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DRUMSTICK BASED AGROFORESTRY SYSTEMS: A REVIEW

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ABSTRACT

Agroforestry is the incorporation tree species in agriculture field to boost farmer's income in several aspects through tangible intangible way. It is a sustainable land management system that increases overall production combines, tree crop and animals. Depending on the type of soil, the agro-climatic zone, and the farmer's inclination, several agroforestry systems are employed. The best method to combat malnutrition in rural areas is to implement agroforestry systems based on drumsticks. Nearly all essential nutrients and development factors, vitamin, amino acid, protein, mineral, and metal, including potassium, iron, and zinc, is present in the leaves of the *Moringa* plant. In addition to this, modern times allow for the preparation of numerous dietary supplements and medicines using plant leaves. Due to its great drought tolerance and extensive canopy, which shades the soil, *M. oleifera* L. can be a key component in agroforestry systems for preserving soil and water. Drumsticks are able to adapt to various climates and have a rapid growth rate, which could be useful for restoring damaged landscapes. Numerous studies confirm the ability of *Moringa oleifera* seed powder to purify water and explain how seed extracts work to inhibit some bacterial growths. The purpose of the following study was to examine the advantages and requirements of a durum-stick-based agroforestry system in the 21st century in order to satisfy farmers' needs and promote environmental sustainability.
Keywords **:** Agroforestry systems, environmental sustainability etc.

Introduction

Agroforestry is not a novel idea; it has been practiced since the beginning of human agriculture. Trees are necessary for ecological sustainability, as is well known. Compared to natural forests, the production of fast growing trees like *Populous, Drumstick, Bamboo* and *Shoo babool* produced outside of forests is substantially higher, and these trees are also in high demand. Every year, trees outside of forests provide about 49 per cent of the fuel wood and 48 per cent of the lumber (Rai and Chakraborty, 2001). Agroforestry offers impoverished farmers in developing nation's access to personal benefits while simultaneously benefiting the environment globally. Due to their ability to store carbon from the atmosphere through soil and live biomass, trees can both minimize climate change and boost ecological diversity both above and below ground. It is common to ignore the possible advantages of *Moringa* plants for the environment and life. There is a need to raise awareness and encourage farmers and decision makers to adopt Moringa on marginal and degraded lands with changing climate risks (Atreya *et al.,* 2023). With 80% of the global demand for drumsticks, India is a top exporter in the global market. Approximately 500 tonnes of dried leaves were exported by India to the international market in 2015, valued at ≠ 14.6 crores, compared to ≠ 11.61 crores in 2014. Exports in the first two months of 2016 were worth ≠ 2.5 crores. (APEDA, 2018).

The drumstick is mostly grown in India, however it is also found in various regions of Southeast Asia, Africa, the Middle East, Central America, the Caribbean, northern South America, and Oceania. There are several purposes and uses for *Moringa* trees. It is utilized for the following purposes: alley cropping

(biomass production), animal hay (leaves and sterilized seed cake), natural gas (leaves), barriers (living trees), soil amendment (seed cakes), foliar nourishment (leave juice), organic waste (leaves), the gum (tree trunk), honey and fruit juice clarifier (crushed seed), honey (flower nectar), healthcare (all plant parts), decorative planting, bio-pesticide, rope (bark), tannin (bark and gum) (Mansour *et al.,* 2020). The addition of Moringa plants to a farm with a varied environment can benefit the surrounding ecosystems as well as the farm's owner (Fuglie, 1999). Agroforestry is currently gaining popularity in the tropics as more and more trees are suggested for land restoration in areas with deteriorated soil (Franco *et al.,* 1997), for fallow improvement and for erosion control. In order to decrease external inputs (NPK, nutrients) and maintain or boost agricultural output, impoverished farmers might use the breakdown of leaf litter and the ensuing nitrogen release as a key management strategy under agroforestry system. In *Moringa* based agroforestry system, *Moringa* leaves released more N during the first 8 weeks of decomposition than the other local species (Gamboa *et al.,* 2023).

Soil Improvement through Moringa tree

According to Anjorin *et al.* (2010), *Moringa oleifera* leaves have a significant amount of nitrogen, which makes such a valuable source supplementary organic matter to the soil. Singh *et al.* (2012) examined the output of litter and the amount of nutrients recovered, finding that Drumstick had 237 kg/ha of total litter fall. *Moringa oleifera* leaf parts as organic fertilizer (Foidl *et al.,* 2001) can be used in the tropical environment where scarcity and high cost of chemical fertilizers is prevalent (Yinda and Adeoye, 1994). Rich in Micronutrients: Abounding in potassium, calcium, magnesium, iron, and other vital micronutrients, *Moringa* leaves and seeds are a great source of these “Organic Matter Content”. The organic matter found in *Moringa* leaves is a wonderful phenomenon that can be used to enhance the physical structure and fertility of soil. Nutrient release from fresh and dried *Moringa* leaves added to the soil was greater in the dry leaves than in the fresh (Ekene and Uchenna 2023). The incorporation of 5-15 t ha^{-1} fresh and dry *Moringa* leaves enhances Maize growth and production (Ebido *et al.,* 2014). Using *Moringa* shoot as a green manure can significantly enrich agricultural soil. For this purpose seedlings are plowed into the soil, to a depth of 15 cm and then the soil is prepared for the desired crop (Rashid *et al.,* 2008). Numerous environmental advantages of drumstick farming include soil preservation, carbon sequestration, and watershed protection. Incorporating *Moringa* with alley cropping and intercropping methods lowers soil acidity while simultaneously providing shade for crops (Devkota and Bhusal 2020). Its quick growth rate aids in reforestation and mitigates the effects of climate change, while its deep root structure helps minimize soil erosion. Alley cropping is another way to plant Moringa. According to Abdullahi and Anyaegbu's (2017) research on Soybean and Moringa based alley cropping system, and revealed that planting Moringa reduces the acidity of the soil.

Provides an economic

Moringa is increasingly becoming popular among communities in the world for uses such as a food supplement, as a weaning food in children and for medicinal purposes (Makkar and Becker, 1996). The application of Moringa leaf extract as a foliar spray to late-sown wheat during the tillering stage has been reported by Yasmeen *et al.* (2012), who observed that the yielding was 10% greater than that of the control. It was also discovered that a single foliar treatment at heading in the field increased production by 6.8 percent. Almost all products of tree consumed by people and their livestock remaining products are brought in market for selling (Kumar *et al.,* 2017). *Moringa* becomes a good fodder in present time because; *Moringa* leaves contain 20,718 and 106.3 mg kg^{-1} of macronutrients Mg and K, reported by Nouman *et al.* (2014) while Minson (1990) and Soliva *et al.* (2005) reported that CP contents in raw and extracted *Moringa* leaves are 47 percent and 64 percent higher, respectively, than those of common forages and grasses consumed by livestock. Therefore, Moringa leaves fulfill the dietary and nutritional requirements of livestock animals. Above quality of *Moringa* can reduce the extra cost of quality fodder in farmers account.

Because of its aroma and cosmetic value, Moringa oil, also known as "Ben oil" or "Behen oil," is used for both food and non-food goods, such as hair care and perfumes. (Bhutada *et al.* 2015).Tribal farmers believe in short-term gains from labour and capital investments made in the small land holdings. Diouf *et al.* (2007) and Madi *et al.* (2012) showed the noteworthy economic impact of *Moringa oleifera.* According to Animashaun and Toye (2013), the production of *Moringa oleifera* leaves in Western Nigeria yielded a net profit of US$ 5137 per hectare annually. According to the findings of Rathor *et al.* (2022), the Moringa + Potato system achieved highest net returns (2156.1 US$ /ha), a B:C ratio of 2.63, and a profitability index of 20.53 US$ /ha/day) in the winter months.. From an economic perspective, integrated agroforestry is beneficial since it can create jobs by

supplying resources to adjunct sectors, particularly in the months of low harvest. (Yadav *et al*., 2021b). Enterprises based on *Moringa oleifera* have arisen as an exciting project to empower communities across different regions of Indonesia (Seifu and Teketay, 2020). The implementation of the *M. oleifera* tree-based agroforestry system, known as the MTBA system, has shown to be beneficial, resulting in improved prospects for revenue, financial stability, cost-effective, and stable crop yields (Horn *et al.* 2022).

Environmental benefits- The technique of sustainable agriculture can be improved through agroforestry using Moringa trees. This approach offers an environmentally responsible and sustainable way to increase agricultural output and stress tolerance. A study conducted by Villafuerte *et al.* (2009) found that the rate at which the Moringa tree absorbs carbon dioxide (CO_2) is twenty times (20x) higher than that of the general vegetation and fifty times (50x) higher than that of the *Japanese cedar* tree. Additionally, the seed works well as a water clarifier, giving the nearby towns access to clean drinking water. The leaves, fruit, flowers and immature pods of this tree are used as a highly nutritive vegetable in many countries (Mishra *et el.,* 2012). Generally speaking, *Moringa* trees can enhance plant yield and soil quality. According to Nouman *et al.* (2013), Moringa is an enduring plant that can be raised in saline environments and in an assortment of soil types. The assumption that *Moringa* can be grown in drought-prone areas is supported by this report. *Moringa oleifera* is very adaptable, making it a potential crop for reducing the effects of climate change where they are already being felt. Moringa's ability to soak up carbon dioxide can be experimented with to mitigate the effects of global warming while simultaneously dealing with the nation's issues with food, poverty and many more agricultural issues (Devkota and Bhusal, 2020).

Moringa is well adapted to adverse conditions where other plants have a very low level of survival rate (Takur and Bajagain 2020). Although *Moringa* is a wild plant that can grow in hard soil, it is advised for use in wind break shelterbelts to shield afflicted areas from wind and soil storms. Even with its various possible uses and intriguing characteristics, *M. oleifera* is most commonly cultivated in Ghana as a backyard tree or as a live fence (Amaglo, 2007). The utilization of *Moringa* in bioenergy not only broadens our sources of energy but also plays a major role in promoting a more sustainable future, reducing environmental degradation, and conserving the environment (Mahaveerchand and Salam. 2024). Likewise, carbon sinking attribute of its soft wood can be pivotal for curbing global warming and climate change (Thakur and Bajagain, 2020). *Moringa* leaves used as growth promoter. Utilizing Moringa extract in biofertilizers has a beneficial impact on agriculture (Ekene and Uchenna, 2023). Effectiveness of *Moringa* leaves for preserving soil fertility, regulating soil pH, and increasing garden egg production since they are less expensive and more environmentally friendly than chemical fertilizers (Kekong and Ojikpong, 2013). The most significant contributor to climate change is the methane (CH_4) gas emissions from cattle. A study conducted by Akanmu *et al.* (2020) a forage-based diet with 50 mg/kg of extracts from *Moringa oleifera* and *Tithonia diversifolia* decreased the formation of CH_4 without having a negative impact on feed digestion, according to findings made under in vitro circumstances.

Livelihood support- For millennia, going all the way back to 150 BC, the Greeks and Egyptians utilized a plant termed *Moringa oleifera* Lam to foster mental stability and general health (Sujatha and Poonam, 2017). Past research has mostly concentrated on the medicinal benefits and oil content from a commercial point of view; nevertheless, there is a need to increase awareness and urge farmers and decision makers to use *Moringa* on marginal and degraded soils with changing climate hazards. Generally, Moringa is a good source with vitamins A, C, E, and is high in calcium, which supports bone health and prevents heart disease. Vitamins A, C, E and the trace element zinc assist in enhancing the skin barrier function (Horn *et al.,* 2022). Additionally, Ntila *et al.* (2020) find out that the Moringa is a fantastic source of potassium, which lowers tension and anxiety. In Namibia, moringa powder may be an effective ingredient for strengthening in many kinds of regional goods, including traditional alcohol. Some other research shows that *Moringa* leave product has the ability to improve nutritional products singly or when used as a supplement in food products. Moringa has been linked to lowered blood sugar levels in humans; diabetic patients who received powdered Moringa leaves demonstrated a significant drop in blood sugar levels (Owens *et al.,* 2022). The best biomimetic agent to regulate the remineralization of enamel tissue, according to Elgamily *et al.* (2016), is *Moringa oleifera* leaf extract. A useful technique for addressing with clime change, livestock food scarcity and livestock quality is the application of silvopastoral as an alternative to livestock production in tropical regions. According to NDDB, *Moringa* has the potential to yield high-quality, year-round fodder on a plot of land for four to five years. In four to five

cuttings, *Moringa* can yield more than 100-120 tons of green fodder per hectare, which is enough to feed eighteen to twenty animals in a mixed feeding system.

Conclusion

A popular crop in Asian and African nations, *Moringa oleifera* also known as the "Diamond of Plants," "Tree of Wonders," and "Tree of Life"-is noted for its nutrient-rich qualities, quick growth, and resistance to drought (Su *et al.,* 2023). A type of plant called *M. oleifera* is useful for both food and medicinal. Many study shows that it makes a variety of contributions to the welfare of people. Because of its strong antioxidant qualities, this nutrient rich and phytoconstituents-rich plant is not only good for human consumption yet it is also employed in numerous formulations. In light of the various issues our globe faces, *Moringa oleifera* presents a viable, environmentally responsible, and effective substitute. Generally *Moringa* tree based agroforestry practice is more profitable and less sensitive for change in price than mono-cropping system this facility can be improves farmer's economic conditions in many countries.

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