



Science

MORINGA: ALTERNATIVE FOR THE FOOD SECURITY, CLIMATE RESILIENCE AND LIVELIHOOD IMPROVEMENT IN NEPAL



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Abstract

Moringa oleifera L. is indigenous to northern foothills which includes Northern India, Pakistan and Nepal and genetic diversity is especially available in the Tarai region of Nepal including northern India. It's well climate stress adaptive nature, easy propagation, less input and intercultural operation requirement has proven to be boon in many ways. As it is the economical and reliable alternative for good nutrition, medicinal use, animal feed and fodder, plant supplement and soil reclamation, it can be touted as a miracle plant. Diverse form and edible utility of Moringa, helps for food and nutritional security for present and future. Likewise, carbon sinking attribute of its soft wood can be pivotal for curbing global warming and climate change. Moringa can thus help to create a well-nourished, healthy individual with happy family engaged in agriculture and agro-forestry blessed with good return and livelihood improvement. This review provides a brief overview about multipurpose use of Moringa and its implication to curb impacts on climate change, ensure food and nutrition security and sustain livelihood.

Keywords: Climate Change; Food Security; Livelihood; Moringa; Nutrition and Resilient.

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1. Introduction

Moringa oleifera L. is a tree plant and it's native to India. However, it is widely grown in Africa, Pacific Islands, Caribbean, Philippines, South Africa, Asia, Florida, and Latin America (Fahey 2005). It is a fast-growing, multi-purpose, drought-tolerant and one of most useful tree because of its medicinal and nutritional properties in world and therefore globally described as a 'miracle tree' (Yishehak *et al.* 2011). It is reputedly known as "cabbage tree", 'drumstick tree' or "horseradish tree", 'benzoil tree', 'miracle tree' and 'mother's best friend tree' (Koul & Chawe 2015). It has multipurpose use, well adapted and significant economic importance, as it has vital nutritional, industrial, and medicinal applications (Dawit *et al.* 2016). It's all parts (leaves, fruits, immature

Pods, and flowers) are combined into the traditional food for human consumption (Sidhhuraju & Becker 2003).

In Nepal the two-third of the population depends on agriculture to sustain livelihood which contributes about one third of national GDP (CBS 2011). The pressing challenge at present context is that agriculture has to be relied mostly upon women, children and senior citizen. *Moringa* can thus be an efficient commodity, as it is a hardy plant and doesn't demand stringent requirements. It is fast growing plant, well adapted to grow in adverse conditions where many other plants would not. Propagation through both sexual and asexual method (Paliwa *et al.* 2011), and well adaptive in broad ecological areas and less-intensive intercultural operation has proved its significance in livelihood uplift.

Livelihood has direct connection with climate change on all the assets (human, social, natural, physical and financial capital). Adaptation includes the activities like reducing poverty, improving access to resources, lowering inequities of resources and wealth, improving education, improving infrastructure, improving institutional capacity and efficiency and promoting local indigenous knowledge (Smit *et al.* 2001). As such, *Moringa* can be pivotal in solving both issues: related to climate change and livelihood. The carbon sinking attribute of *Moringa* can be utilized to curb the effect of global warming and at the mean time the problem of malnutrition, hunger, poverty, and unemployment could be addressed by promoting agri-business of *Moringa* in national and international level.

Classification

Kingdom - Plantae

Subkingdom - Tracheobionta

Superdivision - Spermatophyta

Division - Magnoliophyta

Class - Magnoliopsida

Subclass - Dilleniidae

Order - Capparales

Family - Moringaceae

Genus - *Moringa*

Species - *Oleifera* Lam.

(Source: USDA 2019)

Distribution

There are thirteen known species in the genus *Moringa* of family Moringaceae. These are *Moringa oleifera*, *M. arborea*, *M. borziana*, *M. concanensis*, *M. drouhardii*, *M. hildebrandtii*, *M. longituba*, *M. ovalifolia*, *M. peregrine*, *M. pygmaea*, *M. rivae*, *M. ruspoliana* and *M. stenopetala*.

Moringa arborea, *M. borziana*, *M. longituba*, *M. pygmaea*, *M. rivae* and *M. ruspoliana* are native to certain areas of Africa, and exist nowhere else in the world. Similarly, *M. drouhardii* and *M. hildebrandtii* are native to Madagascar. These two, along with *M. ovalifolia* and *M. stenopetala*, both native to parts of Africa, are called "bottle trees." *M. oleifera* L. can be distinguished by the stalked glands at the leaf base and rachis articulations; the three-valved fruits; the three-winged seeds and by a pungent horseradish odor from the leaves (FNAEC 2017). *M. oleifera* is found

worldwide in the tropics and subtropics. The species is present in Asia, Africa, North America, Central America, the Caribbean, South America and Oceania.

M. oleifera L. is indigenous to northern foothills which includes Northern India, Pakistan and Nepal (Leone, *et al.* 2015). Much genetic diversity is especially available in the Tarai region of Nepal and India (Uttar Pradesh) (NPC 2006). Thus, *M. oleifera* has found wide acceptance, recognition and usefulness among the various ethnicities in different parts of Nepal. In Nepal, *M. oleifera* L. is cultivated in 13 different districts within the land area of 67 ha and 554 metric ton is produced every year (RDISPL 2072).

2. Methodology

This study is based on rigorous review of *Moringa* and related documents. It includes but is not limited to food security, climate change and livelihood convention related documents, national and international policies and strategies including plans and programmes, documents, published reports, journal articles, literatures and research papers. The information was drawn from national and international sources and they were critically scanned, skimmed, reviewed, shorted and analyzed for this study. This study was done from September 2018 to March 2019.

3. Result and Discussion

Moringa is a multipurpose tree and its each and every part has their use in human welfare and socio-cultural aspects. Their use and benefits are explained here under.

General Use

It can be said that there are multiple use of the *Moringa* in day to day life. Some of the use of the plant parts includes, but not limited to, uses like: alley cropping (bio-mass production), animal forage (leaves and treated seed cake), biogas (leaves), cleaning agent (crushed leaves), blue dye (wood), fencing (living trees), fertilizer (seed-cakes), foliar nutrient (leave juice), green manure (leaves), gum (tree trunk), honey and juice clarifier (powdered seed), honey (flower nectar), medicine (all plant parts), ornamental planting, bio-pesticide, rope (bark), tannin (bark and gum) (Fuglie 1999).

Food and Nutritional Value of Moringa

Moringa contains much more nutrient and medicinal chemical, and so, it is named as miracle tree plant. *Moringa* leaves contain more vitamin A than carrots, more Vitamin C than orange, more potassium than bananas, and on top of that the protein quality of *Moringa* leaves competes with that of milk and eggs (Fahey 2005).

Moringa tree is rich in nutrients such as minerals, fiber and proteins that can play essential role in human nutritional consumption. Numerous of the research reports have shown that *Moringa oleifera* leaves has high protein compared to with other leaves eaten as food (Suchada, Supawan, & Thanapat 2010). Each part of the *Moringa* tree (fruits, seeds, leaves, flowers, barks and roots) is associated with the presence of at least one, or in most number of benefits (Zaku *et al.* 2015). It have multiple uses i.e. leaves can be eaten fresh, cooked, or stored as dried powder for many months without loss of nutritional value. Till date, *Moringa* has seven use categories identified

namely, medicine, food, fodder, fencing, firewood, coagulant and gum (Popoola & Obembe 2013). Each part of the *Moringa* tree (fruits, seeds, leaves, flowers, bark and roots) is associated with the presence of at least one, or in most number of benefits (Zaku *et al.* 2015). The analysis of dietary iron supplements in the liver influenced by *M. oleifera* leaves revealed that iron from *Moringa* can overcome iron deficiency (Saini *et al.* 2014).

Table 1: Comparison of *Moringa* fresh and dry leaves with common foods per 100 grams

Nutrient	Common foods	Moringa leaves	
		Fresh leaves	Dried leaves
Vitamin A	1.8 mg Carrots	6.8 mg	18.9 mg
Calcium	120 mg Milk	440 mg	2003 mg
Potassium	88 mg Banana	259 mg	1324 mg
Protein	3.1g Yogurt	6.7 mg	27.1 g
Vitamin C	30 mg Orange	220 mg	17.3 mg

Source: Chukwuebuka 2015

Besides, it has great use in culinary purpose. Wide varieties of dishes can be prepared from the parts of *moringa*, as a whole or mixed. In south Indian varieties, culinary items like sambars and fries are prepared from *moringa* pod. Likewise, it is used in curries, kormas and dal to enhance the taste; and at some place it is reported to be used in preparing outlet dishes (Paliwa *et al.* 2011).

Role in Ensuring Food Security and Hunger Alleviation

In present global context, future of food security is in peril. There are about 30,000 edible plant species present of, only 30 are used to feed the world. As such, food security can only be assured by breaking the monoculture and promotion of neglected and underutilized crop species.

Food security is defined as achieving food security at the individual, household, national, regional and global levels when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO 1996). The absolute number of undernourished people, i.e. those facing chronic food deprivation, has increased to nearly 821 million in 2017, from around 804 million in 2016 (FAO 2018). It is evident that among diverse availability of food crops, our world is dependent upon only few major crops and cereals; which have raised the issue of crop diversification.

In order to secure the future from food availability and nutrition, *Moringa* can be an effective crop species. Fresh *Moringa* leaves can be eaten raw, if they're very young and tender, but can be cooked as vegetable. Similarly, as a way to preserve nutrients leaf powder can also be made; this can be consumed as a whole food or added to other cooked food. Likewise, *Moringa* pod can be boiled, steamed, fried and eaten when they are young and tender and the seeds can also be consumed like other peas. It is also used in *fortification of bread, biscuit, yoghurt, cheese, soup etc.* (Oyeyinka & Oyeyinka 2016). *The inclusion of Moringa flower, seed or leaf powder in bread preparation has been reported to improve the nutritional value of bread* (Chinma *et al.* 2012).

Promising Source of Feed and Fodder

Easy availability of fodder, vigorous growth and foraging nature, adaptability in climatically challenged land has increased the potential of *Moringa* plant as promising source of feed and

fodder. *Moringa* can be used as a good source of ration for livestock. The high nutritional quality and better bio-mass production: especially in dry periods, supports in significance as livestock fodder (Nouman *et al.* 2014).

In a study, sunflower seed-cake was found possible to be replaced by *Moringa Oleifera* leaves as a conventional feed (Sarwatt *et al.* 2002). The cost advantage of *Moringa* can thus be a drive for engagement in animal husbandry. Similarly, a study concluded that *Moringa* leaf meal is well tolerated by the chicken, up to the level of 7.5% and can replace soybean meal in the broiler diet. Thus, significant impact on animal husbandry can be made using the feed and fodder from locally grown *Moringa* plant. It helps to reduce importing expensive feeds and also broaden the prospects in international trade by export of raw and processed materials.

Medicinal Use

Moringa is really a miracle plant that has wide range of medicinal uses. *Moringa* plant have several specific remedial properties including its anti-fibrotic, anti-inflammatory, anti-microbial, anti-hypoglycemic, anti-oxidant, anti-tumor and anti-cancer properties (Razis *et al.* 2014). Practically, most parts of the *Moringa* tree are utilized for some medicinal use which is presented in Table 2.

Table 2: Medicinal uses of different parts of Moringa plant

Plant Part	Medicinal Use
Root	Anti-lithic, rubefacient, vesicant, carminative, anti-fertility, anti-inflammatory, stimulant in paralytic afflictions; act as a cardiac/circulatory tonic, used as a laxative, abortifacient, treating rheumatism, inflammations, articular pains, lower back or kidney pain and constipation
Leaf	Purgative, applied as poultice to sores, rubbed on the temples for headaches, used for piles, fevers, sore throat, bronchitis, eye and ear infections, scurvy and catarrh; leaf juice is believed to control glucose levels, applied to reduce glandular swelling.
Stem-bark	Rubefacient, vesicant and used to cure eye diseases and for the treatment of delirious patients, prevent enlargement of the spleen and formation of tuberculosis glands of the neck, to destroy tumors and to heal ulcers. The juice from the root bark is put into ears to relieve earaches and also placed in tooth cavity as a pain killer, and has anti-tubercular activity.
Flower	High medicinal value as a stimulant, aphrodisiac, abortifacient, cholagogue; used to cure inflammations, muscle diseases, hysteria, tumors, and enlargement of the spleen; lower the serum cholesterol, phospholipid, triglyceride, VLDL, LDL cholesterol to phospholipid ratio and atherogenic index; decrease lipid profile of liver, heart and aorta in hypercholesterolemia rabbits and increased the excretion of fecal cholesterol.
Seed	Seed extract exerts its protective effect by decreasing liver lipid peroxides, antihypertensive compounds thiocarbamate and isothiocyanate glycosides have been isolated from the acetate phase of the ethanolic extract of Moringa pods.

Source (Farooq et al. 2006)

Moringa has been used in the traditional medicine passed down for centuries in many cultures around the world, for skin infections, anemia, anxiety, asthma, blackheads, blood impurities, bronchitis, catarrh, chest congestion, cholera, conjunctivitis, cough, diarrhea, eye and ear infections, fever, glandular, swelling, headaches, abnormal blood pressure, hysteria, pain in joints, pimples, psoriasis, respiratory disorders, scurvy, semen deficiency, sore throat, sprain, tuberculosis, for intestinal worms, lactation, diabetes and pregnancy (Nikkon et al 2003).

Measure to Curb Global Warming and Climate Change

Climate change is a pressing issue at present and not only for farmers but its effect is a matter of concern for all. The role of farmers and forest user is however pivotal to reduce climate change. The adaptation strategies and plan to cope and curb the climate change impacts is thus required (Gedefaw 2015). In developing country like Nepal, rather than innovating sophisticated measures, it is judicial to look up the available solution which have not been explored. *Moringa* can thus be efficient tool in this context, due to its invincible attributes like hardiness and adaptation on various environmental variations.

Moringa and its bushes can survive well even in the dry climate. The wood absorbs atmospheric carbon dioxide and sequesters it and thus helps to curb global warming. The rate of assimilation of CO₂ is higher than that in other plants. In a study, when the rate of absorption CO₂ of *Moringa* and Japanese cedar was compared, *Moringa* was found fifty fold higher. Similarly, comparing with the normal vegetation it was twenty times higher (Daba 2016). From another study, it was also found that, for the total 320 kg of carbon dioxide emitted from a person per year, it requires 23 Japanese cedar trees a year of 50 years but in case of *Moringa*, 2 *Moringa* trees just takes 2 years to absorb that amount.

In the face of climate change and variability, the standing tree of *Moringa Oleifera* can thus act as reservoir of carbon dioxide and reduce the extent of global warming. Also, it helps to sustain biodiversity in adverse climatic condition. It helps to control soil erosion, wind speed and wild animals by fencing.

***Moringa* As Bio-Fertilizer and Plant Supplement**

Moringa has an immense potential as fertilizer supplement for plants. Analysis of plant data proves it to be a good nutrient carrier, containing nutrient elements that can enhance effective and productive cultivation of crops, while in-turn maintaining soil fertility status (Adiaha 2017).

Similarly, in one study, *Moringa* extract was found to increase growth and yield of tomato in both greenhouse and field. It was found that its extract significantly increased above ground dry matter yield (DM), root dry matter weight and plant height for the crop (Culver, Fanuel, & Chiteka 2012). Similarly, *Moringa* leaf extract was found to improve fruit set, yield, fruit weight, firmness, color, soluble solids content, vitamin C, anthocyanin content and antioxidant activity of "Hollywood" plum (Thanaa et al. 2017).

Exogenous application of *Moringa* leaf extract, whether it is an aqueous or ethanol extract, improves productivity in many crops, because *Moringa* leaf extract possesses great antioxidant activity and is rich in plant secondary metabolites such as ascorbic acid and total phenols, making it a potential natural growth stimulant (Yasmeen et al. 2012).

Thus, self-reinforcing nature of *Moringa* i.e. standing plant utilizing nutrients from less potential soil and its extract replenishing the nutrient is beneficial in agricultural land.

***Moringa* For Soil Reclamation**

It has been found that *Moringa* have metal binding properties and can help remove several contaminants from aqueous solutions. It also possesses strong anti-coagulant properties like 'Alum' that can remediate contaminated water (Sinha *et al.* 2009). *Moringa* seed extract removes heavy metal ions from the soil at pH levels of 6 to 8 (Sajidu *et al.* 2006).

Thus, in the marginalized land, *Moringa* can be cultivated at low cost to ensure its fertility. Similarly, in a study on application of *Moringa* leaf extract on root development and yield of Soybean (*Glycine max*), physio-chemical properties of the soil were found to be improved. Also, the result suggested soil application of *Moringa* leaf extract as soil exogenous nutrient could enhance growth process and leads to increase mineralization of nutrient (Asagwara & Emeribe 2017). Likewise, *Moringa oleifera* seeds have been shown to remove arsenic from water (Kumari *et al.* 2006).

Hence, it is evident that the marginalized land and degraded land can be effectively utilized, and in turns be transformed to cultivable land for other major crops later.

Socio-Cultural Aspects and Prosperity

In socio-economic consideration, *Moringa* is a promising plant. It helps to battle malnutrition and hunger, and also provides employment of social relevance. Farm and nurseries could be established even in a drought regime, and social institution in return gets benefited from it. In one hand, food secure society operates in harmony and on other hand, trade and business of same product help to prosper the economy. Thus, *Moringa* can be used as an effective tool in uplifting local communities, promoting social responsibility and encouraging social integrity.

Unlike mainstream crops, it doesn't require intensive care – home made compost and manure application with sporadic irrigation just to make the soil wet is sufficient for optimum result. It can be grown under high-density monoculture, or intercropped with other crops. Flooded land, dry river bed or waste land which is otherwise unused could be utilized for *Moringa* plantation and hence, even the marginalized people can get benefitted. In Nepal, *Moringa* can be attributed to cultural values as well. In the second day of the Nepalese New Year, sacred water is sprinkled as a symbolic relief from the upcoming summer and *Moringa* vegetable is consumed for the same purpose, and the day celebrated as Moringa Day. It thus helps to maintain cultural integrity and social well-being.

Thus, *Moringa* can help to create a well-nourished, healthy individual with happy family engaged in agriculture and agro-forestry blessed with good return and food-security. Therefore, *Moringa* cultivation can be envisaged as a precursor of prosperity.

As economic value, this tree leaves can be processed and marketed in different forms like *Moringa* tea, *Moringa* powder, moinga juice, *Moringa* capsule, *Moringa* pellete, etc. It's leaves used in kitchen as many recipe such as *pakauda*, *sag*, *amlet*, *bada* and powder in fish and meat items. The leaves are also used for feed and fodder of fish, poultry, pigs, goat and cattle, which gives farmers

more benefit from different enterprises. The sticks can be sold as vegetable in the market at off and on season at higher price. The oil and oil cake from seed can be prepared and sold for various cosmetic and medicinal purposes. This is the one of the high value crops for poor and vulnerable families too. The most nutritive, fast growing, hardy, easily propagated, medicinal use, eco-friendly and economically profitable nature of *Moringa*, the tree crop serves as boon for poor country like Nepal. The higher productivity of leaves and pods fetches higher income for farmers, traders, processor and retailers. Considering these points, Climate change adaptation in Agriculture sector of FAO, Heifer Nepal, soil conservation office, and other projects and programmes have promoted *Moringa* plantation in project area.

4. Conclusion

Moringa oleifera L. is a plant native to India but it is widely grown tree in Africa, Pacific Islands, Caribbean, Philippines, South Africa, Asia, Florida and Latin America. It is a drought-tolerant, fast-growing, multi-purpose, eco-friendly and one of most useful tree due to its medicinal and nutritional properties in world and therefore described as a 'miracle tree'. *Moringa* tree is rich in nutrients such as vitamins, minerals, fiber and proteins that. It is a very nutritious plant containing more vitamin A than carrots, more Vitamin C than orange, more potassium than bananas, and protein quality of leaves competing with that of milk and eggs. Hence, it can play essential role in human nutritional consumption. *Moringa* has wide range of medicinal uses as anti-fibrotic, anti-inflammatory, anti-microbial, anti-hypoglycemic, anti-oxidant, anti-tumor and anti-cancer properties.

Fresh *Moringa* leaves can be used in vegetables. Leaf powder can also be consumed as food, nutrient supplement and medicinal purpose. The tender pods can be consumed as boiled, steamed, and fried and the seeds can also be consumed like peas. *Moringa* can be effective in assuring food security by breaking the monoculture and also promote promotion of other neglected and underutilized crop species.

Moringa can be used as a good source of animal and bird feeds due to its nutritional quality and better bio-mass production especially in dry periods. Similarly, its leaf extract was found to improve fruit set, yield, fruit weight, firmness, color, soluble solids content, vitamin C, anthocyanin content and antioxidant activity. Thus, Self-reinforcing nature of *Moringa* from less potential soil and its extract replenishing the nutrient is beneficial in agricultural land.

The most alarming challenge, like climate change and global warming, for country like Nepal, it is judicial to look up the available solution which has not been explored. As such, due to its hardiness and adaptation on various environmental variations, *Moringa* can be an efficient commodity. Its wood also absorbs atmospheric carbon dioxide and sequesters them and thus helps to curb global warming. Nepal, with one fourth of population under the poverty line and being highly vulnerable to climate change, has wide scope for *Moringa* plantation for their livelihood improvement. Till date, in Nepal not much research has been done on *Moringa* cultivation. Imminent threats from food security, malnutrition, climate change and livelihood quality decline could be addressed if immediate initiation for systematic and scientific research as well as promotion of the *Moringa* is done at different agro-climatic regions of Nepal.

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