

Biodiversity conservation of the neglected and underutilized Nigerian horticultural crops

Funmilayo Mary Oloyede*¹, Dickson Stephen Ola¹, Emmanuel Adegboyega Iwalewa²

¹Osun State University, Department of Agronomy, Osogbo, Nigeria

²Obafemi Awolowo University, Department of Crop Production and Protection, Ile-Ife, Nigeria

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Biodiversity is fundamental for ecosystem functioning, sustainable crop production, soil health, and attainment of food and nutrition security. Loss of biodiversity in Africa and across the globe, and its negative impacts on food security, climate, and health must be curbed. African indigenous and underutilized crops are not likely to cause diet-related diseases. In addition, some of them cannot be adversely affected by climate change, and they also require minimum agronomic input to yield optimally. Besides supplying appropriate proportions of essential minerals, underutilized horticultural crops can also reduce hunger and alleviate poverty. While abiotic stresses like low/high temperature, drought, light intensity, and sub-optimal relative humidity will have negative impacts on exotic plants growth and development, indigenous crops are seldom affected. It is of great importance that the neglected and underutilized plant species (NUS) also serve a dual purpose as food for man as well as animal feed. Despite these crucial roles that the NUS play, some are still threatened with neglect and potentials not maximized. This paper discusses strategies that can be adopted to conserve NUS for their optimum utilization, with the Nigerian rain forest species as prototypes. Deliberate identification and cultivation of the NUS, establishment of gene and field banks, recognition and promotion of the NUS through national and special research and development programmes, use of media, including social, extension agents and agencies, linking the NUS to relevant industries including food, feed, and pharmaceuticals, and biodiversity conservation through diversified farming systems etc. are major key strategies for Climate-smart and sustainable agriculture.

Keywords: biodiversity, Climate-smart agriculture, food security, gene banks, value chain

1 Introduction

Horticulture is one of the agricultural spheres that accelerate the growth of economy over the years. Its role in ensuring nutrition security, climate change/pollution control, poverty alleviation, environmental aesthetic appeal, employment generation programmes, and health is crucial (Adejumo, 2002; Oloyede, 2021). Horticulture offers a wide range of options of crop diversification to the farmers as it involves cultivation of a wide range of crops with high value, encompassing fruits and nuts, vegetables, roots and tubers, spices, and aromatic, medicinal and ornamental crops both in rural areas and within cities and in their surrounding areas (Lutaladio et al., 2010). However, horticultural crop species have suffered from genetic erosion due to overexploitation of a few exotic and popular species, which has taken place at the expense of the indigenous counterparts also known

as the underutilized species (Adejumo, 2002; Oloyede, 2021; Oloyede et al., 2022).

Neglected and underutilized horticultural crop species (NUHS) are often considered “minor crops” because they are regarded as less important than the staple crops and agricultural commodities in terms of global production and market value. However, from the standpoint of the resource-poor farmers who depend on many of these species for their food security, nutrition and income, they are hardly really minor (Osewa et al., 2013). They are also considered underutilized in terms of their potential to contribute to the income and well-being of the global food security in general (Oloyede et al., 2011). NUHS are also described as “neglected” or “orphan” crops since they have received scant attention from research and development, and there is little scientific information about them (Peruzzi et al., 2004; Dansi et al., 2012; Oloyede, 2017).

***Corresponding Author:** Oloyede Funmilayo Mary, Osun State University, Department of Agronomy, P.M.B. 4494, Osogbo, Osun State, Nigeria; E-mail: mary.oloyede@uniosun.edu.ng; funmilayooyede@yahoo.co.uk

NUS play a major role in alleviating nutritional problems and poverty. They are not likely to cause diet-related diseases. They have been found to be viable and potent sources of food, feed, shelter, and medicine, contributing thus to improvements of the quality of life and well-being of mankind in various ways (Oloyede et al., 2012a ; Osewa et al., 2013; Oloyede, 2017). In addition, some of these crops cannot be adversely affected by climate change, and they also require minimum agronomic input to yield optimally (Oloyede, 2011; Oloyede et al., 2012b; Oloyede et al., 2014).

Biodiversity is used to refer to the collective of ecosystems, species, and genes which together comprise the Earth. Crop biodiversity is one of the major inventions of humanity through the process of domestication. It is an important source for crop improvement, adjusting crop production, mitigating the adverse effects of climate change, and for satisfying consumer preference (Hufford et al., 2019). Biodiversity in crops, cultivated crops, and particularly in horticultural crops naturally underpins sustainability, nutrition security, and above all a diversified food basket (Lutaladio et al., 2010; Hufford et al., 2019). Together with overall natural resources, biodiversity in horticulture is the key to crop and dietary diversification, and indeed human well-being and survival (Lutaladio et al., 2010).

In addition to food provision, biodiversity in agriculture is important for ensuring nutrient cycling, carbon sequestration, soil erosion control, greenhouse gas emissions reduction and control of hydrological processes (Chivenge et al., 2015). Around 30,000 of the total of approximately 250,000 flowering plant species are edible, with the vast majority of the edible species being “minor crops”. These may be culturally important cultigens, semi-wild species, wild species, or weeds; in turn, they may be locally cultivated on a small scale, semi-cultivated in and around settlements, gathered from the wild, or tolerated in the cultivated areas (Bemejo & Léon, 1994; FAO, 1997). Broad range of traditional crops, which were previously grown on a sustainable scale in some parts of the world, has been replaced by a narrow range of major crops, grown as large-scale monocultures over a couple of decades, leading to vast reduction in horticultural and agricultural biodiversity among popular species. This has consequently decreased the number of species upon which the global food security depends (Lutaladio et al., 2010; Oloyede, 2021).

Biodiversity conservation of the horticultural crops is essential for achieving two of the United Nations Millennium Development Goals (MDGs): halving the proportion of people who suffer from hunger, and ensuring environmental sustainability. Diversifying

crop production is no doubt a viable climate-smart agriculture solution that must be embraced by all and sundry. This paper assesses the importance of Nigerian underutilized horticultural crops, and the possibilities for their conservation for maximum utilization.

2 Why neglect and underutilization?

2.1 Ignorance of the crops and their potential by the elites

According to Oloyede (2011), many NUHS in Nigeria are becoming unknown to the new generation, especially to the urban dwellers that have the means to explore their potential in food, feed, pharmaceutical etc. industries. Rural women cultivate some of such crops for their immediate use, and no serious cultivation attention is given to them by any farmer in the country. There is deficiency in the documented knowledge of the nutritional composition of NUHS, as well (Amujoyegbe et al., 2007; Amujoyegbe et al., 2015; Oloyede, 2021).

2.2 Seed constraints and difficulties in the propagation process

Due to under-cultivation, the seeds/planting materials of NUHS are scarcely available for potential researchers and farmers. Hence, commercial cultivation of the NUHS is impaired (Oloyede, 2011). *Solanecio bialfræe* (Worowo) grows as understory in a tree crop plantation, while the seeds of *Crassocephalum crepidoides* (Ebolo) are carried away by air, since they are very light. Hence, the domestication of NUHS has been very difficult because of the mode of propagation and the fact that some seeds of NUHS are also dormant (Oloyede et al., 2011; Amujoyegbe et al., 2015). In addition, Adebooye & Ajayi (2008) noticed restrictions on the production time, as the crops were mostly grown under rainfed conditions, and were available only seasonally.

2.3 Lack of adequate acceptance by people

Salami (2011) identified lack of adequate acceptance of some of the NUHS by people, thereby making them uneconomical and less profit-oriented. Oloyede (2011) reported that NUHS carried the “poor-man-food” label. Some people think that those who still eat such crops are poor, and they express the same notion in their actions towards the crops. Above all, some NUHS like pumpkin (*Cucurbita pepo* L.) are often utilized during the off-season after being stored for a number of months, and fresh products such as tomato and other fruits and vegetables are scarce.

2.4 Some NUHS are considered weeds

Many NUHS are generally harvested from the wild. Some grow as weed on the cultivated arable field but they are harvested and utilized as food components in Nigeria. Some grow as volunteer weeds in fallow land, e.g. *Amaranthus viridis* (Tete Abalaye), *Crassocephalum crepidoides* (Ebolo), *Solanum nigrum* (Odu), and *Solanum nodiflorum* (Ogumo), while *Launea taraxacifolia* (Yanrin) grows around homesteads (Amujoyegbe et al., 2007; Oloyede et al., 2014; Amujoyegbe et al., 2015).

2.5 Constraints in production techniques and processing

Amujoyegbe et al. (2015) reported that despite the economic, nutritional and medicinal importance of NUHS, they were being endangered by several socio-economic factors that served as constraints in the cultivation of most of them. These constraints relate to inadequate knowledge of NUHS production techniques and processing. Oloyede (2012b) reported that exocarp of the pumpkin fruit, which is very hard when matured, made its processing by the rural dwellers very laborious. This challenge is adequate to frustrate the processing of the crop manually.

2.6 Lack of organized markets

According to Dansi et al. (2012), farmers highlighted the lack of the organized markets as one of the main reasons behind the giving up on NUHS.

2.7 Poor financial support

Another major cause of neglect and underutilization of NUHS is poor financial support from both private and public spheres (Dansi et al., 2012).

2.8 Lack of national promotion policies

Lack of national promotion policies for the NUHS is another bottleneck in popularizing the use and utilization of the crops (Dansi et al., 2012).

3 Conservation strategies for the neglected and underutilized plant species (NUS)

Conservation of the biodiversity of the neglected and underutilized horticultural crops can be achieved through one or the combination of the following means:

3.1 Establishment of gene bank

A gene bank is a type of biorepository which conserves genetic resources of various types, and make them available to users (Osewa et al., 2013; Toll et al., 2015). Biodiversity, conservation and genetic resources are three buzzwords that have assumed a significant position in

most biological and environmental scientific fora of the recent times (Ogbu et al., 2010). Plant genetic resources (PGR), as a vital segment of biodiversity in general and agrobiodiversity in particular, constitute the genetic material of plants with a resource value for both present and future generations of human beings (Dhillon & Saxena, 2003; LEISA, 2004). As a genetic resource, the PGR may consist of reproductive or vegetative propagule such as seeds, shoots, tissues, cells, pollen, DNA molecule etc, containing the functional unit of heredity in addition to the corresponding information and knowledge of its use, which can be applied in the crop improvement programme and other product development. Categories of PGR range from landraces and farmers' varieties, modern cultivars, breeding lines, genetic stocks, wild relatives, weedy races and potential domesticated species, to exotic and indigenous species (Engels & Visser, 2006; Sharma, 2007). Horticultural genetic resources (HGR) are a subset of agrobiodiversity that is related to the horticultural plant species or their wild gene pool, having genetic material of actual or potential value (Engels & Visser, 2006; Sharma, 2007). National Centre for Genetic Resources and Biotechnology (NACGRAB), located at Ibadan, Oyo State, Nigeria has the mandate to conserve plant genetic materials in Nigeria.

3.2 Recognition

According to Dansi et al. (2012), it was reported that for the promotion of the neglected and underutilized crop species, it would be important to put in place national and special research and development programme under the patronage of ministries of agriculture and scientific research sponsored by the government, which would involve all the possible actors including researchers, extension agents, rural farmers, developers, and producers. The conservation of Horticultural genetic resources (HGR) is extremely important for meeting the present and future needs of various crop improvement programmes (Ogbu et al., 2010). The genetic material of the neglected and underutilized horticultural crops can be conserved *ex situ* in cryo-storage gene bank. In crops that produce seeds, which are suitable for to desiccation and can tolerate low temperature (orthodox seeds), germplasm conservation through the seed is the most common approach. Seeds, equilibrated from 3–5% moisture content, are stored at -20 °C for long-term conservation. However, many horticultural plants that are propagated vegetatively or have recalcitrant seeds, require field gene bank for their conservation (Ogbu et al., 2010). The germplasm of major commercial fruits and ornamental trees in Nigeria are mainly being maintained in field gene banks by the horticultural and related research institutes.

3.3 On the farm

Production and cultivation of the indigenous vegetables in traditional farming systems is an effective strategy for conservation of the biodiversity of the neglected and underutilized horticultural crops (Diouf, 1997; Adebooye et al., 2005; Janick, 2011). Botanical gardens, greenhouses, orchards and arboreta play an important role in the conservation of the neglected and underutilized horticultural crops. Many fruit trees, medicinal and aromatic plants, spices, ornamentals, other plants of economic value, and their wild relatives are being maintained in several botanical gardens around the world (Ogbu et al., 2010). Botanical gardens fill an important gap in the conservation of the neglected and underutilized horticultural crop species, which otherwise would not receive much attention from traditional seed and field

gene banks (Ogbu et al., 2010). In country like Nigeria, it is of particular importance to conserve the neglected and underutilized horticultural crops on farms and in home gardens, and provide households and local markets with diverse food and other products. Large percentage of the national food needs still comes from the traditional farming systems characterized mostly by mixed cropping as seen in a typical home garden setting. Neglected and underutilized horticultural crop conservation need to be carried out on farms in the areas where landraces and locally adapted farmers' varieties are cultivated, and thus it requires active farmers' participation in conserving landraces and traditional farmers' varieties. Novel genetic resources may be conserved in home gardens, too (Tao, 2003; Rathore et al., 2005).

Table 1 Lists and descriptions of the selected neglected and underutilized leaf vegetables

Botanical name	Family name	Plant description
<i>Ocimum gratissimum</i>	Lamiaceae	– it is a small erect plant, less than 1 metre tall, found in tropical and subtropical regions of the world. Its leaves are used in traditional medicine to treat upper respiratory tract problems, skin diseases, pneumonia, cough, headaches, fever and conjunctivitis, among others (Ilori et al., 1996)
<i>Murraya koenigii</i> (L.) Spreng.	Rutaceae	– it is used mainly as a spice and culinary herb, owing to its essential oils. There are few references to its role in medicine and traditional folklore
<i>Basella alba</i> L.	Basellaceae	– <i>Basella alba</i> plant parts are used as a laxative, rubefacient, demulcent, diuretic, febrifuge, and astringent; and to treat conjunctivitis, catarrh, dysentery, diarrhoea, indigestion, constipation, boils, and sores, and as an antidote to poison (Kumar et al., 2013; Useful Tropical Plants, 2017)
<i>Ceratotheca sesamoides</i> Endl.	Pedaliaceae	– it is an annual herb up to 1.2 metre tall, sometimes with woody rootstock, and prostrate, ascending or erect pubescent stems. The leaves are steeped in water and the slimy liquid is used to treat conjunctivitis (Bedigian & Adetula, 2004)
<i>Telfairia occidentalis</i> – Hook.f.	Cucurbitaceae	– it is a perennial climbing and dioecious plant that can be found in West Tropical Africa, and can grow up to 15 metres. Medicinally, the plant is used for convulsion, malaria, anaemia, and cardiovascular diseases (Plants for A future, 2020)
<i>Cucurbita pepo</i> L.	Cucurbitaceae	– it is an annual herbaceous, climbing, trailing or bushy, polymorphic plant. The plant is, of course, grown principally for the fruit. The pulp is eaten as a vegetable or in soup. Young leaves and shoots, as well as flowers, are used as a potherb (Burkill, 1985). Recently, it has been found out that the plant has antioxidant potential (Oloyede, 2017)
<i>Crassocephalum crepidioides</i> (Benth.) S. Moore	Asteraceae	– <i>C. crepidioides</i> is an erect, sparingly branched, aromatic annual weed, about 0.5–1 metre tall with a seemingly stout stem. It is used in traditional African medicine to treat indigestion, stomach ache, epilepsy, sleeping sickness, and swollen lips. Studies also show that it possesses antitumor and antioxidant potential (Aniya et al., 2005; Tomimori et al., 2012). Additionally, it has been proved that it possess pharmacological properties that promote prevention and treatment of several human diseases such as hypertension, headaches, breast cancer, burns, inflammations, injuries, liver diseases, and sexually transmitted diseases (Dairo & Adanlawo, 2007; Adjatin et al., 2013)
<i>Bidens pilosa</i> L.	Asteraceae	– the leaves of <i>Bidens pilosa</i> are reported by the local population to possess antibacterial, anti-dysenteric, anti-inflammatory, antimicrobial, antimalaria, diuretic, hepatoprotective, and hypotensive effects (Hassan et al., 2011)
<i>Vernonia amygdalina</i>	Asteraceae	– it is a perennial plant that grows up to 1.5 metre. It is believed to contain secondary metabolites in the form of phytochemicals, vitamins and minerals

3.4 Media

Both print and social/electronic media play a major role in raising awareness of the great potential in terms of nutritional, medicinal, and economic value embedded in NUS. Furthermore, environmental education, awareness and training play another vital role in evolving strategies for conservation and preservation of the biodiversity of the neglected and underutilized horticultural crops. The media can help raise public awareness of both rural and urban dwellers of the importance of the most neglected and underutilized crops, and of the ways how they can be cultivated in home gardens or on the farm fields in order to sustain their diversity. The mass media are not the only methods that can be adopted to raise awareness or popularize the importance of the neglected and underutilized crop among the public, but also seminars, workshops, rallies, training courses, public meetings, exhibitions, and agritourism are needed to be organized on a regular basis to spread the message of the importance of the most neglected and underutilized crops, and of the ways how they can be cultivated in

home gardens or on the farm fields (Oloyede, 2011; Oloyede et al., 2014; Oloyede, 2021).

3.5 Popularization by research

Recently, there has been increase seen in the awareness of the natural and herbal therapy, with a basic approach to nature, due to people's awareness of the side effects of the synthetic drugs (JothiKarumari et al., 2014). Potential of a particular fruit or food is determined primarily by its nutrient composition. Fruits, vegetables, nuts, and seeds are a rich source of minerals, vitamins and antioxidants. Several studies and research have been conducted, and some underutilized horticultural plants have been found to have medicinal properties and nutritional attributes. The medicinal value lies in plant chemical substances called phytochemicals, which have a definite physiological effect on the human body. The leaf of *Cleome gynandra* consumed as vegetable has anti-inflammatory and lysosomal stability effects (Narendhirakannan et al., 2007), potent dose-dependent anticancer effect comparable to that of 5-fluorouracil (Bala et al., 2010),

Table 2 Lists and descriptions of the selected neglected and underutilized fruit vegetables

Botanical name	Family name	Plant description
<i>Solanum melongena</i> L.	Solanaceae	– it is used for medicinal purposes for curing diabetes, cholera, bronchitis, dysuria, dysentery, otitis, toothache, and skin infections. It is also ascribed narcotic, anti-asthmatic and antirheumatic properties (Daunay & Chadha, 2004; Weese & Bohs, 2010; Bidaramali et al., 2020)
<i>Solanum macrocarpon</i> L.	Solanaceae	– it is a perennial plant that grows up to 150 cm, has a dark purple stem and no trichomes. It contains phytochemicals such as tannins, flavonoids, and alkaloids. Leaves are used for a variety of medicinal purposes (Kohlaga et al., 2014; Olanipon et al., 2020)
<i>Solanum nigrum</i> L.	Solanaceae	– this plant possesses antioxidant and anticancer properties (Aboul-Enein et al., 2014)
<i>Piper guineense</i> Schumach. & Thonn.	Piperaceae	– it is a climbing dioecious non-pubescent plant with ripe reddish brown fruits, it is found in Tropical and East African countries (Hutchinson & Dalziel, 1954)
<i>Trichosanthes cucumerina</i> L.	Cucurbitaceae	– studies indicate the presence of free radical scavenging ability and antioxidant property in <i>Trichosanthes cucumerina</i> . Alkaloids, flavonoids, carotenoids, phenols, tannins, and other active compounds present in this plant make it pharmacologically and therapeutically effective (Adebooye et al., 2008; Stephin & Gangaprasad, 2015)
<i>Aframomum melegueta</i> K Schum.	Zingiberaceae	– it is also known as alligator pepper, with stems up to 1.5 metre tall, and pink or white inflorescences found at the forest floors. Medicinally, it is used as analgesic, laxative, and depressant (Burkill, 1985; Osewa et al., 2013)
<i>Cucumis melo</i> L.	Cucurbitaceae	– the fruit has high water content with a delicate flavour, and it is very refreshing. It is rich in vitamins B and C. The flesh of the fruit can be dried, ground into a powder, and used with cereals when making bread, biscuits etc. (Plants for a future, 2020)
<i>Cucurbita pepo</i> L.	Cucurbitaceae	– the plant is grown principally for the fruit. The pulp is eaten as a vegetable or in soup. Young leaves and shoots, as well as flowers, are used as a potherb (Burkill, 1985; Oloyede, 2017)

Table 3 List and descriptions of the selected neglected and underutilized cereals and legumes

Botanical name	Family name	Plant description
<i>Phaseolus lanatus</i> L.	Fabaceae	– <i>P. lanatus</i> is an aggressive herbaceous climbing plant, growing up to 6 metres in length, with seeds and leaves valued for their astringent qualities and consequently used for fever in traditional Asian medicine (Hernandez & Leon, 1994)
<i>Lablab purpureus</i> – (L.) Sweet.	Fabaceae	– it is a climbing, pubescent, herbaceous perennial pulse, whose fresh seeds are poisonous but flowers and pods are used as vegetables (George, 2011)
<i>Marcrotyloma geocarpum</i> (Harms) Maréchal & Baudet	Fabaceae	– kersting's groundnut leaf decoction acts as a vermifuge. The Igbo of Nigeria use the plant in the treatment of dysentery, venereal diseases, fever, and diabetes (Achigan Dako & Vodouhè, 2006)
<i>Pennisetum glaucum</i> L.	Poaceae	– Pearl millet is also known as pigeon grass. It is consumed in a form of flour, and it is also used as a beverage in some communities
<i>Cyperus esculentus</i> L.	Cyperaceae	– Tubers of tigernut (<i>Cyperus esculentus</i>) are said to be aphrodisiac, carminative, diuretic, and stimulant, contain potent antioxidants, and have anti-inflammatory properties (Adejuyitan, 2011). Tigernut tuber are said to be used in the treatment of flatulence, indigestion, diarrhoea, dysentery, and excessive thirst (Adejuyitan, 2011). Owing to its high dietary fibre content, it is effective in the treatment and prevention of many diseases, including colon cancer, coronary heart diseases, obesity, diabetes, and gastrointestinal disorders (Ekeanyanwu & Ononogbu, 2010)
<i>Sphenostylis stenocarpa</i>	Fabaceae	– African yam bean is a crop with food security potential in Africa. It has a broader amino acid spectrum of most of the essential amino acids, especially lysine, methionine, histidine, and isoleucine, than other legumes, including soybean (Ojiakor et al., 2010)
<i>Vigna subterranea</i>	Fabaceae	– bambara groundnut is a mineral rich underutilized crop with huge food value. It is consumed boiled or in a form of pudding. It can be considered a cheap substitute for cowpea and groundnut (Amarteifio et al., 2006)
<i>Cajanus cajan</i> (L.) Millsp.	Fabaceae	– seeds of <i>Cajanus cajan</i> , known also as pigeon pea, are consumed, and the leaves are cooked as vegetables, too. It is a source of livestock feed and forage

and free radical scavenging effect (Narendhirakannan et al., 2005, Muchuweti et al., 2007). It is also believed that it improves eyesight and provides energy (van den Heever & Venter, 2007). Similarly, *Launaea taraxacifolia* is locally believed (indigenous knowledge) to have, through simple and regular consumption as leafy vegetable, lactogenic, aphrodisiac, antibiotic, and antimalaria properties, and a wonderful blood pressure regulating and haemorrhoids treatment capacity (Dansu et al., 2008). Details about the descriptions and food and medicinal properties of the selected neglected and underutilized leaf vegetables, fruit vegetables and cereals/legumes are presented in Tables 1–3, respectively.

3.6 Role of an extension agent

New information is sometimes obtained by “political farmers”, when there is an innovation but the real (needy) farmer is left in the dark. As a result of this, the role of agricultural extension officers comes to the fore, as they are known to understand the language of the farm families as well as of the researcher (Adesoji and Farinde, 2006). Availability of the extension demonstration land/plot is

absolutely crucial for effective awareness and adoption. This can be conducted with the help of the government, research institutes and agro-industries (Iwalewa, 2010). Since the extension agents represent the link between research institutes (academic institutions), agricultural policy makers and the clientele, it is necessary to extend the space of the agricultural information dissemination of the neglected horticultural crops to the “grassroot” farmers to ensure a firm grasp of the new scientific information with or without further external assistance. Not only will the level of biodiversity, which can be accrued from shedding light on these underutilized crops, be heightened, but it will also provide natural capital to consumers and farmers alike, as these species will provide a means of land and agricultural sustainability with a reduced input (Oloyede, 2021).

4 Conclusion

Neglected and underutilized horticultural crops are of great importance in food security. Nigeria has a large diversity of these neglected and underexploited crop species, and most of them have enormous nutritional,

medicinal, and economic benefits. Concerning the conservation of the NUHS, it has to be performed deliberately by all stakeholders, including the government at all levels, non-governmental entities, farmers' groups, and individuals. This will highly contribute to poverty reduction in rural areas and the country at large. Improvement of both nutritional and health status of the populace, enhancement of food security, and improvement of the farmers' economy should be fostered. Through campaigns in media, and training of potential farmers, cultivation of NUHS in home gardens and farms should be popularized. Furthermore, awareness of the great potential in terms of the nutritional, medicinal, and economic values embedded in NUHS should be raised, and such information should reach people in the society through various platforms. In addition, agritourism to the areas where the neglected and underutilized crops are cultivated is an important avenue to raise awareness of people in the society. Finally, for the conservation and promotion of NUHS, the role of standard gene and field banks cannot be emphasized enough. With the huge significance of biodiversity conservation of NUHS, especially as a means of mitigating and adapting to climate change, their promotion for the industrial utilization should be the priority of the national, continental, and global agricultural research system, and the government at all levels.

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