

**NEGLECTED AND UNDERUTILISED SPECIES (NUS): AN
ANALYSIS OF STRENGTHS, WEAKNESSES, OPPORTUNITIES
AND THREATS (SWOT)**

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ABSTRACT

Despite the growing attention to the neglected and underutilised species (NUS) as a valid instrument to promote not only sustainable agriculture and food systems but also sustainable development in rural areas, attempts to move from good intentions to effective actions have been limited. This is due, among others, to a gap in knowledge about the myriads of existing NUS and their potential. In this context, the present paper provides a comprehensive analysis of the strengths, weaknesses, opportunities and threats (SWOT) of crop NUS. Data for the SWOT analysis were retrieved through a review of the literature carried out in June 2022 on the Web of Science. Strengths relate, inter alia, to adaptability to harsh, marginal conditions, tolerance to biotic and abiotic stresses (e.g. pests and diseases, drought) and low external input requirements of NUS as well as their high medicinal and nutritional values combined with widespread culinary traditions. Weaknesses regard low productivity as well as difficult access to quality seeds, inputs, technologies and knowledge. Higher demand from consumers as well as increasing attention to sustainability and resilience in the whole agri-food system and agroecology represent opportunities for the promotion of NUS to address challenges such as food and nutrition insecurity and poverty. Climate change, biodiversity loss and genetic erosion, land and agroecosystem degradation, loss of traditional knowledge and heritage, and competition from commercial crops are among the main threats to NUS. The SWOT of NUS outlined in this work should inform evidence-based policies and strategies for the promotion of NUS, especially in developing countries. They should also guide the undertakings and actions of all stakeholders interested in the development of NUS value chains.

Keywords: *orphan crops, NUS, SWOT analysis, sustainable agriculture, rural development.*

INTRODUCTION

Crops can be divided into staple, commercial crops and underutilized, neglected and orphan ones (cf. neglected and underutilized species - NUS) (Li & Siddique, 2018). Padulosi et al. (2013) posit that “*Neglected and underutilized species (NUS) are those to which little attention is paid or which are entirely ignored by agricultural researchers, plant breeders and policymakers*” (p. 5). More than 7,000 crop species have been either cultivated and domesticated for food, or collected from the wild during the course of human history (FAO, 1998; Garn & Leonard, 2009). Nevertheless, only about 150 species are cultivated commercially (FAO, 1995; Prescott-Allen & Prescott-Allen, 1990), so tens of thousands of edible plant species remain relatively ‘underutilized’ (Chivenge et al., 2015).

The enhancement and promotion of NUS have been reported to contribute to climate change adaptation and mitigation (Mabhaudhi et al., 2019), agrobiodiversity conservation (Padulosi et al., 2013), environmental integrity and health (Mabhaudhi et al., 2019), food and nutrition security (Padulosi et al., 2013; Ulian et al., 2020), human health (Tadele, 2018), and rural livelihoods sustainability and resilience (Kour et al., 2018; Padulosi et al., 2013). Mabhaudhi et al. (2019) argue that with adequate research, NUS could play an important development role in the Global South and that research is also needed to advocate for policies and strategies as well as investments in orphan crops. Indeed, many challenges hinder the mainstreaming of NUS (Mabhaudhi et al., 2019). To promote NUS, barriers against their mainstreaming have to be identified and thoroughly analysed through research (Baldermann et al., 2016). Padulosi et al. (2013) postulate that “*Neglect by agronomic researchers and policy makers, genetic erosion, loss of local knowledge, marketing and climate change are major challenges to the sustainable use of NUS*” (p. 6). Likewise, Williams and Haq (2002) enumerate among the constraints to NUS development: lack of interest by farmers, researchers and extension agents, limited germplasm availability, and lack of technical information and tailored national policies. Therefore, research, innovation and development are highly needed to unlock the potential of NUS (Mabhaudhi et al., 2017), especially in developing countries (Chivenge et al., 2015).

In a recent systematic review on orphan crops in Burkina Faso and Niger, El Bilali (2020) puts that “*despite the noted benefits of orphan crops in addressing multiple challenges—such as climate change, livelihoods vulnerability and poverty, food and nutrition insecurity, and biodiversity loss and ecosystem degradation—current gaps in knowledge and research hinder the capacity to promote and exploit these crops in both countries*” (p. 7). Such a negative assessment is not limited to Burkina Faso and Niger and can be extended to many other countries, especially developing ones. Indeed, the real potential of NUS is largely unknown due to the lack of scientifically-sound and comprehensive assessments. Some studies on the

use and potential NUS exist but systematic, comprehensive evaluations are generally lacking. This regards the strengths and opportunities as well as the weaknesses and threats, which hinders initiatives and undertakings to valorise and promote them. In this context, the present review paper is meant to fill this gap by providing a comprehensive SWOT analysis of NUS.

MATERIAL AND METHODS

SWOT analysis is a technique for strategic planning and strategic management used to help identifying strengths, weaknesses, opportunities, and threats related to a business, project, activity, etc. (Benzaghta et al., 2021; Gürel & Tat, 2017). It is sometimes called situational assessment or situational analysis (Wehrich, 1982). This technique is designed for use in the preliminary stages processes of decision-making (Silva, 2005). SWOT analysis is intended to identify the internal and external factors that are either favourable or unfavourable to achieving the objectives. The name SWOT is an acronym for the four components encompassed in the technique: *Strengths*: characteristics giving an advantage over others; *Weaknesses*: characteristics considered as disadvantages relative to others; *Opportunities*: elements in the environment that could be exploited to one's advantage; and *Threats*: elements in the environment that could cause trouble and problems. The result of SWOT analysis is usually presented in the form of a matrix (Ansoff, 1980). Internal factors and characteristics are usually classified as strengths and weaknesses, while external ones are placed under opportunities and threats (Gürel & Tat, 2017; Minsky & Aron, 2021). The classification of internal factors as strengths or weaknesses is not universal and depends on the objectives. While SWOT analysis is a widely used technique (Benzaghta et al., 2021), it has some limitations (Hill & Westbrook, 1997) that relate, inter alia, to the usefulness/usability of its outputs as well as biases that might stem from how it is performed and who is involved in the process.

Data for the SWOT analysis of NUS were collected through a systematic review (Moher et al., 2009; Page et al., 2021). A search was carried out on the Web of Science (WoS) on June 4th, 2022, using the following search string: (“SWOT” OR “strength” OR “weakness” OR “opportunity”* OR “threat”) AND (“neglected and underutilised species” OR NUS OR “neglected species” OR “neglected and underutilized crop” OR “neglected crop” OR “abandoned crop” OR “abandoned species” OR “alternative crop” OR “alternative species” OR “local crop” OR “local species” OR “lost crop” OR “lost species” OR “minor crop” OR “minor species” OR “niche crop” OR “niche species” OR “orphan crop” OR “orphan species” OR “traditional crop” OR “traditional species” OR “underdeveloped crop” OR “underdeveloped species”). The search returned 497 records/documents whose eligibility was checked against two criteria: addressing NUS and providing SWOT elements.

The screening of titles and abstracts as well as, in case of doubt, the scrutiny of full-texts led to the exclusion of 449 documents. Out of these, 322 documents were excluded because they do not deal with neglected and underutilized species

(NUS)¹. Further documents deal with major commercial crops such as soybean, fava bean, rice, maize/corn, pear, chestnut, pepper, banana, tobacco, and lettuce. Other articles deal with forest trees such as eucalyptus. Also, documents referring to local and minor arthropod and insect species as well as fish, bird and animal species were discarded. Further 122 documents were excluded because they do not address SWOT analysis. Consequently, 48 documents resulted eligible and provided data for the SWOT analysis of NUS.

RESULTS AND DISCUSSION

The analysis of the selected documents shows that the geographical coverage of the studies ranges from global to local through regional and national levels. Interestingly, many studies deal with developing regions and countries in Africa (e.g. Benin, D. R. Congo, Guinea, Ethiopia, Ghana, Madagascar, Mozambique, Nigeria), Asia (e.g. India, Sri Lanka) and Latin America (e.g. Bolivia, Paraguay, Peru). While many studies address NUS in general, others focus on specific botanical families/groups (e.g. legumes, medicinal and aromatic plants, grains) or, even species (e.g. African nightshade, baobab, amaranth, bambara groundnut, breadfruit, cassava, cowpea, emmer, enset, fonio, miracle plant, moringa, oat, oca, pigeon pea, pitaya, quinoa, sesame, tef).

The literature reports many *strengths* of NUS (Table 1). One of the main strengths is their adaptability to grow in harsh conditions. These include marginal, poor and nutrient-depleted soils/lands as well as areas characterised by difficult climatic conditions such as mountains. This high adaptability confers on the NUS the capability of fitting into multiple niches in crop production systems. In addition, many NUS seem adapted to cultivation in low-input systems as they have low requirements in terms of fertilisers and agrochemicals. Moreover, their tolerance to pests and diseases reduces the need to resort to pesticides. Indeed, the tolerance of NUS to biotic (pests and diseases) and abiotic/environmental stresses (e.g. drought) is widely recognized. NUS are also claimed to be tolerant to drought and resilient to extreme climate events, which makes them an important ally in the context of climate change and variability. Certainly, NUS perform well even in the case of harsh climatic conditions or low external inputs; some studies report that local NUS landraces outperform modern, improved varieties (Mondo et al., 2021). Other strengths of NUS are the high diversity of genetic resources available at the local level as well as the easiness of their propagation and cultivation by local

¹ For instance, some documents refer to some forest tree species, such as *Pinus* (e.g. *Pinus attenuata*, *Pinus radiata*, *Pinus oocarpa*, *Pinus ponderosa*), or National University of Singapore (NUS), National University of Samoa (NUS), networked universities (NUS), non-uniform in-situ stress (NUS), neuromuscular ultrasound (NUS), nonlinear unified strength (NUS), non-uniform sampling (NUS), normalized updraft strength (NUS), never users (NUS), normal nutritional status (NUS), nerve ultrasonography (NUS), new urbanist subdivision (NUS), next-generation sequencing (NUS), new urbanization strategy (NUS), non-autistic university students (NUS), National Health Service (NUS), rather than neglected and underutilised species (NUS).

communities that already possess considerable traditional knowledge. Many scholars point out the outstanding nutritional benefits of NUS and highlight their nutritional properties (Assogbadjo et al., 2021; Kodahl & Sørensen, 2021). Indeed, many NUS have high nutrient density and high contents of proteins (cf. legumes) as well as bioactive, health-enhancing and health-protecting compounds such as calcium, iron, potassium and zinc, fatty acids (omega-3 and -6 fatty acids), antioxidants, etc. These characteristics confer them also good sensory properties and acceptance by consumers.

The *weaknesses* of NUS regard all the phases of the food supply chain from production to consumption through processing and distribution. At the production level, the main problem relates to low yield and productivity, especially when compared to modern, commercial varieties (Giuliani et al., 2009). This can be due to the low potential of the local varieties used as it might be a direct consequence of the difficult access to and low use of inputs (e.g. fertilisers) when cultivating NUS. Low yield and productivity lead to low production levels and this makes it difficult for NUS to benefit from economies of scale, which has negative implications in terms of the organisation and development of their value chains; indeed, value chains are often either disorganized or non-existent. Another constraint at the production level regards difficult access to quality seeds and propagation materials. This is due to the low volume of seeds as well as the lack of seed improvement programs. Difficult access to information is another problem faced by producers, which affects negatively their agronomic skills and knowledge. At the processing level, there is a lack of adequate technologies, which determines difficulties in processing, especially for smallholders, as well as drudgery problems. All the above-mentioned constraints affect product distribution and consumption. Indeed, there are only a few products available on the market and their quality does not always meet the consumers' expectations. Furthermore, low volumes marketed and lack of economies of scale push prices up and affect product affordability.

The *opportunities* reported in the analysed scholarly literature relate to the increasing recognition of NUS as an important asset for the sustainability and resilience of agri-food systems as well as to address numerous challenges such as food and nutrition insecurity, malnutrition, livelihoods vulnerability and poverty in the context of climate change. This positive trend is due, among others, to the growing attention to sustainable and green systems such as agroecology. Local NUS are also increasingly promoted by the government as a strategy for food self-sufficiency and import substitution. The success of NUS is also explained by the growing attention to health, which determines the adoption of more sustainable, diversified diets that are mainly plant-based. This, in turn, determines an increase in demand for a variety of NUS and products based on them in domestic as well as export markets. Also the versatility and diversity of uses of NUS as food and feed as well as medicinal or pharmaceutical, cosmetic and magico-therapeutic ones open up many avenues of opportunities for the development of NUS value chains. Some NUS are even considered 'functional foods' or 'superfoods'. Further

opportunities for NUS arise from the development of technologies, especially in breeding, which leads to the development of improved varieties. While research and development on NUS remain below commercial crops, there is a growing number of national and international, collaborative and multi-stakeholder projects, programmes and initiatives that deal with them. This corresponds to an increase in investments and funding from national governments, international organisations as well as philanthropic organisations.

Threats to NUS are environmental, economic, socio-cultural and political. One of the most important threats to NUS relates to the loss of diversity. The erosion of genetic resources is caused by many phenomena including climate change, which makes local conditions unsuitable for the cultivation of some NUS by affecting rainfall patterns as well as temperature regimes. Some scholars point out the increasing adoption of modern, improved varieties as one of the causes of the erosion of traditional genetic resources (Balemie & Singh, 2012; Moscoe & Emshwiller, 2016). What is even more alarming is that the erosion of genetic resources is combined with the erosion of the collective and traditional cultural heritage and knowledge relating to NUS. In fact, there are serious problems regarding the transmission of knowledge about NUS in rural areas to new generations, which are often less interested in agriculture and prefer to migrate to cities. In general, an important threat relates to the negative perception of NUS as ‘foods of the poor’ as well as to the changing culture and socio-cultural structure in rural areas. Indeed, NUS products are often labelled by youth as ‘backward’ and ‘unmodern’. This is particularly alarming given the ongoing erosion of local food cultures and the loss of traditional dietary habits caused by the standardization of local food cultures arising from globalization as well as the global use of fast-food or ‘junk food’ that favours standard and low-quality ingredients. Furthermore, low attention to NUS in agricultural policies and research programmes implies that they are ill-equipped to compete with commercial crops. In general, the lack of knowledge and data about NUS remains one of the main constraints hampering attempts to unlock their potential in effective development endeavours. Some scholars enumerate alien, invasive pests and diseases among the threats to NUS (Chater et al., 2018; Shah et al., 2019), especially in the context of a lack of knowledge about their interaction with orphan crops and damages they might cause in local conditions. A further threat stems from the green revolution approaches pushing productivity in agriculture thus favouring high-yielding, improved cultivars to the detriment of local, traditional farmer varieties and landraces.

Table 1. SWOT analysis of NUS based on the literature review.

Strengths (S)	Weaknesses (W)
Climate resilience, drought tolerance Adaptability to cultivation on marginal and poor soils/lands, tolerance to salinity and sodicity Vast genetic resources and diversity in	Difficult access to quality seeds and propagation material Low agronomic skills and knowledge of producers Low yield and production levels

<p>landraces Resistance/tolerance to pests and diseases Adaptability to local agroecosystems and low-input conditions Easiness of propagation and potential cultivation High contents of nutrients and health-enhancing compounds Good sensory properties and consumer acceptability Long-term storability</p>	<p>Variation in product quality Lack of appropriate storage, processing and packing technologies Limited processing knowledge Disorganized or non-existent value chains and markets Low market value discouraging investment High consumer prices due to a lack of economies of scale Low consumption in production areas</p>
<p>Opportunities (O)</p>	<p>Threats (T)</p>
<p>Recognized contribution to addressing major challenges such as food and nutrition insecurity and poverty High genetic variability within the cultivated and wild relatives Improved knowledge of genetics and biotechnologies Modern technologies in breeding, development of improved varieties Increasing use and demand of NUS in diversified, sustainable diets Significant industrial opportunities (food, feed, etc.) Growing attention and new market potential associated with nutritional and health properties Availability of a local market and appreciation by local consumers Increased recognition of agro-biodiversity in policies as a strategic asset Development of pro-poor and fair trade value chains Policies promoting the inclusion of NUS in school feeding programs Increasing investments and funding for research and development projects and programmes Increasing international collaboration on NUS</p>	<p>Climate change and variability Degradation of arable lands Invasive pests and diseases Erosion of the cultural heritage and knowledge relating to NUS New Green revolution approaches pushing to increase productivity in agriculture Loss of biodiversity due to the adoption of modern, improved varieties, and competition from commercial, commodity crops Changes in the socio-cultural structure: abandonment of agriculture by young people and migration from rural areas Changes in consumer taste and preferences, eroding local food cultures and loss of traditional dietary habits Consumer unawareness about NUS Negative cultural perceptions about NUS as the 'foods of the poor' Decline of government support for and intervention in agriculture and rural areas Inadequate funding for and investment in research, development and extension Discriminating agricultural and trade policies</p>

The classification of the different items is not unanimous or universal and can change from one source to another depending, inter alia, on the concerned NUS and context as well as the ideological settings and worldviews of scholars. For instance, while some scholars consider very high genetic variation within the species as a strength since it allows the species to adapt to different conditions and

environments and can be used to develop varieties with different features and traits, others consider it as a weakness that hampers standardisation so the development of commercial cultivars as well as opportunities for processing. Similarly, genetics is considered by some scholars as an opportunity to allow the conservation and genetic improvement of NUS while it is seen by others as a threat that can lead to the further erosion of the genetic resources relating to the NUS by favouring modern, commercial cultivars to the detriment of traditional, local varieties.

CONCLUSIONS

The present review provides a comprehensive analysis of the strengths, weaknesses, opportunities and threats (SWOT) of NUS with a particular focus on crops. The analysis of the scholarly literature shows that research on NUS is growing and expanding both in terms of geographical coverage (with more attention devoted to developing countries) and the range of NUS species addressed; nevertheless, it also clearly shows that comprehensive SWOT analyses in the NUS field are still hard to find. Therefore, the present review is timely and fills an existing knowledge gap. While the classification of the different items is far from being unanimous and depends, among others, on the concerned NUS, which makes generalisation difficult, some general trends emerged from the literature review. In general, strengths relate to the good agronomic performance of NUS even in unfavourable growing conditions. Indeed, most NUS are adapted to harsh, marginal conditions, tolerant to biotic and abiotic/environmental stresses, and require low external inputs. This makes NUS suitable for cultivation by smallholders in remote rural areas. The main weaknesses of NUS regard low yield and productivity, which determines a low level of production and, consequently, underdeveloped value chains. Moreover, producers have difficulty in access to quality seeds and propagation material, inputs, technologies for production and processing as well as information and knowledge on good agronomic practices. The analysis of the scholarly literature shows that there is increasing recognition in policies and strategies of the role of the NUS in the sustainability and resilience of agri-food systems as well as their contribution to addressing challenges such as food and nutrition insecurity, livelihood vulnerability and poverty. Further opportunities for the promotion of NUS stem from the increasing demand from consumers as they are becoming more aware of their benefits, especially in nutritional and health terms. Meanwhile, NUS are threatened by many trends and phenomena in the environmental, economic and socio-cultural realms. One of the most important threats regards the loss of biodiversity and the erosion of genetic resources that are caused by the degradation of lands and agroecosystems as well as climate change and variability. However, NUS are also threatened by societal and socio-cultural changes that determine the loss of their value among young generations as well as the erosion of the traditional, local knowledge relating to their cultivation, storage, processing, preparation and consumption in local communities.

The present SWOT provides general information that are valid for most of NUS but not necessarily for all. Therefore, contextualisation is needed to make it fit for specific cases. Nevertheless, the work provides valuable insights and scientifically sound evidence that should inform policies and strategies aiming at the valorisation and promotion of NUS. Moreover, the proposed SWOT analysis provides a baseline that can guide the actions and endeavours of all stakeholders and actors involved in the development of the value chains of NUS.

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