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LITERATURE REVIEW

Neglected and underutilized food plants: Prospects in the Near East and North Africa – a review

Plantas alimentares negligenciadas e subutilizadas: Perspectivas no oriente próximo e norte da África – uma revisão

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HIGHLIGHTS:
Traditional knowledge supports agrobiodiversity and sustainable farming in the Near East and North Africa (NENA) region.
Underutilized food species support food security and agricultural resilience in dry regions, particularly in the NENA region.
Policy and structural barriers hinder the use of neglected species for sustainability.

ABSTRACT: This review aimed to clearly examine the role and future prospects of neglected and underutilized food plant species (NUSs) in enhancing food security, agricultural sustainability, and climate resilience in the Near East and North Africa (NENA) region. NUSs represent a diverse group of plant species with untapped potential to combat food insecurity, reduce poverty, and tackle climate change challenges. Despite their resilience and adaptability, these wild and semi-domesticated varieties remain overlooked by agricultural researchers, policymakers, and plant breeders, resulting in their underutilization. In arid and semi-arid regions, particularly the NENA region, NUSs could transform agricultural systems by diversifying production, fostering sustainable livelihoods, and enhancing climate resilience. As key custodians of biodiversity, cultural heritage, and traditional knowledge, indigenous women play a crucial role in promoting these NUSs. This review synthesizes existing research on the multidimensional roles of NUSs in food and nutrition security, sustainability, and climate adaptation in the NENA region. It examines global examples of successful NUS integration, analyzes the historical and structural barriers to their adoption, and highlights policy and research directions, supporting their mainstream utilization. The findings highlight that leveraging neglected plant species can promote sustainability, resilience, and economic opportunities, contributing significantly to the achievement of sustainable development goals in the NENA region.

Key words: agroecological sustainability, climate change adaptation, food security, agricultural diversification

RESUMO: Esta revisão teve como objetivo examinar claramente o papel e as perspectivas futuras das espécies vegetais alimentares negligenciadas e subutilizadas (NUS) na promoção da segurança alimentar, sustentabilidade agrícola e resiliência climática na região do Oriente Próximo e Norte da África (NENA). As NUS representam um grupo diversificado de espécies vegetais com potencial inexplorado para combater a insegurança alimentar, reduzir a pobreza e enfrentar os desafios das mudanças climáticas. Apesar de sua resiliência e adaptabilidade, essas variedades selvagens e semi-domesticadas continuam sendo negligenciadas por pesquisadores agrícolas, formuladores de políticas e melhoristas de plantas, o que leva à sua subutilização. Em regiões áridas e semiáridas, especialmente na região NENA, as NUS poderiam transformar os sistemas agrícolas ao diversificar a produção, promover meios de subsistência sustentáveis e melhorar a resiliência climática. Mulheres indígenas, como principais guardiãs da biodiversidade, do patrimônio cultural e do conhecimento tradicional, desempenham um papel crucial na promoção dessas NUS. Esta revisão sintetiza pesquisas existentes sobre os papéis multidimensionais das NUS na segurança alimentar e nutricional, sustentabilidade e adaptação climática na região NENA. Examina exemplos globais de integração bem-sucedida das NUS, analisa as barreiras históricas e estruturais à sua adoção e destaca direções para políticas e pesquisas que apoiem sua utilização generalizada. Os resultados destacam que aproveitar as espécies vegetais negligenciadas pode promover sustentabilidade, resiliência e oportunidades econômicas, contribuindo significativamente para o alcance dos objetivos de desenvolvimento sustentável na região NENA.

Palavras-chave: sustentabilidade agroecológica, adaptação às mudanças climáticas, segurança alimentar, diversificação agrícola

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Introduction

Plants are central to human existence and food systems, but global food security remains dependent on a narrow selection of staple crops—mainly wheat, rice, and maize. These three species occupy nearly 40% of the world's arable land and provide over half of plant-derived calories globally. Although they are vital in addressing hunger and poverty, they fall short of meeting humanity's complete nutritional needs. Dietary diversity remains limited among poor and marginalized communities (Kay et al., 2022). To address these nutritional and ecological challenges, growing global interest has focused on neglected and underutilized species (NUSs), estimated at around 5000 globally. Despite their historical and cultural value, NUSs have been overshadowed by dominant crops due to social, economic, and agricultural constraints (Li et al., 2020). However, they have vast potential for supporting diversified, sustainable, and resilient food systems.

Environmental pressures, such as climate change, resource depletion, and monoculture farming, underscore the urgency of adopting climate-resilient NUSs (Wang, 2022). These species often thrive under challenging conditions with minimal inputs, benefiting smallholder farmers that are vulnerable to climate impacts (Talucder et al., 2024; Oguche et al., 2025). Although overlooked by mainstream research, NUSs remain embedded in traditional knowledge and practices. Preserving this knowledge is vital for rural livelihoods, food access, and agricultural resilience (Akinola et al., 2020). Quinoa exemplifies this dynamic; once confined to Andean communities, its global rise has sparked "food sequestration", limiting availability for local consumers (Andreotti et al., 2022). Collaborations among indigenous communities, smallholders, and organizations, such as IFAD, emphasize the nutritional, cultural, and ecological value of NUSs. These partnerships advocate for inclusive policies and innovations that respect local rights while also opening access to global markets (Tung et al., 2024). Success requires placing the custodians of NUSs at the center, as their engagement is vital for biodiversity and future food security (Wijerathna-Yapa & Pathirana, 2022). Notable NUSs include quinoa, amaranth, millet, sorghum, teff, fonio, and bambara groundnut (Hunter et al., 2019; Naresh et al., 2021; Talucder et al., 2024).

Although regions, such as Latin America, Asia, and Sub-Saharan Africa, recognize the value of NUSs, conservation remains inadequate, with only 25% of countries reporting good measures (FAO, 2010; Padulosi et al., 2021a). Use patterns vary widely, with intensive use in India, Nepal, and Malaysia and moderate use elsewhere (Astutik et al., 2019; Ulian et al., 2020; Padulosi et al., 2021b). This review aimed to examine the role and future prospects of NUSs in enhancing food security, agricultural sustainability, and climate resilience in the Near East and North Africa (NENA) region.

NUS Uses and Distribution

Key factors contributing and challenges to the use of NUSs

Several factors drive the propagation and use of NUSs, particularly in rural and indigenous communities:

- Religious Practices: Certain underutilized NUSs are cultivated specifically for religious ceremonies in some regions. For example, the Rai community offers millet to deities during religious rituals in the Eastern Himalayas (Chhetri et al., 2020).
- Traditional Festivals: NUSs hold special significance during traditional festivals. In regions, including Sikkim and North Bengal, NUSs, such as millet and tubers (yams and taro) are consumed during festivals, such as Makarsakranti (Chhetri et al., 2020). NUSs are also offered to deities as a symbol of thanksgiving after the harvest in tribal societies, such as those in Jharkhand and Odisha (Tripathi & Vyas, 2023).
- Local Cuisine: NUSs contribute significantly to local cuisine. For example, the Mongpa tribals of Arunachal Pradesh prepare a traditional porridge, Zan, from millet flour, and fermented foods, such as gundruk and axone, are commonly prepared in Northeast India (Sharma & Kant, 2023).
- Traditional Food Systems: Many NUSs are indigenous and form a cornerstone of food security for local populations. The fiddlehead fern, stinging nettle, air potato, and white yam are widely consumed in the Eastern Himalayas, highlighting the essential role of indigenous heritage in sustaining food security (Patel et al., 2024).
- Folk Traditions and Cultural Folklore: NUSs also feature prominently in folk traditions and cultural celebrations. For example, the traditional Punjabi folk song 'Bajre Da Sitta' celebrates the millet harvest and is sung at weddings in the Punjab region (Attique et al., 2024).

These examples reveal the critical role that NUSs play in food security and preserving cultural identity, traditional practices, and agricultural biodiversity (Heywood, 2011). Despite the challenges in recognizing and conserving these species, NUSs play a crucial role in fostering a more sustainable, diverse, and resilient agricultural system (Ulian et al., 2020).

In addition to the common reasons for the importance of NUS, their significance in the NENA region arises from the unique and pressing challenges faced by the region. NENA is among the driest regions in the world, with an average annual precipitation of approximately 150 mm (Iskandar et al., 2025). Considering that renewable water resources per capita in NENA are among the lowest globally (690 m^3 per capita per year), the limited rainfall starkly contrasts with the world's average of 6400 m^3 per capita per year (El Chami, 2022). The region's water availability is rapidly declining due to population growth, with over half of the population living under water stress conditions, and projections suggest that this number will grow as the population is expected to reach 700 million by 2050 (Marsily, 2007). As a result, water availability per capita will be halved. Furthermore, in 2020, the region experienced one of the worst desert locust outbreaks, impacting over 23 countries, including Yemen and Djibouti, and worsening food security and livelihoods for millions (Kassegn & Endris, 2021).

The second key challenge is population growth, which remains the highest globally. Urban areas in the NENA region are expanding rapidly, with 66% of the population expected to reside in cities by 2030. Although countries, such as Egypt have achieved productivity gains above the world average (FAO, 2023), overall agricultural productivity in the NENA region has not kept pace with the increasing population. According to the United Nations World Population Prospects (2024), the population reached 549 million in the NENA region in 2022 (United Nations, 2024), placing substantial pressure on regional resources, infrastructure, and food systems.

The third major challenge is dietary patterns and nutrition. The NENA region is highly dependent on imported food, especially wheat and other staple grains, with imports accounting for half of the food supply and up to 90% in Gulf Cooperation Council countries (Abay et al., 2020). Although wheat-based products comprise a large portion of the daily calorie intake, this system does not provide sufficient nutritional value. Despite meeting the caloric needs, the region faces a dual burden of malnutrition, with stunting and obesity prevalent (Steyn & Nel, 2022). In Yemen, 16.4% of children under 5 suffer from wasting, a severe acute malnutrition condition; among adults 25.4% of women and 14.6% of men are obese. In Djibouti, adult obesity affects 20.3% of women and 10.0% of men, highlighting the need for integrated nutritional reforms across NENA food systems (Global Nutrition Report, 2024a, b).

NUS and Scientific Research

In terms of scientific research, there has been a notable increase in publications focused on NUSs. Research articles on NUSs steadily increased from 2018 (8.96%) to 2021 (16.42%) (Figure 1) (Talucder et al., 2024).

The peak in publications in 2021 underscores the rising significance of NUSs in tackling food and nutrition security challenges and mitigating climate change (Rokka et al., 2025). Academic interest in NUSs has also increased. Between 2018 and 2021, scholarly publications on NUSs nearly doubled, peaking in 2021 when they represented 16.42% of total NUS-related research output. This reflects the growing recognition of NUSs as crucial to solving issues of food and nutrition insecurity, biodiversity loss, and climate vulnerability (Talucder et al., 2024; Rokka et al., 2025).

NUS Diversity in the Nena Region

Underutilized food species are often referred to by such terms as NUS, orphan, underdeveloped, abandoned, alternative, promising, and minor species. The term "underutilized" refers to plant species that were widely cultivated in ancient times due to such factors as agronomy and economics (Tanimonure et al., 2021). NUS are complementary parts of local culture and essential components of local consumption and production systems. These species are highly adaptable to agroecological conditions and peripheral areas (Johns et al., 2013). Also known as NUSs or foods of the poor, they play a significant role in halting biodiversity loss and addressing the malnutrition crisis (Knez et al., 2024). Figure 2 provides an illustrated overview of the main NUSs across the NENA region, highlighting their diversity and potential. Figure 3 presents a mind map that summarizes key NUSs in the NENA region, offering a visual representation of their classification and various uses.

"Hidden hunger" is a term that describes the state of nutrient deficiencies affecting a large portion of the population, especially in regions such as Sub-Saharan Africa and South Asia (Lowe, 2021). Once used by rural consumers, food industries, and agriculture, these NUS resources serve as fundamental solutions for reducing malnutrition, hunger, and environmental degradation (Sibanda et al., 2023). For instance, NUSs include cereals, pseudocereals, roots, legumes, vegetables, tubers, and minor millets (Tadele, 2019). NUSs have been agronomically proven to offer significant benefits. A previous study has shown that these NUSs adapt well to marginal environments, require fewer inputs, contribute to food and nutritional security, maintain agrobiodiversity, and exhibit resilience to climate change (Padulosi et al., 2021a).

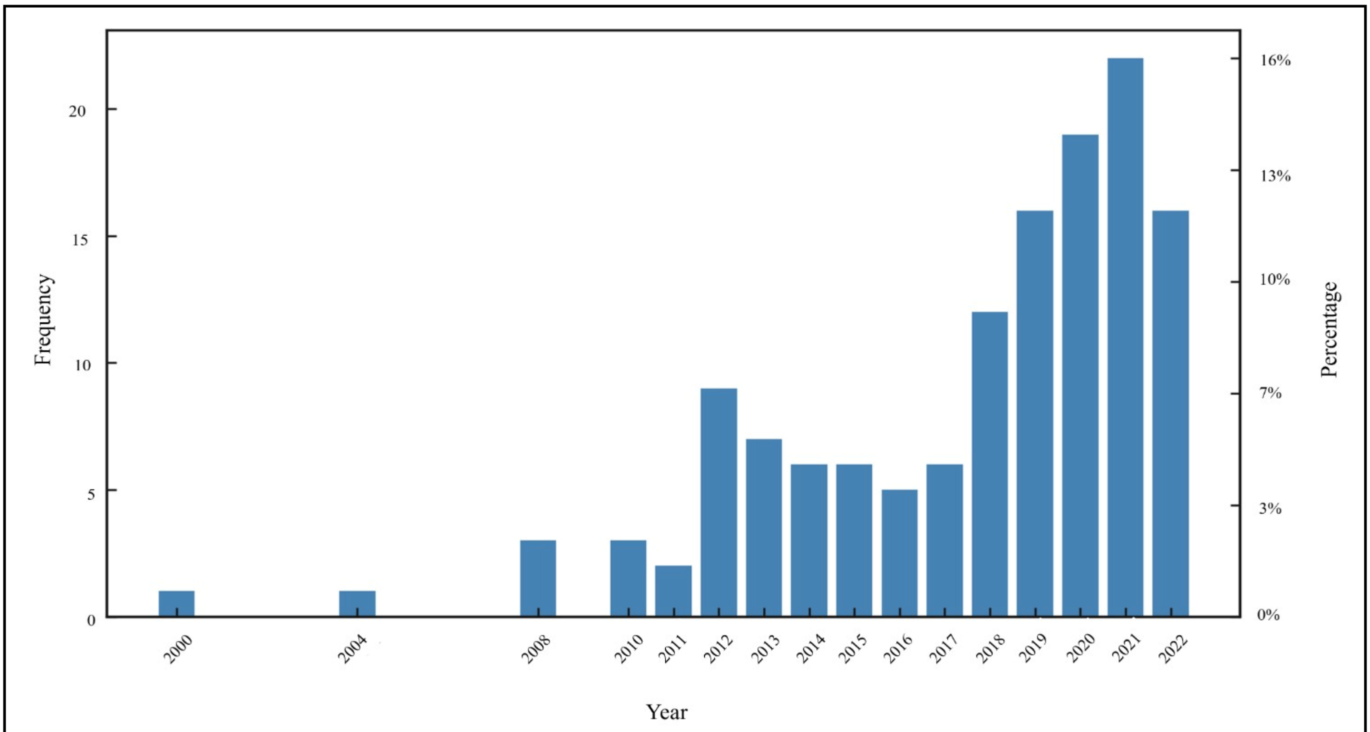

Figure 1. Distribution of published research articles over two decades (Talucder et al., 2024)

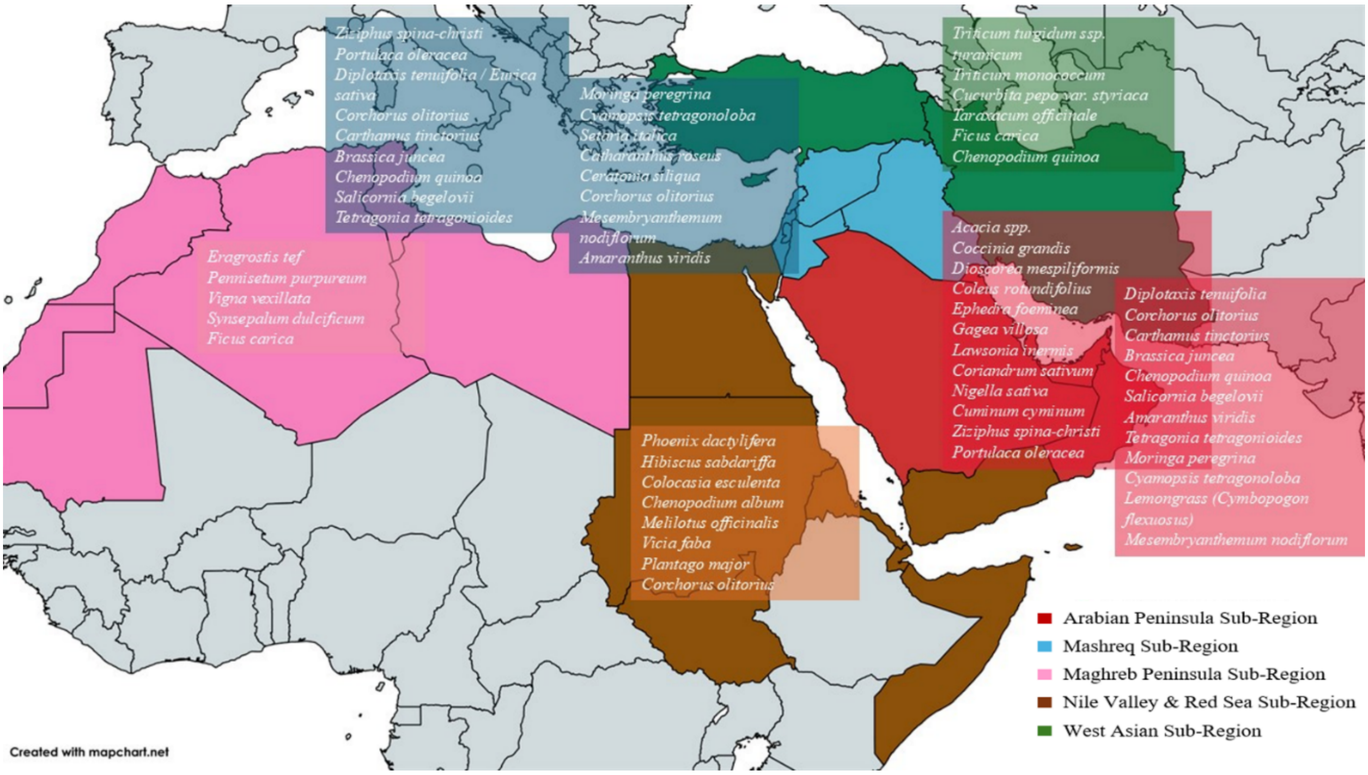

Figure 2. Illustrated overview of main neglected and underutilized food plant species (NUSs) in Near East and North Africa (NENA)

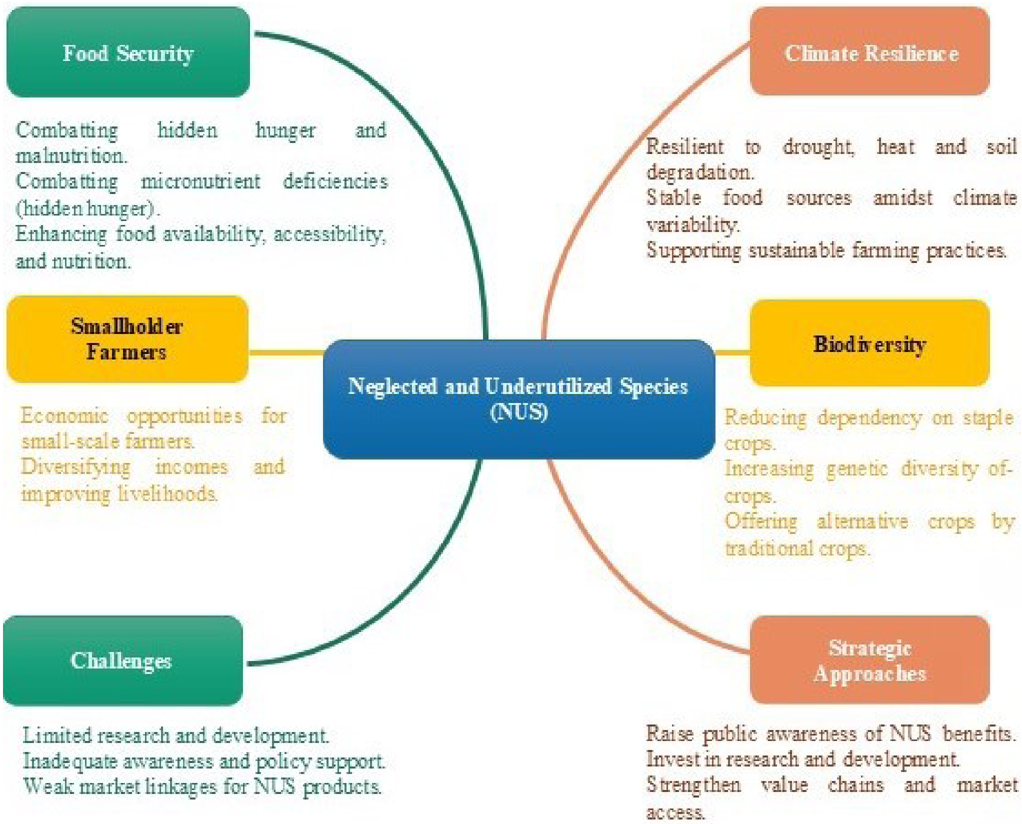

Figure 3. Key main neglected and underutilized food plant species (NUSs): a mind map for NENA (Near East and North Africa)

For example, minor millets and pseudocereals, such as quinoa and amaranth, are recognized for their drought tolerance and high nutritional value (Rodríguez et al., 2020). Similarly, root and tuber NUSs, such as cassava and yams, serve as important staples in many regions but have historically been less researched than cereals (Nanbol & Namo, 2019). These agronomic characteristics highlight the potential of NUSs to contribute to sustainable agriculture and global food security (Ulian et al., 2020). Compared to mainstream NUSs, these underutilized species offer special advantages, such as being able to withstand stressful conditions and requiring minimal input and low-tech agricultural practices. Despite their potential to enhance food security and resilience, NUSs have received limited attention from policymakers. These NUSs are often excluded from national research agendas, development programs, and investment strategies, which focus primarily on major staple crops, such as wheat and rice (Hunter et al., 2019). As a result, NUSs remain underfunded, under-researched, and largely absent from formal agricultural policies, despite their adaptability to marginal environments and nutritional value (Lara et al., 2023).

Efforts are needed to improve the cultivation, harvesting, post-harvesting, and management of these NUSs and to regulate their use, nutritional value, and marketability (Tadesse et al., 2024). Most underutilized species, particularly landraces, require enhancement, but cultivated NUSs can be improved by adopting innovative cultivation practices and utilizing local knowledge (Rosero et al., 2020).

The following survey provides examples of NUSs and their distribution across NENA:

A. Cereal and pseudo-cereal NUSs (Nandan et al., 2024): amaranth (*Amaranthus caudatus*), emmer (*Triticum dicoccon*), einkorn (*Triticum monococcum*), spelt (*Triticum spelta*), cañihua (*Chenopodium pallidicaule*), little millet (*Panicum sumatrense*), and buckwheat (*Fagopyrum* spp.).

B. Roots and tubers: vacon (*Smallanthus sonchifolius*), yams (*Dioscorea* spp.), ulluco (*Ullucus tuberosus*), American yam bean (*Pachyrhizus* spp.), oca (*Oxalis tuberosa*), and cocoyam (*Xanthosoma sagittifolium*).

C. Fruit and nuts: breadfruit (*Artocarpus altilis*), maya nut (*Brosimum alicastrum*), jackfruit (*Artocarpus heterophyllus*), jujube (*Ziziphus mauritiana*), baobab (*Adansonia digitata*), pomegranate (*Punica granatum*), annona species, nipa palm (*Nypa fruticans*), acacia (*Acacia toritilis*), tree grapes (*Lamnea* spp.), Malabar chestnut (*Pachira aquatica*), egg nut (*Couepia longipendula*), Araza (*Eugenia stipitata*), and miracle fruit (*Synsepalum dulcificum*).

D. Vegetables and herbs: African eggplant (*Solanum aethiopicum*), moringa (*Moringa oleifera*), leaf amaranth (*Amaranthus* spp.), locust bean (*Parkia biglobosa*), brassica (*Brassica rapa* varieties), winged bean (*Psophocarpus tetragonolobus*), bitter gourd (*Momordica charantia*), Ceylon spinach (*Basella rubra*), black nightshade (*Solanum nigrum*), egusi (*Citrullus lanatus*), giant swamp taro (*Cyrtosperma merkusii*), cardoon (*Cynara cardunculus*), and bitter leaf (*Vernonia amygdalina*).

E. Legumes: mungbean (*Vigna radiata*), adzuki bean (*Vigna angularis*), lupin (*Lupinus mutabilis*), jack bean (*Canavalia ensiformis*), pigeon pea (*Cajanus cajan*), Kersting's groundnut (*Macrotyloma geocarpum*), and African yam bean (*Sphenostylis stenocarpa*).

F. Spices, condiments, and food dye agents: Annatto (*Bixa orellana*), Makoni (*Fadogia ancylantha*), mustard seed (*Brassica juncea*), pandan (*Pandanus amaryllifolius*), antidesma (*Antidesma venosum*), rocket (*Diplotaxis* spp.), monkey cola (*Cola lateritia*), nigella (*Nigella sativa*), and sea buckthorn (*Hippophae rhamnoides*).

Table 1 provides an overview of several NENA species, emphasizing their diverse distribution and remarkable adaptability. This wide array of species shows their ability to

Table 1. Documented neglected and underutilized food plant species (NUS) in the Near East and North Africa (NENA) region

	Scientific name	Local/Common name	Country	Reference
1	*Sorghum bicolor* (L.)	Sorghum	NENA	Devkota et al. (2025)
2	*Hordeum vulgare* (L.)	Barley	NENA	Devkota et al. (2025)
3	*Triticum turgidum* ssp. *durum*	Durum wheat	NENA	Devkota et al. (2025)
4	*Triticum turgidum* ssp. *turanicum*	Kamut (Khorasan wheat)	NENA	Devkota et al. (2025)
5	× *Triticosecale* Wittmack	Triticale	NENA	Devkota et al. (2025)
6	*Triticum monococcum* L. subsp. *monococcum*	Einkorn wheat	NENA	Devkota et al. (2025)
7	*Cicer arietinum* L.	Chickpea	NENA	Devkota et al. (2025)
8	*Lens culinaris* subsp. *culinaris*	Lentil	NENA	Devkota et al. (2025)
9	*Lathyrus sativus* (L.)	Grass pea	NENA	Devkota et al. (2025)
10	*Acacia* spp.	Acacia pods	NENA	Devkota et al. (2025)
11	*Colocasia esculenta* (L.)	Taro	NENA	Devkota et al. (2025)
12	*Phoenix dactylifera* L.	Date palm	NENA	Devkota et al. (2025)
13	*Opuntia basilaris* P.	Cactus pear (Nopal)	NENA	Devkota et al. (2025)
14	*Olea europaea* L.	Olive	NENA	Devkota et al. (2025)
15	*Atriplex halimus* L.	Atriplex (Saltbush)	NENA	Devkota et al. (2025)
16	*Halophytes* spp.	Halophytes	NENA	Devkota et al. (2025)
17	*Coccinia grandis* (L.) Voigt	Ivy Gourd	Arabian Peninsula	Hegazy et al. (2019)
18	*Diospyros mespiliformis* Hochst. ex A. DC.	Jackalberry	Arabian Peninsula	Hegazy et al. (2019)
19	*Coleus rotundifolius* (Poir.) A.Chev.	Madagascar Potato	Arabian Peninsula	Hegazy et al. (2019)
20	*Ephedra foeminea* Forssk.	Ephedra	Arabian Peninsula	Hegazy et al. (2019)
21	*Gagea villosa* (M.Bieb.) Sweet	Hairy Star of Bethlehem	Arabian Peninsula	Hegazy et al. (2019)
22	*Lawsonia inermis* L.	Henna	Arabian Peninsula	Gotor et al. (2013)
23	*Coriandrum sativum* L.	Coriander	Arabian Peninsula	Gotor et al. (2013)
24	*Nigella sativa* L.	Nigella	Arabian Peninsula Nile Valley Iran	Gotor et al. (2013)
25	*Cuminum cyminum* L.	Cumin	Arabian Peninsula	Gotor et al. (2013)
26	*Ziziphus spina-christi* L.	Christ's Thorn Jujube Sidr (Arabic)	Mashreq subregion Arabian Peninsula	Rao et al. (2014)
27	*Portulaca oleracea* L.	Purslane	Mashreq subregion Arabian Peninsula	Rao et al. (2014)
28	*Eruca sativa* Mill. and *Diplotaxis tenuifolia* (L.) DC.	Rocket	Mashreq subregion Arabian Peninsula	Rao et al. (2014)

Continued on next page

Continuation of Table 1

	Scientific name	Local/Common name	Country	Reference
29	*Corchorus olitorius* L.	Jute Mallow	Mashreq subregion Arabian Peninsula	Rao et al. (2014)
30	*Carthamus tinctorius* L.	Safflower	Mashreq subregion Arabian Peninsula Pakistan	Rao et al. (2014)
31	*Brassica juncea* (L.) Czern. & Coss.	Leaf Mustard	Mashreq subregion Arabian Peninsula	Rao et al. (2014)
32	*Chenopodium quinoa* Willd.	Quinoa	Mashreq subregion Arabian Peninsula	Rao et al. (2014)
33	*Salicornia bigelovii* Torr.	Salicornia	Mashreq subregion Arabian Peninsula	Rao et al. (2014)
34	*Amaranthus viridis* L.	Amaranthus auentlls L.	Mashreq subregion Arabian Peninsula	Rao et al. (2014)
35	*Tetragonia tetragonioides* (Pall.) Kuntze	New Zealand spinach	Mashreq subregion Arabian Peninsula	Rao et al. (2014)
36	*Moringa peregrina* (Forssk.) Fiori	Wild drumstick tree	Mashreq subregion Arabian Peninsula	Rao et al. (2014)
37	*Cyamopsis tetragonoloba* (L.) Taub.	Guar	Mashreq subregion Arabian Peninsula	Rao et al. (2014)
38	*Vigna vexillata* (L.) A. Rich.	Zombi Pea	North Africa	Dachapak et al. (2018)
39	*Synsepalum dulcificum* (Schumach. & Thonn.) Daniell	Miracle fruit	North Africa	Tchokponhoué et al. (2017)
40	*Pennisetum purpureum* Schumach.	Napier grass	North Africa	Khan et al. (2010)
41	*Setaria italica* (L.) P. Beauv.	Foxtail millet	Mashreq subregion Arabian Peninsula	Devkota et al. (2025)
42	*Hibiscus sabdariffa* L.	Hibiscus or Roselle	Nile valley sub-region	Mudau et al. (2022)
43	*Catharanthus roseus* (L.) G. Don	Cape periwinkle graveyard plant	Mashreq subregion	Levy et al. (1983)
44	*Cucurbita pepo* var. *styriaca* (L.)	Pumpkin	Iran	Shamari et al. (2021)
45	*Chenopodium album* L.	Scarlet pimpernel	Nile Valley	El-Razik et al. (2019)
46	*Melilotus officinalis* (L.) Pall.	Sweet clover	Nile Valley	El-Razik et al. (2019)
47	*Cymbopogon citratus* (Lemongrass)	Cymbopogon flexuosus (Nees ex Steud.) W. Watson	Arabian Peninsula	Sujatha et al. (2010)
48	*Abelmoschus esculentus* (L.) Moench	Ladies' fingers or Okra	North Africa Iran	Xavier et al. (2019)
49	*Plantago major* L.	Plantain	Nile Valley	El-Razik et al. (2019)
50	*Taraxacum officinale* F.H. Wigg.	Common dandelion	Iran	Zhu et al. (2022)
51	*Ceratonia siliqua* L.	Carob	Cyprus Mashreq	Mahdad & Gaouar (2023)
52	*Eragrostis tef* (Zuccagni) Trotter	Teff	North Africa	Andreotti et al. (2022)
53	*Vicia faba* L.	Faba Beans	North Africa	Abou-Khater et al. (2022)
54	*Ficus carica* L.	Figs	Turkey Syria	Ivković et al. (2024)
55	*Corchorus olitorius* L.	Molokhia	Nile Valley Mashreq subregion	Salem & Tawfiq (2023)
56	*Mesembryanthemum nodiflorum* L.	Samh (Wild Mustard)	Mashreq subregion Arabian Peninsula	Alhejoj et al. (2015)

thrive in various agroecological conditions and highlights their potential nutritional benefits. These species may play a vital role in enhancing food security and promoting sustainable agricultural practices in the region. By incorporating them into modern agricultural systems, their unique characteristics, such as resilience to harsh environments and minimal input requirements, could address pressing challenges related to food shortages, malnutrition, and environmental sustainability. Integrating these underutilized NUSs could reduce reliance on conventional NUSs, diversify diets, and promote agricultural biodiversity. Their adaptability could also mitigate the impacts of climate change, providing more robust, climate-resilient alternatives for future food systems (Zhou et al., 2023).

NUS and Food Security

Food security is a key indicator of development, contributing to population productivity and cognitive growth (Borowski & Patuk, 2021). NUSs have the potential to significantly enhance global food security amidst increasing populations and climate change. These species have been overlooked in favor of major staple NUSs, but they offer a viable path to improving food systems. Recent research has highlighted the potential of NUSs in addressing malnutrition, food insecurity, and environmental sustainability (Knez et al., 2024).

Combatting Hidden Hunger and Malnutrition

Despite global efforts to combat malnutrition, hunger continues to rise, exacerbated by the impact of the COVID-19 pandemic. It is currently estimated that 9–10% of the global population faces hunger, equating to approximately 720–811 million people. Additionally, 30.4% suffer from severe food insecurity, which affects around 2.37 billion people, mainly in Asia and Africa (Mrabet, 2023). The agricultural sector is key for improving health and nutrition through targeted, nutrition-sensitive interventions (Muonde et al., 2024).

Recent data from the United Nations International Children's Emergency Fund (UNICEF) have shown that one-third of children under five in the NENA region are malnourished, manifesting as stunting, wasting, or being overweight. Wasting, characterized by a low weight-to-height ratio, affects about 6% of children under 5 in the NENA region, which is approximately 3.5 million children. Alarmingly, countries such as Djibouti (10.6%), Libya (10.2%), and Syria (11.5%) have particularly high rates. This is even more critical in Yemen (16.4%) and Sudan (16.3%) (WHO-WFP-UNICEF, 2025). In 2023, about 66.1 million individuals in the Arab region experienced hunger, and 186.5 million (39.4% of the population) faced moderate or severe food insecurity, with 72.7 million experiencing severe food insecurity (WHO-WFP-UNICEF, 2025). Underutilized species are valuable for addressing micronutrient deficiencies in humans, often referred to as "hidden hunger", which affects billions globally. These species are crucial in regions suffering from food insecurity and micronutrient deficiencies (Li et al., 2020). As the global population is expected to reach 9.7 billion by 2050 (Gu et al., 2021), underutilized species provide vital opportunities for enhancing food availability, accessibility, and nutrition. According to the World Health Organization, more than two billion people have experienced micronutrient deficiencies, particularly in regions such as Sub-Saharan Africa and South Asia (WHO-WFP-UNICEF, 2025). NUSs, such as amaranth, buckwheat, and teff are highly nutritious and can address nutritional deficiencies. For instance, amaranth is rich in iron, calcium, and essential amino acids, which are essential for combating iron and protein malnutrition in impoverished nations (Jahan et al., 2022). Buckwheat is high in zinc and magnesium, which are both critical for immune function and overall health (Sonawane et al., 2024). Incorporating these NUSs into daily diets can alleviate malnutrition, particularly among vulnerable populations, such as children, pregnant women, and the elderly (Li et al., 2020).

Enhancing Climate Adaptation and Ecological Sustainability

The NENA region is particularly vulnerable to climate change impacts. Temperatures are anticipated to rise between 1.7 and 3.0 °C in most areas and up to 5.0 °C in inland regions, accompanied by decreased rainfall and more frequent drought events. Approximately 86% of the region's land is subject to degradation and desertification, which threatens the livelihoods of 410 million people. Water scarcity and soil degradation are critical concerns and will be worsened by climate change. High population density and low-lying coastal areas in countries such as Egypt, Kuwait, Libya, Qatar, Tunisia, and the UAE are particularly exposed to sea-level rise and saltwater intrusion. Agriculture and food security are under threat, with 80% of NENA countries predicting higher levels of food insecurity and malnutrition among smallholder farmers and pastoral communities. Urbanization has increased air pollution in the region. Addressing these challenges requires collective efforts to improve climate resilience and environmental sustainability, adopt climate-smart agricultural practices, and ensure sustainable land and water resource management, creating a sustainable future for the region (Bilgiç & Baba, 2023).

Underutilized species are more resilient to climatic stressors, such as drought, heat, and soil degradation. Due to climate change, food systems reliant on staple NUSs, such as rice, maize, and wheat, will become increasingly unstable. However, underutilized species provide a reliable alternative with minimal growth requirements (Hunter et al., 2019). For example, finger millet (*Eleusine coracana*) is drought-resistant and thrives on marginal soils using limited irrigation, making it an ideal NUS for areas with low water availability and erratic rainfall (Reddy et al., 2021). In East Africa, finger millet is a stable food source under dry conditions, benefiting millions of people (Gebreyohannes et al., 2021). Similarly, sorghum (*Sorghum bicolor*), a drought-tolerant NUS, is a staple in the Sahel region of West Africa, as it can withstand high temperatures and unpredictable rainfall (Mwamahonje et al., 2024).

The resilience of these species ensures food security through reliable food sources and promotes water conservation, reduced pesticide use, and sustainable farming practices. In an era where agricultural systems are increasingly vulnerable to climate variability, underutilized species offer a pathway for enhancing food system resilience and preserving the environment (Ulian et al., 2020).

Increasing Agricultural Biodiversity and Reducing Dependence on Staple NUS

Excessive dependence on a handful of staple NUSs diminishes the genetic diversity of food plants, making global food systems more vulnerable to pests, diseases, and climate change. Diversifying NUS production with underutilized species could increase resilience and sustainability. Species, such as little millet (*Panicum sumatrense*), cañihua (*Chenopodium pallidicaule*), and spelt (*Triticum spelta*), complement traditional NUSs by providing nutritional benefits. For example, cañihua, grown in high-altitude areas of the Andes, is rich in amino acids, antioxidants, and micronutrients, such as iron and zinc, which could greatly benefit undernourished populations in the region (Gomez-Cahuata et al., 2022). In India, the reintroduction of little millet has been seen as an effective strategy for combatting food insecurity, particularly in areas where rice and wheat are less resilient to climate change. Little millet's resilience to low water availability and poor soil conditions makes it a promising NUS for enhancing food security in dryland regions (Lydia et al., 2023).

In the NENA region, the over-reliance on a small number of staple NUSs has led to significant genetic erosion, increasing vulnerability to pests, diseases, and climate change. The 2015 International Union for Conservation of Nature (IUCN) Red List listed 2476 species in the NENA region that were at risk, including approximately 700 fish species and 450 plant species. Overfishing and habitat degradation in the Arabian Gulf, for example, have reduced fish species diversity, with several species now classified as threatened. This highlights the need for sustainable management practices that conserve both terrestrial and aquatic genetic resources (Ben-Hasan & Daliri, 2023).

Supporting Smallholder Farmers and Enhancing Livelihoods

NUSs offer valuable economic opportunities for smallholder farmers, particularly in low-income countries, where farmers are often marginalized and have limited access to global markets. NUSs, such as teff (*Eragrostis tef*), moringa, and sorghum, can help diversify income sources and improve the economic resilience of small-scale farmers. Teff, a drought-resistant NUS highly valued in Ethiopia, is a staple food and cash NUS for export. The market for ancient grains and superfoods is growing, offering local farmers opportunities to engage in local and international markets (Salvador-Reyes, 2023).

Commercializing these NUSs improves food security and empowers farmers and revitalizes rural economies, creating new opportunities for local communities (Padulosi et al., 2021a). Underutilized species become economically viable for smallholder farmers through better market access, improved value chains, and fair-trade practices, alleviating poverty (Padulosi et al., 2021b).

Challenges to Reviving NUS

For centuries, farming communities in the NENA region have preserved NUSs as an integral part of local food systems. However, in the past decade, there have been increasing pressures on NUSs, including population growth, the expansion of land devoted to staple and cash NUSs, and the decline in pollinator and disperser populations due to modern agricultural practices, environmental degradation, and pollution. Other challenges include limited seed and planting material availability, the migration of younger generations to cities, a shift in dietary preferences toward energy-dense rather than nutrient-rich foods, and insufficient attention and support for NUSs in research, extension, education, and policy (Drangert, 2024). The role of underutilized species in enhancing food and nutrition security has received substantial attention from scientists in recent years (Adelabu & Franke, 2023). Numerous projects and studies have shown their potential to meet the needs of future generations in both international and domestic markets. For example, the Teff Value Chain Project in Ethiopia, supported by SNV and IFAD, has demonstrated how *Eragrostis tef* can meet the demands of the gluten-free market and support local farmers (Barretto et al., 2021). The Moringa Value Chain Development Project in Kenya and Rwanda (Kwaambwa et al., 2024) has shown the ability of *Moringa oleifera* to combat malnutrition and provide economic opportunities. Additionally, studies by the FAO and Bioversity International have highlighted NUSs as key to agricultural diversification and climate adaptation in arid and semi-arid lands (Devkota et al., 2025). This potential can be realized through two main strategies: 1) by offering genetic traits for adaptation and 2) by promoting NUS diversification to strengthen agroecosystem resilience (Boni et al., 2022). Andreotti et al. (2022) describe a "boom-and-bust" cycle to explore the sustainability transition of NUSs in agriculture, focusing on past, current, and future trends (Figure 4). This cycle offers a framework for understanding the future potential of NUSs and emphasizes the need for a sustainable transition.

The cycle included in Figure 4 consists of five phases:

a) NUS Promotion: This phase focuses on the dynamics of supply and demand for NUSs, with particular attention given to economic analysis and market relationships.

b) NUS Boom: A brief, rapid phase marked by increased land conversion for agriculture, export market growth, higher farmgate prices, and expanded cultivation areas. Government interventions influence these dynamics through top-down and bottom-up approaches.

c) NUS Bust: Food security concerns arise in this phase, as fluctuating farm incomes and local well-being are impacted. The waning interest in NUSs often results in diminished benefits for local communities. However, growing local awareness and changing global consumer behavior, as observed with teff in Ethiopia, may mitigate these effects.

d) Sustainability Transition: Smallholders and local communities are re-evaluating the structure of NUS production, processing, and consumption. This phase aims to re-establish connections between various actors to add value to NUSs and create a more sustainable system.

e) Achieving Sustainable NUS: The final phase proposes a set of guidelines aligned with the United Nations' 2030 Agenda for Sustainable Development and focuses on driving sustainable NUS production and market strategies, emphasizing inclusivity and addressing poverty and hunger.

These goals align with sustainability principles and seek to address the underlying causes of poverty and hunger (Van Dijk et al., 2020; Arora & Mishra, 2022).

Figure 4. Stages of the underutilized food plant species (NUS) boom-and-bust cycle: Phases 4 and 5 depend on a sustainability transition guided by the Sustainable Development Goals (SDGs), namely SDGs 1, 2, 3, 9, and 12 (Andreotti et al., 2022)

Based on this framework, the challenges facing NUS utilization can be summarized into four main aspects:

a) Limited Research and Development: Underutilized species have received significantly less research investment for genetic improvement and agronomy than major staple NUSs, limiting their potential to address food security challenges.

b) Inadequate Knowledge among Stakeholders: In general, farmers, policymakers, and consumers lack awareness of the benefits associated with these species and the cultivation practices that enhance their productivity and nutritional value.

c) Weak Market Linkages: Poor value chain development and insufficient market incentives discourage farmers from cultivating NUSs, limiting their integration into broader agricultural systems.

d) Policy Bias: Agricultural policies often prioritize high-yielding and export-oriented NUSs, marginalizing indigenous and underutilized species, which restricts their ability to support food security and promote environmental sustainability.

Strategic Approaches for Revival

Figure 5 illustrates several recommendations for effective NUS utilization, encompassing strategic approaches (Talucder et al., 2024).

Biodiversity Preservation Approach

The biodiversity preservation approach conserves genetic resources, exploits gene pools and banks, and requires intensive breeding research. Commercial and therapeutic species require appropriate in situ and ex situ conservation methods (Larranaga et al., 2024). The genetic heritage of NUSs should be preserved through breeding programs that avoid gene erosion and consolidate conservation efforts, livelihood improvement, and knowledge transfer into a single process, with the use of NUSs in food and animal feed recommended and ex situ conservation encouraged. The limitations of production and marketing have led to genetic erosion, necessitating conservation practices (Jones et al., 2021). Cultivars can be improved by utilizing the gene pool of *Leymus racemosus* and its relatives, which possess abiotic stress tolerance (Subbarao et al., 2021). Cultural and environmental factors are significant, and the physiological responses of landraces to stress must be investigated. Molecular identification and management of genetic resources are essential for future breeding programs, which should focus on environmentally friendly, stress-resistant cultivars with higher yields (Marone et al., 2021).

Market-Oriented Cultivation

Commercial NUS production contributes to nutritional diversification, economic opportunities, environmental sustainability, and biodiversity conservation in local communities. NUS, such as wild vegetables, contain bioactive compounds, including dehydroascorbic and ascorbic acid, which can improve diets and be used as functional food additives (Sánchez-Mata et al., 2012). For example, Indian *Rubus* spp. show potential for antioxidant activities and nutrient composition, suggesting their value for commercial production (Trivedi et al., 2016). Large-scale NUS farming can provide marginalized farmers with low-input, sustainable alternatives to conventional NUSs (Tiemann & Douxchamps, 2023) and enhance biodiversity, maintaining ecosystem and genetic diversity for climate-resilient species. A significant constraint to large-scale production is the scarcity of efficient farming practices for NUSs. Thus, the development of NUS commercialization, supported by adequate farming techniques, will enhance farmers' incomes, addressing food security challenges through research and large-scale production (Sultan et al., 2024).

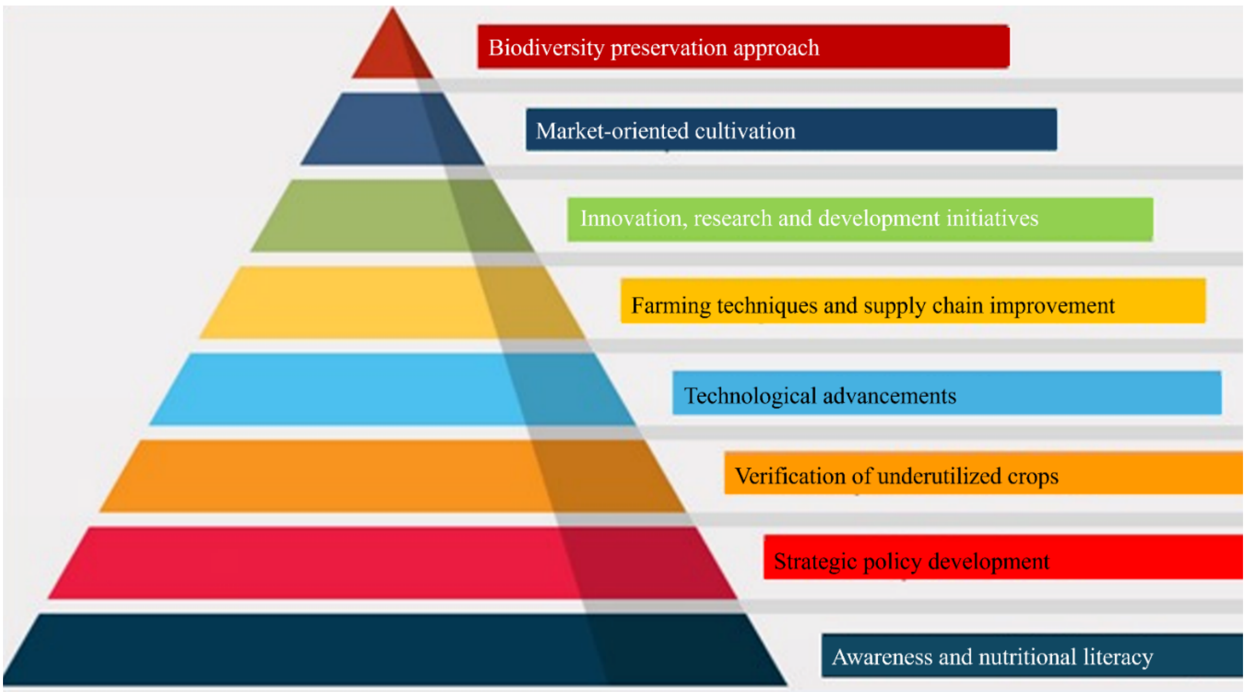

Figure 5. Strategic approaches for the effective utilization of underutilized food plant species (NUSs)

Innovation, Research, and Development Initiatives

Research and development programs supported by manufacturers, business owners, researchers, and governments are crucial for promoting NUSs. Extensive research and increased investment in underutilized NUSs are essential for transforming agriculture in developing Asian countries (Jahanshiri et al., 2022). However, such research and investment is still lacking (Andreotti et al., 2022). Achieving a sustainable balance between socioeconomic and environmental needs is crucial. These efforts should encompass research and development initiatives and post-harvest processing measures for reducing waste and promoting efficient resource utilization, which will facilitate the wider dissemination and expansion of NUSs (Foo, 2013).

Farming Techniques and Supply Chain Improvement

Effective management and infrastructure will enhance the use of NUSs, creating more opportunities for income generation and food security. Better marketing, packaging, and promotion of NUSs will contribute to the resilience and economy of local communities (Masao et al., 2023). For example, underutilized wild foods, including *Dioscorea pentaphylla* L., *Commiphora evansii*, and *Heliotropium lophophorum* (Buenavista et al., 2022), can be integrated into the Philippine food system for value addition and to support rural community development. Improving agronomic practices, managing water use, and diversifying farming systems are essential. In Kenya, for instance, the underutilized cereal finger millet increased yields on small farms, and technical efficiency was enhanced through conservation tillage, increasing diversity and improving nutrition and income opportunities for marginalized communities (Jerop et al., 2020).

Technological Advancements

Resource-based exploration of multipurpose food and plant species, technological improvements in seed quality, farmer training, and market development are essential. Further genotypic improvement and propagation are needed to enhance nutritional ingredients and conserve endangered species through mass propagation (Mondo et al., 2021); genetic resources should be better utilized in breeding, conservation, and off-season production, with knowledge of genetic diversity recommended for breeding programs. High-value tree species should be prioritized in germplasm management alongside improved marketing strategies (Nakanwagi et al., 2020), and new underutilized fruit cultivars may be developed using breeding techniques, molecular characterization, and biochemical analysis (Nagarani et al., 2014). These NUSs must be further improved through various programs to support the adoption of better agricultural practices and technology, thus improving nutritional quality and adaptability. Traditional fermentation processes can improve the nutritional value and storage quality of underused vegetables and legumes. Evaluating germplasm collections and optimizing processing techniques will contribute to consumption and preservation (Shayo et al., 2022).

NUS Verification

Verification is a crucial aspect in establishing the safety and potential health hazards of NUSs. Some NUSs may contain harmful substances, including natural toxins, allergens, anti-nutritional factors, heavy metals, and chemicals. For instance, certain plants, such as beans with lectins, can be toxic if not adequately cooked. Allergens can cause skin rashes and itching, and anti-nutritional factors may inhibit nutrient absorption. Moreover, NUSs grown in polluted soil can accumulate heavy metals, such as cadmium, mercury, and lead, posing health risks (Padhan et al., 2020). In vitro studies on the antioxidant compounds and biological activities should be conducted in NUSs. Unexamined parameters of NUSs and wild germplasm should be assessed to identify the best varieties and their antioxidant properties (López-Yerena, 2018). There is also a need to detect antinutrients and promote the safe consumption of underutilized vegetables. Studies on the medicinal and agricultural importance, potential hazards, and health benefits of NUSs are necessary. Further research on pathogenicity is also needed (Salim et al., 2023).

Strategic Policy Development

The implementation of policy programs is crucial for supporting strategies that promote NUSs. These policies should raise awareness about nutritional benefits and require clinical trials (Orqueda et al., 2020). Encouraging the development of value chains and cultural aspects is essential for expanding the variety of products offered by local farmers. Some wild edible plants have high potential and significantly contribute to women's diets. Further research is needed on their nutritional values, marketability, and integration into farming systems (Downs et al., 2022), with a focus on detailed nutritional profiling and clinical validation, assessment of consumer demand and value chain development, improvement of agronomic practices for better yield and resilience, strengthening of seed systems and germplasm conservation, and understanding of sociocultural factors that support adoption and sustainable use. Policies should ensure species development, enhance seed delivery systems, and improve germplasm conservation. Moreover, the adoption of agricultural innovations related to conservation practices and seed varieties should be promoted (Bogliotti et al., 2021)

Awareness and Nutritional Literacy

Raising public awareness, securing government support, and developing a strong market structure are crucial for the sustainable production and conservation of NUSs and for improving livelihoods, food security, and nutrition education. Efforts should prioritize educating communities on the nutritional benefits of root and tuber NUSs, product transformation, farmer training, and the establishment of permanent markets for NUSs (Luziatelli et al., 2020). Documenting the nutritional properties of these species is essential for effective natural resource management, and gathering knowledge on nutritionally rich NUS legumes can enhance food security (Sathya & Siddhuraju, 2015). Research on underutilized Indian fruit, known for their antioxidants, carbohydrates, and other beneficial compounds, highlights the need to further explore their antioxidant potential (Singh et al., 2012). Greater focus should be placed on research, strategic policy development, domestication, and local awareness campaigns to reveal the food security potential of these species. Comprehensive studies on underutilized species and their ecosystems are also necessary to maximize these benefits (Tay et al., 2024). Although some NUSs have been successfully domesticated and integrated into smallholder farming systems, there are significant gaps in agronomic data, including optimal cultivation practices, pest and disease management, and yield improvement. Addressing these gaps through targeted research is critical for scaling up cultivation and ensuring sustainable NUS production (Mabhaudhi et al., 2017; N'Danikou & Tchokponhoue, 2020).

Conclusions

1. Leveraging NUS can help achieve key Sustainable Development Goals in the NENA region.
2. NUSs enhance food system resilience, address climate change, and create economic opportunities for marginalized communities.
3. Reviving NUSs represents a commitment to sustainability, equity, and resilience.
4. Embracing ancient NUSs can drive change in food security, environmental conservation, and cultural preservation.
5. Appropriate policies and investments can transform food systems into sustainable and innovative models.

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