



The role of traditional knowledge and food biodiversity to transform modern food systems

Gina Kennedy^{a,*}, Zeyuan Wang^{b,c}, Patrick Maundu^d, Danny Hunter^e

^a Global Alliance for Improved Nutrition, 1201 Connecticut Ave NW, Washington, DC, 20036, USA

^b Division of Social and Behavioral Health Sciences, Dalla Lana School of Public Health, The University of Toronto, Toronto, ON, Canada

^c Culinary Research Centre, Collaborative Specialization in Food Studies, Department of Historical and Cultural Studies, The University of Toronto Scarborough, Toronto, ON, Canada

^d KENRIK, National Museums of Kenya, Museum Hill, P.O. Box 40658, 00100, Nairobi, Kenya

^e Alliance of Bioversity and CIAT, Rome, Italy

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ABSTRACT

Background: The current way our food systems operate does not result in healthy and nutritious diets for all, nor are we producing food in a manner that the planet can sustain. Food biodiversity, or the range of animal and plant species used for food is one solution to improve the health of both people and the planet.

Scope/approach: Case studies were used to illustrate current initiatives and programs aimed to bring greater food biodiversity into our food systems. Case studies were developed by subject matter experts and reviewed for demonstrated and potential impact on four food system outcomes: healthy diets and nutrition, agro-ecological resilience, livelihoods and income and socio-cultural wellbeing.

Key findings/conclusion: The six case study examples demonstrate that there are multiple approaches that confer benefits across a range of food system outcomes. The case studies demonstrate contributions to the body of knowledge on food composition, dietary diversification, strategies to prioritize crops that regenerate soil and purify water, require few inputs or can grow in harsh conditions, as well as provide increased income to communities and rebuild cultural knowledge. Some approaches were initiated by government and others at community level; they all demonstrate ways to achieve greater integration of food biodiversity into food systems. This collection of case studies illustrates a fraction of what is currently being done to support biodiverse food production and consumption. The evidence base for how to bring greater food biodiversity back into our food systems should be improved and should not be an isolated occurrence, but rather a continuous process.

1. Introduction

Globally, we are not making sufficient progress in collective efforts toward zero hunger and healthy diets for all, and the way in which we produce and consume food is not sustainable for our planet. The Food and Agriculture Organization of the United Nations (FAO) estimates that 828 million persons now face hunger, an increase of approximately 2% since 2019 and a healthy diet is unaffordable for 3 billion people (FAO, IFAD, UNICEF, WFP and WHO, 2022). Even though there are thousands of species that have been used for food, over half of global production in 2019 was accounted for by four crops; rice (0.8 billion tons), wheat (0.8 billion tons), maize (1.1 billion tons) and sugar cane (1.9 billion tons) (FAO, 2021a). In the wake of current global events, the speed and scale

of increasing food, fuel, and fertilizer prices and resultant shortages has demonstrated the far-reaching impact of our reliance on a few crops and commodities and accentuated the call for a coordinated international focus on diversity in production systems, markets and diets (HLPE, 2022). There is a broad agreement that food system transformation needs to include greater reliance on food biodiversity so that a greater number of food species can be incorporated into sustainable food system strategies (FAO, 2021b; FAO, 2022a). To accomplish this, more research and investment into programmes and policies focussed on food biodiversity is needed (Hunter et al., 2020).

Our food systems are responsible for approximately 80% of deforestation (Campbell et al., 2017; Kissinger et al., 2012) and around 30% of all greenhouse gas emissions (Crippa et al., 2021; FAO, 2021c; IPCC,

* Corresponding author.

E-mail addresses: gkennedy@gainhealth.org (G. Kennedy), zey.wang@mail.utoronto.ca (Z. Wang), patrickmaundu@gmail.com (P. Maundu), d.hunter@cgiar.org (D. Hunter).

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2019). Agriculture uses 34% of all land on the planet (FAO, 2022b), withdraws 70% of freshwater (IPCC, 2019), and threatens 86% of at-risk species (Chatham House, 2021). Oceans are critically overfished, with 34% of fish stocks at biologically unsustainable level (FAO, 2020). The FAO *Whipala Paper* on Indigenous Peoples' food systems states “*Unmitigated, our current food systems will result in radical modification of ecosystems, environments, coastlines, mountain tops, glaciers, water bodies and weather patterns, with consequences for human wellbeing and life on earth. More efficient, sustainable, resilient and equitable food systems are needed if we are to eliminate hunger and achieve the Sustainable Development Goals*” (FAO, 2021b, p. 1).

Despite the grim global scale outlook, there are examples that point the way forward in creating the type of food systems we need. Numerous reports confirm that one solution to the global problems of food insecurity, malnutrition and unsustainable food production is food biodiversity (Bioversity International, 2017; FAO, 2019; FAO, 2021b; FAO, 2022a; Hunter et al., 2020) or the diversity of plants, animals and other organisms used for food, covering the genetic resources within species, between species and provided by ecosystems (Kennedy et al., 2017). A summary of eight reviews on urgent food system actions needed to transform food systems included the recommendation to support the production and consumption of nutritious, traditional and Indigenous foods through agrobiodiverse cropping systems, agricultural extension, breeding programmes, subsidies, land tenure rights, regulatory protection, market development and public awareness (GAIN & Johns Hopkins University, 2021).

The International Union of Nutritional Sciences (IUNS) Task Force on Traditional and Indigenous Food Systems and Nutrition (TIFSAN) has a mandate to raise awareness of the value of traditional and Indigenous foods for improved nutrition and does so through a lens that recognizes, respects and supports, Indigenous Peoples as the primary knowledge holders. Indigenous Peoples have managed and conserved their own cultural traditions for harvesting, preserving, preparing and consuming their local foods, and are the keepers of knowledge for much of the world's food biodiversity (FAO, 2021b; FAO and the Alliance of Bioversity International and CIAT, 2021). Indigenous Peoples' food systems and knowledge encompass a vast diversity of plants, animals, and other organisms, both cultivated and wild. Species use is adapted to local environmental conditions and respects principles of sustainable harvest and use. The species' usage can be very different among groups of Indigenous Peoples as it is characterized by local ecological specificity and uses in local food traditions. The growing body of scientific evidence points to the importance of traditional foods for improving food and nutrient security, yet there appear to be hurdles for its expanding use and popularization. With care toward the principles of “free, prior and informed consent” and “access and benefit sharing”, traditional foods that offer health and environmental benefit can be entry points for the transformation of food systems. Such windows of opportunity need to be explored comprehensively.

This paper will briefly review the scientific evidence on the benefits of food and cultural diversity to enhance human nutrition, food security, livelihoods and environmental sustainability, then highlight through case studies, six unique approaches that demonstrate current efforts to incorporate more food biodiversity into our food systems.

1.1. Benefits of food biodiversity

Food biodiversity can contribute to sustainable food systems that strengthen efforts to end hunger, curb malnutrition, improve livelihoods and contribute to greater socio-cultural wellbeing.

1.1.1. Food biodiversity and nutrition

Examples of the superior nutrient density of underutilized food biodiversity compared to some of the most commonly produced, marketed and consumed global species are numerous (Hunter et al., 2019; Hunter et al., 2020; Bioversity International, 2017; FAO, 2021a). At the

food group level, many underutilized species have superior macro and micronutrient densities when compared to more commonly consumed species. For example, teff and minor millets have higher levels of protein, fat, and iron than rice and wheat (Andreotti et al., 2022). Similarly, the nutrient content of cultivars and varieties within a species can also vary dramatically. For example, several cultivars of banana contain high levels of pro-vitamin A carotenoids, whereas the most common banana variety, Cavendish contains none (Bioversity, 2017).

In addition to superior nutrient density of specific varieties and cultivars of species, there are clear nutritional and health benefit to be gained from diets that contain a diversity of foods. At the most basic level, diet diversity, measured as the intake of a diverse number of food groups, where food items with similar nutritional properties, such as vegetables, fruits or pulses are classified into food groups, is associated with higher nutrient intakes (FAO, 2021d). Food-based dietary guidelines, present in many countries worldwide, use food group classification systems to provide population guidance on the types and amounts of food to eat for optimal health and nutrition outcomes. Food biodiversity contributes to the array of options that consumers can choose from when opting to diversify their diets and also increases the likelihood of nutritional adequacy (Lachat et al., 2018) and improved health (Hanley-Cook et al., 2021).

1.1.2. Food biodiversity, food security and improved livelihoods

Food biodiversity plays an important role in food security and livelihoods (FAO, 2019; Hunter et al., 2020). Relying on diverse species for food improves food security by providing food resources throughout the entire year, including during periods of seasonal food shortages as well as during periods of climate vulnerability (Li et al., 2020; Sunderland, 2011). Several case studies from diverse regions and contexts highlight the role of biodiversity in supporting food security and livelihoods (FAO, 2019; FAO and Alliance of Bioversity International and CIAT, 2021). Examples include documenting local knowledge of forest systems in Bhutan that provide over 40 species of edible wild vegetables and 350 species of edible mushrooms used directly for food and income. Arbediehtu (Inherited Knowledge in Norway), aims to integrate traditional knowledge of the Sámi people on the management of local natural resources, including wild foods, that support their livelihoods (FAO, 2019).

1.1.3. Food biodiversity for sustainable food systems

Diversity within food systems is beneficial to diets and nutrition, but also creates greater sustainability and climate-resilience (Li et al., 2020). Food biodiversity provides more options for farmers and the systems they manage that in turn boosts the resilience of the system and the landscape in which the food production system is linked (Hunter et al., 2017). There are documented benefits of numerous ecosystem services at different levels of production (Bioversity International, 2017). At crop level, biodiversity provides protection against pests and diseases as well as attracts pollinators. For example, planting diverse varieties of the same species can decrease pest and disease damage, while varietal differences in timing of flowering attracts pollinators (Bioversity, 2017). At farm-level, inputs can be reduced, soil health is maintained, and nutrient cycling is more efficient, by for example adding biodiverse cover crops such as grasses and nitrogen-fixing legumes during fallow periods. At landscape level, biodiversity protects against pests, reduces soil erosion and conserves water as well as provides habitat for pollinators and beneficial insect diversity. For example, forests adjacent to agricultural lands reduce crop damage from pests and enhance crop pollination (Gergel et al., 2020).

1.2. Case studies

Case studies from around the world are used to highlight the potential for food biodiversity to be used to improve food security and nutrition, bring economic and cultural benefits to communities and

exemplify nature-positive food production pathways. Case studies were selected based on requesting TIFSAN task force members, who represent a body of international scientific experts on this topic, to identify examples for consideration. In all but one case, the examples proposed were deemed relevant for inclusion in the paper because of the description of how food biodiversity contributes to our primary thematic consideration of diets and nutrition, but also demonstrates connectivity to other food system outcomes, including food security, environmental sustainability, livelihoods and cultural wellbeing.

Six case study examples from diverse settings illustrate how food biodiversity is being used as a solution to address food insecurity and malnutrition, improve diet quality and bring economic and cultural benefits to communities. The six case studies demonstrate efforts of international organizations, national and local governments, small businesses, environment and tourism sectors and local communities. The wide thematic variation demonstrates multiple approaches and pathways used to improve food system outcomes using food biodiversity.

1.2.1. Case study 1: FAO Future Smart Foods (FSF) initiative to revitalize food biodiversity in Asia and the Pacific

The recognition that neglected and underutilized regional foods are nutrient-dense, climate-resilient, economically viable, and locally available or adaptable, guided the Future Smart Food (FSF) initiative of FAO and the governments of Bhutan, Bangladesh, Cambodia, India (West Bengal), Lao PDR, Myanmar, Nepal, and Vietnam to prioritize food biodiversity they wanted to promote within their food systems. By undertaking a series of steps, countries that were part of the Future Smart Food Initiative prioritized 36 traditional foods with high potential for integration into national agricultural systems. This case study will provide a description of the process to enable others to follow this example.

The first step undertaken by each of the eight countries was to identify and list underutilized species, by food group. The second step was to enlist multi-disciplinary national experts from government, academia and research to provide information about each species based on knowledge of the species nutritional value, agricultural production zones, agronomic properties, ecological sustainability and socio-economic sustainability (Table 1), documenting data sources and including photographs of each species. The final step involved prioritizing the species with national and international experts during a Regional Expert Consultation hosted by FAO.

Table 2 below provides a summary of the FSF species prioritized by national stakeholders in Bhutan, Bangladesh, Cambodia, India (West Bengal), Lao PDR, Myanmar, Nepal, and Vietnam. All chosen FSFs have the potential to transform current conventional agricultural systems into more sustainable, nutrient-sensitive, and climate-resilient systems (Li & Siddique, 2020).

A set of ten recommendations to promote the list of priority species was proposed by representatives and other experts during an Expert Consultation organized by FAO. These recommendations include; Raise

Table 1
Four dimensional benefits of Future Smart Food.

Nutrition	Nutritional value and health benefits
Agricultural production practices	Local knowledge, availability and seasonality Productivity, intercropping and competing with other crops Processing
Ecological sustainability	Agro-ecology Adaptation to local climate and soil types
Socio-economic sustainability	Cultural acceptance and consumer preferences Access to markets and potential income generation

Li, X., & Siddique, K. H. M. (2020). Future smart food: Harnessing the potential of neglected and underutilized species for Zero hunger. *Maternal & Child Nutrition*, 16(S3). <https://doi.org/10.1111/mcn.13008>
Source: Li & Siddique, 2020.

Table 2
Foods prioritized by the Future Smart Food Initiative.

Cereals	Roots and Tubers	Pulses	Fruits and Vegetables	Nuts, Seeds and Spices
Buckwheat	Taro	Grass pea	Drum stick	Linseed
Tartary buckwheat	Swamp taro	Faba bean	Chayote	Walnut
Foxtail millet	Purple yam	Cow pea	Fenugreek	Nepali butter tree
Proso millet	Fancy yam	Mung bean	Snake gourd	
Finger millet	Elephant's food yam	Black gram	Pumpkin	
Sorghum	Sweet potato	Rice bean	Roselle	
Amaranth		Lentil	Indian gooseberry	
Quinoa		Horse gram	Jackfruit	
Specialty rice		Soybean	Wood apple	

FAO. (2018). FUTURE SMART FOOD Rediscovering hidden treasures of neglected and underutilized species for Zero Hunger in Asia, Executive summary | International Treaty on Plant Genetic Resources for Food and Agriculture | Food and Agriculture Organization of the United Nations. Bangkok, Thailand. Retrieved July 9, 2022, from
Source: FAO, 2018.

national awareness of the nutritional and climate smart benefits of these species.

Promote their complementarities within existing production systems.

Establish National Coordinating Committees for FSF.

Provide policy incentives for mainstreaming FSF, especially with regards to public procurement.

Establish nationally supported research programs to quickly generate more knowledge in relation to supply and demand for FSF.

Document success stories.

Develop educational materials to promote public uptake of FSF.

Invest in value chain development.

Strengthen collaborative learning and development across sectors, including private sector.

Establish a regionally coordinated network for FSF.

1.2.2. Case study 2: Revival of millet a traditional grain in India

Millet is a traditional staple grain in India and is gaining in popularity as a staple food in India and beyond. Millets are a family of small seeded grains, the most common of which that are grown in India, include pearl millet, finger millet, proso millet and foxtail millet (FAO & ICRISAT, 1996). Millet production and consumption declined in India over the past fifty years, from an historical high of 14 kg/capita/year in the 1960s and 1970s (FAOSTAT -2013), with more recent production data from the Food and Agriculture Organization showing declines in the early 2000's from a three year average availability of 9 kg/capita/year (2010–2012) to 7.18 kg/capita/year (2017–2019). Declines in availability for consumption are due to a combination of factors including production incentives that favored rice and wheat over millet, low market demand, poor financial return for millet farmers, negative social stigma and an underdeveloped food processing and product development sector. The Government of India is setting out to change the status of millets by changing government policy to actively promote millets through both national and state-level initiatives (Niyogi, 2020). Increased production and consumption of millet is seen as a win-win solution to a complex set of problems that include India's stubbornly high rates of undernutrition and micronutrient deficiencies; rapidly escalating diet-related non-communicable disease, most notably diabetes and environmental challenges related to soil degradation and water scarcity. Millets are a front runner solution for several reasons. Their nutritional profile (protein and micronutrients) is superior to that of rice and wheat, they have a lower glycemic index and higher fiber

content, important in the context of rising diet related non-communicable diseases. Millets can also be grown in marginal soils, withstand drought and require little to no irrigation. Millets have a short growing season of 65 days and are therefore helpful in food insecure areas and to buffer pre-harvest hunger periods.

The Government of India has several policies in place to support millet. States such as Odisha and Karnataka are developing their own strategies and policies to promote millets (Andreotti et al., 2022). At national level the National Food Security Mission, under the Ministry of Agriculture and Farmers Welfare, has a new policy in the 12th five-year plan to focus on millet production in addition to rice, wheat and pulses (National Food Security Mission, 2022). In 2018, the Ministry of Agriculture and Farmers Welfare announced the inclusion of minor millets in India's Public Distribution System (Ministry of Agriculture and Farmers Welfare, 2018), one of the world's largest social safety nets providing food grains to millions of food insecure households. To counter the negative association and social stigma that surrounds consuming millet, the government has coined the term nutri-cereals to raise public awareness of the nutrition and health promoting properties of this traditional food. The State Government of Karnataka is promoting millets with the use of messages such as "Good for you, good for the farmer and good for the earth" (Andreotti et al., 2022). Millets are becoming trending in India and being featured on upscale restaurant menus, cooking shows and in modern recipes (see for example Eat Right India – recipe for millet).

FAO has accepted the proposal submitted by the Government of India, for 2023 to be the International Year of Millets. This will certainly draw global attention to the role of millets for nutrition, food security and environmental sustainability. Whether or not the slogan about millets as "Good for you, good for the farmer and good for the earth" will become a reality will depend on many factors. The rise and fall of quinoa provides some lessons learned that can now be applied to millets (Andreotti et al., 2022). For millets to be good for nutrition, private sector should be encouraged to keep added sugar, salt and processing minimal, otherwise products made from millets could become just another ultra-processed high sugar, high salt, high fat product disguised as "good nutrition" because it contains some millet. Nutrition education for the public in India should stress the importance of a diversified diet, with millet as one healthy option within an overall balanced diet that also includes adequate amounts of fruits, vegetables and pulses. For millet to benefit farmers the government needs to ensure inclusive decision making that includes farmers as active decision makers and links local farmers to consumers. Finally for millets to be good for the earth, their production systems should evolve in nature positive ways, that avoid pitfalls associated with monocropping and erosion of genetic diversity (Andreotti et al., 2022).

1.2.3. Case study 3: Empowering women through Hela Bojun in Sri Lanka

Sri Lanka is one of the world's key biodiversity hotspots and is home to significant food biodiversity including wild food plants, local livestock and fish breeds and traditional nutrient-rich varieties of fruit and vegetables (Rathnasinghe et al., 2019; Hunter et al., 2020). Sri Lankan farmers have maintained this rich food biodiversity in their fields for generations. Today, urbanization and changes in food preferences and lifestyles have led to changes in eating habits which have eroded traditional Sri Lankan dietary patterns. Obesity and diabetes rates are on the rise, while intake of fresh fruits and vegetables has declined. Though the current economic and food crisis the country is experiencing is raising some awareness of the importance of food biodiversity for food security and nutrition.

Sri Lanka's nutrient-rich traditional food species represent untapped resources for improving food security and nutrition in the country. Promoting food biodiversity and strengthening local supply chains and food systems can help solve nutrition and health issues by providing ready access to the diversity of nutrients needed for a healthy diet (Rathnasinghe et al., 2019). However, there are many constraints to the

production and consumption of these traditional foods, including; a lack of research and development investment, poor quality seed systems and inadequate policies and an extension service without the capacity to promote their cultivation. There are also issues related to lack of infrastructure and capacity for value chain development for much of this food biodiversity (Hunter et al., 2020). Oftentimes, locally available traditional fruits and vegetables are considered inferior or foods of the poor or they do not meet aesthetic standards that consumers have come to expect. Much more is required in terms of research, political and financial support, as well as incentives and public awareness, if farmers are to conserve and grow these foods and if consumers are to find them desirable (Rathnasinghe et al., 2019).

Hela Bojun or 'True Sri Lankan Taste' food outlets are one approach that has been used in an effort to address these many barriers and challenges. These networks of food outlets are operated by women trained through the Women's Agriculture Extension Programme in the Department of Agriculture. Women receive training on the nutritional value of traditional food species, food preparation, food hygiene, customer care and business management. Hela Bojun are largely located near urban spots like government offices and school and university campuses and offer people access to clean, nutritious and safe local food at reasonable prices. Hela Bojun stalls have expanded to a total of 22 locations and sell a range of foods prepared from traditional ingredients including foxtail and finger millet, jackfruit and traditional rice varieties. Hela Bojun food outlets help generate agriculture-based entrepreneurship, employment and private enterprise opportunities for women and provide a sustainable and stable family income. They also contribute to creating awareness and interest among new generations about healthy eating and the nutritional value of disappearing traditional foods and recipes (Rathnasinghe et al., 2019). Efforts to enhance awareness and presentation of local, healthy traditional foods are continuing, including additional capacity-building of outlet vendors. The food outlets have been selling local foods at competitive and affordable prices, helping make traditional foods more available to the general population. Some women have been empowered to earn a decent living wage (600–800 USD/month).

Since opening in Colombo and Peradeniya, the Hela Bojun outlets and shops became immensely popular, earning highly positive reviews from locals and tourists. The shops promote underutilized crops identified by the Biodiversity for Food and Nutrition (BFN) Project (Hunter et al., 2020), including medicinal plants such as water lily (*Nymphaea pubescens*), used in Ayurvedic medicine, and pulses such as cowpea (*Vigna unguiculata*), black gram (*Vigna mungo*) and green gram (*Vigna radiata*), as well as traditional rice varieties (*Oryza* spp.). Furthermore, this has created market demand for traditional foods such as honey, jaggery, treacle, bananas and organic products, boosting production for smallholders.

Hela Bojun centres have also drawn on Biodiversity for Food and Nutrition project research in order to publish nutrition facts for 91 traditional and local dishes (Hunter et al., 2020). Efforts to make Hela Bojun snacks and offerings healthier include further uptake and adaptation of these dishes with a focus on diverse local ingredients. In an offshoot of Hela Bojun, Wayamba University held cooking demonstrations with locally available dark green leafy vegetables to raise awareness of nutrition, hygiene and food safety, and to encourage the cultivation of diverse food species in home gardens. Further work is being done to produce more shareable recipes and discuss the potential of integrating the Hela Bojun model into school canteens with the support of the Ministry of Education (Rathnasinghe et al., 2019; Hunter et al., 2020). Other ongoing activities include chefs working with the women's groups to build capacity in quality, presentation and handling of food through. Qualitative research has documented women's empowerment and skills development of women participating in Hela Bojun (Muthulingam & Madhuwanthi, 2020).

Some data on the nutritional composition of food sold in Hela Bojun outlets has been made available through the Biodiversity for Food and

Nutrition project and partnerships with a university research network. Assessments of the nutritional value of some foods on sale in Hela Bojun have found that some traditional breakfast meals and snacks might not be categorised as 'healthy'. This has resulted in various BFN partners working with Hela Bojun organisers to identify more nutritious and healthy alternatives and recipes once common in Sri Lankan food culture, especially traditional cereal products (millet), underutilized seasonal fruits, vegetables and a variety of green leafy vegetables in efforts to make these more widely available (Rathnasinghe et al., 2019). Future plans include displaying the nutritional composition of local foods sold in Hela Bojun outlets to better inform customers of the nutritional value of the food items for sale.

Finally, ongoing efforts are focusing on creating innovative, healthy food promotion campaigns, communication strategies using social media and mass media with the collaboration of the Department of Agriculture, private sector and universities. Promoting healthy foods, especially traditional cereals, pulses, fruits and vegetables, may not only strengthen the health promotion aspect of the initiative but at the same time could better link Hela Bojun outlets to schools, home gardens, urban gardens, workplaces and small-scale farms (Rathnasinghe et al., 2019).

1.2.4. Case study 4: The story of *Ottelia acuminata* in Yunnan Province, China

The story of *Ottelia acuminata* is one of a traditional food that is closely interconnected to the natural environment where it grows and also boosts local economies due to its draw as a tourist attraction. *Ottelia acuminata* is a perennial aquatic plant, belonging to *Ottelia* Genus, Hydrocharitaceae Family (Li et al., 2009). The *Ottelia* Genus is distributed in tropical and subtropical regions in Africa, Asia, Oceania, and South America (Li, 1985).

Ottelia acuminata has existed in the world for 38 million years (Li, 1985). In China, the earliest written record of *Ottelia acuminata* consumption was in the 19th century (Li, 1985). Multiple ethnic groups in Yunnan Province, such as the Han, Bai, Yi, and Mosuo groups, have a long history of consuming *Ottelia acuminata* (Zhou, 2012, pp. 46–47). *Ottelia acuminata* is nutrient dense, and a source of calcium, iron, zinc, phosphorus, manganese, potassium, nitrogen, and essential amino acids (Li et al., 2009; Zhou, 2012; Zhu et al., 2010, p. 47). The water content of *Ottelia acuminata* is 93%. The dry weight of protein, carbohydrates and fat are between 312.73 and 315.29 g/kg, 59.12–63.14 g/kg, and 72.67–80.11 g/kg respectively (Li et al., 2019). The flowers, scapus, fruits, and leaves of *Ottelia acuminata* are edible (Zhou, 2012, pp. 46–47).

Different ethnic groups have various ways to cook *Ottelia acuminata*. It including mixing with meat, boiling in a soup with tofu or taro, pickling with chili or corn flour, and using as a condiment for peas (Zhou, 2012, pp. 46–47; Jiang et al., 2010). As with many food biodiversity species, traditional uses goes far beyond food. In the case of *Ottelia acuminata*, it is used as herbal medicine for several gastro-intestinal, bladder and lung conditions (Jiang et al., 2010; Zhou, 2012, p. 47) and is being studied for anticancer properties (Jiang et al., 2010). People also use *Ottelia acuminata* for pig breeding, and fertilizer (Li, 1985).

In the 20th century, as a result of excessive fish farming and lake pollution, *Ottelia acuminata* disappeared from many lakes in Yunnan Province (Li, 1985; Yang et al., 2013). For example, *Ottelia acuminata* disappeared in Dian Lake and markets nearby in Kunming in the 1960s (Li, 1985) and the wild *Ottelia acuminata* disappeared in Erhai lake in Dali in 1996 (Chen et al., 2014). To protect *Ottelia acuminata*, the species was listed as a national protected plant (Jiang et al., 2010). Several reserves to protect *Ottelia acuminata* were established (Jiang et al., 2010). The success of these conservation and pollution control actions, resulted in cleaner water quality in Dian Lake and a small amount of *Ottelia acuminata* began to re-emerge. Scholars have also discussed the potential to use *Ottelia acuminata* to detect lake pollution (Jiang et al.,

2010) and serve as a water purifier for lakes (Chen et al., 2014). In addition to the environmental properties, *Ottelia acuminata* is an attractive plant with white, elegant flowers (Jiang et al., 2010) and is considered a tourist attraction. For example, in Lugu Lake in Ninglang County, *Ottelia acuminata* attracts millions of tourists every year (Jiang et al., 2010) thus boosting the local economy.

With the support of the local government, citizens have started to cultivate *Ottelia acuminata* and increase their income (Jiang et al., 2010). According to a survey in 2003, the annual supply of cultivated *Ottelia acuminata* was 1500 tons (Jiang et al., 2010). Gradually, *Ottelia acuminata* is gaining popularity as a traditional food, with evidence of an increasing consumer base (Jiang et al., 2010).

The story of *Ottelia acuminata* demonstrates diverse benefits accrued to multiple sectors (health, environment, tourism and local development) gained from the conservation, cultivation and use of this one traditional food species. This case also demonstrates the diversity of food system stakeholders, from farmers, to tourists, consumers and researchers who can also benefit use this example as incentive to consider food biodiversity for multiple benefits.

1.2.5. Case study 5: Linking farmers, traditional vegetables and schools to improve diets and nutrition in Busia County, Kenya

Institutional food procurement, especially school meals, has emerged as a massive opportunity for mainstreaming food biodiversity, with schools acting as one of the most promising entry points (Swensson et al., 2021). School meals are a vital source of daily nutrients for millions of children, and can also act as a vehicle for education on nutrition, health and food choices. For example, it is estimated that school meals in Brazil impact 45 million children and supply up to 70% of children's nutritional needs. Likewise, school meals can be a determining factor in student attendance, and physical and mental development (Borelli et al., 2021; Hunter et al., 2019).

Home-grown school feeding (HGSF) whereby school meals are diversified by including locally sourced traditional vegetables, has shown potential to simultaneously promote social protection and agricultural growth. Preliminary evidence suggests that the approach can have positive downstream impacts on dietary diversity in school meals, the cultivation of neglected and underutilized species, and economic and social outcomes for the producers involved (Borelli et al., 2021). The case study of a pilot project in Busia County, Kenya demonstrates how an enabling policy environment is key to the realization of successful HGSF programs. However, additional research is needed to assess the impacts and effectiveness of the Busia approach if used elsewhere in Kenya and in different geographic locations.

Home-grown school feeding (HGSF) approaches can benefit local smallholder farmers while building market capacity for food biodiversity. Farmers are more likely to diversify their production if they are certain their crops will later be purchased at a fair price by schools, hospitals, prisons and other public institutions. Brazil's experiences with home-grown approaches and public policies that incentivizes regional and traditional foods demonstrate how this could be accomplished at the national level (Beltrame et al., 2021). In Kenya, under the auspices of the Biodiversity for Food and Nutrition (BFN) project, the Sustainable Income Generating Investment Group (SINGI) led a farmer business school approach that empowered local farmers, while also trialing a direct procurement model, to supply African indigenous leafy vegetables such as amaranth, slender leaf, spider plant, cowpea leaf and African nightshade of sufficient quality and quantity for school meals. This form of HGSF has already shown to be profitable for both farmers and the schools that they sell to, cutting out market intermediaries and streamlining the delivery process. Though as the program grows, it requires training and standardization to improve consistency and safety at a larger scale, home-grown school feeding has many positive implications including for community livelihoods, ecosystem resilience and student health (Borelli et al., 2021).

To equip farmers with relevant knowledge and skills, SINGI led

classes for 4000 farmers on sustainable agriculture methods, with a strong focus on maintaining local biodiversity and piloted a Farmer Business School (FBS) model whereby twenty-five farmer groups received training on sustainable agriculture practices, with cultivation techniques such as mandala, keyhole and multi-story gardens incorporated traditional crops and varieties. Farmers learned about the crops' nutritional value and how they could be incorporated into local markets, plus value addition and quality control. Perhaps most importantly, the FBS trained farmers in Busia County on contract farming, business plans and the ability to respond to demands from institutional markets including local schools and clinics. Those who received training were mostly women and youth, who reported they were able to grow small enterprises by commercializing African leafy vegetables (ALVs) and other nutritious crops (Borelli et al., 2021).

An important offshoot of the FBS was the trial of a Direct Food Procurement Model linking local farmer groups to school canteens that provide meals to students and staff. In the schools where this was trialed, farmer groups travelled to local schools and presented their produce to the administration and catering staff. Subsequently, memorandums of understanding between the farmer and school were created. These arrangements bypassed market operators, thus cutting out the "middle man" which was seen as mutually beneficial for schools and farmers and ensured consistent pricing of farmers produce (Borelli et al., 2021).

To reduce transport costs and avoid food losses, one farmer group arranged to grow vegetables directly on school land. As a result, the school received a reliable and constant source of quality ALVs, while farmers reduced their costs and found a dependable buyer for their produce. Early projections for the dry season show that, when market prices for leafy greens are higher, the school can save up to 10 Ksh (USD \$0.10) per kg of leafy greens supplied, which translates into weekly savings of approximately \$9 per week and yearly savings of \$360 a year. Projected average profits for the smallholder farmer group, which supplies 91 kg of ALVs to the school per week, amount to 15Ksh (\$0.15) per kg of leafy green. This translates into a weekly profit of 1,365Ksh (\$13) and yearly profits of approximately \$540. While further monitoring of the economic benefits to the school and to the farmers is needed over time, it has already become apparent that farming of ALVs is a viable business, slowly gaining ground in Busia County, with farmers increasingly willing to invest resources in ALV production and marketing (Borelli et al., 2021).

1.2.6. Case study 6: Bottle gourd (*Kitete*) in Kitui County, Kenya

In Kitui County in eastern Kenya, *Kitete* is the Kamba name for the bottle gourd, *Lagenaria siceraria*. In this county, *Kitete* appears in a myriad of varieties, as seen in the shapes, sizes and shell thickness of the fruits. While the majority of the fruit types are used as containers, some landraces are also cooked and eaten as a vegetable. The huge gourd diversity seems to be maintained by the different uses the fruit serves. Container types (*kitete*) are used as utensils, musical instruments, decoration, storage for salt, seed and household liquid (water and porridge). The local name for edible bottle gourd varieties is *Mongu ma muyo*.

Kitui County has ideal growing conditions for *Kitete* and a rich cultural knowledge of the species. *Kitete* use is virtually in every aspect of traditional life of the Kamba people. In recent years, the use of *Kitete* and its value in the Kamba society has been undermined by the introduction and popularization of modern plastic containers. Plastic containers replace the traditional *kitete* in the home and lead to erosion of local knowledge, which eventually, threatened the local varieties of *Kitete* with extinction. Kamba culture is intricately intertwined with *Kitete* and therefore loss of its knowledge and varieties would mean loss of an important cultural and food item in the Kamba culture.

In 2001, Kyanika Adult Women Group (KAWG), a local women's group in Kyanika village, Kitui county approached researchers from the International Plant Genetic Resources Institute (IPGRI) (now Alliance of Bioversity International and CIAT) and the National Museums of Kenya

(NMK) to seek a solution to this impending loss of landraces and knowledge. KAWG members expressed several concerns, including that the cultivation of *Kitete* and the numerous traditional varieties available, was declining. They expressed worry that younger women did not have sufficient knowledge about the available varieties and that older women were not passing knowledge to the younger women because either there was little interest, or the gourds were no longer present in crop fields. In addition, group members were concerned about plastic containers replacing gourd containers, since they felt plastic was bad for environment. Finally, some community members were concerned about the loss of edible varieties of bottle gourd, consumed by both people and animals. The women went on to discuss the important cultural significance of *kitete*, with hundreds of uses in their culture. For example, it is used in kitchens, crop fields, food stores, religious ceremonies and so on. *Kitete* can be decorated and sold. Some types, *mongu*, have edible young fruits. The plant covers the soil effectively therefore controls soil erosion.

A two-year project was initiated, with the aim of 'bringing back' the lost landraces and the local knowledge associated with the species in Kitui. The project focused on reintroducing lost *Kitete* landraces, distribution of seed among community members and documenting and disseminating indigenous knowledge. Training was provided to the women's group to teach them how to document traditional knowledge of *kitete* landraces by conducting interviews and using cameras and tape recorders.

After the training, the women's group were very active in raising community awareness through a diverse array of activities, including:

- demonstrations and many types of community competitions (eg. repairing broken calabashes, community members with the largest diversity of gourd species etc.)
- seed fairs and seed exchanges with other groups
- conducting training on how to document traditional knowledgeable, especially from elderly women
- documenting local knowledge on *Kitete* including recipes, use as medicine, songs, folklore, religious uses etc. Indigenous knowledge (IK) was documented through tape recording, video taking, photographing and writing.
- developing a *Kitete* centre/museum. The group established a community-based *Kitete* 'museum' (a community resource and documentation centre) within Kyanika village. The museum is used as a fruit repository and also seed source but also an information and education centre for school children and other visitors.
- safeguarding seeds and gourds, and creating a Resource Centre for others to see and learn

During the project period, the group collected 197 landraces of *Kitete* from within Kitui and neighbouring counties. These were referred to by approximately 70 different local names (Morimoto & Maundu 2002; Morimoto et al. 2005; 2008; 2010). Seeds of various landraces were propagated in the group's field and also by group members. Rare landraces acquired during seed fairs were distributed to other groups as well. The group has gone a step further and shared its acquired Indigenous Knowledge with other groups in the county. It has achieved this through seed fairs, field days and joint planting activities. Hundreds of farmers have participated in these activities. Rare cultivars of gourd, are now once again in the farms and in use. This essentially has contributed to the conservation of these important cultivars that are important not only as containers but also as food (Maundu and Morimoto, 2022). The group has transcribed all recorded information and compiled it in a 700-page document.

The group sells seeds, *Kitete*-based products such as decorated fruits, necklaces, bowls and containers and T-shirts. This has significantly increased the group's income. Orders of products are increasingly being received from local entrepreneurs, particularly restaurants. Besides income, most members of the community grow edible landraces of *Kitete*,

locally called Mongu. Some Mongu landraces, according to the group, are very drought-resistant and hence getting more popular in the wake of climate-change. The project has enhanced harmony among members and many neighbours wanting to join the group have been facilitated by KAWG to form different community groups. The community's motivation of safeguarding the diversity of Kitete landraces has increased. The area covered with Kitete in crop fields has increased among group members and neighbouring communities and the number of landraces in Kyanika village has also increased.

The group has shared their experience both locally and internationally. Its activities have been picked up several times by the local media. More groups in other parts in the country are now using lessons learned from Kyanika to implement similar projects. In 2004, the government independently noticed the impact and conferred the group with a trophy for “the best group for community-based income-generation projects in Kenya”.

A survey conducted in March 2022 (two decades later) found that the fruits of the edible types (mongu) were available in all main markets of Kitui West, Kitui Central and Kitui East Constituencies. The 314,801 residents and 32,544 households of these constituencies are indirect beneficiaries of the initiative as found in the 200 household farms sampled during the survey. All farmers here have access to mongu seeds from the increased number of farmers growing the crop and have access to the fruit through own fields or local markets. Despite the time lapse, Kyanika women were found to be earning income from the sale of decorated ornamental gourds and half calabashes used for serving porridge in restaurants throughout the country. Further evidence of the impact of this case study is that the method has been replicated to restore different crops (e.g. cowpea). This demonstrates the scalability of this community-driven approach.

2. Discussion

A range of diverse case studies were used in this paper to demonstrate the potential of food biodiversity to enrich local food systems. They also highlight an important theme on the value of holistic, systems thinking, a characteristic fundamental to Indigenous Peoples way of life (FAO, 2021a). However, it is not so easy to achieve at higher levels of decision making, especially within government, where thinking is more narrowly siloed to specific sectors such as health, agriculture, tourism or finance. The evidence that creates these interesting case studies spans many “sectors” of political action (health, agriculture, education, tourism, development). The case studies show that multiple approaches, both starting from the top down or bottom up can be utilized to take action to increase food diversity within food systems; and that the actions create multiple beneficial outcomes.

The case studies from the FAO Initiative on Future Smart Food and millets in India provide examples of national level commitment to increase the use of food biodiversity to enhance the achievement of multiple goals, including reduction of all forms of malnutrition, healthier diets, more sustainable and resilient food production systems and enhanced cultural wellbeing. The case studies from Sri Lanka and Kenya demonstrate community-led initiatives to increase local use of food biodiversity. In the case of Kitete, the Kyanika Adult Women Group (KAWG) approached Kenyan research organizations for assistance with a problem that was of concern to them. The problem was about conservation of one crop, bottle gourd, but the concerns of KAWG spanned loss of biodiversity, loss of traditional culture and knowledge, food security and malnutrition. As the group continued to learn, conserve, produce and promote bottle gourd, many positive benefits emerged, including income opportunities, preservation of cultural knowledge through the creation of a museum and passing on of traditional knowledge through cooking demonstrations, food fairs and hands on learning where younger generations were taught the value of this traditional crop. The case of *Ottelia acuminata* shows that not only direct programs and policies can increase the use of traditional foods;

other relevant factors, such as environment and tourism, can also affect the use of traditional food. Table 3 shows the unique importance of each case study featured in this paper.

Each of the case studies can also be considered through the lens of food system outcomes. Table 4 categorizes evidence, potential impact and continuing research needed with respect to each case study when considering four outcomes; healthy diets and nutrition, agro-ecological resilience, livelihoods and income and socio-cultural wellbeing.

2.1. Healthy diets and nutrition

Each of the case studies provides some evidence of the potential to contribute to healthy diets and improved nutrition outcomes. Many of the case studies, include evidence that is based on our knowledge of food composition, or the amount of nutrients provided by individual food species. In the case of millets, food composition data confirms a superior nutrient density when compared to the more commonly consumed grains such as rice and wheat. The high nutrient content of dark green leafy vegetables is well established and measured as a part of healthy diet diversity (FAO, 2021d). In Kenya, preliminary evidence suggests that the approach has had positive downstream impacts on dietary diversity in school meals. The case study from Sri Lanka specifically mentions an aim of the Hela Bejun initiative to curb fast food culture, by stimulating more interest and reliance on locally available, healthy meals and snacks.

Table 3

Unique approaches and characteristics of each case study.

Case study	Unique approaches and characteristics
Future Smart Food	This case shows the feasibility for the national government to explore and prioritize future smart food species. FAO helped develop a common framework and a multidisciplinary methodology (to identify and prioritize neglected and underutilized species that are nutrition-dense, climate-resilient, economically-viable and locally available or adaptable that was used by all of the countries and can promote wider uptake in other countries in other regions in the future.
Millets in India	This case demonstrates how national and local policy can lead to promotion of nutrient dense traditional grains. The government of India pinpointed why people did not like to use millet and is finding and implementing solutions through policies and general promotion. The Government advocated for international attention to millets and 2023 has been declared by FAO as the International Year of Millets.
Hela Bojun in Sri Lanka	This case demonstrates an approach that combines nutrient-rich indigenous species and small businesses (outlets and shops). The participation of women in this project is high and it also increased the family income significantly. It can also target different traditional food in different regions of the world. The project can be continuous without external funding.
<i>Ottelia acuminata</i> in China	This case shows how the environment can affect people's consumption of traditional food, either positively or negatively. The fact that tourism significantly increases the use of <i>Ottelia acuminata</i> provides a new method to market and encourage traditional foods.
African Leafy Vegetables in Kenya	This project smartly combines diversified horticultural production and school meals. It has multiple advantages, such as encouraging the cultivation of traditional foods, providing nutritious food to schools, and increasing farmers' income. This project profoundly changed the local food dynamics and benefits different groups.
Bottle gourd in Kenya	This case shows the close connection between food and culture. Bottle gourd is not just food in the communities in Kitui, but also utensils, musical instruments, and decorations. Thus, the revival of bottle gourd is not only encouraged to use as food, but also to develop cultural products for community use and sources of income.

Source: Authors

Table 4
Evidence of Food System outcomes from each case study.

Case Study	Nutrition and promotion of healthy diets	Agro-ecological resilience	Livelihoods and income generation	Socio-cultural well-being
Future Smart Food	39 species belonging to diverse food groups including cereals, roots and tubers, pulses, fruits and vegetables and nuts, seeds and spices were prioritized. Greater consumption of these species could increase nutritional adequacy of the diet as well as protect against diet-related non-communicable disease.	39 species were prioritized based on agro-ecological properties. Increased production of these priority species could boost overall yield, while reducing reliance on fertilizer and water inputs.	Prioritizing product development has the potential to increase livelihood opportunities.	Many of the 39 species are traditional foods, whose revival can build stronger social cohesion by strengthening cultural connections to food heritage.
Millet in India	Superior nutrient density compared to most commonly consumed staples	Drought tolerant, low-input, early and fast maturing,	Require support for food processing and co-creation plans to ensure equitable benefit sharing	Cultivated for centuries and therefore part of collective memory. Cultural revival through social media, restaurant and cooking industries
Hela Bojun in Sri Lanka	Broad focus on species diversity that promotes diet diversity. Also, a focus to reduce the influence of the growing fast-food culture and raise awareness of diet-related NDC.	Not specifically mentioned	Generates agriculture-based entrepreneurship, employment and private enterprise opportunities, especially for women, in order to provide a sustainable and stable family income. Hela Bojun stalls are present in 22 locations. Women report earning 600–800 USD/month and women report an increase in empowerment and business skills.	Restores culture and traditional food customs across a wide range of local species create awareness and interest among new generations about healthy eating and the nutritional value of disappearing traditional foods and recipes, creating demand for local produce.
Ottelia acuminata in China	Documented as rich in micronutrients	Potential to use to detect water pollution and also provides many ecosystem services, including water purification	Potential to provide local income from eco-tourism	Historically important food, tied to local knowledge and local medicine
African Leafy Vegetables in Kenya	Dark green leafy vegetables are nutrient dense. A main component of healthy diets is plentiful and diverse vegetable consumption. 5500 pupils were reached in this program.	Diversify agricultural production, which in turn contributes to greater ecosystem services	Evidence of income generation for local farmers. Six farmers groups, including one youth group signed contracts to supply ALV to schools and one hospital. Profits of up to USD 540 per year were documented.	Restores culture and tradition of consuming African leafy vegetables. students gained hands-on experience regarding the sustainable cultivation of local crops, while also learning about nutrition and economics.
Bottle gourd in Kenya	Some varieties of bottle gourd are edible. The bottle gourd varieties contribute to dietary diversity as well as food security. Most members of the community grow edible landraces of bottle gourd. The local name for the edible varieties is Mongu.	Bottle gourds have a unique niche in local food systems. 197 varieties of bottle gourd were documented in this case study. The varieties have diverse uses including, for erosion control, but also post-harvest are used as utensils (bowls, spoons) as well as storage containers, replacing the role that plastic containers often play. Some Mongu landraces, according to the group, are very drought-resistant and hence getting more popular in the wake of climate-change	Evidence of income generation for local farmers as well as women's groups who are adding value by decorating and selling the gourds as storage containers, that can replace the use of plastic in the home.	Restores culture and traditional food customs across a wide range of gourd landraces. Generated lots of local awareness and interest, resulting in the creation of one museum, seed banks and publication on the landraces of bottle gourd.

Source: Authors

2.2. Agro-ecological resilience

The Future Smart Food Initiative used agro-ecological resilience as one of the main criteria for species selection. Millets (foxtail, proso and finger) are featured in both the Future Smart Food priority list and also were selected as a stand-alone case study due to their integration into several national and state policies in India. The crops shown in Table 1 of the Future Smart Food case study were intentionally chosen due to their ability to grow in marginal soils and under more extreme conditions which include extremes of heat, water scarcity and fluctuations in moisture, such as flooding. Taro for example can tolerate both low and higher moisture levels (FAO, 2018). Pulses are also well known for nitrogen fixing and adding organic matter to soils. The case study on *ottelia acuminata* demonstrates the decline and reemergence of a species that can also be used as an indication of environmental health of water bodies.

2.3. Livelihoods and income generation

The case study on African leafy vegetables provided direct evidence of the income generation to local farmers, with farmers earning up to USD 540 per year. Similarly, the Hela Bejun case study has documented some women earning up to USD 600–800 per month. The continued expansion of Hela Bejun outlets provides further evidence of business model success. Some of the case studies indicate the potential for income generation, but could benefit from more focused documentation of impact. For example, in China, it would be helpful to document the impact that *ottelia acuminata* has had on the rise in local eco-tourism. The case study on bottle gourd in Kenya also demonstrated that women's groups can earn income through the sale of gourd products, but it would be helpful to provide additional evidence in this regard.

2.4. Socio-cultural well-being

The FAO Wiphala Paper acknowledges that protecting biodiversity is

essential for wellbeing and sustainability (FAO, 2021a). Each of the case studies illuminates the potential of food biodiversity to improve socio-cultural wellbeing. Our food traditions ground us in our own cultures, but also are an important entry point to learning about other cultures. This receptive mindset is evidenced by the increasing popularity of food biodiversity that is featured in popular culture. There has been a huge increase in cooking shows, recipe books, restaurants and television documentaries celebrating traditional and indigenous foods (Kennedy et al., 2021). This receptivity to learning how to accommodate greater food biodiversity through culinary learning, can be used as an entry point to stimulate learning on environmental stewardship, equitable benefit sharing and other concepts central to wellbeing.

2.5. Considerations

When using a food systems approach, it is often necessary to consider trade-offs and unintended consequences that can occur. Firstly from both a human nutrition as well as environmental perspective, there is a downside to promotion of “single” food solutions, sometimes referred to as “silver bullets”. The dangers of single food, silver bullet approaches are that people can become overly focused on the potential of just one species to provide income and food, thus perpetuating the cycle of narrowing food biodiversity both on farms and plates. Therefore a key recommendation is to promote a wide array of food biodiversity that can be used to diversify our landscapes, farms and plates.

It is well documented that Indigenous Peoples have suffered diverse kinds of malnutrition, from undernutrition to obesity and its consequences, resulting from heavily marketed commercially available foods that are more easily accessed than the more nutritious foods available from their local lands and cultural traditions. Public health promotion programs are successful when local foods are promoted and access is increased (Swinburn et al., 2019). The Hela Bejun case, highlighted that more support is often needed to help vendors hold true to claims of healthy foods being sold. It is often the case that food stalls offer a mixed selection of healthy and less healthy items. To overcome this problem in the context of Hela Bojun, vendors worked to incorporate more nutritious traditional recipes that use traditional ingredients such as millet, underutilized seasonal fruits, vegetables and a variety of green leafy vegetables. The vendors also strive to offer healthier food options that are visually appealing to consumers.

For local food security and equitable distribution of benefits, the case studies demonstrate the potential benefits, but previous studies have warned that there can be cases of unintended harm when a species is heavily promoted without regard to lessons learned from previous experience, such as the boom and bust cycles of specialty crops like quinoa, palm oil, cacao and shrimp, where the “boom” involves increases in consumer demand and prices, land-use change to accommodate greater production, followed by the “bust” cycle of a rapid decline in price and subsequent fall in production, which can damage local landscapes, local economies and farmer livelihood (Andreotti et al., 2022). Lack of a plan to ensure local benefits, can be detrimental, particularly to Indigenous Peoples and rural, small-scale farmers. It is very important for initiatives that focus on specific crops (eg. millet and *Ottelia acuminata*) actively co-design with communities, inclusive plans for sustainable and equitable management and benefit sharing. A fundamental policy perspective that is inclusive of and beneficial to the Indigenous People will lead to the ecological conservation of use of indigenous foods, knowledge preservation and support environmental sustainability.

While this paper aimed to highlight the multiple benefits of food biodiversity that include but go beyond diet and nutrition, lack of outcome level evidence on for example dietary diversity or population level nutritional status resulting from increased production and consumption of food biodiversity is a weakness. Another limitation of this paper is the use of a case study methodology, which is less scientifically rigorous and therefore less generalizable to other contexts when

compared to more rigorous methods such as a systematic literature review. This weaker level of evidence in relation to research on food biodiversity is in part due to limited funding to conduct more rigorous evaluations. The FAO report on the State of Biodiversity for Food and Agriculture, notes the uneven and limited data on assessment and monitoring and calls for strengthening monitoring of biodiversity for food and agriculture (FAO, 2019).

3. Conclusion

The wealth of food biodiversity available on the planet is undervalued. These case studies demonstrate the feasibility and importance of greater inclusion of food biodiversity for a wealth of benefits ranging from healthy diets and nutrition to improved ecosystems, prosperity and socio-cultural wellbeing. The six case study examples demonstrate that there are multiple approaches, some initiated by government and others initiated at community level, that can be used to achieve greater integration of food biodiversity into food systems. It is important to use a holistic perspective, which comes more naturally to communities, who use system-level decision making processes as compared to silo approaches, often the default of government institutions. Finally, it is important to create spaces for inclusive, active decision making, to develop partnerships between all food system actors to create more sustainable, diverse production systems that work toward the benefit of all.

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