FIELDS OF HARMONY:

PULSES AND SUSTAINABLE LAND MANAGEMENT

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As at
February 2024

FIELDS OF HARMONY: PULSES AND SUSTAINABLE LAND MANAGEMENT

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List of Abbreviations

ASAL	Arid and semiarid land
BMZ	Federal Ministry for Economic Cooperation and Development, Germany
BNF	Biological nitrogen fixation
CA	Conservation agriculture
COVID-19	Coronavirus disease
DS	Decision support
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
ISFM	Integrated soil fertility management
IYP	International Year of Pulses
K	Potassium
KM	Knowledge management
N	Nitrogen
P	Phosphorus
SLM	Sustainable land management
SNNPR	Southern Nations, Nationalities, and Peoples' Region
SOC	Soil organic carbon
UNCCD	United Nations Convention to Combat Desertification
UNGA	United Nations General Assembly
WOCAT	World Overview on Conservation Approaches and Technologies

About

Germany's Federal Ministry for Economic Cooperation and Development (BMZ) has made significant investments in sustainable land and soil management as well as adaptation to climate change and exploring co-benefits with carbon sequestration in Africa and India. As part of BMZ's special initiative "Transformation of Agriculture and Food Systems", the Global programme "Soil Protection and Rehabilitation for Food Security" (ProSoil) implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH is supporting smallholder farmers in Benin, Burkina Faso, Ethiopia, India, Kenya, Madagascar and Tunisia to learn how to use climate-smart, agroecological practices to protect their land from soil erosion and restore and maintain soil fertility. To that end, it is offering training and guidance to both farmers and agricultural consultants. The programme is further cooperating with governmental institutions and entities from the realms of science, research, the private sector, and civil society to establish framework conditions that will promote change in agricultural and food systems. The European Union (EU) is co-funding the programme's work in the field of agroecology. Another co-founder is the Bill & Melinda Gates Foundation.

The World Overview of Conservation Approaches and Technologies (WOCAT) is a global network on sustainable land management (SLM) that promotes the documentation, sharing, and use of information and knowledge to support adaptation, innovation, and decision-making in SLM. WOCAT supports governments and their development partners in effective knowledge management (KM) and decision support (DS) tools and processes.

The Alliance of Biodiversity International and the International Center for Tropical Agriculture (hereafter the Alliance) is a member of the steering committee of WOCAT. The Alliance supported the coordination and collection of SLM practices in partner countries where ProSoil is deployed.

This compilation consists of SLM and its potential impact on transforming agri-food systems, specifically highlighting the pivotal role of pulses in addressing soil degradation. This report aims to shed light on the significance of utilizing pulses for safeguarding and rehabilitating soils for sustainable agricultural production.

Preface

Teodardo Calles, Agricultural Officer (Legumes) at the Food and Agriculture Organization of the United Nations (FAO), 2024

Teodardo Calles is an Agricultural Officer at the Plant Production and Protection Division of the FAO who advocates for the inclusion of legumes in agricultural production as a means to improve the sustainability of production systems and nutrition of smallholder farmers. As an agronomist, Teodardo has worked on research projects oriented towards improving low-input agricultural systems, including grasslands, through the inclusion of leguminous species. He is also well experienced on plant genetic resources and taxonomy of legumes. Teodardo holds a bachelor's degree in agronomy from the Central University of Venezuela, Maracay, Venezuela and a master's degree in agricultural sciences, food security and natural resources management from the University of Hohenheim, Stuttgart, Germany, where he also earned a doctorate degree in agricultural sciences.

World population is expected to reach nine billion inhabitants before 2050. Feeding this swelling global population will imply improving the efficacy of agricultural production systems and changing consumption patterns to more nutrient-dense foods such as pulses. Pulses have been an essential part of human diets and agricultural systems for centuries, while, unfortunately, their benefits are usually underappreciated. For this reason, the United Nations General Assembly (UNGA) declared 2016 as the International Year of Pulses (IYP). The IYP was successfully implemented by the Food and Agriculture Organization of the United Nations (FAO) and thanks to this success, the UNGA designated in 2018 the 10th of February as the World Pulses Day, a globally celebrated annual observance day.

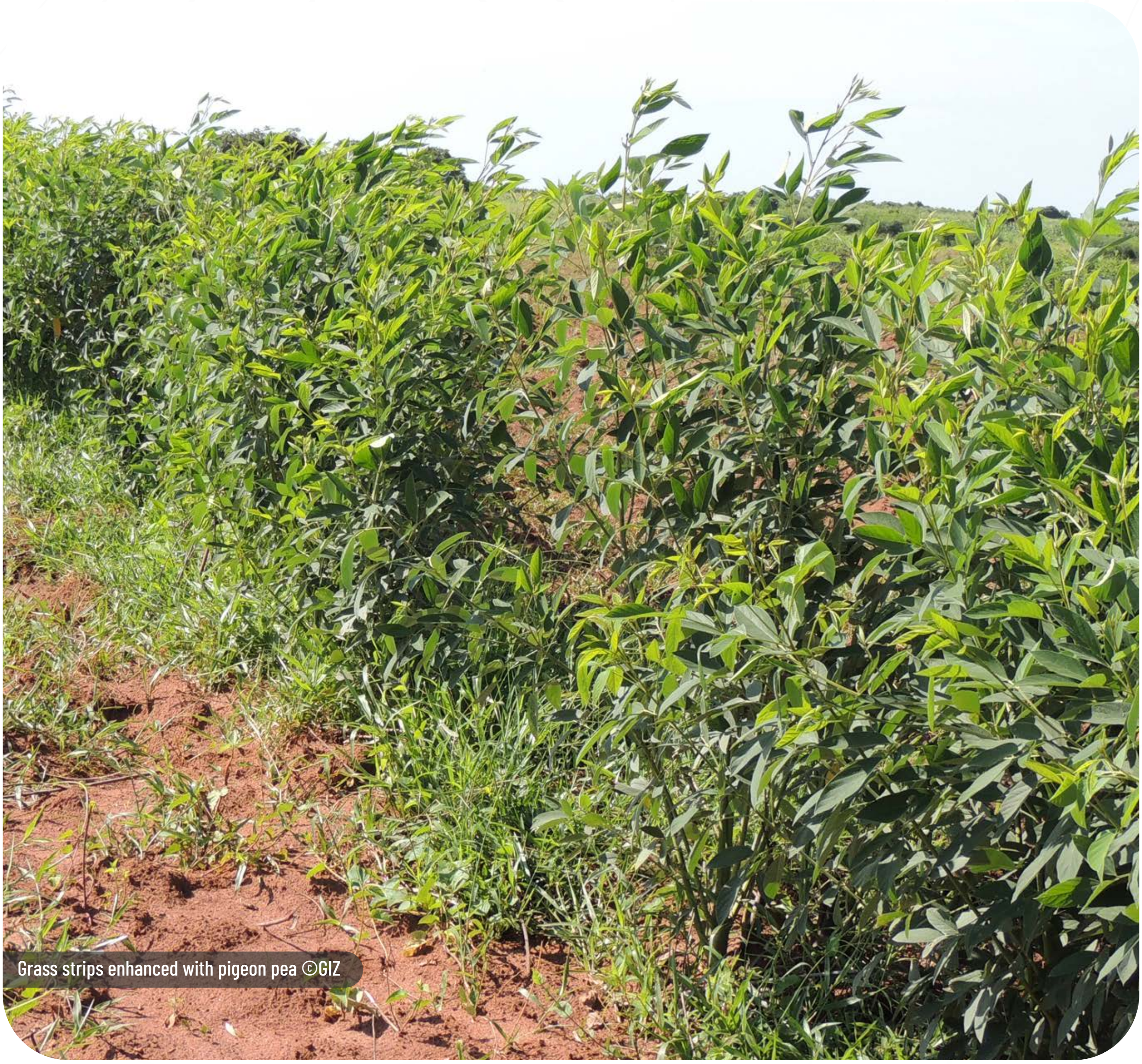
According to FAO, pulses are a subgroup of crops belonging to the family of *Leguminosae* (alternative name: *Fabaceae*) harvested for their dried grains which are used for both human and animal consumption. Legume species used for oil extraction like soybean (*Glycine max (L.) Merr*.), for sowing purposes like alfalfa (*Medicago sativa L*.) and when they are used as vegetables like green beans (*Phaseolus vulgaris L*.) are excluded from this subgroup.

Nitrogen (N) and phosphorous (P) are essential nutrients for agricultural production. Reactive nitrogen required for agricultural fertilisers is mainly provided by the energy-intensive Haber-Bosch process. Plants are not able to uptake the whole applied nitrogen fertilisers and consequently, the rest is lost to the environment (around 50 per cent). Therefore, there are environmental concerns, besides the emission of greenhouse gases, regarding the overuse of fertiliser (e.g., impaired water quality, enhanced invasive plant species). On the other hand, phosphorous fertilisers are produced from non-renewable and relatively scarce phosphorite; therefore, improving phosphorous cycling, for example, by incorporating phosphorous efficient pulses, is a pre-requisite to improve agricultural sustainability.

One of the most important advantages of pulses, and some other legumes, is their ability to fix atmospheric nitrogen through a symbiosis with some bacteria (e.g., Rhizobium, Bradyrhizobium), which provides them the potential for improving nitrogen cycling and soil health. There are some pulses that can mobilize soil-bound phosphorous, thus enhancing the biological turnover of phosphorous. For these reasons, the main advantage of including pulses in multiple cropping systems (e.g., agroforestry, crop rotations, intercropping) is that they provide different ecological services (e.g., increasing soil biodiversity, improving nutrient cycling) that make agro-ecosystems more resilient and improve their sustainability.

It is imperative that farmers, technicians, and decision makers at local, national, regional, and global levels understand how significant the environment for the survival of humankind is. Agricultural production and soils are connected through different and complex cycles and processes. Land management practices implemented today can have a future positive or negative impact not only on soil health and the environment but also on agricultural production and food security. For this reason, it is crucial to start implementing sustainable land management practices that include pulses and legumes in order to make a more efficient use of natural resources and ensure long-term agricultural productivity. Fields of harmony: Pulses and sustainable land management has carefully chosen real-life examples on how integrating pulses into sustainable land management practices can help covering qualitative and quantitative food demands while reducing the negative impact that agricultural production may have on the environment.

Last but not least, I hope this publication motivates other decision makers to improve land management through the inclusion of pulses and legumes and, consequently, enhance nutritional outcome of agriculture while safeguarding natural resources.



Grass strips enhanced with pigeon pea ©GIZ

1. Introduction

Sustainable land management (SLM) entails the judicious use of land resources, incorporating soils, water, animals, and plants, to meet dynamic human needs, while concurrently safeguarding the sustained use of these resources and preserving their environmental functions[1]. SLM serves as a guiding framework for sustainable agriculture, aligning its goals with environmental stewardship, efficient resource use, and long-term productivity. Adopting SLM practices promotes soil health, biodiversity conservation, water management, climate resilience, and economic viability in agricultural production.

Land degradation accounts for about 46 per cent of the total land in Africa[2], with accelerated degradation not only across Africa, but also in Asia, and Latin America[3]. On the African continent, low agricultural productivity due to land degradation and climate change results in food and nutritional insecurity and decelerates economic development. Low crop yields are prevalent in African developing countries due to soil degradation[4]. While agriculture is a vital component of the region's economy, it is also a dominant driver of land degradation and climate change. Unsustainable farming practices, such as excessive tillage, improper irrigation, and deforestation for agricultural expansion, contribute to soil erosion, loss of soil fertility and soil organic carbon (SOC), and reduced water retention capacity. Addressing this complexity requires a holistic approach that integrates SLM practices to ensure food security while mitigating the detrimental impact of agriculture on land quality and climate change. Balancing the need for increased agricultural output with responsible land management becomes imperative to secure the long-term resilience of African landscapes.

In this delicate balance between meeting food demands and safeguarding natural resources, the integration of pulses into SLM is significant. Pulses, belonging to the family *Leguminosae* (alternative name: *Fabaceae*), have garnered increasing attention not only for their nutritional richness but also for their pivotal role in fostering agricultural sustainability. Pulses are dry, nutrient-dense leguminous seeds, that offer essential proteins, vitamins, and minerals, enhancing nutrition and health. Moreover, growing these legumes builds ecosystem resilience, provides livestock feed, and boosts household income.

Legumes possess the ability to engage in symbiotic relationships with nitrogen-fixing bacteria, converting atmospheric nitrogen into a form accessible by plants. Known as biological nitrogen fixation (BNF), this process enhances soil fertility[5]. Enhanced BNF has the potential to reduce the dependence on synthetic nitrogen fertilisers and promotes environmentally friendly agricultural practices. Leguminous crop residues further contribute to soil nitrogen. This holds relevance in many developing countries across Africa, where the capacity for fertiliser manufacturing is limited and smallholder farmers often face financial constraints. By cultivating legumes that engage in BNF, farmers can effectively reduce production costs, offering a sustainable and cost-effective approach to enhancing soil fertility.

Legumes contribute to enhanced soil structure[6] with their deep root systems, breaking up compacted soil and improving water infiltration and root penetration. This, in turn, fosters better soil aeration and drainage, reducing the risk of soil erosion and run-off. Additionally, it increases water availability in the soil, holding the potential for improved crop yields.

[1]WOCAT, "SLM," Wocat, accessed December 9, 2023, https://www.wocat.net/en/slm/.

[2]Africa Group of Negotiators Expert Support, "Land Degradation and Climate Change in Africa," March 19, 2020, https://cgspace.cgiar.org/handle/10568/107809.

[3]UNCCD, "At Least 100 Million Hectares of Healthy Land Now Lost Each Year," UNCCD, 2023, https://www.unccd.int/news-stories/press-releases/least-100-million-hectares-healthy-land-now-lost-each-year.

[4]Rattan Lal, "Chapter Four - Improving Soil Health and Human Protein Nutrition by Pulses-Based Cropping Systems," in Advances in Agronomy, ed. Donald L. Sparks, vol. 145 (Academic Press, 2017), 167–204, https://doi.org/10.1016/bs.agron.2017.05.003.

[5]Jagdish K. Ladha et al., "Biological Nitrogen Fixation and Prospects for Ecological Intensification in Cereal-Based Cropping Systems," Field Crops Research 283 (July 1, 2022): 108541, https://doi.org/10.1016/j.fcr.2022.108541.

[6]Kumar Dinesh et al., "The Roles of Legumes in Soil Health Management," August 23, 2023.

Intercropping pulses with other crops promotes biodiversity on farmlands. Diverse agricultural systems are more resilient to pests and diseases, creating a healthier ecosystem. Pulses also demonstrate water use efficiency, particularly in rainfed agriculture, contributing to sustainable water management practices. Crop rotation, another key practice, involves incorporating pulses into rotation systems. This not only breaks pest and disease cycles, minimizing the need for chemical pesticides but also improves overall soil health by preventing nutrient depletion and mitigating soilborne diseases.

Beyond their agronomic benefits, pulses play a crucial role in reducing greenhouse gas emissions.[7] By minimizing the need for synthetic nitrogen fertilisers, pulses contribute to lower carbon footprints in agriculture. Incorporating pulses into agricultural systems aligns with SLM, fostering resilient and productive land use. With their myriad benefits, pulses also play a vital role in agroecology and the transformation of agri-food systems.[8]


©GIZ/Faith Innocent

[7]Marie-Benoit Magrini et al., "Pulses for Sustainability: Breaking Agriculture and Food Sectors Out of Lock-In," Frontiers in Sustainable Food Systems (October 24, 2018): Sec. Nutrition and Sustainable Diets Volume 2 - 2018 | https://doi.org/10.3389/fsufs.2018.00064

[8]Wellington Mulinge et al., "Economics of Land Degradation and Improvement in Kenya," in Economics of Land Degradation and Improvement – A Global Assessment for Sustainable Development, ed. Ephraim Nkonya, Alisher Mirzabaev, and Joachim von Braun (Cham: Springer International Publishing, 2016), 471–98, https://doi.org/10.1007/978-3-319-19168-3_16.

2. Promoting Sustainable Land Management in Western Kenya: Harnessing the Power of Velvet Bean and Greenleaf Desmodium for Soil Health and Agricultural Prosperity

Arid and semi-arid lands (ASALs) occupy over 80 per cent of Kenya's total land, while humid to sub-humid areas account for less than 20 per cent of the land. The ASALs are homes to pastoral communities, primarily dependent on livestock farming. The humid to sub-humid areas support diverse agricultural activities including crop cultivation. In Kenya, progressing land degradation is a significant environmental challenge with multifaceted impacts on ecosystems, agriculture, and livelihoods. The main drivers of land degradation include deforestation, unsustainable agricultural practices, overgrazing, and urbanisation. Deforestation contributes to the loss of crucial vegetation cover, leading to soil erosion and reduced water retention capacity. Unsustainable agricultural methods, such as improper irrigation and excessive use of agrochemicals, degrade soil quality and fertility. Overgrazing by livestock accelerates soil compaction and contributes to desertification in the ASALs. Urbanisation, marked by infrastructure development, often leads to habitat loss and fragmentation.

Soil fertility decline is a major form of degradation in the country attributed to nutrient mining, deforestation, and desertification.[8,9] This decline has resulted in low crop yields over the years[10] affecting food security and community livelihoods. Low soil fertility reduces nutrient availability for plants and increases susceptibility to pests, diseases, and water stress leading to low crop productivity. Smallholder farmers primarily rely on the purchase of inorganic fertilisers. High costs and fluctuations in their prices have limited fertiliser use contributing to low crop productivity. For instance, between 2020 and 2021, fertiliser prices in the country increased by 50 to 60 per cent due to disruptions in supply chains[11]. This was attributed to interacting factors including COVID-19, export limitations from China, reduced production in Europe, and high input costs[12]. Proper and cost-effective soil management strategies regarding macronutrients, N, P, and potassium (K), are needed to enhance soil fertility and crop productivity.

ProSoil promotes the cultivation of *Mucuna pruriens* and *Desmodium intortum* in the Bungoma, Siaya, and Kakamega counties.

2.1 Velvet bean

Velvet bean, also known as mucuna (*Mucuna pruriens* (L.) DC.), is cultivated in Western Kenya as part of conservation agriculture (CA) practices. The soils in these regions are highly degraded due to unsustainable agricultural methods. ProSoil has been instrumental in promoting the cultivation of velvet bean, recognising its unique qualities and contributions to SLM. Velvet bean is a good source of crude protein (21 to 31.33 per cent), crude carbohydrate (42.79 to 64.88 per cent), and crude fibre (5.3 to 11.5 per cent) for humans and the plant's foliage is utilised as animal fodder.

A key attribute of mucuna is its ability to fix nitrogen through BNF. This process facilitates the conversion of atmospheric nitrogen into a form readily available to plants, thereby enhancing soil fertility. Additionally, velvet bean serves as a valuable green manure crop, further contributing to the improvement of soil fertility. Velvet bean provides effective protection against soil erosion caused by rain and reduces water run-off by

[9] Catherine C. Sang, Daniel O. Olago, and Zedekia J. Ongeri, "The Factors Driving Land Cover Transitions and Land Degradation and the Potential Impacts of the Proposed Developments in the Isiolo Dam Watershed, LAPSSET Corridor, Kenya," Discover Sustainability 4, no. 1 (February 13, 2023): 9, https://doi.org/10.1007/s43621-023-00126-w.

[10] J.A Omwakwe et al., "Macro and Micro-Nutrient Status of Selected Kenya Soils | East African Agricultural and Forestry Journal," 2023, .

[11] IFPRI, "High Fertilizer Prices Contribute to Rising Global Food Security Concerns," 2022, .

[12] WFP and BCG, "Impact of Increasing Fertilizer Prices on Maize Production in Kenya," 2022, .

establishing a dense ground cover. Its extensive root system binds soil particles, providing a natural defence against erosion. As velvet bean grows and decomposes, it adds organic matter to the soil, improving structure, water retention, and nutrient-holding capacity. The plant's vigorous growth suppresses weed development, reducing the need for synthetic herbicides, and minimizing soil disturbance.

Ultimately, velvet bean promotes food security and household income. Intercropping or crop rotation with velvet bean has resulted in a 50 per cent grain yield increase under CA in the Bungoma, Siaya, and Kakamega counties.[12] Maize (*Zea mays L.*) yield has been reported to increase by up to 60 bags per acre in the fifth year of intercropping with mucuna.[15] In these systems, mucuna additionally breaks pest and disease cycles and the increase in yields implies better financial returns for farmers. To summarise, the incorporation of mucuna into agricultural systems contributes to soil health, biodiversity, and productivity.

More to know:

Learn more about how ***mucuna*** is used to add value for female farmers in Kenya!

Scan or click on the QR Code below:

2.2 Greenleaf desmodium

ProSoil promotes the cultivation of greenleaf desmodium (*Desmodium intortum* (*Mill.*) Urb.) as an intercrop and cover crop. It is further cultivated under the push-pull technology for pest management in cereals. The crop is commonly intercropped with maize in Western Kenya.

Similar to velvet bean, greenleaf desmodium contributes to soil management through its ability to fix atmospheric nitrogen, enhancing soil fertility and minimising the need for synthetic fertilisers. Like velvet bean, this leguminous cover crop can be incorporated as green manure, enriching the soil with organic matter. With its dense growth pattern, greenleaf desmodium effectively suppresses weeds, reducing competition for resources, and serving as a natural tool for soil erosion control. As an intercrop, it helps to suppress the purple witchweed (*Striga hermonthica* (Delile) Benth.) in maize cultivation.[14] Furthermore, greenleaf desmodium releases allelopathic compounds, providing a natural defense against pests and pathogens. For this reason, it is used in the push-pull technology, acting as a push plant by repelling pests such as fall armyworms from the main crop (cereal).[17] In contraty to a pull crop, which is planted at the border of the intercrop and attracts and traps the pests.

More to know:

Learn more about how ***desmodium*** is used to control pests in Kenya!

Scan or click on the QR Code below:

In Western Kenya, high N and P levels leading to better yields have been attributed to maize-greenleaf desmodium intercrop, contrary to maize monocrop.[18] Integrating greenleaf desmodium into agricultural systems underscores the holistic approach of agroecology and SLM, promoting soil health and improving crop productivity.

[13] H Fitriyah, Fawzi Anwar, and Elke Palupi, "Morphological Characteristics, Chemical and Amino Acids Composition of Flours from Velvet Beans Tempe (Mucuna Pruriens), an Indigeneous Legumes from Yogyakarta," Journal of Physics: Conference Series 1869 (April 1, 2021): 012012,.

[14] Mary Stella Wabwoba, "Promoting Mucuna Beans Production for Soil Rehabilitation, Incomes, Food and Nutrition Security in Kenya," Global Journal of Nutrition & Food Science 2, no. 4 (November 13, 2019): 1–6, .

[15] Mamie Souadou Diop and Et Al, "Production, Seed Management and Utilization of Velvet Bean (Mucuna Pruriens L. Dc) in Western Kenya," 2021, http://41.89.164.27:8080/xmlui/handle/123456789/1632.

[18] Pierre Celestin Ndayisaba et al., "Intercropping Desmodium and Maize Improves Nitrogen and Phosphorus Availability and Performance of Maize in Kenya," Field Crops Research 263 (April 1, 2021): 108067, https://doi.org/10.1016/j.fcr.2021.108067.

[19] Guta Megerssa and Yadeta Bekele, "Causes, Consequences and Coping Strategies of Land Degradation: Evidence from Ethiopia," Journal of Degraded and Mining Lands Management 7 (October 7, 2019): 1953–57, https://doi.org/10.15243/jdmlm.2019.071.1953.

3. Mitigating Land Degradation and Enhancing Agricultural Sustainability in Ethiopia: The Role of Hyacinth Bean and Lupine in Integrated Soil Fertility Management

Land degradation is a pressing environmental concern in Ethiopia attributed to natural and human-induced factors. Deforestation, primarily driven by the clearing of forests for agriculture, fuelwood, and construction materials,[19] leads to soil erosion and loss of biodiversity. Overgrazing intensifies the issue, exposing the soil to erosion and diminishing fertility, especially in ASALs. Unsustainable agricultural practices, such as inadequate irrigation and improper use of agrochemicals, further exacerbate soil erosion, negatively impacting agricultural productivity. The expanding population in Ethiopia, reliant on the land for sustenance, adds to the pressure on natural resources,[20] resulting in the conversion of forests into agricultural land. Climate change exacerbates these challenges, with altered rainfall patterns and increased drought frequency.

The progressing land degradation affects food security and community livelihoods as over 85 per cent of the Ethiopian population is dependent on agriculture[17]. Soil erosion and soil fertility decline are major threats to food production in Ethiopia. Annually, the nation experiences a loss of approximately 106 million dollars due to soil and nutrient erosion[21], contributing to low agricultural productivity. The adoption of SLM practices constitutes measures for improved productivity. The integrated soil fertility management (ISFM) component of ProSoil in Ethiopia promotes the cultivation of pulses in selected areas of the Amhara, Oromia, SNNPR, Sidama, and Tigray regions.

Hyacinth bean (*Lablab purpureus* L. Sweet), also known as lablab, and lupine (*Lupinus* sp.) play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[20] Simachew Bantigegn Wassie, "Natural Resource Degradation Tendencies in Ethiopia: A Review," Environmental Systems Research 9, no. 1 (November 10, 2020): 33.

[21] Bekele Tsegaye, "Effect of Land Use and Land Cover Changes on Soil Erosion in Ethiopia," International Journal of Agricultural Science and Food Technology 5, no. 1 (May 13, 2019): 026–034.

integral roles in SLM through diverse contributions. As leguminous plants, both hyacinth bean and lupine possess the ability to fix atmospheric nitrogen in the soil and convert it into a plant-accessible form, fostering enhanced soil fertility. These legumes serve as valuable cover crops, utilising their dense growth patterns to safeguard the soil from erosion caused by wind and water. The robust root systems of hyacinth bean and lupine aid in binding soil particles together, promoting soil stability and structure. Additionally, these plants contribute organic matter to the soil upon decomposition, thereby enriching soil health and enhancing water retention.

The incorporation of hyacinth bean and lupine into crop rotation systems disrupts pest and disease cycles, fosters biodiversity, and reduces reliance on chemical pest control. Moreover, these legumes can be strategically integrated with tree crops, further contributing to improved soil structure and nutrient cycling.

In acidic soils, yield benefits from the use of hyacinth bean, lupine, and common vetch (*Vicia sativa* L.) as green manures in the cultivation of wheat could be attributed to improved soil water content, improved P-availability, significantly increased exchangeable potassium, calcium and magnesium, and increased pH of soil.[22] Moreover, green manuring of maize with hyacinth bean improves soil chemical properties (N, P, and K).[23] The improved soil status improves crop productivity. In essence, the cultivation of hyacinth bean and lupine exemplifies a holistic approach to production, emphasising the importance of nitrogen fixation, soil conservation, and organic matter enrichment for sustainable and resilient land management practices.

More to know:

Learn more about how ***hyacinth bean*** and ***lupine*** are used as green manure in Ethiopia!

Scan or click on the QR Code below:

[22] Tilahun Amede et al., "Short Term Fallow and Partitioning Effects of Green Manures on Wheat Systems in East African Highlands," Field Crops Research 269 (July 15, 2021): 108175, https://doi.org/10.1016/j.fcr.2021.108175.

[23] Girma Jibat and Hailu Garkebo, "Effects of Green Manure Legumes and Their Termination Time on Yield of Maize and Soil Chemical Properties," Archives of Agronomy and Soil Science 67 (March 19, 2020): 1–13, https://doi.org/10.1080/03650340.2020.1733536.

4. Velvet Bean Cultivation: Nurturing Soil Health in Benin

Land degradation is a significant environmental challenge in Benin, characterised by the deterioration of soil quality and loss of ecosystem functionality. This issue arises from a combination of factors, including population pressure, unsustainable agricultural practices, deforestation, and climate variability.[24] The rapidly growing population in Benin puts substantial pressure on the land for agricultural expansion, leading to deforestation and the conversion of natural habitats into cropland. This, coupled with improper land management practices such as overgrazing and inappropriate irrigation, contributes to soil erosion and reduced soil fertility. Currently, inland valleys in Benin are experiencing rapid soil degradation and biodiversity loss due to increased agricultural intensification.[25]

As the soil undergoes degradation, essential nutrients are depleted, adversely impacting agricultural productivity and the overall health of the ecosystem. About 90 per cent of the country's soils exhibit low soil fertility,[26] which poses significant threats to food security and community livelihoods.[27] The cultivation of pulses is pivotal in improving soil fertility and general soil health for improved crop yields and income for smallholder farmers. As part of the ProSoil approaches, velvet bean is cultivated in the Zou-Collines and Borgou-Alibori regions of Benin.

More to know:

Learn more about how ***mucuna*** is used to enhance soil fertility in Benin!

Scan or click on the QR Code below:

Velvet bean performs multipurpose roles in terms of food, feed and SLM as discussed in Section 2. Improved soil fertility has been attributed to increased maize yields with the use of mucuna and cajanus as green manure cover crops in Bantè, Bembéréké, Kandi, and Zagnanado districts in Benin.[24] Maize-velvet bean intercrop is here associated with increased biological activity.[28]This enhances nutrient cycling, improves the availability of essential nutrients for plants, contributes to the formation of stable soil aggregates, supports pest and disease suppression, and promotes the decomposition of organic matter. Through the integration of velvet bean into agroecological systems, such as crop rotation or intercropping, farmers can not only enhance immediate soil fertility but also ensure long-term soil health and productivity.

[24]S. T. C. Adjiba et al., "Impact of Sustainable Land Management Technologies Adoption on Maize Farmers' Well-Being in North East Benin," Moroccan Journal of Agricultural Sciences 4, no. 3 (September 20, 2023), https://doi.org/10.5281/zenodo.8388074.

[25]Justin F. Djagba et al., "Ecological Sustainability and Environmental Risks of Agricultural Intensification in Inland Valleys in Benin," Environment, Development and Sustainability 21, no. 4 (August 1, 2019): 1869–90, https://doi.org/10.1007/s10668-018-0107-1.

[26]JAD Dossou et al., "Agronomic Evaluation of the Effects of Two Green Manure Cover Crops on Maize (Zea Mays) Cultivation in Four-Agroecological Zones of Benin," 2022.

[27]Katrin Gaesing and Frank Bliss, "Land Rights, Gender and Soil Fertility in Benin - Food4Transformation," September 22, 2021, https://www.foodfortransformation.org/full-article/land-rights-gender-and-soil-fertility-in-benin.html.

5. Revitalising Madagascar's Soils: Harnessing Pigeon Pea, Cowpea, and Mung Bean for Sustainable Land Management

Land degradation in Madagascar is driven by various interconnected factors. Deforestation stands out as a primary concern,[29,30], as widespread practices such as slash-and-burn agriculture and logging have led to the loss of crucial natural vegetation. The removal of this protective cover intensifies soil erosion, resulting in the depletion of fertile topsoil and diminishing agricultural productivity. Additionally, uncontrolled grazing by livestock disrupts the natural balance of vegetation, leading to soil compaction and further contributing to erosion. Through mining activities, extractive industries contribute to altered landscapes and diminished soil quality.[31]

Agricultural degradation holds significance in Madagascar resulting from agricultural expansion due to the growing population.[28] The growing demand for food promotes unsustainable agricultural practices depreciating the soil quality. Consequently, soil fertility depletion is progressing in agricultural lands due to nutrient mining and erosion. The consequences of soil and land degradation in Madagascar are profound, encompassing biodiversity loss, reduced agricultural output, and challenges to local livelihoods. The cultivation of pulses has the potential to restore and rehabilitate degraded soils for agricultural production. ProSoil promotes the cultivation of pulses in the Boeny region.

More to know:

Learn more about how small forests of ***pigeon pea*** are used to enrich soils in Madagascar!

Scan or click on the QR Code below:

5.1 Pigeon pea

Pigeon pea (*Cajanus cajan* (L.) Huth), is pivotal in SLM, playing a crucial role in improving soil fertility. Pigeon pea forms nitrogen-fixing nodules on its roots, fostering a symbiotic relationship with nitrogen-fixing bacteria. This BNF process enriches the soil by converting atmospheric nitrogen into a readily available form for plants, reducing the need for synthetic nitrogen fertilisers.

Pigeon pea contributes significantly to soil erosion control. Its deep root system plays a crucial role in stabilising the soil structure and increasing infiltration[32], mitigating the risks of water and wind erosion. This erosion control capacity is particularly beneficial in cultivated lands. As a result, the integration of pigeon pea into agricultural landscapes aids in maintaining soil integrity and preventing the adverse effects of erosion. Additionally, by incorporating pigeon pea into crop rotations or intercropping arrangements, farmers can break the cycle of pests and diseases that often afflict monoculture practices. For instance, intercropping maize with pigeon pea reduces the population density of Asiatic witchweed (*Striga asiatica* (L.) Kuntze).[33]Pigeon pea contributes to overall soil health, pest management, and the long-term sustainability of agricultural systems.

[28]NCAT, "Velvet Bean (Mucuna Pruriens Var Utilis): A Cover Crop for Hot and Humid Areas – ATTRA – Sustainable Agriculture," 2021,.

[29]Daniel Kübler, "Deforestation, Land Degradation and Natural Resource Management in Madagascar" (Symposium International sur la Biodiversité et la Santé, Mahajanga, 2021),

[30]FAO, "Madagascar | The Forest and Landscape Restoration Mechanism | Food and Agriculture Organization of the United Nations," 2023,.

[31]Andriamampiandra Tsimiovalaza Tsimangataka and Marcel Mamonjy, "Impact of Cause and Effect of Ecological Degradation Relationship Economy: Case of Madagascar," Revue Internationale de La Recherche Scientifique (Revue-IRS) 1, no. 3 (June 23, 2023): 338–49, .

[32]World Agroforestry, "Agroforestree Species Profile. Cajanus Cajan," 2023,.

5.2 Cowpea and mung bean

The cultivation of cowpea (*Vigna unguiculata* (L.) Walp.) and mung bean (*Vigna radiata* (L.) R. Wilczek) reveals additional prospects for advancing SLM in Madagascar. These leguminous crops, similar to pigeon pea, contribute significantly to soil fertility enhancement through nitrogen fixation. By forming symbiotic relationships with nitrogen-fixing bacteria in their root nodules, cowpea and mung bean facilitate the conversion of atmospheric nitrogen into a plant-accessible form, reducing reliance on synthetic nitrogen fertilisers. Additionally, their extensive root systems provide valuable erosion control, aligning with the objectives of SLM in mitigating soil degradation risks in Madagascar. As with pigeon pea, integrating cowpea and mung bean into crop rotations and diversification reduces pest and disease cycles, fostering overall soil health.

More to know:

Learn more about how ***cowpea*** and ***mung bean*** are intercropped with maize in Madagascar!

Scan or click on the QR Code below:

[33]Donald Scott et al., "Identifying Existing Management Practices in the Control of Striga Asiatica within Rice-Maize Systems in Mid-West Madagascar," Ecology and Evolution 11, no. 19 (2021): 13579–92, https://doi.org/10.1002/ece3.8085.

6. Cultivating Resilience: The Role of Pea and Fenugreek in Sustainable Land Management to Counter Land Degradation in Tunisia

Land degradation in Tunisia presents a complex challenge with multifaceted environmental and socio-economic implications. The country grapples with the significant issue of desertification, particularly in its southern regions,[34] where prolonged droughts and the impacts of climate change contribute to the expansion of arid and semi-arid areas. This process leads to heightened soil erosion as vegetation cover diminishes, leaving the soil exposed to the erosive forces of wind and water. The consequences are profound, negatively affecting agricultural productivity and exacerbating the loss of fertile topsoil, which is crucial for sustaining crop growth.

Unsustainable agricultural practices further contribute to land degradation in Tunisia. Intensive farming methods, inappropriate irrigation practices, and the overuse of chemical inputs can lead to soil compaction, nutrient depletion, and a decline in overall soil health.[35] The resulting degradation not only affects the quality of arable land but also has ripple effects on the socio-economic fabric of the country. Impacts include reduced agricultural yields, compromised food security, and increased vulnerability of rural communities dependent on agriculture for their livelihoods. To address these challenges, ProSoil promotes the cultivation of pulses in Northwest Tunisia (Jendouba, Béja, Kef, and Siliana) and Central West Tunisia (Kairouan, Kasserine, and Sidi Bouzid).

6.1 Chickpea, fava bean, lentil and common bean

The cultivation of pulses, comprising chickpea (*Cicer arietinum* L.), fava bean (*Vicia faba* L.), lentil (*Lens culinaris* Medik.) and common bean (*Phaseolus vulgaris* L.), holds considerable promise for sustainable land management (SLM) in Tunisia. These leguminous crops play a pivotal role in enhancing soil fertility through their ability to fix atmospheric nitrogen in collaboration with nitrogen-fixing bacteria.[36] The incorporation of these pulses into crop rotations or intercropping systems can contribute to reduced dependence on synthetic nitrogen fertilisers, fostering sustainable agricultural practices. Furthermore, their deep root systems help prevent soil erosion, a critical concern in Tunisia, by stabilising the soil structure and reducing the risk of water and wind erosion. Lastly, these pulses contribute to overall soil health by breaking the cycle of pests and diseases associated with monoculture.

More to know:

Learn more about how ***peas*** and ***fenugreek*** are used to feed livestock and rehabilitate the soil in Tunisia!

Scan or click on the QR Code below:

[34] Olfa Terwayet Bayouli, Bouajila Essifi, and Mohamed Ouessar, "Assessing Land Degradation Neutrality (LDN) in Southeastern Tunisia Based on Earth Observation Data and Open Source Applications," in *Recent Advances in Environmental Science from the Euro-Mediterranean and Surrounding Regions (2nd Edition)*, ed. Mohamed Ksibi et al., Environmental Science and Engineering (Cham: Springer International Publishing, 2021), 1829–36,.

[35] Donia Jendoubi, Hanspeter Liniger, and Chinwe Ifejika Speranza, "Impacts of Land Use and Topography on Soil Organic Carbon in a Mediterranean Landscape (North-Western Tunisia)," *SOIL* 5, no. 2 (September 2, 2019): 239–51, https://doi.org/10.5194/soil-5-239-2019.

[36] Takwa Gritli et al., "Genotypic and Symbiotic Diversity of Native Rhizobia Nodulating Red Pea (Lathyrus Cicera L.) in Tunisia," Systematic and Applied Microbiology 43, no. 1 (January 1, 2020): 126049, https://doi.org/10.1016/j.syapm.2019.126049.

6.2 Pea and fenugreek

The inclusion of pea (*Pisum sativum* L.) and fenugreek (*Trigonella foenum-graecum* L.) in agricultural practices complements the diverse array of pulses discussed earlier. As leguminous crops, pea and fenugreek share the advantageous trait of nitrogen fixation, collaborating with nitrogen-fixing bacteria to enhance soil fertility. Incorporating these pulses into crop rotations or intercropping systems aligns with SLM objectives, contributing to sustainable agricultural practices and reducing the need for synthetic nitrogen fertilisers.

The cultivation of pea and fenugreek also plays a crucial role in addressing soil erosion, a significant challenge in Tunisia. Their robust root systems contribute to stabilising the soil structure, offering effective erosion control against the persistent threats of water and wind erosion. This erosion control aspect is particularly valuable in regions prone to desertification and land degradation, reinforcing the resilience of agricultural landscapes. Similarly, incorporating these legumes in intercropping and crop rotation systems disrupts pest and disease cycles, promoting general soil health. Research trials in Tunisia indicated a significant reduction of broomrape weed (*Orobanche foetida* Poir.) infestation in fava beans when intercropped with fenugreek. [37] As a result, the seed yield of fava beans increased. The integration of pea and fenugreek into Tunisia's agricultural landscape enhances soil conservation and productivity.

More to know:

Learn more about how various pulses are used to fertilise the soil in Tunisia!

Scan or click on the QR Code below:

[37] Zouhaier Abbes et al., "Intercropping with Fenugreek (Trigonella Foenum-Graecum) Enhanced Seed Yield and Reduced Orobanche Foetida Infestation in Faba Bean (Vicia Faba)," Biological Agriculture & Horticulture 35, no. 4 (October 2, 2019): 238–47, https://doi.org/10.1080/01448765.2019.1616614.

7. Conclusion

Pulses are pivotal in soil protection and rehabilitation and already contribute to an agroecological transition in ProSoil partner countries. In addition, they offer nutritional benefits, contributing to diversified diets and improved food and nutrition security. Some pulses are also valuable fodder for livestock. Their economic importance, highlighted by their market value and potential to generate income for local farmers, emphasises their role in enhancing livelihoods and economic resilience.

The broad category of pulses, with their dual role as soil enhancers and nutritional contributors, exemplifies the holistic impact of pulse cultivation. This aspect is crucial in combating malnutrition and improving overall health, aligning seamlessly with the broader goals of SLM, where the synergy between ecological resilience and human well-being is paramount.

The multifaceted benefits of pulse cultivation underscore the importance of documenting these practices. Systematic recording of successful approaches and technologies paves the way for further dissemination and scaling of pulse-related practices. This documentation not only preserves valuable knowledge but also facilitates knowledge-sharing among communities, researchers, and policymakers, fostering a collective effort to harness the full potential of pulses for SLM, improved nutrition, and economic well-being on a broader scale.

In the promotion of pulse cultivation, the collaborative efforts of WOCAT, the United Nations Convention to Combat Desertification (UNCCD), and GIZ emerge as instrumental in advancing SLM practices. Documenting, disseminating, and scaling successful pulse-related practices contribute significantly to global knowledge-sharing. Initiatives on the ground are complemented by global awareness campaigns such as the World Pulses Day, a designated United Nations event to recognise the importance of pulses as global food hosted by FAO. By fostering partnerships and providing essential support, these organisations play a pivotal role in amplifying the positive impacts of pulse cultivation on soil health, nutrition, and economic resilience on a global scale.

The effective documentation, dissemination, and adoption of pulse cultivation in Africa is dependent on policy formulation and implementation. Policies that advocate for sustainable land management, incentivise pulse cultivation, and facilitate market access are crucial. Efforts to seamlessly integrate pulses into land management practices necessitate a collaborative approach between local governments and civil society, where the role of policy support becomes essential for ensuring the continued success of these initiatives.

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