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# Mulberry (*Morus spp*) as a Plant for Building the Resilience of Smallholder Farmers during Climate Change and COVID 19 Pandemic

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**ABSTRACT**

Global warming and the COVID 19 pandemic have imposed a devastating effect on life all over the world. Agriculture faces daunting challenges in the coming decades due to these two issues. The aim of this review paper is to provide pertinent information on mulberry to justify its use in building the resilience of smallholder farmers in the phase of climate change and COVID 19 pandemic. Agricultural production has been constrained by lack of sensitization about crops that could be incorporated for the dual purpose of mitigating the effects of both climate change and COVID 19. Although mulberry has a multiplicity of uses, information on its suitability for climate change mitigation and its nutraceutical potential especially during the times of COVID 19 has not been documented. In this paper the suitability of mulberry in climate change mitigation is also discussed. The paper concludes' that the resilience of mulberry against drought, its multipurpose nature as food, its medicinal properties and the extent of its effect on the environment gives it priority as a plant that could be incorporated into the farming system as a cushion against the effects of climate change on the conventional crops. Mulberry is therefore a plant that is suitable for building the resilience of smallholder farmers against climate change and COVID 19 pandemic.

**Abbreviations:**

| | |
|---|---|
| CCAFS | Climate Change Agriculture and Food Security |
| CGIAR | Consultative Group on International Agricultural Research |
| FAO | Food and Agricultural Organization |
| GHG: | Greenhouse gases |
| SDG | Sustainable Development Goal |
| UN | United Nations |
| USGCRP | United States Global Change Research Program |

## Introduction

Global warming is reported to have far reaching and multifaceted effects on the earth as a planet (Bajwa et al., 2021). Once considered an issue for a distant future it has moved firmly into the present. This has been evidenced by a rise in atmospheric and ocean temperatures, changing precipitation patterns, rising sea levels, oceans becoming more acidic, and increased frequency and intensity of some extreme whether events (Grossman, 2018). The phenomenon has been caused exclusively by human beings (USGCRP, 2017). The emission of greenhouse gases (GHG) which move about in the atmosphere and absorb

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terrestrial radiation that leaves the earth's surface, trapping the heat underneath has been the main cause of global warming. High concentration of GHGs cause an increase in the earth's absorption energy and the resulting increase in temperature is referred to as global warming (Grossman, 2018). Although global warming and climate change are used interchangeably, they refer to different phenomena. Climate change is the manifestation of the changes in earth's temperature, humidity, air pressure, wind, clouds and precipitation patterns over time. Global warming on the other hand is a contributing factor to climate change and it specifically refers to the effect of GHG on earth's temperature.

The recent climate changes have been attributed to marked rise in GHG emissions, particularly of carbon dioxide ($CO_2$), due to human activities. Available information states that $CO_2$ concentration has increased from 280 parts per million by volume (ppmv) to 402.2 ± 2.8 ppmv since 1750s (Li et al., 2020), mainly due to use of fossil fuel and large scale deforestation. Plants through photosynthesis sequester atmospheric $CO_2$ and convert it as biomass in different parts of plant and soil organic matter (Zaki et al., 2018).

Agriculture faces daunting challenges in the coming decades due to climate change. The 17 sustainable development goals of the United Nations call for action by all countries to end poverty and hunger, improve health and education, reduce inequality and spur economic growth while tackling climate change and working to preserve the planet's resources (United Nations, 2015). Agricultural production will have to be increased to sustain the increasing population particularly in sub-Saharan Africa. Smallholder agriculture remains crucial for sustainable development and achievement of the Sustainable Development Goals (SDGs) (Herraro et al., 2017). Reports have indicated that at least 30% of many food commodities in Africa and Asia are produced on farms that are 2 ha and less and 60-75% is produced on farms less than 20 ha (Ricciardi et al., 2018). Climate trends over the last several decades have been affecting agriculture. For instant negative production trends have been noticed in wheat and maize production in many regions (Porter et al., 2014), though high altitude regions have benefitted from the warming trends by experiencing increased yields. Temperature shifts are likely to change the distribution and productivity of major cash crops such as coffee and cocoa in some tropical regions (Schroth et al., 2016). Climate change impact projections in livestock systems and fisheries show that forage availability in some regions will experience a drastic reduction both in yield and quality (Barange et al., 2014).

As climate change continues to take toll on agriculture, farmers are increasingly opting for alternative farming methods that are more profitable and resilient to unpredictable weather patterns. There has been an overall reduction of undernourishment and improved nutrition levels although substantial regional differences exist. However, the last 3 years have seen a rise in world hunger after prolonged decline (FAO, 2018). There have been challenges in scaling up successful pilots in agricultural production (Westermann et al., 2018). As a result, though climate smart interventions exist, there is only limited evidence of overall progress in uptake in the last decade. For instance, household surveys conducted by the Consultative Group on International Agricultural Research (CGIAR) research program on Climate Change Agriculture and Food Security (CCAFS) in lower and middle income countries found limited evidence of smallholder farming changes at the scale needed to adapt to climate change and enhance food security of significant proportions of the population. On average, more than 13% of the households surveyed across five regions of the world were food insecure, with more than five hunger months per year and only 16% were intensifying production in some way (Thornton et al., 2018). This scenario calls for a paradigm shift in the selection of the crops to be grown in order to mitigate the effects of climate change.

Agricultural sector is normally dominated by smallholder farming and rain-fed food production systems that are facing increasing challenges from land degradation and declining soil fertility (Mango et al., 2018). In most cases the staple crop such as maize is the one grown regardless of land suitability. Mango et al. (2018) further stated that due to increased cases of malnutrition and food insecurity in the wake of climate change, the government of Malawi has in the past few years intensified extension efforts for crop diversification. This is a scenario that needs to be replicated in other countries.

The outbreak of the Corona virus disease in 2019 (COVID-19) pandemic caused extraordinary disruption to the global food distribution system (Benton, 2020). Small farms have been claimed to contribute to food and nutritional security, not only in the Global South but even at local and regional levels in largely industrialized regions such as Europe (Printezis et al., 2019).

According to TechnoServe (2020) report, farming families need support in order to safeguard their incomes, food security and health so that they emerge from the COVID-19 crisis in a position to participate in the economic recovery. Much of the early focus on the impacts of the disease has been centered on densely populated urban areas but the pandemic is also creating major disruptions in smallholder farming communities. Weber and Reichelt-Zolho (2020) reported that biodiversity and sustainable agriculture ensure nutrition of societies and also provide better protection against the outbreak of pandemics.

A plant that could be considered as a possible candidate in the face of climate change is the mulberry (*Morus* spp.). This is a flowering plant in the Moraceae family that is found growing wild and under cultivation in many temperate and tropical world regions. It is regarded as a unique plant on this earth due to its broader geological distribution across the continents, ability to be cultivated in different forms, multiple uses of leaf foliage and its positive impact in environmental safety approaches such as ecorestoration of degraded lands, bioremediation of polluted sites, conservation of water, prevention of soil erosion, and improvement of air quality by carbon sequestrating (Gulab et al., 2020). There are about 68 species of the genus *Morus*, and the majority of them occur in Asia (Datta, 2000). The most popular species in the world are *M. alba* and *M. indica*.. These have been the subject of intensive selection from open pollination, controlled hybridization and selection and mutation breeding in several countries (de Almeida and Fonseca, 2000). The synonyms for *M. alba* are; *M. tatarica* L., *M. pumila* Balb.; *M. multicaulis* Perr. and *M. serrata* Wall. The genus *Morus* is a rich source of phenolic compounds, including flavonoids and anthocyanins of great biological, pharmacological and structural interest because of their antioxidant properties (Kumar and Chauhan, 2008). Traditionally, the species are used for the prevention of liver and kidney diseases, joint damage and anti-aging, due to their antioxidant properties (Mena et al., 2016). In addition, it has been shown to be an ally in the treatment of type 2 diabetes mellitus (DM2) due to its hypoglycemic effects (Sanchez-Salcedo et al., 2017).

There are 24 *Morus* species and at least 100 varieties of known subspecies that adapt to varying climatic, topographical and soil conditions which stand out due to the presence of compounds considered as nutraceuticals, since they provide health benefits and act in the treatment of diseases (Ercisli and Orhan, 2006). The most common species are *M. alba* (white mulberry) and *M. nigra* (black mulberry) (Ercisli and Orhan, 2006; Imran et al., 2010). Scientific evidence further suggests that the anthocyanins and flavonoids present in the fruit of *M. nigra* have anticeptive and antibacterial activities against microorganisms such as *Escherichia coli, Pseudomonas aeruginosa* and *Staphylococcus aureus*. The species *Morus* has promising potential for medicinal products more than other medicinal plants (Elisana et al., 2019). Kumar and Chauhan (2008) reported that mulberry is the most medicinally important plant. The white mulberry (*M. alba*) is known as the primary food source for silk worms and is widely used in China for that purpose. This can be extended to other countries for use by smallholder farmers.

Several studies have examined the possibility of this plant for direct browsing by cattle in Italy (FAO, 1993), in France and in Japan (Kitahara, 1999). Although the results have been promising, a great deal of work will need to be done before the plant is incorporated into the grazing systems on a large scale (FAO, 1999). Although the mulberry country summary, use and research around the world (Table 1) is well known, no data is available as to the plant's use specifically for alleviating the vagaries of global warming. There is a need for a programme that can serve as a source of reliable information for farmers who are exposed to a great deal of false information as suggested by TechnoServe (2020). Though mulberry is a plant with multiple uses; as a food source, medicinal plant, fodder and timber among its many uses, its incorporation into the smallholder farming system is still minimal due to constrains related to a lack of sensitization of the smallholder farmers on the said uses. A major gap in addressing farmer recovery in the post COVID 19 era is that there has no focus on economic development endeavors that incorporate messaging about healthy behaviors in their training sessions as espoused by TechnoServe (2020). Though crop diversification has been touted as able to contribute to household food security (Mango et al., 2018) it has not received the attention that it ought to be given.

**Table 1. Country summary of mulberry area (1000 $ha^{-1}$), its usages, and research purposes (FAO, 1999).**

| | Country | Area | Utilization | | | | Research | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Silk | Fruit | Forage | Other* | Agr. | Breed. | Feed |
| AFRICA | Egypt and Tunisia | n.a.** | Ö | Ö | | | Ö | | |
| | Ethiopia | n.a. | Ö | | | | Ö | | |
| | Kenya | n.a. | Ö | | Ö | | Ö | | Ö |
| | Madagascar | n.a. | Ö | | | | Ö | | |
| | Tanzania | n.a. | | | Ö | | | | Ö |
| AMERICAS | Argentina and Bolivia | n.a. | | | | Ö[1] | | | |
| | Brazil | 38 | Ö | | Ö | | Ö | Ö | Ö |
| | Colombia | n.a. | Ö | | Ö | | Ö | | |
| | Costa Rica | n.a. | | | Ö | | Ö | | Ö |
| | Cuba | < 1 | | | Ö | | Ö | | Ö |
| | Dominican Rep. | < 1 | | | Ö | | | | |
| | El Salvador | < 1 | | | Ö | | | | Ö |
| | Guatemala | n.a. | | | Ö | | | | Ö |
| | Honduras and Panama | < 1 | | | Ö | | | | |
| | Mexico | < 1 | Ö | Ö | Ö | Ö[1] | Ö | | Ö |
| | Panama | < 1 | | | Ö | | | | |
| | Peru | n.a. | | | | Ö[1] | | | |
| | Saint Vincent | < 1 | | | Ö | | | | |
| | United States | n.a. | | | | Ö[1] | | | Ö |

| | Country | Area | Utilization | | | | Research | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Silk | Fruit | Forage | Other* | Agr. | Breed. | Feed |
| ASIA | Afghanistan | n.a. | | | Ö | | | | |
| | China | 626 | Ö | | | Ö[2] | Ö | Ö | |
| | India | 280 | Ö | | Ö | Ö[3] | Ö | Ö | Ö |
| | Indonesia | n.a. | Ö | | | | | | |
| | Japan | n.a. | Ö | Ö | Ö | Ö[2] | Ö | Ö | Ö |
| | Korea | n.a. | Ö | | Ö | | Ö | Ö | |
| | Kyrgyzstan | n.a. | Ö | Ö | | | Ö | | |
| | Malaysia | n.a. | Ö | | | | Ö | | |
| | Pakistan | n.a. | Ö | | Ö | | Ö | | |
| | Philippines | n.a. | Ö | | | | Ö | | |
| | Syrian Arab Republic and Turkey | n.a. | | Ö | | | | | |
| | Tajikistan | n.a. | Ö | | | | Ö | | |
| | Turkmenistan | n.a. | Ö | Ö | | | Ö | | |
| | Viet Nam | n.a. | Ö | | Ö | | Ö | Ö | |
| | Uzbekistan | n.a. | Ö | | | | Ö | | |
| EUROPE | Bulgaria | n.a. | | | | | Ö | | |
| | France | n.a. | | | Ö | Ö[1] | Ö | | Ö |
| | Greece | n.a. | | | | Ö[1] | | | |
| | Italy | n.a. | | | | Ö[1] | Ö | | Ö |
| | Poland | n.a. | | | | | Ö | | |
| | Spain | n.a. | | | | Ö[2] | | | |

* Other uses: [1]Landscaping and gardening; [2]Medicinal and infusion;
[3] Handicrafts and cabinet work ** n.a. data not available

The rationale for addressing the suitability of mulberry for integration into the farming system for the mitigation of climate change is that this tree is known to have a multiplicity of uses ranging from pharmacological to livestock feed and human nutrition. Since economies and food systems are likely to be disrupted for a period of time after the initial health crisis passes, farming families will continue to face risks to their food security and nutrition. Mango et al. (2018) in their studies concluded that crop diversification is one viable option in smallholder farming that can ensure establishment of resilient agricultural systems that can contribute significantly to household food security.

This paper reviews the potential of mulberry as a game changer in the socioeconomic fortunes of the farming in the context of the dynamics of the farming system in changing climatic patterns. The review question is anchored on the suitability of mulberry for climate change mitigation.

### *Potential of mulberry for climate change mitigation*

This plant is a source of timber, fuel wood, fodder, food, drinks, medicines, constituent of cosmetics among other uses (Dimobe et al., 2018). It is a widespread and important plant that is used as silkworm feed, fruit, timber and an amenity tree. Due to its broad geographical distribution, ability to be cultivated in different forms, multiple uses of leaf foliage and its positive impact on the environment, it is regarded as a unique plant on earth (Rohela et al., 2020). When grown in regions where soil fertility is high, the plant is able to withstand disease attack. It has been reported that *Cercospora* leaf spot, a devastating disease in many plants and also in mulberry can be suppressed with as little as 200 kg $ha^{-1}$ of nitrogen nutrition (Mutebi and Davin, 2021; Mutebi et al., 2021a, b).

Mulberry is known to be a fast growing shrub that has been explored in pharmacy, livestock feed, and fresh and processed fruit consumption (Sasmita *et al.*, 2019). It can be incorporated in the farming system as an agroforestry plant. The agroforestry system that incorporates the mulberry would be a suitable alternative farming practice as agroforestry is known to be an excellent tool for mitigating climate change (Mosquera-Losada et al., 2017). Multipurpose trees such as mulberry can make a significant contribution to agricultural systems by improving soil fertility and providing a variety of useful products.

Studies with mulberry genotypes have revealed that several of them display higher leaf yield that can be attributed to minimal plasticity in foliar gas exchange traits and better quantitative growth characteristics under low water regimes. The genotypes tolerate drought stress because they have superior osmoprotectant mechanisms under water limited growth regimes that is a biochemical response. The plant is highly capable of resisting drought and other natural hazards (Wani et al., 2017). It has been known to grow in arid and semi-arid areas with less than 300 mm annual rainfall. This has been as a result of natural and artificial selection of mulberry ecotypes. Ji et al. (2004) reported that under drought stress the net photosynthetic rate and water use efficiency (WUE) of the mulberry leaves declined. Table 2 compares *M. alba* with other candidate plants suitable for mitigation of climate change.

**Table 2.** Comparative transpiration coefficient of mulberry and other drought tolerant species (Hu and Zhou, 2010).

| Tree | | Novel characteristics | | | |
|---|---|---|---|---|---|
| **Common name** | **Scientific name** | **Transpiration coefficient** | **Root system** | **Uses** | **Ref.** |
| Mulberry | *Morus alba* L. | 350-450 | Tap rooted | Sericulture, fodder, food, medicinal, timber, landscaping | (Sánchez, 2002; Lui et al., 2004; Hu and Zhou, 2010; Rohela et al., 2020) |
| Conebush | *Petrophile diversifolia* R.Br. | 300 | Fibrous root system | Ornamental | (Rowell, 1991) |
| Coneflower | *Echinacea angustifolia* de Candolle | 383 | Fibrous root system | Ornamental | (Rowell, 1991) |
| Seabuck thorn | *Hippophae rhamnoides* Linnaeus | 483 | Cluster roots | Medicinal | (WebMD, 2005) |
| Poplar | *Populus deltoids* Marshal | 513 | Tap root | Paper manufacture, timber | (Eckenwalder, 2001) |

### *Potential of white mulberry as a nutraceutical crop*

According to Munir et al. (2018), *M. alba* frequently known as white mulberry is considered as a medicinal and aromatic plant that contains a wide range of essential oils rich in phenolic and a large variety of biologically active compounds that are used for the treatment of many diseases including cancer. It is a good source of vitamins C, K1, E and minerals. It provides excellent material for preparation of desserts, dairy product, shakes, tea and also used for preparation of beverages. Muni et al. (2018) further reported that it also deals with respiratory disorders, fever and colds. This is therefore a plant that strengthens the body to withstand COVID attack.

Faseeha and Sadia (2020) reported that it is mandatory to attain and maintain good nutritional status to fight against COVID 19. Optimal nutrition and dietary nutrient intake impact the immune system, therefore the only sustainable way to survive in current context is to strengthen the immune system. Mulberry is able to not only act as a medicinal option in the fight against the disease but also as a source of the required nutrition for the body.

It can be suggested that mulberry is a more superior candidate for mitigation of climate change basing on its multiplicity of uses. It can help alleviate poverty at farm level. Table 3 compares the WUE of mulberry with other plants that are important in climate change mitigation. It can be observed that mulberry has the highest WUE suggesting that it produces more with the same water quantity as compared to the other plants.

**Table 3.** Comparison of water use efficiency of mulberry and other plants important in climate change mitigation

| Tree | | Water use efficiency | Ref |
|---|---|---|---|
| **Common name** | **Scientific name** | | |
| Mulberry | *Morus alba* L. | 48.99 | (Rajaram and Qadri, 2014) |
| Coneflower | *Echinacea angustifolia* de Candolle | 13.00 | (Pinto et al., 2008) |
| Seabuck thorn | *Hippophae rhamnoides* Linnaeus | 7.57 | (Ahani et al. (2015); Hamid et al., 2014) |
| Poplar | *Populus deltoids* Marshal | 40.00 | (Liang et al., 2006) |

The mulberry plant has a strong role in soil erosion control (Wani et al., 2017). It has a strong root system that is crossed with a dense network that anchors soil. A mulberry plantation can suppress sand storms and conserve water and soil. Wani et al. (2017) reported that the shear strength of the soil was increased from 75.2 kPa to 138.4 kPa while soil layer was deepened from 0-10 cm to 30-40 cm in mulberry field. Mulberry is considered a candidate for water and soil conservation and management of ecological environment (Wani et al., 2017). Jian et al. (2013) has stated that mulberry have wide geographical distribution with abundant ecological type based on a long time natural selection. These plants are shade resistant that can adapt and grow in many areas from 0 – 3300 meters above sea level and in a wide variety of soils (Sasmita et al., 2019).

Despite the fact that mulberry has important uses and grows in natural forests and forest plantations, little attention has been paid to investigate its agroforestry role as a way to mitigate climate change.

In America, mulberry is an important urban vegetation that directly helps to improve air quality (Nowak, 2002). It acts as a good carbon sink. It is ideal in landscaping due to it form, leaf colour, growth vigour, tenacity and resistance. Its leaves have the capacity to absorb air pollutants such as methane, chlorine and sulfur dioxide. Mulberry embankment reduces air temperature and increases humidity (Liu et al., 2004). Apart from economic importance, mulberry can also play a role in mitigate greenhouse gases (Bajwa et al., 2021). Photosynthetic carbon sink of mulberry has been found to be greater compared to the total carbon emission which indicates a beneficial effect for the environment (Li et al., 2020).

A major constraint to animal production, and which is bound to escalate as climate change takes effect, is scarcity and fluctuation of quantity and quality of year round feed supply. This is particularly a serious problem in developing countries. Traditional agro pastoral systems have undergone a reshaping and are now called upon to confront the challenges facing their future (Farinella et al., 2017). For example, animal feed shortage will be overcome by use of tree leaves and soft branches to feed livestock. Mulberry stands to be a candidate for this as studies have shown that it has high leaf protein content of up to 100-180 g $kg^{-1}$ (Mosquera-Losada et al., 2017). Mulberry trees are known as a feed material in India and Japan but not much is known in many other countries. This knowledge gap will have to be addressed in a participatory approach that will involve the farmers and the technology developers and disseminators. Its leaves and young bark are recognized as excellent animal feed and are used as a by-product. The interest in mulberry as a purpose-grown fodder for larger livestock has developed in recent years (Sánchez, 2002).

Many tropical and subtropical regions are beset by increasing human presence amidst climate change dynamics. This calls for exploitation of resources that can withstand this increasingly dynamic trend. The mulberry fruit is rich in nutrition and complete with all nutritional indexes significantly higher than other common fruits (Wani et al., 2017). Mulberry seeds are rich in fatty oils ranging from 25% to 32%. The oil is mainly linolenic and oleic acid, both with broad perspective for development and utilization.

### *Potential of mulberry in post COVID 19 smallholder farmer recovery and resilience*

According to a report by TechnoServe (2020), the COVID 19 pandemic will cause a global recession with the World Bank estimating that an additional 40-60 million pushed to extreme poverty. This economic crisis will put pressure on food and agricultural systems in developing countries with the direct implications for the incomes of women and men smallholders. The demand for many crops will shift and the prices paid to farmers will be volatile. Since the mulberry fruit is good for the body with various medicinal aspects such as nourishing the liver and kidney, alleviating rheumatism, promoting saliva generation, promoting transformation of lymphocytes and boosting the immune system (Wani et al., 2017), with its multipurpose nature can be key in aiding farm households to keep their agricultural businesses afloat during the crisis and in a position to participate in the recovery and limiting the long-term consensus of the shock to agricultural value chains.

### *Priority of mulberry over other plants during climate change and COVID 19*

Gulab et al. (2020) summarized the qualities of mulberry that make it stand out as having priority over other plants by stating that it is a unique plant on this earth due to its broader geological distribution, ability to be cultivated in different forms, multiplicity of uses, positive environmental impact, medicinal and food uses, use in sericulture, industrial uses for paper making, and cosmetics. In a study by Durgadevi and Vijayalakshmi (2020) the drought tolerant genotypes of mulberry recorded maximum increase in WUE by maintaining higher photosynthetic rate and transpiration rate under severe water stress. This results qualifies the mulberry further as a plant of choice that can withstand the vagaries of weather as experienced in the case of climate change.

All these characteristics make mulberry to be a plant with priority over others for the purpose of building the resilience of smallholder farmers during climate change and COVID 19 as it provides a safety net for sustained income at farm level, personal nutrition and medicinal use that are all too important for strengthening the body in the face of the disease.

## Conclusion

It can be concluded that the resilience of mulberry against drought, its multipurpose nature as food, animal feed, and medicinal plant and the extent of its effect on the environment gives mulberry priority as a plant that could be incorporated into the farming system as a cushion against the effects of climate change on the conventional crops. It is a plant that is suitable for building the resilience of smallholder farmers against climate change and COVID 19 Pandemic.

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## Conflict of Interest

The author indicates no conflict of interest in this work.

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