-location assessment in durum wheat, barley, and lentil. Agronomy 11(11):2283. https://doi.org/10.3390/agronomy11112283
El Mokni R, Barone G, Maxted N, Kell S, Domina G (2022) A prioritised inventory of crop wild relatives and wild harvested plants of Tunisia. Genet Resour Crop Evol 69(5):1787–1816. https://doi.org/10.1007/s10722-021-01340-z
El-Ramady H, Hajdú P, Törős G, Badgar K, Llanaj X, Kiss A, Abdalla N, Omara AE-D, Elsakhawy T, Elbasiouny H, Elbehiry F, Amer M, El-Mahrouk ME, Prokisch J (2022) Plant nutrition for human health: a pictorial review on plant bioactive compounds for sustainable agriculture. Sustainability 14(14):8329. https://doi.org/10.3390/su14148329
Engels JMM, Thormann I (2020) Main challenges and actions needed to improve conservation and sustainable use of our crop wild relatives. Plants 9(8):968. https://doi.org/10.3390/plants9080968
Esquinas-Alcázar J (2005) Protecting crop genetic diversity for food security: political, ethical and technical challenges. Nat Rev Genet 6(12):946–953. https://doi.org/10.1038/nrg1729
Evans MI (1993) Conservation by commercialisation. In: Ladik CM, Hladik A, Linares OF, Pagezy H, Semple A, Hadley M (eds) Tropical forests, people and food: biocultural interactions and applications to development, MAB series, vol 13. UNESCO, Paris and Parthenon Publishing Group, Carnforth, pp 815–822
FAO (2017) Voluntary guidelines for the conservation and sustainable use of crop wild relatives and wild food plants. United Nations, New York
FAO (2019) The state of the world's biodiversity for food and agriculture. In: Bélanger J, Pilling D (eds) FAO Commission on Genetic Resources for Food and Agriculture Assessments. Rome. 572 pp. http://www.fao.org/3/CA3129EN/CA3129EN.pdf
FAO (2001) International treaty on plant genetic resources for food and agriculture. https://www.fao.org/plant-treaty/en/; https://www.fao.org/3/i0510e/i0510e.pdf. Accessed 11 Dec 2022
FAO, IFAD, UNICEF, WFP, WHO (2020a) The State of Food Security and Nutrition in the World 2020. Transforming food systems for affordable healthy diets. Food and Agriculture Organization of the United Nations, Rome. https://doi.org/10.4060/ca9692en
FAO, UNEP (2020b) The State of the World's Forests 2020. Forests, biodiversity and people. Food and Agriculture Organization of the United Nations, Rome
Fatima A, Farid M, Safdar K, Fayyaz A, Ali SM, Adnan S, Nawaz M, Munir H, Raza N, Zubair M (2020) Loss of agro-biodiversity and productivity due to climate change in continent Asia: a review. In: Hasanuzzaman M (ed) Plant ecophysiology and adaptation under climate change: mechanisms and perspectives I. Springer, Singapore, pp 51–71
Fielder H, Brotherton P, Hosking J, Hopkins JJ, Ford-Lloyd B, Maxted N (2015) Enhancing the conservation of crop wild relatives in England. PLoS One 10(6):e0130804. https://doi.org/10.1371/journal.pone.0130804
Fitzgerald H (2013) The national crop wild relative strategy report for Finland. MTT report. EU Seventh Framework Programme, Jokioinen
Ford-Lloyd BV, Schmidt M, Armstrong SJ, Barazani O, Engels J, Hadas R, Hammer K, Kell SP, Kang D, Khoshbakht K, Li Y, Long C, Lu B-R, Ma K, Nguyen VT, Qiu L, Ge S, Wei W, Zhang Z, Maxted N (2011) Crop wild relatives—undervalued, underutilized and under threat? Bioscience 61(7):559–565. https://doi.org/10.1525/bio.2011.61.7.10
Fu Y-B (2017) The vulnerability of plant genetic resources conserved ex situ. Crop Sci 57(5): 2314–2328. https://doi.org/10.2135/cropsci2017.01.0014

Fuchs C (2008) Convention on international trade in endangered species of wild fauna and flora (CITES)—conservation efforts undermine the legality principle. German Law J 9:1565–1596. https://doi.org/10.1017/S2071832200000584

Garcia SM, Rice J (2020) Assessing progress towards Aichi biodiversity target 6 on sustainable marine fisheries. Technical Series No. 87. Secretariat of the Convention on Biological Diversity, Montreal

Gepts P, Papa R (2003) Possible effects of (trans)gene flow from crops on the genetic diversity from landraces and wild relatives. Environ Biosaf Res 2(2):89–103. https://doi.org/10.1051/ebr:2003009

Ghanimi R, Ouhammou A, Ahouach A, Cherkaoui M (2022) Ethnobotanical study on wild edible plants traditionally used by Messiwa people, Morocco. J Ethnobiol Ethnomed 18(1):16. https://doi.org/10.1186/s13002-022-00500-4

Gnanesh BN, Fetch JM, Zegeye T, McCartney CA, Fetch T (2014) Oat. In: Pratap A, Kumar J (eds) Alien gene transfer in crop plants, vol 2. Springer, New York, pp 51–73

Godfray HCJ, Beddington JR, Crute IR, Haddad L, Lawrence D, Muir JF, Pretty J, Robinson S, Thomas SM, Toulmin C (2010) Food security: the challenge of feeding 9 billion people. Science 327(5967):812–818. https://doi.org/10.1126/science.1185383

Goettsch B, Urquiza-Haas T, Koleff P, Acevedo Gasman F, Aguilar-Meléndez A, Alavez V, Alejandre-Iturbide G, Aragón Cuevas F, Azurdia Pérez C, Carr JA, Castellanos-Morales G, Cerén G, Contreras-Toledo AR, Correa-Cano ME, De la Cruz Larios L, Debouck DG, Delgado-Salinas A, Gómez-Ruiz EP, González-Ledesma M, González-Pérez E, Hernández-Apolinar M, Herrera-Cabrera BE, Jefferson M, Kell S, Lira-Saade R, Lorea-Hernández F, Martínez M, Mastretta-Yanes A, Maxted N, Menjívar J, Ángeles Mérida Guzmán M, Morales Herrera AJ, Oliveros-Galindo O, Orjuela-R. MA, Pollock CM, Quintana-Camargo M, Rodríguez A, Ruiz Corral JA, Sánchez González J d J, Sánchez-de la Vega G, Superina M, Tobón Niedfeldt W, Tognelli MF, Vargas-Ponce O, Vega M, Wegier A, Zamora Tavares P, Jenkins RKB (2021) Extinction risk of Mesoamerican crop wild relatives. Plants People Planet 3(6):775–795. https://doi.org/10.1002/ppp3.10225

Guarrera PM, Savo V (2016) Wild food plants used in traditional vegetable mixtures in Italy. J Ethnopharmacol 185:202–234. https://doi.org/10.1016/j.jep.2016.02.050

Gupta C, Salgotra RK, Mahajan G (2020) Future threats and opportunities facing crop wild relatives and landrace diversity. In: Salgotra RK, Zargar SM (eds) Rediscovery of genetic and genomic resources for future food security. Springer, Singapore, pp 351–364

Hajjar R, Hodgkin T (2007) The use of wild relatives in crop improvement: a survey of developments over the last 20 years. Euphytica 156(1–2):1–13. https://doi.org/10.1007/s10681-007-9363-0

Hanson AA (1952) The origin, variation, immunity, and breeding of cultivated plants: selected writings of N. I. Vavilov, translated from Russian by K. Starr Chester. Chronica Botanica, Vol. 13, No. 1/6 (pp. viii + 366). Waltham, Mass.: The Chronica Botanica Co., New York City: Stechert-Hafner, Inc. $7.50. Agron J 44(2):102–102. https://doi.org/10.2134/agronj1952.00021962004400020016x

Harlan JR, Wet JMJ (1971) Toward a rational classification of cultivated plants. Taxon 20(4): 509–517. https://doi.org/10.2307/1218252

Hay FR, Probert RJ (2013) Advances in seed conservation of wild plant species: a review of recent research. Conserv Physiol 1(1):cot030. https://doi.org/10.1093/conphys/cot030

Heywood V, Casas A, Ford-Lloyd B, Kell S, Maxted N (2007) Conservation and sustainable use of crop wild relatives. Agric Ecosyst Environ 121(3):245–255. https://doi.org/10.1016/j.agee.2006.12.014

Hickey GM, Pouliot M, Smith-Hall C, Wunder S, Nielsen MR (2016) Quantifying the economic contribution of wild food harvests to rural livelihoods: a global-comparative analysis. Food Policy 62:122–132. https://doi.org/10.1016/j.foodpol.2016.06.001

Holness S, Hamer M, Brehm JM, Raimondo D (2019) Priority areas for the in situ conservation of crop wild relatives in South Africa. Plant Genet Resour 17(2):115–127

Hunter D (ed) (2012) Crop wild relatives. Routledge
Idohou R, Assogbadjo AE, Fandohan B, Gouwakinnou GN, Glele Kakai RL, Sinsin B, Maxted N (2013) National inventory and prioritization of crop wild relatives: case study for Benin. Genet Resour Crop Evol 60:1337–1352. https://doi.org/10.1007/s10722-012-9923-6
Iriondo JM, Fielder H, Fitzgerald H, Kell SP, Labokas J, Negri V, Phillips J, Rubio Teso ML, Sensen S, Taylor N, Maxted N (2016) National strategies for the conservation of crop wild relatives. In: Maxted N, Dulloo ME, Ford-Lloyd BV (eds) Enhancing crop genepool use. Capturing wild relative and landrace diversity for crop improvement. CAB International, Wallingford, pp 161–171
IUCN (2020) The IUCN red list of threatened species. Version 2021-3. https://www.iucnredlist.org. Accessed 2020-08-01
Jarvis A, Lane A, Hijmans RJ (2008) The effect of climate change on crop wild relatives. Agric Ecosyst Environ 126(1–2):13–23. https://doi.org/10.1016/j.agee.2008.01.013
Ju Y, Zhuo J, Liu B, Long C (2013) Eating from the wild: diversity of wild edible plants used by Tibetans in Shangri-la region, Yunnan, China. J Ethnobiol Ethnomed 9(1):28. https://doi.org/10.1186/1746-4269-9-28
Kahane R, Hodgkin T, Jaenicke H, Hoogendoorn C, Hermann M, (Dyno) Keatinge JDH, d'Arros Hughes J, Padulosi S, Looney N (2013) Agrobiodiversity for food security, health and income. Agron Sustain Dev 33(4):671–693. https://doi.org/10.1007/s13593-013-0147-8
Khakurel D, Uprety Y, Łuczaj Ł, Rajbhandary S (2021) Foods from the wild: local knowledge, use pattern and distribution in Western Nepal. PLoS One 16(10):e0258905. https://doi.org/10.1371/journal.pone.0258905
Khoury CK, Greene S, Wiersema J, Maxted N, Jarvis A, Struik PC (2013) An inventory of crop wild relatives of the United States. Crop Sci 53(4):1496–1508
Khumalo S, Chirwa PW, Moyo BH, Syampungani S (2012) The status of agrobiodiversity management and conservation in major agroecosystems of Southern Africa. Agric Ecosyst Environ 157:17–23. https://doi.org/10.1016/j.agee.2012.01.028
Kidane L, Kejela A (2021) Food security and environment conservation through sustainable use of wild and semi-wild edible plants: a case study in Berek Natural Forest, Oromia special zone, Ethiopia. Agric Food Secur 10(1):29. https://doi.org/10.1186/s40066-021-00308-7
Kumar A (2021) How can India leverage its botanic gardens for the conservation and sustainable utilization of wild food plant resources through the implementation of a global strategy for plant conservation? J Zool Bot Gard 2(4):586–599. https://doi.org/10.3390/jzbg2040042
Labokas J, Maxted N, Kell S, Brehm JM, Iriondo JM (2018) Development of national crop wild relative conservation strategies in European countries. Genet Resour Crop Evol 65:1385–1403. https://doi.org/10.1007/s10722-018-0621-x
Ladio AH, Lozada M (2004) Patterns of use and knowledge of wild edible plants in distinct ecological environments: a case study of a Mapuche community from northwestern Patagonia. Biodivers Conserv 13:1153–1173. https://doi.org/10.1023/B:BIOC.0000018150.79156.50
Lala S, Amri A, Maxted N (2018) Towards the conservation of crop wild relative diversity in North Africa: checklist, prioritisation and inventory. Genet Resour Crop Evol 65(1):113–124. https://doi.org/10.1007/s10722-017-0513-5
Lauzer D, Laublin G, Vincent G, Cappadocia M (1992) In vitro propagation and cytology of wild yams, *Dioscorea abyssinica* Hoch. and *D. mangenotiana* Miège. Plant Cell Tissue Organ Cult 28:215–223. https://doi.org/10.1007/BF00055520
Lavorgna A, Rutherford C, Vaglica V, Smith MJ, Sajeva M (2018) CITES, wild plants, and opportunities for crime. Eur J Crim Policy Res 24(3):269–288. https://doi.org/10.1007/s10610-017-9354-1
Lawson C, Humphries F, Rourke M (2019) Legislative, administrative and policy approaches to access and benefit sharing ("ABS") genetic resources: digital sequence information ("DSI") in New Zealand and Australian ABS laws. Intellect Prop Forum 118:38–50

Lemmon ZH, Reem NT, Dalrymple J, Soyk S, Swartwood KE, Rodriguez-Leal D, Van Eck J, Lippman ZB (2018) Rapid improvement of domestication traits in an orphan crop by genome editing. Nat Plants 4(10):766–770. https://doi.org/10.1038/s41477-018-0259-x

Luo B, Liu B, Zhang H, Zhang H, Li X, Ma L, Wang Y, Bai Y, Zhang X, Li J, Yang J, Long C (2019) Wild edible plants collected by Hani from terraced rice paddy agroecosystem in Honghe Prefecture, Yunnan, China. J Ethnobiol Ethnomed 15(1):56. https://doi.org/10.1186/s13002-019-0336-x

Mammadov J, Buyyarapu R, Guttikonda SK, Parliament K, Abdurakhmonov IY, Kumpatla SP (2018) Wild relatives of maize, rice, cotton, and soybean: treasure troves for tolerance to biotic and abiotic stresses. Front Plant Sci 9:886. https://doi.org/10.3389/fpls.2018.00886

Maxted N, Ford-Lloyd BV, Jury S, Kell S, Scholten M (2006) Towards a definition of a crop wild relative. Biodivers Conserv 15(8):2673–2685. https://doi.org/10.1007/s10531-005-5409-6

Maxted N, Scholten M, Codd R, Ford-Lloyd B (2007) Creation and use of a national inventory of crop wild relatives. Biol Conserv 140:142–159. https://doi.org/10.1016/j.biocon.2007.08.006

Maxted N, Kell S, Toledo Á, Dulloo E, Heywood V, Hodgkin T, Hunter D, Guarino L, Jarvis A, Ford-Lloyd B (2010) A global approach to crop wild relative conservation: securing the gene pool for food and agriculture. Kew Bull 65(4):561–576. https://doi.org/10.1007/s12225-011-9253-4

Maxted N, Kell S, Ford-Lloyd B, Dulloo E, Toledo Á (2012) Toward the systematic conservation of global crop wild relative diversity. Crop Sci 52(2):774–785. https://doi.org/10.2135/cropsci2011.08.0415

Maxted N, Avagyan A, Frese L, Iriondo JM, Magos Brehm J, Singer A, Kell SP (2015) ECPGR Concept for in situ conservation of crop wild relatives in Europe. Wild Species Conservation in Genetic Reserves Working Group. European Cooperative Programme for Plant Genetic Resources, Rome, Italy

Mba C, Abang M, Diulgheroff S, Hrushka A, Hugo W, Ingelbrecht I, Jankuloski L, Leskien D, Lopez V, Muminjanov H, Mulila Mitti J, Nersisyan A, Noorani A, Piao Y, Sagnia S (2020) FAO supports countries in the implementation of the second global plan of action for plant genetic resources for food and agriculture. Acta Hortic:197–208. https://doi.org/10.17660/ActaHortic.2020.1267.30

Meilleur BA, Hodgkin T (2004) In situ conservation of crop wild relatives: status and trends. Biodivers Conserv 13(4):663–684

Menendez-Baceta G, Pardo-de-Santayana M, Aceituno-Mata L, Tardío J, Reyes-García V (2017) Trends in wild food plants uses in Gorbeialdea (Basque Country). Appetite 112:9–16. https://doi.org/10.1016/j.appet.2017.01.010

Meyer A, Barton N (2019) Botanic gardens are important contributors to crop wild relative preservation. Crop Sci 59(6):2404–2412. https://doi.org/10.2135/cropsci2019.06.0358

Milla R (2020) Crop Origins and Phylo Food: a database and a phylogenetic tree to stimulate comparative analyses on the origins of food crops. Glob Ecol Biogeogr 29(4):606–614. https://doi.org/10.1111/geb.13057

Mishra A, Swamy SL, Thakur TK, Bhat R, Bijalwan A, Kumar A (2021) Use of wild edible plants: can they meet the dietary and nutritional needs of indigenous communities in Central India. Foods 10:1453. https://doi.org/10.3390/foods10071453

Montenegro de Wit M (2016) Are we losing diversity? Navigating ecological, political, and epistemic dimensions of agrobiodiversity conservation. Agric Hum Values 33(3):625–640. https://doi.org/10.1007/s10460-015-9642-7

Montenegro de Wit M (2017) Stealing into the wild: conservation science, plant breeding and the makings of new seed enclosures. J Peasant Stud 44:169–212. https://doi.org/10.1080/03066150.2016.1168405

Mponya NK, Magombo ZLK, Pungulani L, Brehm JM, Maxted N (2020) Development of a prioritised checklist of crop wild relatives for conservation in Malawi. Afr Crop Sci J 28(2):279–311. https://doi.org/10.4314/acsj.v28i2.12

Mutie FM, Rono PC, Kathambi V, Hu G-W, Wang Q-F (2020) Conservation of wild food plants and their potential for combatting food insecurity in Kenya as exemplified by the drylands of Kitui County. Plants 9(8):1017. https://doi.org/10.3390/plants9081017

Nduche M, Magos Brehm J, Abberton M, Omosun G, Maxted N (2021) West African crop wild relative checklist, prioritization and inventory. Genet Res J 2(4):55–65. https://doi.org/10.46265/genresj.EIFL1323

Norton SL, Khoury CK, Sosa CC, Castañeda-Álvarez NP, Achicanoy HA, Sotelo S (2017) Priorities for enhancing the ex situ conservation and use of Australian crop wild relatives. Aust J Bot 65(8):638. https://doi.org/10.1071/BT16236

Nyakoojo C, Tugume P (2020) Traditional use of wild edible plants in the communities adjacent Mabira Central Forest Reserve, Uganda. Ethnobot Res Appl 20:1–14

Oseni OM, Pande V, Nailwal TK (2018) A review on plant tissue culture, a technique for propagation and conservation of endangered plant species. Int J Curr Microbiol App Sci 7(7): 3778–3786. https://doi.org/10.20546/ijcmas.2018.707.438

Padulosi S, Heywood V, Hunter D, Jarvis A (2011) Underutilized species and climate change: current status and outlook. In: Yadav SS, Redden RJ, Hatfield JL, Lotze-Campen H, Hall AE (eds) Crop adaptation to climate change. Wiley-Blackwell, Oxford, pp 507–521

Pandey A, Bhandari DC, Bhatt KC, Pareek SK, Tomer AK, Dhillon BS (2005) Wild relatives of Cflip plants in India: collection and conservation. National Bureau of Plant Genetic Resources, New Delhi

Pardo-de-Santayana M, Macía MJ (2015) The benefits of traditional knowledge. Nature 518(7540): 487–488. https://doi.org/10.1038/518487a

Pascual-Mendoza S, Saynes-Vásquez A, Pérez-Herrera A (2021) Traditional knowledge of edible plants in an indigenous community in the Sierra Norte of Oaxaca, Mexico. Plant Biosyst 156(2): 515–527. https://doi.org/10.1080/11263504.2021.1887956

Pawera L, Khomsan A, Zuhud EAM, Hunter D, Ickowitz A, Polesny Z (2020) Wild food plants and trends in their use: from knowledge and perceptions to drivers of change in West Sumatra, Indonesia. Foods 9(9):1240. https://doi.org/10.3390/foods9091240

Pence VC, Finke LR, Chaiken MF (2017) Tools for the ex situ conservation of the threatened species, *Cycladenia humilis* var. *jonesii*. Conserv Physiol 5:cox053. https://doi.org/10.1093/conphys/cox053

Perrino EV, Perrino P (2020) Crop wild relatives: know how past and present to improve future research, conservation and utilization strategies, especially in Italy: a review. Genet Resour Crop Evol 67(5):1067–1105. https://doi.org/10.1007/s10722-020-00930-7

Perrino EV, Wagensommer RP (2021) Crop Wild Relatives (CWR) priority in Italy: distribution, ecology, in situ and ex situ conservation and expected actions. Sustainability 13(4):1682. https://doi.org/10.3390/su13041682

Phillips J, Magos Brehm J, van Oort B, Asdal Å, Rasmussen M, Maxted N (2017) Climate change and national crop wild relative conservation planning. Ambio 46(6):630–643. https://doi.org/10.1007/s13280-017-0905-y

Pilling D, Bélanger J, Hoffmann I (2020) Declining biodiversity for food and agriculture needs urgent global action. Nat Food 1(3):144–147. https://doi.org/10.1038/s43016-020-0040-y

Pinela J, Carvalho AM, Ferreira ICFR (2017) Wild edible plants: nutritional and toxicological characteristics, retrieval strategies and importance for today's society. Food Chem Toxicol 110: 165–188. https://doi.org/10.1016/j.fct.2017.10.020

Porch T, Beaver J, Debouck D, Jackson S, Kelly J, Dempewolf H (2013) Use of wild relatives and closely related species to adapt common bean to climate change. Agronomy 3:433–461. https://doi.org/10.3390/agronomy3020433

Punchay K, Inta A, Tiansawat P, Balslev H, Wangpakapattanawong P (2020) Traditional knowledge of wild food plants of Thai Karen and Lawa (Thailand). Genet Resour Crop Evol 67(5): 1277–1299. https://doi.org/10.1007/s10722-020-00910-x

Rahman W, Magos Brehm J, Maxted N (2019) Setting conservation priorities for the wild relatives of food crops in Indonesia. Genet Resour Crop Evol 66(4):809–824. https://doi.org/10.1007/s10722-019-00761-1
Rajasekharan PE, Sahijram L (2015) In vitro conservation of plant germplasm. In: Bahadur B, Venkat Rajam M, Sahijram L, Krishnamurthy KV (eds) Plant biology and biotechnology. Springer India, New Delhi, pp 417–443
Ray A, Ray R, Sreevidya EA (2020) How many wild edible plants do we eat—their diversity, use, and implications for sustainable food system: an exploratory analysis in India. Front Sustain Food Syst 4:56. https://doi.org/10.3389/fsufs.2020.00056
Raza A, Razzaq A, Mehmood S, Zou X, Zhang X, Lv Y, Xu J (2019) Impact of climate change on crops adaptation and strategies to tackle its outcome: a review. Plants 8(2):34. https://doi.org/10.3390/plants8020034
Reeve R (2014) Policing international trade in endangered species: the CITES treaty and compliance. Taylor and Francis, Hoboken
Reyes-García V, Guèze M, Luz AC, Paneque-Gálvez J, Macía MJ, Orta-Martínez M, Pino J, Rubio-Campillo X (2013) Evidence of traditional knowledge loss among a contemporary indigenous society. Evol Hum Behav 34(4):249–257. https://doi.org/10.1016/j.evolhumbehav.2013.03.002
Robertson L, Labate J (2006) Genetic resources of tomato (*Lycopersicon esculentum* Mill.) and wild relatives. In: Razdan MK, Mattoo AK (eds) Genetic improvement of Solanaceous crops, vol 2. CRC Press, pp 25–75
Sánchez-Mata M d C, Matallana-González MC, Morales P (2016) The contribution of wild plants to dietary intakes of micronutrients (I): vitamins. In: Sánchez-Mata M d C, Tardío J (eds) Mediterranean wild edible plants. Springer, New York, pp 111–139
Sarkar A, Dasgupta A, Sensarma SR (2019) Climate change and food security in India: adaptation strategies and major challenges. In: Sarkar A, Sensarma SR, vanLoon GW (eds) Sustainable solutions for food security. Springer International Publishing, Cham, pp 497–520
Schanbacher WD (2010) The politics of food: the global conflict between food security and food sovereignty. Praeger Security International, Santa Barbara
Schulp CJE, Thuiller W, Verburg PH (2014) Wild food in Europe: a synthesis of knowledge and data of terrestrial wild food as an ecosystem service. Ecol Econ 105:292–305. https://doi.org/10.1016/j.ecolecon.2014.06.018
Schunko C, Li X, Klappoth B, Lesi F, Porcher V, Porcuna-Ferrer A, Reyes-García V (2022) Local communities' perceptions of wild edible plant and mushroom change: a systematic review. Glob Food Sec 32:100601. https://doi.org/10.1016/j.gfs.2021.100601
Shelef O, Weisberg PJ, Provenza FD (2017) The value of native plants and local production in an era of global agriculture. Front Plant Sci 8:2069. https://doi.org/10.3389/fpls.2017.02069
Siddiqui A, Shukla S (2015) Conservation of plant genetic resources and their utilisation in global perspective. Int J Life Sci 4:46. https://doi.org/10.5958/2319-1198.2015.00007.X
Singh B, Bedi YS (2017) Eating from raw wild plants in Himalaya: traditional knowledge documentary on Sheena tribes along LoC border in Kashmir. Indian J Nat Prod Resour 8(3):269–275
Singh A, Dubey PK, Chaurasia R, Dubey RK, Pandey KK, Singh GS, Abhilash PC (2019) Domesticating the undomesticated for global food and nutritional security: four steps. Agronomy 9(9):491
Smýkal P, Hradilová I, Trněný O, Brus J, Rathore A, Bariotakis M, Das RR, Bhattacharyya D, Richards C, Coyne CJ, Pirintsos S (2017) Genomic diversity and macroecology of the crop wild relatives of domesticated pea. Sci Rep 7(1):17384. https://doi.org/10.1038/s41598-017-17623-4
Tanksley SD, McCouch SR (1997) Seed banks and molecular maps: unlocking genetic potential from the wild. Science 277(5329):1063–1066. https://doi.org/10.1126/science.277.5329.1063
Tardío J, Pardo-De-Santayana M, Morales R (2006) Ethnobotanical review of wild edible plants in Spain. Bot J Linn Soc 152(1):27–71. https://doi.org/10.1111/j.1095-8339.2006.00549.x

Taylor NG, Kell SP, Holubec V, Parra-Quijano M, Chobot K, Maxted N (2017) A systematic conservation strategy for crop wild relatives in the Czech Republic. Divers Distrib 23(4): 448–462. https://doi.org/10.1111/ddi.12539

Tewksbury JJ, Nabhan GP, Norman D, Suzan H, Tuxill J, Donovan J (1999) In situ conservation of wild chiles and their biotic associates. Conserv Biol 13(1):98–107. https://doi.org/10.1046/j.1523-1739.1999.97399.x

Thorn JPR, Thornton TF, Helfgott A, Willis KJ (2020) Indigenous uses of wild and tended plant biodiversity maintain ecosystem services in agricultural landscapes of the Terai Plains of Nepal. J Ethnobiol Ethnomed 16(1):33. https://doi.org/10.1186/s13002-020-00382-4

Thorpe T (2007) History of plant tissue culture. J Mol Microbial Biotechnol 37:169–180

Turner NJ, Łuczaj ŁJ, Migliorini P, Pieroni A, Dreon AL, Sacchetti LE, Paoletti MG (2011) Edible and tended wild plants, traditional ecological knowledge and agroecology. Crit Rev Plant Sci 30(1–2):198–225. https://doi.org/10.1080/07352689.2011.554492

Tyack N, Dempewolf H, Khoury CK (2020) The potential of payment for ecosystem services for crop wild relative conservation. Plants 9(10):1305. https://doi.org/10.3390/plants9101305

Ulian T, Diazgranados M, Pironon S, Padulosi S, Liu U, Davies L, Howes MR, Borrell JS, Ondo I, Pérez-Escobar OA, Sharrock S, Ryan P, Hunter D, Lee MA, Barstow C, Łuczaj Ł, Pieroni A, Cámara-Leret R, Noorani A, Mba C, Nono Womdim R, Muminjanov H, Antonelli A, Pritchard HW, Mattana E (2020) Unlocking plant resources to support food security and promote sustainable agriculture. Plants People Planet 2(5):421–445. https://doi.org/10.1002/ppp3.10145

Upreti BR, Upreti YG (2002) Factors leading to agro-biodiversity loss in developing countries: the case of Nepal. Biodivers Conserv 11:1607–1621. https://doi.org/10.1023/A:1016862200156

Uprety Y, Poudel RC, Shrestha KK, Rajbhandary S, Tiwari NN, Shrestha UB, Asselin H (2012) Diversity of use and local knowledge of wild edible plant resources in Nepal. J Ethnobiol Ethnomed 8(1):16. https://doi.org/10.1186/1746-4269-8-16

van Treuren R, Hoekstra R, Wehrens R, van Hintum T (2020) Effects of climate change on the distribution of crop wild relatives in the Netherlands in relation to conservation status and ecotope variation. Glob Ecol Conserv 23:e01054. https://doi.org/10.1016/j.gecco.2020.e01054

Vavilov NI (1951) The origin, variation, immunity and breeding of cultivated plants. Soil Sci 72: 482. https://doi.org/10.1097/00010694-195112000-00018

Vincent H, Amri A, Castañeda-Álvarez NP, Dempewolf H, Dulloo E, Guarino L, Hole D, Mba C, Toledo A, Maxted N (2019) Modeling of crop wild relative species identifies areas globally for in situ conservation. Commun Biol 2(1):136. https://doi.org/10.1038/s42003-019-0372-z

Vincent H, Hole D, Maxted N (2022) Congruence between global crop wild relative hotspots and biodiversity hotspots. Biol Conserv 265:109432. https://doi.org/10.1016/j.biocon.2021.109432

Viruel J, Kantar MB, Gargiulo R, Hesketh-Prichard P, Leong N, Cockel C, Forest F, Gravendeel B, Pérez-Barrales R, Leitch IJ, Wilkin P (2021) Crop wild phylorelatives (CWPs): phylogenetic distance, cytogenetic compatibility and breeding system data enable estimation of crop wild relative gene pool classification. Bot J Linn Soc 195:1–33. https://doi.org/10.1093/botlinnean/boaa064

von Wettberg E, Davis TM, Smýkal P (2020) Editorial: wild plants as source of new crops. Front Plant Sci 11:591554. https://doi.org/10.3389/fpls.2020.591554

Warschefsky E, Penmetsa RV, Cook DR, von Wettberg EJB (2014) Back to the wilds: tapping evolutionary adaptations for resilient crops through systematic hybridization with crop wild relatives. Am J Bot 101(10):1791–1800. https://doi.org/10.3732/ajb.1400116

Wessels C, Merow C, Trisos CH (2021) Climate change risk to southern African wild food plants. Reg Environ Chang 21(2):29. https://doi.org/10.1007/s10113-021-01755-5

Winstead DJ, Jacobson MG (2022) Food resilience in a dark catastrophe: a new way of looking at tropical wild edible plants. Ambio 51(9):1949–1962. https://doi.org/10.1007/s13280-022-01715-1

Xu Y, Liang D, Wang G-T, Wen J, Wang R-J (2020) Nutritional and functional properties of wild food-medicine plants from the coastal region of South China. J Evid Based Complement Altern Med 25:2515690X2091326. https://doi.org/10.1177/2515690X20913267

Yeşil Y, Çelik M, Yılmaz B (2019) Wild edible plants in Yeşilli (Mardin-Turkey), a multicultural area. J Ethnobiol Ethnomed 15(1):52. https://doi.org/10.1186/s13002-019-0327-y
Yu H, Lin T, Meng X, Du H, Zhang J, Liu G, Chen M, Jing Y, Kou L, Li X, Gao Q, Liang Y, Liu X, Fan Z, Liang Y, Cheng Z, Chen M, Tian Z, Wang Y, Chu C, Zuo J, Wan J, Qian Q, Han B, Zuccolo A, Wing RA, Gao C, Liang C, Li J (2021) A route to de novo domestication of wild allotetraploid rice. Cell 184(5):1156–1170.e14. https://doi.org/10.1016/j.cell.2021.01.013
Yuan Z, Lun F, He L, Cao Z, Min Q, Bai Y, Liu M, Cheng S, Li W, Fuller A (2014) Exploring the state of retention of traditional ecological knowledge (TEK) in a Hani Rice Terrace Village, Southwest China. Sustainability 6(7):4497–4513. https://doi.org/10.3390/su6074497
Zair W, Maxted N, Amri A (2018) Setting conservation priorities for crop wild relatives in the Fertile Crescent. Genet Resour Crop Evol 65(3):855–863. https://doi.org/10.1007/s10722-017-0576-3
Zair W, Maxted N, Brehm JM, Amri A (2021) Ex situ and in situ conservation gap analysis of crop wild relative diversity in the Fertile Crescent of the Middle East. Genet Resour Crop Evol 68(2):693–709. https://doi.org/10.1007/s10722-020-01017-z
Zamora-Tavares P, Vargas-Ponce O, Sánchez-Martínez J, Cabrera-Toledo D (2015) Diversity and genetic structure of the husk tomato (*Physalis philadelphica* Lam.) in Western Mexico. Genet Resour Crop Evol 62:141–153. https://doi.org/10.1007/s10722-014-0163-9
Zhang H, Mittal N, Leamy LJ, Barazani O, Song B-H (2017) Back into the wild-Apply untapped genetic diversity of wild relatives for crop improvement. Evol Appl 10(1):5–24. https://doi.org/10.1111/eva.12434
Zhu X-G, Zhu J-K (2021) Precision genome editing heralds rapid de novo domestication for new crops. Cell 184(5):1133–1134. https://doi.org/10.1016/j.cell.2021.02.004
Ziska LH (2021) Crop adaptation: weedy and crop wild relatives as an untapped resource to utilize recent increases in atmospheric CO2. Plants 10(1):88. https://doi.org/10.3390/plants10010088