



The Scientific Group for the
UN Food Systems Summit
<https://sc-fss2021.org/>

Food Systems Summit Brief
prepared by Research Partners of the Scientific Group for the Food Systems Summit
April 5, 2021

MARGINAL AREAS AND INDIGENOUS PEOPLE PRIORITIES FOR RESEARCH AND ACTION

by Sayed Azam-Ali, Hayatullah Ahmadzai, Dhruvad Choudhury, Ee Von Goh, Ebrahim Jahanshiri,
Tafadzwanashe Mabhaudhi, Alessandro Meschinelli, Albert Thembinkosi Modi, Nhamo Nhamo,
Abidemi Olutayo

CONTEXT

Business-as-usual is not working. Marginal environments and the indigenous people who cultivate them have one thing in common – they are forgotten. Their soils and climates, crops and livestock, beliefs and knowledge systems rarely attract academic interest, policy studies or investment. Marginal environments refer to Less-Favourable Agricultural Areas (LFAAs) characterized by constrained agricultural potential and resource degradation attributable to biophysical and politico-socio-economic factors.¹ Their low production potential is driven by rugged terrains, extreme weather conditions, poor soil and water quality, lack of socio-economic connectivity and limited exposure to agricultural intensification opportunities. In such regions, drought and erratic rainfall, salinization, and other factors present significant constraints for intensive agriculture. Marginal environments encompass all LFAAs and any favourable agricultural areas (e.g., areas not constrained by biophysical factors) with limited access to rural infrastructure and agricultural markets where cost-effective production is unfeasible (without additional support) under given conditions, cultivation techniques, and policy or macro-economic setting.

The agricultural expertise of indigenous communities is often overlooked by decision makers who, instead, advocate interventions based on mainstream crops and external technologies. Whilst such approaches have had demonstrable impacts on food security and poverty alleviation elsewhere, they often fail in indigenous communities where a vast range of crops are cultivated in diverse production systems and in marginal environments. As a result, agricultural yields in marginal areas continue to decline and the gap between the actual and potential yield of mainstream food crops widens.^{2,3,4} Hunger, malnutrition, and poverty in indigenous communities continue to increase as one in five people on the planet is malnourished.⁵

We need diverse food systems. An alternative to top-down technological packages is to approach the existential challenges that indigenous people face from their own perspectives and resources. However, the agrobiodiversity and associated knowledge systems that these communities have protected for millennia are under threat. Nearly 10% of all domesticated breeds of animals for food and agriculture are already extinct and another one million plant and animal species now face extinction.⁶ Many of these species are climate-

resilient and nutritious crops. For example, millets and gluten-free grains, such as amaranth, teff and quinoa are rich in vitamins, minerals, essential fatty acids, phytochemicals, and antioxidants and crops such as finger millet, cowpea and bambara groundnut are also adapted to extreme weather (drought and heat stress) and poor soil conditions.^{7,8} Whilst the genetic diversity found in indigenous farming systems could become the foundation for future agricultural and food systems, of over 30,000 edible plants, fewer than 30 species grown as monocultures now provide most of the food consumed by 7.8 billion people.⁹ These mainstream crops monopolise agricultural research, investment, support and formal markets.

Languages are the basis of knowledge. From over 7,000 languages, only six are spoken by half the global population.¹⁰ Roughly 40 % of languages are now classed as endangered and as few as 600 might still be spoken in 2100.¹¹ For indigenous people, this represents not just a catastrophic loss of languages but of cultural and ethnic identity and agricultural knowledge that, without a written record, has been conveyed verbally for generations. Where a language is unwritten, or its speakers are illiterate, the indigenous knowledge of a community along with potential solutions to modern challenges facing humanity are lost.

Climate Change and Sustainable Development. Climate change threatens those least able to withstand its impacts. In 2015, UN member parties agreed to limit mean global temperature increases to 2°C above pre-industrial levels.¹² Predicted global heating is between 3.1-3.7°C.¹³ The consequences of such increases and the frequency of extreme events will disproportionately impact indigenous people – since many already live in hostile and marginal environments. However, indigenous people are inheritors of a unique social and cultural identity, have a distinct historical continuity and traditional knowledge of how people have interacted closely with their environments, and have developed, and passed on such expertise across many generations.^{14,15} It has been estimated that indigenous people have an approximate population of 476 million across 90 countries with about 5,000 distinct cultures, accounting for most of the world's cultural diversity.¹⁶

Of the 17 UN Sustainable Development Goals (SDGs), SDG1 commits the world to *eradicate poverty in all its forms*, and SDG2 to *end hunger, achieve food security and improved nutrition and promote sustainable agriculture*.¹⁷ This entails moving from an economic definition of poverty (lack of income) and hunger (lack of food) to a multidimensional concept involving sustainable livelihoods, healthy

diets, knowledge of food heritage and agricultural systems and the agency of communities to make their own decisions. A more articulate and inclusive notion of poverty and hunger eradication means achieving sustainable livelihoods, better nutrition and greater resilience of *all* communities including indigenous people to climate shocks.

APPROACH

The consolidation of mainstream agriculture, the decline of species and associated knowledge and the climate crisis call for a different approach for indigenous people living in hostile environments. In such circumstances, it is they, not us, who are the experts. The challenge is how research can help these communities become agents of change and co-owners of innovations to help secure sustainable livelihoods and healthier lifestyles. Rather than being seen as passive recipients of external technologies, indigenous people need fair and equitable partnerships with research, education, extension, and private institutions that recognize human rights as the basis for sustainable food systems. This means that, wherever possible, the development of agricultural products, value chains, markets and food systems should remain under the jurisdiction of indigenous communities in terms of benefits, intellectual property, labour conditions, and negotiating power. This includes the contribution of underutilized or 'forgotten' crops and their knowledge systems to food security, balanced diets, income generation, agricultural diversification and better use of marginal lands.

EVIDENCE

Knowledge Diversity. Marginal environments are biogeographically distinct, and their communities are culturally diverse. For indigenous people to secure sustainable livelihoods and healthier lifestyles, we need research approaches that suit the particularities of regions and people and knowledge systems that provide the best options for different circumstances. This requires complementary skills to address systemic challenges to the whole food system rather than its components and networks from which viable options can be considered, evaluated and delivered by indigenous people in their own localities.

Knowledge Partners. Whilst there are many knowledge systems for mainstream agriculture, we are not aware of any integrated system that relates specifically to marginal environments and indigenous people. However, a number can be adapted to these circumstances by research institutions with expertise

in different biogeographical regions. For example, Crops For the Future (CFF) has developed *CropBASE* as a global knowledge base for underutilized crops,¹⁸ their suitability,¹⁹ economic potential and nutritional values in different environments. Along with its partners in the Association of International Research and Development Centers for Agriculture (AIRCA), CFF has proposed a Global Action Plan for Agricultural Diversification (GAPAD).²⁰ The International Centre for Integrated Mountain Development (ICIMOD) facilitates the *Global Framework for Climate Service*²¹ to collate, curate, and share data to support robust planning and policy decisions for climate resilience in mountain regions. The International Center for Biosaline Agriculture (ICBA) has developed integrated drought management, monitoring/early warning systems, vulnerability and impact assessment and mitigation for crop diversification with underutilized, stress-tolerant crops for food, feed and biofuel.²² The UKN *Centre for Transformative Agricultural and Food Systems* is building resilient, sustainable and healthy food systems for climate-resilient agriculture to improve human wellbeing and livelihoods in Semi-Arid regions of sub-Saharan Africa.²³

Impact Pathways. The Global Forum for Agricultural Research and Innovation (GFAR) is building collective actions to improve poor farmers' livelihoods, including indigenous and other communities living in marginal areas, by enhancing the market value of forgotten foods and the crops from which they derive, intervening in supply chain bottlenecks and mobilizing small producers as co-innovators. By recognizing the rich local knowledge behind forgotten foods, GFAR members seek sustainable avenues for a community-centred, pro-poor transformation of food systems and reorientation of research and innovation governance. For this, GFAR is co-ordinating a *Collective Action on Forgotten Foods* and a *Manifesto for Forgotten Foods* which explicitly calls for novel research and innovation systems.²⁴

INDIGENOUS FOOD SYSTEMS AND KNOWLEDGE: CHALLENGES IN DIVERSE SETTINGS

Biogeographical and cultural diversity. Whilst each marginal region and indigenous community is unique, some themes and challenges link them. Common research and innovation approaches can be shared and applied across environments. Here we consider food systems in four biogeographical regions representing a significant proportion of the world's marginal land area, indigenous people and agricultural biodiversity. We then identify innovations, investment opportunities, priorities, and proposed actions to

help transform indigenous peoples' food systems in marginal areas through agricultural diversification beyond mainstream crops and systems.

Arid (drylands, biosaline soils and coastal regions).

The importance of traditional food systems, especially in drylands, where indigenous people reside, cannot be over-emphasized. Indigenous people often hold a historical link between environmental heritage and food systems.²⁵ Recent agricultural interventions have widely acknowledged the role of indigenous knowledge of local people in the development of food systems in drylands. Effective and sustainable utilization of their cultural heritage regarding food systems can support environmental services, food preservation and storage. Integration of various knowledge systems in co-innovation and co-production can transform traditional food systems, including food sovereignty, to avoid future hunger and malnutrition.^{26,27}

Despite the harsh environmental conditions in drylands, some indigenous food crops have exhibited outstanding performance and unmatched adaptation.²⁸ Plant physiological adaptation to environmental stress has been a subject of intense research on dryland crops. Plant responses such as photosynthetic rate alteration, leaf area reduction, stomatal conductance regulation and waxy-substance production have been reported.^{29,30} Drought evasion, albeit at the expense of biomass accumulation, has also been studied for many indigenous food crops. Similarly, rhizosphere microbiota (bacteria and fungi) cultivation has resulted in improved adaptation to water and nutrient stresses.³¹ The application of microsymbionts and the rhizobiology associated with this innovation has explained in-part the mechanisms of adaptation to stress by plant roots. Rhizobacterial nutrient solubilization, mobilization and salt mitigation using *Azotobacter* spp. has been found to increase synergy from inoculation.³² Mycorrhizal associations have also increased nutrient abstraction from the soils by 30%. Thus, co-inoculation with various species such as *Anthrobacter* sp., *Bacillus* sp., *Paenibacillus* sp., *Pseudomonas* sp., and *Rhizobia* sp yielded between 50-70% increase in nutrient uptake and use while enhancing photosynthesis and systems defence.³³ Secretion of root exudates and stimulation of lateral root branching increased phosphorus uptake in the soil.³⁴

Both water and nutrient use efficiency are a function of the plant phenotype, management, and root architecture. Molecular marker-assisted breeding has made some inroads into the characterization of polygenic effects in relation to the dryland environments. There is evidence that water use efficiency (WUE) increases with water deficit but

not beyond 40% of irrigation requirement.³⁵ The combination of high WUE and nutrient use efficiency (NUE) in indigenous crops can improve yields. Recent developments on the integrated drought monitoring and early warning systems have shaped mitigation options for smallholder farmers. With the adoption of controlled environment farming to produce vegetables, indigenous farmers will have the capacity and means to boost production and save about 90% water requirement.³⁶ Research that introduces, evaluates, and adapts underutilized crops for dietary diversification in marginal environments is underway. Several crops with proven tolerance to salt, salinity and/or water stress have been studied in drylands. So far, crop diversification has focused on cereals, legumes, fruit trees and fodder crops. There is evidence of improved crop yields, increased popularization of nutrient-dense crops and fodder suitable for drylands. Examples of dryland food crops include fruit trees (date palms), millets (finger-, pearl-, proso-, fonio-millet), pseudo cereals (amaranths, buckwheat, and quinoa), cereal grass (teff), pulses (chickpea, faba bean, pigeon pea lentil and groundnut), halophytes (Cumin, Salicornia, and Colocynths and oilseeds (mustard, sesame, sunflower, safflower, and rapeseed). These crops have high nutritional values and are adaptable to harsh growing conditions. The genetic diversity amongst these crop species has been preserved and limited to the communities where they were being cultivated, e.g., teff in East Africa (areas around Ethiopia and Eritrea). Commercialization of these crops will contribute significantly to sustainable food and nutrition security.

Indigenous food systems face natural and anthropogenic extinction. While breeding techniques have advanced, only a handful of indigenous crops have received the required promotional support to support widespread utilization.

Semi-Arid (seasonally dry, rainfed, impoverished soils). Semi-arid regions are a subtype of environments with an aridity index (ratio of total annual precipitation to potential evapotranspiration) between 0.20 and 0.50.³⁷ These regions are characterized by mean annual precipitation between 200 and 700 mm³⁸ often with stormy character, clustered in alternating seasons. A complex range of topography, biodiversity and variability in rainfall and microclimatic conditions has meant frequent exposure to droughts and floods with grievous implications for agricultural production, ecosystem services and social and cultural relations. The food system context across semi-arid sub-Saharan Africa (SSA) is one of significant environmental, political, socio-economic and cultural diversity. However, the region is regarded as among the world's

most food-insecure regions.^{39,40} Compounding threats, such as climate change, environmental degradation and increasing populations, have left many marginal communities vulnerable to food and nutritional insecurity.⁴¹ This insecurity is further compounded by globalization and homogenization of the food system, both of which have relegated many African indigenous crops, which are suited to these environments, to the status of neglected and underutilized species.⁴²

Across the SSA, food systems rely primarily on staple food crop production of a few major crops and a few minor or endemic food crops (including underutilized species).⁴³ Cereal staple crops such as maize, sorghum, wheat and pearl millet are grown and consumed extensively by rural farmers across the region.⁴⁴⁻⁴⁷ However, rural farmers also rely on indigenous crops and associated knowledge systems to ensure their food security.⁴⁸ They augment field crop harvests with different types of seasonal edible wild fruits, vegetables, and roots identified, harvested and processed using indigenous knowledge.

Rural farmers, usually women, are generally regarded as the custodians of underutilized indigenous and traditional crops and their knowledge of cultivation and use. It is generally recognized that although indigenous food plants have, in the past, played an important role in the diet of African communities, the industrialization of food systems and formalization of markets has resulted in a decline in the use of African indigenous and traditional food crops. Also, in most cases, the promotion of Green Revolution technologies has inadvertently exacerbated inequalities and food insecurity. For example, in the 2000s, and after the massive roll-out of hybrid technologies, evidence from Rwanda⁴⁹ and Ghana⁵⁰ showed significant growth in agriculture's contribution to the GDP. However, this was accompanied by greater inequalities and food insecurity for rural communities.

On the other hand, reports suggest that underutilized crops offer a pathway to a more sustainable and equitable agricultural system for SSA, capable of addressing several SDGs related to socio-economic and socio-ecological wellbeing.⁵¹ Researchers argue that one of the unintended outcomes of the global agro-industrial food system has been the replacement, and subsequent relegation, of underutilized indigenous and traditional crops through the introduction of exotic and, now considered, "major" crops that were often higher-yielding, but also more input-intensive. This has led to the neglect of traditional crop species that had previously formed the basis of local indigenous food systems, which were resilient, sustainable and healthy.

Despite the lack of support, many smallholder farmers use indigenous crop species as nutritious foods that support cultural and ecosystem services. Many of these crops are favoured in local markets for both household consumption and as medicines.⁵² Using traditional methods and knowledge, farmers select, harvest, store and trade indigenous crop vari-

eties that possess desirable nutritional, medicinal and pharmaceutical properties.⁵³ Decades of research have shown that indigenous crops and associated knowledge-systems can improve food and nutritional security in marginal environments. However, it is important to identify traditional tools and strategies that can help address production constraints within marginal farming communities when integrated with modern and digital technologies.

Humid (tropical, rainforests). Tropical rainforests are home to many indigenous people and serve as a lifeline for many forest-dependent communities. Whilst not all are indigenous, indicative estimates show that, globally, there are approximately 1.3 billion forest-dependent peoples.⁵⁴ Their food systems are complex chains of production, distribution, consumption, recirculation of food refuse, and the acquisition of trusted foods and ingredients from other populations built on a diversity of local or traditional practices for ecosystem management. These practices include multicropping, resource rotation, succession management, landscape patchiness management, and various methods of managing unpredictable ecological surprises.^{55,56} Social mechanisms behind these practices include adaptations for the generation, accumulation, and transmission of knowledge; the use of local stewards and rules for social regulation; mechanisms for cultural internalisation of traditional practices; and the development of appropriate world views and cultural values.^{57,58} Resources are collectively managed, which rely on group decisions, often by consensus and involving elders.⁵⁹ As the result of a constant struggle between modernisation and survival, indigenous peoples have developed flexible strategies to maintain relatively stable and sustainable food systems that are biodiverse, resilient, and long serving. While there is ample variation in the practices of each indigenous community living in the humid tropics, they share certain similarities to adaptive management. These include an emphasis on feedback learning, the treatment of uncertainty and unpredictability and resilience mechanisms with confer obvious advantages over conventional “modern” productive models.⁶⁰⁻⁶²

Tropical rainforests cover only a small part of the earth’s surface (about 7%), yet house over half the species of plants and animals on the planet.⁶³ High deforestation rates result in a significant reduction in the area and geography of mature tropical forests and loss of diversity of tropical forest species.⁶⁴ As a consequence, many native societies of the rainforest have already been destroyed and those cultures that still exist face a grim future due to poor policies and practices.⁶⁵ Indigenous peoples experience extreme disparities compared with greater than global

averages in obesity, undernutrition and micronutrient malnutrition, as well as other health gaps that are grounded in poverty and marginalization.⁶⁶⁻⁶⁸

Conflicts of land tenure and assimilationist policies have compelled and compounded the migration of indigenous peoples to urban areas.⁶⁹⁻⁷¹ This exodus contributes to their inability to realise sustainable diets based on local species and traditional knowledge.⁷²⁻⁸³ Consequently, their vast knowledge and guardianship of 80% of global species diversity is also diminished and lost.⁸⁴ Not only are forest-dwelling cultures losing their forests, they are also losing their next generations to inherit and pass on the traditional indigenous knowledge and practices built over generations. There is a critical urgency to act before the current living generation of knowledge holders and the species that they have inherited are lost for ever. Recognising this importance, there have been sporadic efforts to document this knowledge resulting in highly variable data that lack workability and comparability.⁸⁵⁻⁸⁹ This piecemeal approach highlights the need for a global knowledge base of indigenous species and systems and the design of systematic approaches and methods of data collection and observation. As well as the continuing efforts to reverse the dispossession and marginalisation of indigenous peoples, the recognition of their roles and knowledge should be increasingly advocated not only for the benefit of their own communities but as part of a collective global public good.

Without the contribution of indigenous peoples to international health and sustainability targets, many of the United Nation’s Sustainable Development Goals (SDGs) cannot be achieved, most notably SDG1 (zero poverty anywhere) and SDG2 (food security and improved nutrition). The design of sustainable food systems is also necessary in order to ensure the delivery of healthy, safe, and nutritious foods in both sustainable and equitable ways in an era of changing climates. In each case, the knowledge of indigenous communities can provide essential contributions to sustainable diets and climate-resilient food systems.⁹⁰

Mountains. The mountains and uplands of the world are home to diverse food systems, each with its accompanying repository of indigenous knowledge evolved through generations of empirical experience. In the Hindu Kush Himalaya, rangelands constitute around 60% of the land use, and Yak herding, Angora goat and sheep rearing form the basis of food systems in large parts of the Tibetan Plateau and the higher altitudes.^{91,92} On the southern slopes, transhuman pastoral communities carry out seasonal migrations, grazing their animals in the high altitude *Bugyals*

(pastures) during summer and descend to lower altitudes during the cold winter months.⁹³ The food system of these communities is linked to mixed farming systems across their migratory routes, and foodgrains predominantly obtained from farmers in exchange for milk products. Mixed farming systems with cereal-based agriculture and livestock rearing, intricately linked to forests, constitute the food system in the mid-altitudes of western Himalaya. These systems are built around upland cereals - buckwheat, millet, amaranthus - and legumes, complemented with milk and milk products. In the Eastern Himalaya and much of the uplands of Southeast Asia, shifting cultivation, with a rich diversity of cereals, legumes, tubers and leafy vegetables, together with small ruminants, piggery and poultry, constitutes the food system of diverse communities inhabiting the region.⁹⁴⁻⁹⁷ Regenerating fallows and young forests also form important constituents of the food system of shifting cultivators.⁹⁸⁻¹⁰⁰ Small pockets of settled agriculture, predominantly consisting of wet terraces and complemented with animal husbandry, and intricate links with forests are also found in pockets of Eastern Himalaya, with the *Aji*-system of the Apatanis in Arunachal Pradesh, the *Zabo* system of the Chakesangs of Nagaland and the *Buun* system of the Khasis of Meghalaya being prominent agricultural systems in a landscape otherwise dominated by shifting cultivation.¹⁰¹⁻¹⁰⁴ Further south, in the uplands of Southeast Asia, Forest Gardens complement shifting cultivation and wet paddy systems constituting an important part of food systems of upland communities in Indonesia.¹⁰⁴

Knowledge systems and traditional practices associated with food systems of indigenous communities are rich. They reflect a deep understanding of crop, soil and water dynamics and the functioning of the surrounding environment. Animal husbandry and rangeland management of pastoralists centred around rotational grazing suggest an understanding of the carrying capacity of rangelands and high-altitude meadows. The intricate link between agriculture, animal husbandry and forests found in western Himalayan mixed farming systems similarly reflect an understanding of the link between forest litter, animal dung, nutrient management and crop productivity. Indigenous knowledge of shifting cultivators suggests a robust risk management strategy and underlies the conservation and management of a wide diversity of crops together with a range of landraces. Food systems of these communities also extend to fallow management and indicate an indigenous understanding of the food and nutritional value of wild edibles and animal products supported by regenerating fallows and forests. The indigenous

knowledge of shifting cultivators also includes weed management and traditional pedological knowledge including an understanding of crops best suited to each soil condition. This indigenous knowledge base offers opportunities for developing solutions to several of the challenges arising out of land degradation and climate-induced stress emerging in present-day upland agriculture. Indigenous food systems and the knowledge associated with such systems are under threat today. With the transition to commercially important monocropping driven by markets and a policy promoting commercialisation and homogenisation, indigenous food systems are rapidly being replaced by cash crop plantations and commercial agriculture.^{105,106} The rapid erosion of agro-germplasm has serious consequences for ensuring food and nutritional security of the future as many of the crops found in food systems of the mountains are not only recognised Future Smart Crops but also important as 'building blocks' for developing stress-tolerant, nutrient-dense crops of the future crucial for ensuring food and nutritional security and attaining Zero Hunger.¹⁰⁷

INNOVATIONS AND INVESTMENT OPPORTUNITIES

Current agricultural policies promote staple crops for mainstream agriculture in favourable areas. This has been at the expense of indigenous and underutilized crops, many of which are well adapted to hostile environments and yield nutritious products. Many favoured agricultural lands have reached their saturation potential, are often overexploited due to demographic pressure, and are increasingly impacted by climate change. If we are to nourish more people on a hotter planet, marginal regions will have to play a more significant role in food systems. However, the current promotion of healthier diets and sustainable food systems has excluded indigenous people, their crops and expertise. Evidence shows that where investment has been targeted on such communities and their food systems, they can enhance productivity, improve nutrition and reduce carbon emissions. The challenge is to link formal and local knowledge to identify which crops best suit specific environments, deliver desirable products and support sustainable and equitable livelihoods. This requires investment and policy support for innovations and technologies that can mainstream diverse value chains, their crops, products and knowledge systems.

GAME-CHANGER TECHNOLOGIES AND INNOVATIONS

The need is urgent. To achieve sustainable livelihoods, indigenous people in marginal areas need game-changer technologies in which they are the

agents of innovation. This requires approaches that ensure the conservation, quantity, quality and value of products from forgotten crops to external markets. Innovations and technologies need synergies between researchers and indigenous communities as partners, not clients. The innovation process must allow for participatory and demand-driven approaches that stimulate and build upon farmer innovations and suit local circumstances. For this, indigenous communities need access to better knowledge systems, improved genetic material, integrated management practices and novel technologies across the whole value chain that provide routes to markets. Again, this requires long term research support and an enabling policy environment at each stage of the value chain rather than sporadic efforts at specific points along it.

Better Knowledge Systems. Agricultural research is often confined to silos and excludes local knowledge. Indigenous communities need knowledge systems that integrate their own expertise and belief systems with evidence from scientific studies and predictive models. This requires novel approaches to data collection, collation and curation and digital technologies that can make knowledge available to end-users.

Improved Seed Systems. Breeding approaches need to utilize the inherent genetic variability in local crops to develop widely adapted cultivars for diverse biophysical and socioeconomic conditions. This requires new cultivars with improved yield potential without compromising nutrient density and climate resilience, breeding programmes that utilize technologies and approaches from major and model species and community seed-saving and selection approaches that conserve and enhance agricultural biodiversity.

Integrated management. To be cost-effective, productive and sustainable, crop management in marginal areas must both enhance productivity and reverse resource-degradation. This requires technologies that increase access to water and nutrients and cultivars that are more efficient in water and nutrient use than major crops. Innovations for marginal areas will also need to be context-specific and include survival mechanisms that enhance climate resilience. For this, innovations must utilize an understanding of ecological processes and soil health rather than dependence on external inputs for crop production.

Technologies to markets. Indigenous food systems are predisposed to production and market risks due to harsh biophysical and socioeconomic shocks. New technologies are needed to improve harvesting,

post-harvest storage, milling and drying to support economically viable value chains, and digital systems are needed to trace crops and verify their products from field to consumers. Risk mitigating innovations that promote resilience will protect communities from climate shocks and enhance sustainability.

PRIORITIES AND PROPOSED ACTIONS

Mainstreaming Diverse Value Chains. Addressing climate change, food security and malnutrition are global priorities. However, without mainstreaming the crops, foods and knowledge of indigenous people in marginal areas, sustainable development goals cannot be achieved. If we are to move beyond a narrow focus on specific SDGs, mainstreaming efforts must focus on improving the livelihoods of poor farmers, especially women, by enhancing the value of their underutilized crops and forgotten foods to local and global markets. This needs technological and policy interventions to overcome bottlenecks along the production and consumption chain that also address global mandates for environmental sustainability and biodiversity conservation. This also requires the transformation of research systems to mobilize small producers as co-innovators and sources of ingenuity. Mainstreaming diverse value chains into agrifood systems requires four drivers for change; evidence-based policies and policy support; advocacy by and for indigenous communities; collective actions around forgotten foods; and co-ordinated investment.

Evidence-Based Policies. Development of policies must address challenges and knowledge gaps in technological innovations, social inclusion and environmental and economic equity for indigenous communities. Most importantly, for marginalized communities to actively become part of mainstream economies, policy instruments must ensure equal access to digital innovations, capacity development, crop insurance and friendly financing and investment. Priorities should be informed by global knowledge systems that use digital technologies to link global scientific evidence with local indigenous knowledge of the cultural and traditional value of traditional crops beyond yield-for-profit alone. A key requirement is policy reforms that are explicit in their support for indigenous people, are based on a global evidence base and share best practices between biogeographical regions and indigenous communities.

Advocacy for Agency. We need to raise awareness of the potential of underutilized crops and forgotten foods. This requires recognition of the rich local knowledge of indigenous people as custodians of agrobiodiversity and greater self-awareness of communities to unlock

their creativity as agents of change. By increasing their self-esteem, self-pride and self-confidence, indigenous communities can become active drivers of new technologies for which formal research and innovation systems are currently the decision-makers. Advocacy supported by evidence, policy and the agency of indigenous communities opens avenues for farmer-centred, pro-poor transformation of food systems and the reorientation of research and innovation to mainstream value chains and value-added products from underutilized crops.

Collective Actions. Integrated strategies must evolve around a framework that is all-inclusive but context-specific. An integrated and holistic policy approach is necessary to advocate collective actions with indigenous communities that engage research institutions, policymakers, farmers, consumers and other stakeholders to unlock the untapped potential of marginal agriculture. The GFAR Collective Action on Forgotten Foods²⁴, which explicitly includes a *Manifesto for Forgotten Foods*, is a major opportunity for indigenous communities in marginal areas to be part of a global effort to mainstream diverse value chains.

Co-ordinated Investment. Time is of the essence. If indigenous communities in marginal regions are to become agents of change, they need co-ordinated investment, accessible finance, co-innovations, traditional knowledge, governance, evidence, and empowerment. Policies encouraging public and private investments and research and development for indigenous communities and marginal areas are imperative to improve the sustainability and resilience of their food systems. Public-Private-Partnerships offer an important opportunity to leverage resources, access new technologies and innovations and facilitate risk-sharing. However, a conducive policy environment and global commitment of resources are essential prerequisites if we are to deliver diverse solutions for forgotten people in forgotten regions.

REFERENCES

1. Pender, J. and P. Hazell. 2000. "Promoting Sustainable Development in Less-Favored Areas: Overview". Brief 1 in J. Pender and P. Hazell (eds.), Promoting Sustainable Development in Less-Favored Areas. 2020 Vision Initiative, Policy Brief Series, Focus 4. Washington, DC: International Food Policy Research Institute.
2. Mustafa M, Mabhaudhi T and Massawe F. 2021. Building a resilient and sustainable food system in a changing world – a case for climate-smart and nutrient dense crops. *Global Food Security* 28, 100477. <https://doi.org/10.1016/j.gfs.2020.100477>.
3. Chimonyo VGP, Wimalasiri EM, Kunz R, Modi AT and Mabhaudhi T. 2020. Optimizing traditional cropping systems under climate change: a case of maize landraces and bambara groundnut. *Frontiers in Sustainable Food Systems* 4, 562568. <https://doi.org/10.3389/fsufs.2020.562568>.
4. Leakey RR. A re-boot of tropical agriculture benefits food production, rural economies, health, social justice and the environment. *Nature Food*. 2020 May; 1(5): 260-5. DOI: 10.1038/s43016-020-0076-z.
5. UN Environment Programme. How to feed 10 billion people [Internet]. Nairobi: United Nations Environment Programme; 2020 Jul 13 [cited 2021 Jan 25]. <https://www.unenvironment.org/news-and-stories/story/how-feed-10-billion-people>.
6. Brondizio ES, Settele J, Díaz S, Ngo HT. Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Bonn: IPBES secretariat; 2019 Jul. <https://ipbes.net/global-assessment>.
7. Mabhaudhi T, Chimonyo VGP, Hlahla S, Massawe F, Mayes S, Nhamo L and Modi AT. 2019. Prospects of orphan crops in climate change. *Planta* 250, 695-708. <https://doi.org/10.1007/s00425-019-03129-y>.
8. Tadele Z (2018) African orphan crops under abiotic stresses: challenges and opportunities. *Sci (Cairo)* 2018:1–19.
9. FAO. Once neglected, these traditional crops are our new rising stars [Internet]. Rome: Food and Agriculture Organization of the United Nations; 2018 Oct 2 [cited 2021 Jan 21]. <http://www.fao.org/fao-stories/article/en/c/1154584/>.
10. Eberhard DM, Simons GF, Fennig CD. (eds.). *Ethnologue: Languages of the world*. Twenty-third edition. Dallas, Texas: SIL International; 2020.
11. Krauss M. The world's languages in crisis. *Language*. 1992; 68(1): 4-10. DOI: 10.1075/slcs.142.01sim.
12. TheWorldCounts. World average temperature (°C) [Internet]. Copenhagen: TheWorldCounts; 2021 [cited 2021 Jan 24]. <https://www.theworldcounts.com/challenges/climate-change/global-warming/average-global-temperature/story>.
13. Salawitch RJ, Bennett BF, Canty TP, Hope AP, Tribett WR. *Paris Climate Agreement: Beacon of Hope*. Cham: Springer International Publishing; 2017. 186 p.
14. Berkes, F. (2008) *Sacred Ecology*. 2nd ed. London: Routledge.
15. Kingsbury, B. (1998) *Indigenous Peoples in International*

- Law: A Constructivist Approach to the Asian Controversy. *American Journal of International Law*, 92:414-457.
16. UN 2009. The State of the World's Indigenous Peoples. United Nations, New York, http://www.un.org/esa/socdev/unpfi/documents/SOWIP/en/SOWIP_web.pdf.
17. UN. The Sustainable Development Agenda [Internet]. New York: United Nations; 2021 [cited 2021 Jan 29]. <https://www.un.org/sustainabledevelopment/development-agenda/>.
18. Mohd Nizar, N. M., Jahanshiri, E., Tharmandram, A. S., Salama, A., Mohd Sinin, S. S., Abdullah, N. J., Zolkepli, H., Wimalasiri, E. M., Mohd Suhairi, T. A. S. T., Hussin, H., Gregory, P. J., & Azam-Ali, S. N. (2021). Underutilised crops database for supporting agricultural diversification. *Computers and Electronics in Agriculture*, 180, 105920. <https://doi.org/10.1016/j.compag.2020.105920>
19. Jahanshiri, E., Mohd Nizar, N. M., Tengku Mohd Suhairi, T. A. S., Gregory, P. J., Mohamed, A. S., Wimalasiri, E. M., & Azam-Ali, S. N. (2020). A Land Evaluation Framework for Agricultural Diversification. *Sustainability*, 12(8), 3110.
20. Association of International Research and Development Centers for Agriculture. GAPAD - Global Action Plan for Agricultural Diversification [Internet]. Nairobi: Association of International Research and Development Centers for Agriculture; 2016 [cited 2021 Jan 26]. <http://www.airca.org/index.php/airca-resources/gapad>.
21. ICIMOD 2021 <https://www.icimod.org/initiative/climate-services/>
22. ICBA 2021 <https://www.biosaline.org/research-themes/climate-change-modeling-and-adaptation>
23. UKZN 2021 <https://researchspace.ukzn.ac.za/xmlui/>
24. GFAR. Harnessing Forgotten Foods for improved livelihoods [Internet]. 2017. http://www.gfar.net/sites/default/files/files/Forgotten%20foods%20concept_Sept2017%281%29.pdf29. <https://www.gfar.net/content/kfa1-empowering-farmers-center-innovation>.
25. Kuhnlein, H.V., Erasmus, B., Spigelski, D. and Burlingame, B., 2013. Indigenous people' food systems and wellbeing: interventions and policies for healthy communities. Food and agriculture Organization of the United Nations (FAO), Rome.
26. Huambachano, M., 2018. Enacting food sovereignty in Aotearoa New Zealand and Peru: Revitalizing indigenous knowledge, food practices and ecological philosophies. *Agroecology and Sustainable Food Systems*, 42(9), pp.1003-1028.
27. Pingault, N., Caron, P., Kolmans, A., Lemke, S., Kalafatic, C., Zikeli, S., Waters-Bayer, A., Callenius, C. and QIN, Y.J., 2020. Moving beyond the opposition of diverse knowledge systems for food security and nutrition. *Journal of Integrative Agriculture*, 19(1), pp.291-293.
28. Mabhaudhi, T., Chimonyo, V.G.P., Hlahla, S., Massawe, F., Mayes, S., Nhamo, L. and Modi, A.T., 2019. Prospects of orphan crops in climate change. *Planta*, 250(3), pp.695-708.
29. Hasegawa, P.M., 2013. Sodium (Na⁺) homeostasis and salt tolerance of plants. *Environmental and experimental botany*, 92, pp.19-31.
30. Van Zelm, E., Zhang, Y. and Testerink, C., 2020. Salt tolerance mechanisms of plants. *Annual Review of Plant Biology*, 71.
31. Prasad et al., (2019) Prasad, M., Srinivasan, R. Chaudhary, M., Choudhary, M. and Jat, L.K. 2019. Seven - Plant Growth Promoting Rhizobacteria (PGPR) for Sustainable Agriculture: Perspectives and Challenges. In: A.K. Singh, A. Kumar and P.K. Singh (Eds.), *PGPR Amelioration in Sustainable Agriculture*, Woodhead Publishing, pp. 129-157.
32. Srividhya, S., Kumari, N., Surendranath, R. and Jeyakumar, P. 2020. Role of rhizobacteria in alleviating salt stress. In: V. Sharma, R. Salwan and L.K.T. Al-Ani (Eds.), *Molecular Aspects of Plant Beneficial Microbes in Agriculture*, Academic Press, pp.279-294.
33. Barriuso, J., Solano, B.R., Lucas, J.A., Lobo, A.P., García-Villaraco, A. and Mañero, F.J.G., 2008. Ecology, genetic diversity and screening strategies of plant growth promoting rhizobacteria (PGPR). *Journal of Plant nutrition*, 4, pp.1-17.
34. Weih, M., Hamné, K. and Pourazari, F., 2018. Analyzing plant nutrient uptake and utilization efficiencies: comparison between crops and approaches. *Plant and Soil*, 430(1), pp.7-21.
35. Yu, L., Zhao, X., Gao, X. and Siddique, K.H.M. 2020. Improving/maintaining water-use efficiency and yield of wheat by deficit irrigation: A global meta-analysis. *Agricultural Water Management*, 228, 105906.
36. Eigenbrod, C. and Gruda, N., 2015. Urban vegetable for food security in cities. A review. *Agronomy for Sustainable Development*, 35(2), pp.483-498.
37. Lal, R. 2004. Soil Carbon Sequestration Impacts on Global Climate Change and Food Security. *Science* (80-85). 304(5677): 1623–1627. <https://doi.org/10.1126/science.1097396>
38. Gallart, F., A. Solé, J. Puigdefábregas, and R. Lázaro. 2002. Badland systems in the Mediterranean. *Dryl. Rivers Hydrol. Geomorphol. semi-arid channels*: 299–326.
39. Umetsu, C., T. Lekprichakul, T. Sakurai, T. Yamauchi, Y. Ishimoto, et al. 2014. Dynamics of Social–Ecological Systems: The Case of Farmers' Food Security in the Semi-arid Tropics. p. 157–178
40. Sutherland, A., J. Irungu, J. Kang'ara, J. Muthamia, and J. Ouma. 1999. Household food security in semi-arid Africa—the contribution of participatory adaptive research and development to rural livelihoods in Eastern Kenya. *Food Policy* 24(4): 363–390. [https://doi.org/10.1016/S0306-9192\(99\)00050-0](https://doi.org/10.1016/S0306-9192(99)00050-0).
41. Mugari, E., H. Masundire, and M. Bolaane. 2020. Adapting to Climate Change in Semi-Arid Rural Areas: A Case of the Limpopo Basin Part of Botswana. *Sustainability* 12(20): 8292. <https://doi.org/10.3390/su12208292>.
42. Chivenge PP, Mabhaudhi T, Modi AT and Mafongoya P. 2015. The potential role of neglected and underutilised crop species as future crops under water scarce conditions in sub-Saharan Africa. *Int. J. Environ. Res. Public Health* 12, 5685-5711. <https://doi.org/10.3390/ijerph120605685>.
43. Leff, B., N. Ramankutty, and J.A. Foley. 2004. Geographic distribution of major crops across the world. *Global Biogeochem. Cycles* 18(1): 1–27. <https://doi.org/10.1029/2003GB002108>.

44. Lal, R. 2016. Feeding 11 billion on 0.5 billion hectare of area under cereal crops. *Food Energy Secur.* 5(4): 239–251. <https://doi.org/10.1002/fes3.99>.
45. van Ittersum, M.K., L.G.J. van Bussel, J. Wolf, P. Grassini, J. van Wart, et al. 2016. Can sub-Saharan Africa feed itself? *Proc. Natl. Acad. Sci.* 113(52): 14964–14969. <https://doi.org/10.1073/pnas.1610359113>.
46. Hadebe ST, Modi AT and Mabhaudhi T. 2017. Drought tolerance and water use of cereal crops: a focus on sorghum as a food security crop in sub-Saharan Africa. *Journal of Agronomy and Crop Science* 203, 551–562. <https://doi.org/10.1111/jac.12191>.
47. Bvenura, C., and D. Sivakumar. 2017. The role of wild fruits and vegetables in delivering a balanced and healthy diet. *Food Res. Int.* 99: 15–30. <https://doi.org/10.1016/j.foodres.2017.06.046>.
48. Mabhaudhi T, Chibarabada TP, Chimonyo VGP, Murugani VG, Pereira LM, Sobratee N, Govender L, Slotow R and Modi AT. 2019. Mainstreaming indigenous crops into food systems: A South African perspective. *Sustainability* 11, 172. <https://doi.org/10.3390/su11010172>.
49. Dawson, N., A. Martin, and T. Sikor. 2016. Green Revolution in Sub-Saharan Africa: Implications of Imposed Innovation for the Wellbeing of Rural Smallholders. *World Dev.* 78: 204–218. doi: 10.1016/j.worlddev.2015.10.008.
50. Vercillo, S., T. Weis, and I. Luginaah. 2020. A bitter pill: smallholder responses to the new green revolution prescriptions in northern Ghana. *Int. J. Sustain. Dev. World Ecol.* 27(6): 565–575. <https://doi.org/10.1080/13504509.2020.1733702>.
51. Mabhaudhi, T., O'Reilly, P., Walker, S., Mwale, S., 2016. Opportunities for Underutilised Crops in Southern Africa's Post-2015 Development Agenda. *Sustainability* 8, 302. <https://doi.org/10.3390/su8040302>
52. Chandrasekara, A., J.T. Kumar, and T. Josheph Kumar. 2016. Roots and Tuber Crops as Functional Foods: A Review on Phytochemical Constituents and Their Potential Health Benefits. *International Journal of Food Science* 2016: 1–15. <https://doi.org/10.1155/2016/3631647>.
53. Dansi, a., R. Vodouhè, P. Azokpota, H. Yedomonhan, P. Assogba, et al. 2012. Diversity of the Neglected and Underutilized Crop Species of Importance in Benin. *Sci. World J.* 2012: 1–19. <https://doi.org/10.1100/2012/932947>.
54. Chao, S., 2012. Forest peoples: numbers across the world (pp. p-27). Moreton-in-Marsh, UK: Forest Peoples Programme.
55. Whyte, K., 2015. Indigenous food systems, environmental justice, and settler-industrial states. In *Global Food, Global Justice: Essays on Eating under Globalization*. Edited by M. Rawlinson & C. Ward, 143–156, Cambridge Scholars Publishing.
56. Berkes, F., Colding, J. and Folke, C., 2000. Rediscovery of traditional ecological knowledge as adaptive management. *Ecological applications*, 10(5), pp.1251–1262.
57. Wiersum, K.F., 1997. Indigenous exploitation and management of tropical forest resources: an evolutionary continuum in forest-people interactions. *Agriculture, ecosystems & environment*, 63(1), pp.1–16.
58. Kuhnlein, H.V. and Receveur, O., 1996. Dietary change and traditional food systems of indigenous peoples. *Annual review of nutrition*, 16(1), pp.417–442.
59. Garí, J., 2001. Biodiversity and indigenous agroecology in Amazonia: the indigenous people of Pastaza. *Etnoecologica*, 5(7), pp.21–37.
60. Toledo, V.M., Ortiz-Espejel, B., Cortés, L., Moguel, P. and de Jesús Ordoñez, M., 2003. The multiple use of tropical forests by indigenous peoples in Mexico: a case of adaptive management. *Conservation Ecology*, 7(3).
61. Wilson, G. and Woodrow, M., 2009. Kuka kanyini, Australian Indigenous adaptive management. In *Adaptive environmental management* (pp. 117–141). Springer, Dordrecht.
62. Goldsmith, F.B. ed., 2012. *Tropical rain forest: a wider perspective* (Vol. 10). Springer Science & Business Media.
63. Lima, M., do Vale, J.C.E., de Medeiros Costa, G., dos Santos, R.C., Correia Filho, W.L.F., Gois, G., de Oliveira-Junior, J.F., Teodoro, P.E., Rossi, F.S. and da Silva Junior, C.A., 2020. The forests in the indigenous lands in Brazil in peril. *Land Use Policy*, 90, p.104258.
64. UN DESA, 2009. Indigenous Peoples: Culture [Internet]. United Nations Department of Economic and Social Affairs. <https://www.un.org/development/desa/indigenouspeoples/mandated-areas1/culture.html>.
65. Ohenjo, N., Willis, R., Jackson, D., Nettleton, C., Good, K. and Mugarura, B., 2006. Health of Indigenous people in Africa. *The Lancet*, 367(9526), pp.1937–1946.
66. Port Lourenço, A.E., Ventura Santos, R., Orellana, J.D. and Coimbra Jr, C.E., 2008. Nutrition transition in Amazonia: obesity and socioeconomic change in the Suruí Indians from Brazil. *American Journal of Human Biology: The Official Journal of the Human Biology Association*, 20(5), pp.564–571.
67. Companion, M., 2013. Obesogenic cultural drift and nutritional transition: identifying barriers to healthier food consumption in urban Native American populations. *Journal of Applied Social Science*, 7(1), pp.80–94.
68. Davis, S.H. and Wali, A., 1994. Indigenous land tenure and tropical forest management in Latin America. *Ambio*, pp.485–490.
69. Hansungule, M. and Jegede, A.O., 2014. The impact of climate change on indigenous peoples' land tenure and use: The case for a regional policy in Africa. *International Journal on Minority and Group Rights*, 21(2), pp.256–291.
70. Xanthaki, A., 2003. Land rights of indigenous peoples in South-East Asia. *Melb. J. Int'l L.*, 4, p.467.
71. Lin, K.G., 1994. Resettlement and nutritional implications: the case of Orang Asli in regroupment schemes. *Pertanika: Journal of the Society for Science and Humanity*, 2(2), pp.123–132.
72. Kuhnlein, H.V., 2003. Micronutrient nutrition and traditional food systems of indigenous peoples. *Food Nutrition and agriculture*, (32), pp.33–39.
73. Dounias, E., Selzner, A., Koizumi, M. and Levang, P., 2007. From sago to rice, from forest to town: The consequences of sedentarization for the nutritional ecology of Punan former hunter-gatherers of Borneo. *Food and Nutrition Bulletin*, 28(2_suppl2), pp.S294–S302.
74. Dounias, E. and Froment, A., 2011. From foraging to farming among present-day forest hunter-gatherers:

- consequences on diet and health. *International Forestry Review*, 13(3), pp.294-304.
75. Berbesque, J.C., Marlowe, F.W., Shaw, P. and Thompson, P., 2014. Hunter–gatherers have less famine than agriculturalists. *Biology Letters*, 10(1), p.20130853.
 76. Parrotta, J.A., Dey de Pryck, J., Darko Obiri, B., Padoch, C., Powell, B., Sandbrook, C., et al., 2015. The Historical, Environmental and Socio-Economic Context of Forests and Tree-Based Systems for Food Security and Nutrition. In B. Vira, C. Wildburger, & S. Mansourian (Eds.), *Forests, Trees and Landscapes for Food Security and Nutrition. A Global Assessment Report* (Vol. 33, pp. 51-86): IUFRO World Series.
 77. van Vliet, N., Quiceno-Mesa, M.P., Cruz-Antia, D., Tellez, L., Martins, C., Haiden, E., Oliveira, M.R., Adams, C., Morsello, C., Valencia, L. and Bonilla, T., 2015. From fish and bushmeat to chicken nuggets: the nutrition transition in a continuum from rural to urban settings in the Tri frontier Amazon region. *Ethnobiology and Conservation*, 4.
 78. Ickowitz, A., Rowland, D., Powell, B., Salim, M.A. and Sunderland, T., 2016. Forests, trees, and micronutrient-rich food consumption in Indonesia. *PloS one*, 11(5), p.e0154139.
 79. Crittenden, A.N. and Schnorr, S.L., 2017. Current views on hunter-gatherer nutrition and the evolution of the human diet. *American Journal of Physical Anthropology*, 162, pp.84-109.
 80. Kraft TS, Stieglitz J, Trumble BC, Martin M, Kaplan H, Gurven M. Nutrition transition in 2 lowland Bolivian subsistence populations. *The American journal of clinical nutrition*. 2018 Dec 1;108(6):1183-95.
 81. Bethancourt HJ, Leonard WR, Tanner S, Schultz AF, Rosinger AY. Longitudinal changes in measures of body fat and diet among adult Tsimane'forager-horticulturalists of Bolivia, 2002-2010. *Obesity*. 2019 Aug;27(8):1347-59.
 82. Reyes-García, V., Powell, B., Díaz-Reviriego, I., Fernández-Llamazares, Á., Gallois, S. and Gueze, M., 2019. Dietary transitions among three contemporary hunter-gatherers across the tropics. *Food Security*, 11(1), pp.109-122.
 83. Fernández, C.I., 2020. Nutrition Transition and Health Outcomes Among Indigenous Populations of Chile. *Current developments in nutrition*, 4(5), p.nzaa070.
 84. FAO, 2017. 6 ways indigenous peoples are helping the world achieve #ZeroHunger [Internet]. 9 Aug 2017. <http://www.fao.org/indigenous-peoples/news-article/en/c/1029002/>
 85. Agrawal, A., 2002. Indigenous knowledge and the politics of classification. *International Social Science Journal*, 54(173), pp.287-297.
 86. Ngulube, P., 2002. Managing and preserving indigenous knowledge in the knowledge management era: challenges and opportunities for information professionals. *Information development*, 18(2), pp.95-102.
 87. Quek, P. and Friis-Hansen, E., 2011. Collecting plant genetic resources and documenting associated indigenous knowledge in the field: a participatory approach. *Collecting Plant Genetic Diversity: Technical guidelines—2011 update*.
 88. Naming M., Yu R.A., Tu C.L., 2010. Traditional knowledge conservation and transmission of agrobiodiversity: sharing of experiences by the Penan community in Mulu Sarawak. In: Mirfat A.H.S., Salma I., Mohd Rani M.Y., Mohd Norowi H., Mohd Shukri M.A., Erny Sabrina M.N., Noor Sarinah M.N., Siti Noor Aishikin A.H., Nor Asiah I., editors. *Second National Conference on Agrobiodiversity Conservation and Sustainable Utilization, Agrobiodiversity for Sustainable Economic Development*. Malaysian Agricultural Research and Development Institute (MARDI), Malaysia. pp.54.
 89. Shapi, M., Cheikhoussef, A., Mumbengegwi, D.R., Matengu, K., Van Kent, A. and Sifani, J., 2011. Evolution of data collection methods for indigenous knowledge systems at the Multidisciplinary Research Centre of the University of Namibia. *Knowledge Management for Development Journal*, 7(3), pp.308-316.
 90. Kuhnlein, H., Eme, P. and de Larrinoa, Y.F., 2019. Chapter 7: Indigenous food systems: Contributions to sustainable food systems and sustainable diets. In *Sustainable Diets: Linking Nutrition and Food Systems*, Burlingame S, Dernini Q, editor. CABI; 64–78. 10.1079/9781786392848.0064
 91. Miller, DJ; Craig, SR; (eds) 1996 *Rangelands and pastoral development in the Hindu Kush-Himalayas*. Kathmandu: ICIMOD.
 92. Miller, DJ 1999 *Nomads of the Tibetan Plateau Rangelands in Western China Part Two: Pastoral Production Practices*, *Rangelands* 21 (1): 16-19.
 93. Mitra, M, Kumar, A, Adhikari, B S, Rawat, GS 2013 A note on transhumant pastoralism in Niti valley, Western Himalaya, India. *Pastoralism* 3 (1): 2-7.
 94. Ramakrishnan P S 1992 *Shifting Agriculture and Sustainable Development: An Interdisciplinary Study from Northeast India*. UNESCO-MAB Series. Paris, Carnforth, Lancs, UK: Parthenon Publishers, 424 (Republished Oxford University Press, New Delhi 1993)
 95. Rerkasem K and Rerkasem B 1995 *Montane Mainland South-East Asia: Agroecosystems in Transition*. *Global Environmental Change* 5: 313-322. DOI 10.1016/0959-3780(95)00065-V
 96. Cramb R A, Pierce Colfer C J, Wolfram D, Laungaramsri P, Trang Q, Muloutami E, Peluso N L and Wadley R L 2009 *Swidden transformations and rural livelihoods in Southeast Asia* *Human Ecology* 37: 323-346. DOI: 10.1007/s10745-009-9241-6
 97. Mertz O, Padoch C, Fox J, Cramb R A, Leisz S J, Thanh N and Duc Vien T 2009 *Swidden change in Southeast Asia: Understanding Causes and Consequences*. *Human Ecology* 37: 259-264 DOI 10.1007/s10745-009-9245-2
 98. Delang C O 2006 *Indigenous Systems of Forest Classification: Understanding landuse patterns and the role of NTFPs in shifting cultivators subsistence economies*. *Environmental Management* 37(4): 470-486
 99. Cairns M F (Ed) 2007 *Voices from the Forest: Integrating Indigenous Knowledge into Sustainable Upland Farming*. Resources for the Future, Washington, D C.
 100. Rodericks A 2020 *Living Landscapes: Embracing Agrobiodiversity in Northern Laos* National Agriculture and Forest Research Institute (NAFRI). Ministry of Agriculture and Forestry, Vientiane, Laos PDR
 101. Kumar A and Ramakrishnan P S R 1990 *Energy flow through an Apatani Village Ecosystem of Arunachal Pradesh in Northeast India*. *Human Ecology* 18(3): 315-336
 - 86
 102. Agarwal A. and Narain S. 1995 *Dying Wisdom*. 4th

Citizens Report on the State of Environment. Centre for Science and Environment, New Delhi, India.

103. Sundriyal R C and Dollo M 2013 Integrated Agriculture and Allied Natural Resource Management in Northeast Mountains—Transformation and Asset Building. *Agroecology and Sustainable Food Systems* 37(6): 700-726

104. Mulyoutami E, Rismawan R and Joshi L 2009 Local knowledge and management of simpukng (forest gardens) among the Dayak people in East Kalimantan, Indonesia. *Forest Ecology and Management* 257: 2054-2061

105. Fox J, Fujita Y, Ngidang D, Peluso N, Potter L, Sakuntaladevi N, Sturgeon J and Thomas D 2009.

Policies, Political-Economy and Swidden in Southeast Asia. *Human Ecology* 37: 305-322 DOI 10.1007/s10745-009-9240-7

106. van Vliet N, Mertz O, Heinemann A, Langanke T, Pascual U, Schmook B, Adams C, Schmidt-Vogt D, Messerli P, Leisz S, Castella J C, Jorgensen L, Birch-Thomsen T, Hett C, Bech-Bruun T, Ickowitz A, Kim Chi V, Yasuyuki K, Fox, J, Padoch C, Dressler W and Zeigler A D 2012 Trends, drivers and impacts of changes in swidden cultivation in tropical forest-agriculture frontiers: A global assessment. *Global Environmental Change* 22: 418-429

107. Kadambot H M S, Li X and Gruber, K 2021 Rediscovering Asia's forgotten crops to fight chronic and hidden hunger. *Nature Plants* 7: 116-122.

Food Systems Summit Briefs are prepared by researchers of Partners of the Scientific Group for the United Nations Food Systems Summit. They are made available under the responsibility of the authors. The views presented may not be attributed to the Scientific Group or to the partner organisations with which the authors are affiliated.

The authors are:

Sayed Azam-Ali, Crops For the Future.

Hayatullah Ahmadzai, International Center for Biosaline Agriculture.

Dhrupad Choudhury, International Centre for Integrated Mountain Development

Ee Von Goh, Crops For the Future

Ebrahim Jahanshahi, Crops For the Future

Tafadzwanashe Mabhaudhi, University of KwaZulu-Natal


Alessandro Meschinelli, Global Forum for Agricultural Research and Innovation

Albert Thembinkosi Modi, University of KwaZulu-Natal

Nhamo Nhamo, International Center for Biosaline Agriculture

Abidemi Olutayo, International Center for Biosaline Agriculture

For further information about the Scientific Group, visit <https://sc-fss2021.org> or contact info@sc-fss2021.org

 [@sc_fss2021](https://twitter.com/sc_fss2021)