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Industrial, Carbon Sequestration and Climate Change Mitigation Potentials of Bamboo

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Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

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ABSTRACT

Bamboo is an exceptional ancillary for timbers. It has more than 150 years history as indicated in different scientific investigations. Bamboo is a perennial plant, highest yielding, the fastest growing and renewable natural resource. Global climate change has been identified as the most important environmental, economic and social challenge faced by humankind. Greenhouse gases (GHG) in the earth's atmosphere is increasing and causing climate change. Numerous researchers, policy makers and scientists are trying their best to decrease this greenhouse gases, especially carbon dioxide (CO2) from the earth atmosphere. Bamboo is frequently encouraged as an ideal renewable resource for biomass, valuable for wood and paper industry. Bamboo is source of income in rewarding the diverse requirements of smallholder's farmers in rural areas and has great potential in sequestering carbon and climate change mitigation. Therefore, promoting bamboo farming systems in smallholder farmers to reduce greenhouse gas in atmosphere and expanding bamboo forests in future under wider use and intensive management is suggested. This study provides a brief overview about bamboo potentials as; industrial benefits, carbon sequestration, soil erosion control, water and soil conservation and climate change mitigation.

Keywords: Bamboo; industrial; carbon sequestration; climate change mitigation.

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1. INTRODUCTION

Bamboo is an excellent substitute resource to timber, it is not tree; however, it is a grass of Gramineae family. It is estimated that about or 3.2% (37 million hectares) total forest area of the world's, is made up of bamboos, one of the world's most valuable and important non wood forest products and a large subfamily of the grasses [1]. Global bamboo trade in is expected to contribute to development in bamboo growing areas and currently contributes about 4-7% of the total tropical and subtropical timber trade [2].Ethiopia has an estimated one million hectares of natural bamboo forest, the largest in the African continent [3-5]. The country has an estimated one million hectares of natural bamboo forest, 7% of the world total and 67% of the African total [3,6,7]. Mitigation, Adaptation and Development (MAD) needs study in addressing the concurrent needs of mitigation to the effects of climate change and interaction between all natural systems and people to determine how natural systems can be better utilized [9].

Global climate change mitigation has recently received attention of researchers, scientists, policy makers and resource leaders. The Intergovernmental panel on climate change [10] has promoted climate change mitigation and adaptation strategies; in order to face climate change challenges. Bamboo has the great potential to store carbon and reduce carbon from the atmosphere and mitigate climate change [11-15]. Numerous studies estimated that there are more than 1200 bamboo species beneath the 87 genera of bamboo [16].

Among the numerous uses of bamboo are: large carbon sequestration potentials, climate change and poverty alleviation, enormous geographic distribution and it were used by billions of people every day [9,17-19], it has huge effect on rural incomes and bamboos are utilized in construction of rural houses and traditional crafts [20]. According to the study by Ram et al. [16] and Tariyal et al. [21], bamboo is cheap and plentiful resource and emerged as a precious wood in the last 15–20 years to meet the vast needs of the human population and frequently known as poor man's timber. Most previous studies of bamboo focused on its utilization of bamboo [22,23], Biochar for environmental management [24], improved goat production when used as a feed additive [25]; reduces greenhouse gases emissions such as methane and nitrous oxide from the soil [24,26]. This means that bamboo biochar is a potential carbon sink and that creating bamboo biochar can effectively store large quantities of carbon. Bamboo forests have multi-dimensional importance and provide products that contribute to rural livelihood, poverty reduction, and income diversification [27-29]. Bamboo is not considered significant non-timber forest products (NTFP) and underutilized in Ethiopia. The objective of this study was to review bamboo potentials in industrial application, sequestering carbon and mitigate to climate change.

2. BAMBOO DISTRIBUTION AND GROWTH

According to International Network for Bamboo and Rattan Strategy, INBAR [30], bamboo is widely distributed between 40° southern and northern latitude on all continents and grown throughout the world and it an important natural resource for hundreds of millions of people across the globe. Bamboo can grow in tropical warm climates and humid conditions required annual precipitation range (1000-2000) mm, annual mean temperature of 20℃ to 30℃ and sandy loam to loamy clay soils were preferred for bamboo growth [31]. According to the study by Aggarwal [32], Bamboo is much faster growing than other trees; growing up to 45 meter in just six weeks, occasionally it grow more than 1.2 meter per day and a ground-breaking plant that can grow in over grazed soil. Bamboo is perennial plant, surviving under the harshest of conditions, very strong plant, once established there is no need for replanting, because it substituted by new shoots emerging from the underground rhizome system [31].

3. INDUSTRIAL POTENTIALS OF BAMBOO

Recently bamboo product development and processing innovations have increased; which converted into such durable products as furniture, panel products, construction materials, and floorboards [33]. Bamboo has strong physical properties than numerous other non-timber forest product species, such as light weight, high tensile strength, and high flexibility; as a result, it can replace wood, steel, and concrete in many industrial applications and can be widely used as a building material [17]. An

abundance of bamboo and eager foreign investment made Ethiopia as leader for the bamboo industrial revolution in Africa. Ethiopia is by far the leader in terms of bamboo resource, from the 18 African countries who have joined International Network of Bamboo and Rattan (INBAR) [34]. India is the second highest producer of bamboo in the world and 45% of total production of bamboo of the Country is being utilized in paper industries [35]. Bamboo has been used in more than 1500 applications [23]. According to Boschma and Kwant, [31], bamboo is one of the greatest manageable biomass crops for materials and energy production and abundantly accessible non-timber forest product, a wide application traditionally throughout the subtropical and tropical parts of the world where bamboo substitutes for non-timber forest product. According to Lou et al. [36], bamboo is providing a number of essential ecosystem services in many agricultural and natural eco-systems. Bamboo offers food and raw materials for consumers in developed and developing countries. It can be used to reduce water erosion on slopes and along riverbanks, offering protection against storms, it regulates water flows, treat waste water windbreak in shelterbelts and bamboo buildings are usually cheaper, lighter, and more earthquake-resistant [36]. The study by Li et al. [22], quantified that bamboo fiber fabrics, used in bed sheets and clothing, providing good absorption of ultraviolet rays and good anti-bacterial properties, while also have high permeability to air and a high ability to absorb moisture. In addition, bamboo is a good material for the production of furniture, baskets, handicrafts, tools, mats, toys, fans, carvings, and musical instruments [37].

Numerous scholars reported on the industrial potential of bamboo as: (1) Bamboo in Building Industry (e.g., bamboo furniture, House, Bridges, doors and window frames, Screens and Bathtubs), (2) Bamboo Bio-energy Industry (e.g., Bamboo charcoal, Biofuel, Firewood, Gasification Plant, Briquettes and Pyrolysis), (3) Bamboo in Wood Industry (e.g., Bamboo Flooring, Particle Board, Mat Board, Laminates, Mat Corrugated Roofing Sheets, Poles, Lumber, ply bamboo and beams), (4) Bamboo Textile Industry (e.g., Undergarments, Bullet proof vests, Clothing, Socks, Blankets, Hats, Mattresses, Baby Diapers, Towels and Sheets), (5) Bamboo weaving Industry (e.g., Bags, Decorative products, furniture, Light fixtures, Bamboo packaging and Bamboo Caskets), (6) Bamboo Food and Beverage Industry (e.g., Charcoal Coated Peanuts, Bamboo biscuits, Tea, Wine and Shoots), (7) Bamboo in Electronic Industry (e.g., Watches, Speakers, Keyboards, Laptops, IPhone/Ipad Cases and Headphones), (8) Bamboo Farming Products Industry (e.g., Bamboo Baskets, Greenhouses, Animal Fodder, Water pipes, waterwheels, Baskets for silk worm rearing and containers), (9) Bamboo pulp and paper Industry (e.g., Coffee filters, Newspaper, Bond Paper, Tissue paper, Cement sacks and Cardboard), (10) Bamboo Consumer Industry (e.g. Bamboo cutting boards, Musical Instruments, Medicine, Toothpicks, Incense sticks, Steamers, brushes, cigarette holders and Match sticks).

4. CARBON SEQUESTRATION POTENTIALS OF BAMBOO

Carbon sequestration is the process of capturing and storing atmospheric carbon dioxide. Bamboo forests play an important role as far as carbon sequestration is concerned and consequently, included in the list of eligible afforestation and reforestation projects under the Clean Development Mechanism [38]. A bamboo has high annual re-growth after harvesting and high biomass production and has rapid growth rates [14]. Lobovikov et al. [14], confirmed that bamboos are believed to execute approximately equivalent to fast growing plantation species with an increase biomass of between 5-12 t C/ (ha•yr). According to Zhou and Jiang [39], bamboo's fast growth, the annual carbon fixation of the tree layer in a Moso bamboo forest was 5.10 t ha–1 which was 1.33 times the value for a tropical mountain rain forest and 0.94 times at 12 years old in Huitong County and 1.41 times the value for Chinese fir (*Cunninghamia lanceolata*) at 5 years old [40]. This high annual rate of carbon accumulation means that the bamboo forest is one of the most efficient types of forest vegetation for carbon fixation. According to Aggarwal [32], bamboo is effective agro-forest CO2 sink with high carbon sequestration rate as 47% amounting to 12-17 tCO2 per hectare per annum and generates 35% more oxygen than other timber species and therefore, bamboo has hypothesized as high capacity of sequestering carbon that is similar to that of fast growing forests. Bamboo forest have similar characteristics with other types of forest in terms of their role in the sequester carbon through photosynthesis, and lock carbon in the soil and fibre of bamboo [36]. The use agro-forestry systems across the world have been ranked in carbon sequestration, whereas bamboos in

specific remain unexplored [41]. The importance of bamboo plantation and bamboo forests in sequestering carbon is probably the least considered, thus very few evidence is available concerning the potential use of bamboos as carbon sinks and carbon storage [42]. The numerous research reports by Tariyal et al. [21], Scurlock et al. [43], and Choudhary [44], revealed that bamboo can absorb 12 metric tons of harmful carbon dioxide per hectare from the earth's atmosphere and two times (2x) higher than that of general similar size forest. Bamboo is fastest growing and can be important as a sink of atmospheric carbon [21,45,46].

The study report by Lou et al. [36], confirmed the comparative analysis of carbon sequestration between a fast growing Chinese Fir plantation and monopodial Moso bamboo plantation modeled for subtropical growing conditions in South East China and the results showed that, bamboo sequestered more carbon than the Chinese Fir in the first 5 years. The research report on the whole ecosystem, including the soil and Moso bamboo forest ecosystem carbon storage capacity was reported to be between 102 tC/ha and 289 tC/ha, of which 19-33% was stored within the bamboo culms and vegetative layer and 67-81% stored within the soil layer (rhizomes, roots and soil carbon) and thus, the soil layer carbon content is likely to be about 2-4 times greater than the vegetative layer [36].

5. CLIMATE CHANGE MITIGATION POTENTIALS OF BAMBOO

Bamboo grows more rapidly than any trees and starts to yield within three or four years of planting. So, bamboo is one of the fast growing and responding well against drought which can make the species more acceptable in making ever green environment in addition to soil and water conservation, and rehabilitation of degraded lands [47]. Climate change is among the most challenging economic, environmental and social issue in the worldwide [48]. Climate change is unequivocal to be considered as one of the most threats facing humankind; with evidence from increases in average ocean and air temperatures, sea level rise, melting of ice and snow [49]. The international conference on climate change, COP 21, has started with the aim of keeping global warming below 2℃. International Network of Bamboo and Rattan (INBAR) group tried their best to show case the possibilities of bamboo as an answer to deforestation and climate change to country leaders worldwide [50]. Bamboo's fastest growing is one of its numerous aspects which make it an advantageous resource for mankind [36]. Bamboo is commonly realized as a high potential to capture and sequester atmospheric carbon and subsequently mitigate climate change, in a similar way that other tree species do [36]. Bamboo has a great potential for climate change mitigation and adaptation [14,51-54]. According to a recent report by Nath et al. [55], role of bamboo in climate change adaptation and mitigation and noteworthy contribution in social, economic aspect of rural life and numerous other environmental services, woody bamboos warrant serious consideration for carbon farming and carbon trading. Generally, bamboo could fill an important niche in climate change mitigation, adaptation and sustainable development [14]. Therefore, bamboos have multipurpose uses like *Moringa oleifera* as stated by Daba. [56], fast growing and well adapted to growing in adverse climate conditions, play an important role in soil and water conservation, industrial benefit, sequestering carbon and mitigating to climate change.

6. CONCLUSION

This study has tried to reviews the potential of bamboos in terms of industrial, carbon sequestration and climate change mitigation. Bamboo is the most significant non-timber forest products (NTFPs) since; it is cheap, efficient, adapted in wide range of environment, fast growing, high potential for environmental protection and superior wood substitute. Numerous scholars suggested that bamboo plantation and bamboo forest ecosystems can be providing significant services for human adaptation and development, simultaneously mitigate climate change compared with other types of forests, Through carbon sequestration different bamboo species possess higher potential contribution to climate change mitigation.

Numerous scholars reported on the industrial potential of bamboo as: Bamboo in Building Industry, Bamboo Bio-energy Industry, Bamboo in Wood Industry, Bamboo Textile Industry, Bamboo weaving Industry, Bamboo Food and Beverage Industry, Bamboo in Electronic Industry, Bamboo Farming Products Industry, Bamboo pulp and paper Industry and Bamboo Consumer Industry. Developing countries like Ethiopia is aiming for improved wellbeing and faster rate of growth, therefore, need to promote

bamboo cultivation and preserve their remnant bamboo forests. It is recommended that bamboo is an exceptional pro poor resource, particularly in areas with inadequate off-farm income opportunities and offers very interesting opportunities for smallholder farmers.

Therefore, converting degraded land, shrub and agricultural fields, pasture lands into forested land, with bamboo plantation, which has relatively low levels of carbon and can hold more carbon in the plants, soils and consequently more atmospheric carbon dioxide (CO2) could potentially be sequestered in terrestrial ecosystems. The promotion and expansion of bamboo cultivation and bamboo forest managements can support economic and environmental development, mitigate climate change and restore degraded lands and prevent soil erosion. Government, policy makers and investigators should therefore, promote bamboo plantations and preserve natural bamboo forests for sustainable development.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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