Review Article

Does Arid Land Agroforestry Contribute to Achieving the Saudi Green Initiative Goals? A Review

Abstract:

Aims: Most of the land area of Saudi Arabia is either arid or hyper-arid. In the past decades, many efforts have been exerted to increase the green cover in Saudi Arabia, the most recent of which is the Saudi Green Initiative (S.G.I.), launched in 2021. S.G.I.'s main objectives are to increase the green land surface area and decrease carbon emissions. In this paper, the role of dryland agroforestry in mitigating the effects of climate change was reviewed, and its contribution to fulfilling S.G.I. was discussed.

Methodology: Previously published literature, scholarly research articles, and conference proceeding papers, on agroforestry systems (A.F.S), carbon sequestration and nutrient dynamics under A.F.S over the past 34 years were critically reviewed, examined, and analysed to find various applications of AFS for climate change mitigation and carbon sinks with focus on arid land.

Results: Forests are a vital source for climate change mitigation and adaptation and play a vital role as carbon sinks. A.F.S, eco-friendly and environmentally viable land use and management, provide immense potential to sequester carbon (C). A.F.S. is a reliable tool for increasing C sequestration. As a result of the worth granted to non-timber products, the application of A.F.S. could likewise reduce C emissions to the air by reducing the odds of concrete cutting of trees. Moreover, tree components are a C addition source to the soil through root and leaf litterfall decomposition.

Conclusion: In the perspective of the high threat facing humanity paused the climate variability and climate change, many nations and countries have taken various measures to tackle it which included protecting natural forests, afforestation, managed the natural regeneration of green cover. A.F.S leads to better land-use efficiency, increases the green cover, and thus helps in mitigating climate change.

Keywords: Managed natural regeneration, Climate change mitigation, Agroforestry

Comment [MS1]: source of C for the soil by mean of root and leaves decomposition,

Comment [MS2]: stored more C in the soil

1. INTRODUCTION

Arid lands are tremendously variable concerning land arrangements and fauna, flora, soil structures, water balance, and human occupations. In all arid land, the key element is "aridity", which indicates the dryness of the zone. Thus, arid areas are considered part of drylands with extreme edapho-climatic conditions. The main distinctive feature of the arid land is the low and uncertain rainfall (less than 500mm per annum or Aridity Index of 0.05 -0.2 with more than 50% inter-annual variability in the arid areas of the world, dryness recurrence, and different combinations in vegetation cover and soils 2[1]. In addition, tremendous whirlwind and solar systems surge the effect of rainfall uncertainty, and the all-composite generates a fragile ecosystem in which little agitations may produce a high loss to sustainability, sometimes that are irrevocable 3[2].

The main economic, social, and environmental concerns worldwide are land degradation and desertification. Characterized by water scarcity, arid lands are mainly at risk of land degradation. They are severely vulnerable to the erosion caused by wind velocity, overgrazing of open grasslands, Logging and Mining with insufficient vegetation cover. Mainly dominated by shrublands and deserts, drylands are regularly affected by non-sustainable and non-controlled land practices. Besides these, the exponential growth rate of the population and urbanization promote land degradation and worsen the existing situation of desertification. Organic matter is almost absent in dryland degraded soils; also, they are weak and easily winds-swept, causing dust and sandstorms. Winds transport the fragile soil in the form of fine, small, and large-sized particles, which, when obstacles stop them, form dunes4[3]. When shifting continuously, this movement of dunes is called "Sand Encroachment" or "Sand Movement", which is very hard to control and stabilize and has rising risks to farmlands and pastures.

According to an estimation from the United Nations Convention to Combat Desertification, drylands cover over 34.9% of the Earth's surface (Figure 01)5[4], beside which arid lands are estimated at 18.8%6[5]. With a low richness of woody species and sparse vegetation, arid areas are relatively found on all continents around the globe (Table 01). Africa represents the largest of the world's arid zones with a total area of 46.1%, followed by Asia (35.5%)2[1].

Table 01: **Extent of Arid and Semi-arid Area's superficies in different continents**

Continent	**Area (10^6 ha)**	**Percentage**
Africa	1175.5	46.1
Asia	903.0	35.5
Australia	303.0	11.9
Europe	11.0	0.4
North America	84.6	3.3
South America	70.2	2.8
Total	2547.3	100.0

Source: (Sharma, 2002)

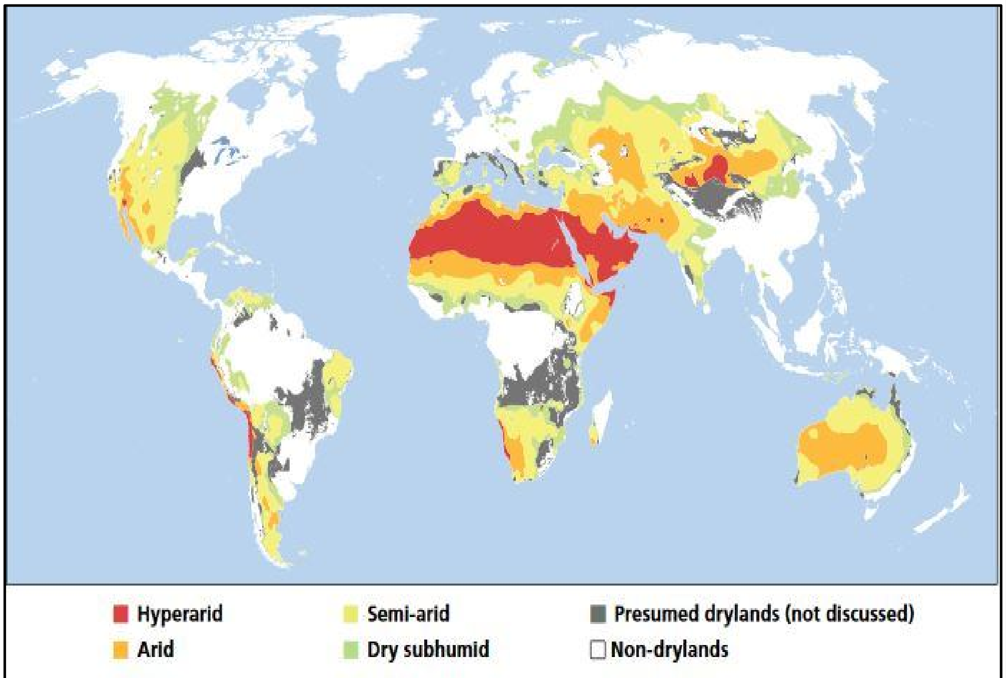

Figure 01: Global distribution of the arid and semi-arid regions 5[4]

In North America, drylands are found in the southern part of the U.S. and Mexico, while in South America, they are found in Brazil, Argentina, and Chile. With 70% of its area classified as dry or semi-arid7[6], Australia is considered the second world's driest inhabited continent. In Europe, no studies have established soil assemblages typical of arid regions8[7]; meanwhile, evidence has proven the existence of semi-arid lands in some European countries such as Greece, Spain, Portugal, and Italy. Significant parts of Sahara Africa with Ethiopia and Namibia are arid zones. Dry areas are found in parts of the Indian subcontinent in South Asia, while Australia has vast dryland areas6[5].

In the Arab regions of the Middle East, arid, semi-arid, and dry sub-humid zones cover 90% of the land area 9[8], with some areas classified as totally arid or desert (Table 02).

Table 02: Arid and Desert Areas in the Middle East 9[8]

Country	Country Area (km2)	Arid Area	
		km^2	%
Bahrain	670	670	100*
Iraq	437,500	166,687	38.10
Jordan	89,206	71,000	79.59
Kuwait	17,818	17,818	100*
Oman	300,000	267,000	89
Palestine	21,090	8,500	40.3
Qatar	11,610	11,610	100*
Saudi Arabia	2,250,000	2,080,000	92.44
Syria	185,180	18,500	9.99
UAE	83,600	83,600	100*
Yemen	536,869	407,182	75.84
Total	3,933,543	3,132,567	79.64

**The source believes that those countries still have some productive areas of rangelands, but there is a lack of recent figures on national levels*

Consequently, arable crops, pasture lands, silvopasture, transportation networks (*i.e.,* roads and railroads), cities and villages are submerged by sand. In addition, geographical morphology also influences soil moulding, and its features, the holding capability of water, and the capability to provide nutrients are essential in drylands.

In general, the soils of arid regions are distinguished by low water retention, low nutrients, and complete volatility of minerals, and consequently, the natural fertility of such lands is low. Throughout most parts of the year, evapotranspiration far exceeds precipitation. In addition, the potential productivity of these lands is generally low. The soils are premature, coarse in texture, with low water holding capacity and poor nutrient status. Under such agroclimatic conditions, significant crop production is low, if not impossible10[9].

Concerning livelihoods systems, from general observation, there is the possibility of slight pastoral practice, whereas rainfed agriculture is not typically possible in arid areas10[9]. Vegetation in arid zones is naturally sparse and involves annual and seasonal grasses, herbaceous plants, and a limited suboptimal growing tree species. These native species have developed the capacity of adaptations that allow them to reproduce, raise and withstand such highly hostile climatic conditions. For instance, one common root adaptation in some species (*e.g.*, *Agave sisalana, Agave americana, Agave attenuata*) is developing large bulb structures that serve as underground water storage (Figure 02), which allow the plants to withstand years of drought by utilizing water stored in their bulbs11[10].

Moreover, other plants (*e.g.,Opuntia ficus-indica, Cactaceae, Ferocactuspilosus*) are characterized by their unique leaf characteristics (*i.e.,* smaller, and fewer leaves, thick waxy cuticles with fewer stomata), allowing them to lower transpiration during long periods of drought2[1]. These drastic leaf adjustments can also protect plants from being eaten by wild animals (Figure 02).

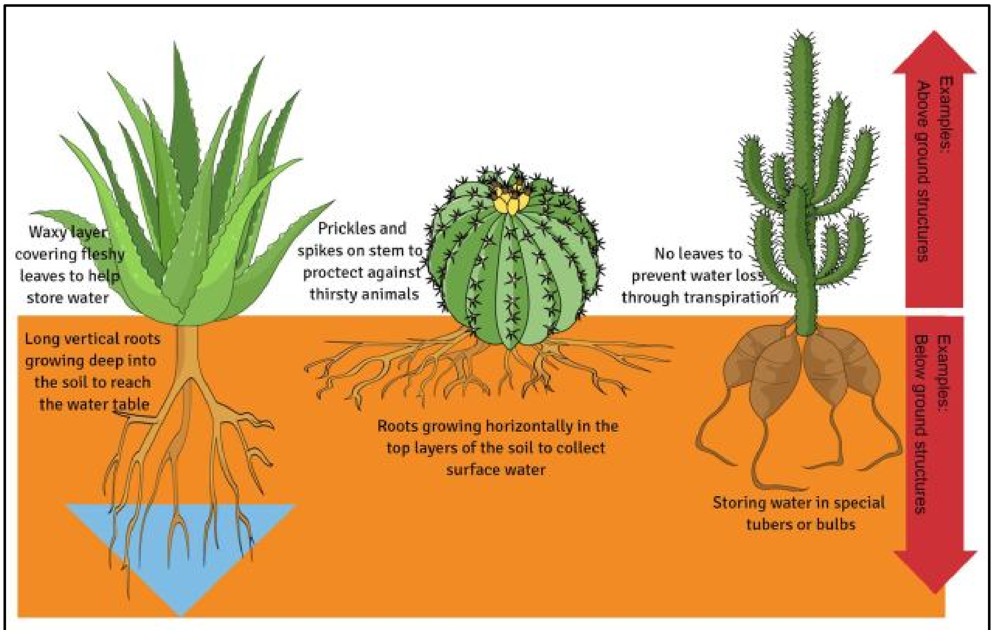

Figure 02: Structural adaptations of succulent plants to conserve and store water11~~[10]~~.

Likewise, afforestation would increase Saudi Arabia vegetation cover, reduce carbon emissions, combat pollution and land degradation. Also, it would increase the percentage of protected areas to more than 30% of its total land area, representing roughly 600,000 square kilometres, and exceed the current global target of 17%12~~[11]~~. Turning the desert to green and rehabilitating lands over the coming decades is a cornerstone of the Saudi Green Initiative.

Saudi Arabia Green Initiative

Vast regions have an arid landscape, almost the total area of Saudi Arabia, Iran, and other countries in the Middle East. Saudi Arabia is the largest country in the Arabian Peninsula, covering an area of 2.15 million km², with a diverse environment and vegetation cover 9~~[8]~~ However, most of its lands are arid and hyper-arid zones (Saudi's Ministry of Environment, Water and Agriculture, 2018).
Approximately 2.1 million hectares of woodland forests exist in Saudi Arabia's highlands, mainly isolated, steep, and inaccessible. In addition, with a natural rangeland area estimated to be 1,460,000 Km^2, 70% of these superficies are affected by desertification and/or are in a degraded condition due to the loss of shrubs and trees, overgrazing, and surface soil instability due to improper farming methods and consequent erosion13~~[12]~~.

Besides these factors, many others contribute to the loss of habitats, such as woodcutting, urbanization, pollution, or loss due to overexploitation of freshwater sources13~~[12]~~. In addition, an average total area of 11,348 ha y^{-1} is burned by wildfire14~~[13]~~. Rangeland degradation has escalated in recent years to the point that the rangelands can no longer physically withstand the demands of herders with growing cattle numbers14~~[13]~~.

The volume of wood consumed in the central region of Saudi Arabia is very high, and the damaging fuelwood collection prioritizes slow-growing woody species15[14]. Plants such as *Acacia spp*., *Haloxylonpersicum*, and *Calligonum spp*. are deliberately fallen or pulled out, drastically altering the physiognomic structure of the habitats, and decreasing plant cover16[15].

The Saudi Green Initiative (S.G.I.) which was launched in 2021 is an initiative of the highest authorities of Saudi Arabia that ambitions to champion climate action and chart a path for protecting the planet within and beyond the Kingdom's borders. With ambitious targets spanning the coming decades, the initiative aims to improve the quality of life and protect future generations by increasing reliance on clean energy, offsetting the impact of fossil fuels, and protecting the environment. The S.G.I. aims to rehabilitate over 40 million hectares of land during the coming decades and plant approximately 10 billion trees. In addition, it aims to contribute to the reduction of global carbon emissions by about 4% by 2030.

In addition, the S.G.I. includes a core component, most notably, planting 10 billion trees within the Kingdom in the upcoming decades, equivalent to rehabilitating roughly 40 million hectares of degraded lands and representing the Kingdom's contribution of more than 4% in achieving the goals of the global initiative to limit the degradation of lands and marine habitats and 1% of the global target to plant 1 trillion trees. Moreover, reforestation can improve air quality, reduce sandstorms, combat desertification, and lower temperatures in adjacent areas12[11].

While arid areas have been observed for forestry development, the focus has been on trees, hedges, and bushes management that are indigenous, exotic or both, mainly for protection goals. Nevertheless, the interest has surged in arid areas for forests and trees in recent years2[1], fuelled mainly by the loss of massive woodlands and trees from such vulnerable ecosystems in numerous nations across the globe. Moreover, to restore degraded land, conserve the natural resource, and increase the forest.

Agroforestry is a substitute land management system in such a fragile and harsh environment that can be sustainable and provide various benefits such as fuelwood, fodder needs, income source, and protect the environment simultaneously17[16]. Whilst the production of food, energy, raw materials, and cash outputs is generally emphasized, the importance of agroforestry systems, environmental advantages and sustainability cannot be neglected.

2. ARID LAND AGROFORESTRY

Agrisilviculture has significant importance in arid zones. Climate instability and the fickle nature of rainfall make cultivable farming on favourable agricultural fields increasingly risky17[16]. Agroforestry, an "informal" practice built on the notion, is an old traditional land managerial form applied and practised for millenaries worldwide10[9]. Decades ago, the concept was widely accepted internationally in the domains of land use. Several definitions describe the term, but scientists from the early 1980s have broadly employed the International Council for Research in Agroforestry (ICRAF) definition. A.F.S. is defined as the land use management system in which trees and crops or pasture are grown in the same field18[17]. The arrangement can be either in spatial arrangement or in a time sequence".

Providing a classification of Agroforestry Systems (A.F.S.) in Agrisilviculture (planting trees and crops together) and Silvopastoral (forestry and grazing together) practices, serial and synchronized systems are divided into zone and compound settlement of trees and cultures. Purposely, Agrisilviculture in arid lands provides the concerned rural population with timber and firewood; protects soil from water and wind erosion; sustains soil fertility; also supplies livestock pasture. Meanwhile, provide an additional income source that contributes to rural development19[18]. In contrast, agrosilvopastoral combines crops, animals/pasture, and trees.

A.F.S. in arid lands help to sustain soil productivity over a long period to the highest levels, compared to sole agricultural cropping; in A.F.S., leguminous trees with their nitrogen fixation capability can enhance soil fertility and add nutrients through litterfall and fine root decomposition20[19].

Most A.F.S. protect soil from many adverse effects and create sustainable land use by helping to ameliorate soil fertility in many ways. Recurrent droughts and crop failure due to the depletion of water availability are some of the characteristics of arid areas, combined with low crop yield and significant yield instability from year to year. In addition, surface and groundwater supplies may decline during drought, affecting water availability and increasing costs to access water for crop or forage irrigation and watering livestock9[8].

In combination with the poor quality of the arid land soil and its high salinity, erosion by wind, high thermic regime, and hot burning whirlwinds are among the severe problems affecting the setting up, growth, and productivity in dry zones. Shrubs and trees planted transversely across whirlwinds blow can reduce the velocity of the wind; integrating trees and shrubs in watersheds has been promoted to improve rural livelihoods and used as major fodder21[20].

The combination of trees in A.F.S. can also serve as windbreaks and shelterbelts that positively affect agricultural production. The utilization of trees as windbreaks or shelterbelts is also an old traditional measure to reduce wind velocity, particularly in commercial farming systems in regions with brisk wind. As airflow barriers, these trees significantly impact the near-ground wind field and heat; incorporating trees into an arid environment attains the same results22[21]. An example of such is the windbreak project to prevent sand encroachment in the Al-Ahsa area (1975) and the Al-Qunfudhah Governorate (2005) in Saudi Arabia23[22].

The evapotranspiration processes also depend on the climatic conditions and the exponentially increased wind speed above the crop canopy or stand. The whirlwind speed reduction has been demonstrated in many studies on the shelterbelt windward front as a role of distance, aerodynamic porousness, and altitude24[23]. Windbreaks are frequently erected in various regions across the globe to mitigate wind erosion on agricultural landscapes, such as China, India, the United States and Australia, particularly in their arid and semi-arid regions25[24;2625;2726]. It is estimated that windbreaks can reduce wind speeds by 20 to 35 times their height on the leeward side28[27;2524].

Through this process, shelterbelts enable other plants to thrive, making them 'safe sites' for establishing and succeeding29[28].

While the distance between shelterbelts is restricted by height and porosity, width within shelterbeltsrows in A.F.S. should be considered during field preparation. Furthermore, since A.F.S. reduces direct sunlight, the decrease in wind velocity and its results on water evaporation and transpiration can effectively improve growth and yield.

The main objective of an A.F.S. in an arid zone is to rehabilitate degraded land, increase land productivity and capability of conserving natural resources, improvement, and encouragement of sustainable traditional and it is an option to increase the forest cover

Nevertheless, the tree's intercropping with crops may apply both mutual and opposing (competition) effects. Trees have some adverse effects on culture output, but the overall productivity increases, although crops and trees' performance may be reduced when significant competition appears. Suitable A.F.S. proposes several possible benefits: providing numerous products and services, like food, fuel, timber, firewood, carbon credit, construction materials, land and water resources preservation, and food availability enhancement30[29;3130]. Though an unsuitable tree species selection can result in competition with other plants and create significant problems, this issue is intensified when competing over limited pools of resources, consequently exhibiting overlapping niches, and hence cannot cohabit efficiently within the identical community32[31].

Several rural areas combine agroforestry applications with other land uses related to their social values and demands. In the arid zone, the value of agroforestry is challenging to assess in monetary terms. Therefore, arid zone agroforestry needs to be mainly understood as managing shrubs and trees to improve rural people's quality of life and living conditions in the arid environment2[1].

In arid zones, indigenous plants can grow and survive in the most hostile climatic and edaphic states. As mentioned previously, some plant species drop their leaves when soil moisture becomes low to prevent water loss. In arid areas, plant species and leaf structures have xeromorphic characteristics, physical control of transpiration and symbiosis, humidity and healthy storing organs, and thorns. This specificity is observable particularly in hyper-dryness conditions, and with the decline in drought, this specificity in vegetables morphology and role tend to lessen6[5].

The number of tree species in arid areas is finite, and generally, are slow-growing due to environmental constraints. When considering A.F.S. in arid zones, the deep root systems of woody species are necessary, taking water from deeper soil layers to upward drier soil surfaces and the possibility of reusing this water in upper soil layers via water redistribution33[32;3433]. Nevertheless, it is not undoubtedly accessible to neighbouring plants during the redistribution of water. The depletion of soil nutrients is a challenging fact and a real threat to farmers food security; Agrisilviculture can provide a wide variety of alternatives for farmers with small lands operating under a small-scale agriculture model without the need for costly fertilizers access 35[34]. Nitrogen-fixing shrubs and trees (e.g., *Acacia spp., Faidherbiaalbida, Leucaena spp., Eucalyptus spp, Ziziphus spp*) have a high eco-friendly capability in arid regions silviculture; they are incorporated frequently into

A.F.S. participating in sustainable agriculture by re-establishing and sustaining the soil's fertility and productivity. A.F.S. secures the prospect of enhancing soil characteristics on cultivable lands via tree (leaf litter and fine roots) and the post-harvest crop stumps incorporated into the soil, improving aggregate soil moulding and texture 36[35].

In the arid agroforestry system, leaf litterfall decomposition is slow due to low moisture and lack of decomposing microorganisms' biomass. Moreover, as stated earlier, the soil's high salinity and extreme temperature make such an environment difficult for many tree species to survive.

3. AGROFORESTRY SYSTEMS IN SAUDI ARABIA

In Saudi Arabia, due to its severe environmental characteristics, many areas are threatened by desertification, soil erosion and the inability to exploit these lands in terms of productivity, whether agricultural or industrial production15[14]. It is observed that large parts of Saudi Arabia have been exposed to the continuous creep of sand caused by strong winds that lead to the burial of cities, villages, factories, civil and economic facilities, transportation routes and others.

Like other countries facing this situation of sand movement, Saudi Arabia, represented by the Ministry of Environment, Water and Agriculture (MEWA), has initiated a series of actions to contain the sand movement in several regions in the Kingdom. The adopted measures are "windbreak" or "shelterbelt", agroforestry practice.

Thus, from 1962 the shelterbelt project in Al-Ahsa Oasis started and was subjected to stop sand encroachment which had already covered a large area of agricultural land; at the same time, eight projects were initiated in Al-Qunfudhah Governorate targeting (Al-Muzailif, Hali, Al-Qaima, Ajaja, Ajlan, Al-Mutahma, Shia, and Douka). In the design of these shelterbelts' projects, the selection of tree species was based on drought tolerance capability, the low demand for water, and salinity resistance (Table 03).

Table 03: Tree species used in Saudi Arabia shelterbelts/windbreaks projects (MEWA, 1999)

Common Name	Scientific Name	Origin
Tamarix Arabica	*Tamarix spp.*	*Indigenous*
Prosopis	*Prosopis juliflora*	*Exotic*
Eucalyptus	*Eucalyptus camaldulensis*	*Exotic*
Acacia	*Acacia spp.*	*Indigenous*
Cazeronia	*Casuarina spp.*	*Exotic*
Bazromia	*Conocarpus spp.*	*Exotic*
Casuarina	*Casuarina spp.*	*Exotic*

Comment [MS3]: I suggest age of the trees included as one column

Figure 03: *Casuarina spp*windbreak project to stop sand encroachment in Al-Ahsa region, Saudi Arabia

Figure 04: *Conocarpus spp.* and *Acacia spp.* windbreak project to stop sand encroachment in Al-Qunfudhah Governorate, Saudi Arabia

3. AGROFORESTRY AND CARBON SEQUESTRATION

"Carbon (C) sequestration" has been defined by the United Nations Framework Convention on Climate Change as the action of withdrawing carbon present in the air and dropping it in a pool37[36]. Sequestering carbon by agroforestry is nowadays thought to be a smart economic prospect for global climate change mitigation and carbon exchange and providing various products 38[37].

Integrating trees on farmlands improves small farmers' robustness capacity to tackle climate hazards and change 39[38;4039] and provides an excellent opportunity to link water conservation with soil conservation. It inverts land deterioration, sequesters CO_2 from the air, and rural sustenance safeguarding 40[39]. For example, the role of A.F.S. in improving soil fertility also enhances land productivity and household flexibility performance by providing differentiated outputs for sale or family consumption 41~~[40]~~.

Agroforestry systems are frequently highly yielding, sequestering a considerable quantity of Greenh~~H~~ouse Gases (GHG) from the air and stock the carbon (C) in standing tree (biomass), soil organic manure, and collected products of biomass 42~~[41]~~. A.F.S. carbon storage capacity is undetermined, although it is estimated to sequester up to 300 Mg C ha^{-1} in 1 m deep soil43~~[42]~~. In their studies, 44~~[43~~;45~~44]~~ showed that agroforestry has higher carbon concentrations than pastures or field crops. Although, the estimated average carbon sequestrated by A.F.S practices is 9, 21, 50, and 63 $MgCha^{-1}$~~, respectively,~~ in semi-arid, sub-humid, humid, and temperate zones, respectively46~~[45]~~.

"In the fifth assessment report on climate change by the intergovernmental panel on climate change (IPCC)", it was assumed that by 2040 trees in farmlands would propose a high capability of carbon sequestration in less developed countries 47~~[46]~~.

Trees integration in farms impact carbon stocks differently than arable land or silviculture land management. Trees on farms, for example, provide tighter coupling of essential processes such as nutrient cycling and weed control than in croplands; trees in agroforestry are pruned more regularly than in forest management 48~~[47]~~. This managerial practice allows A.F.S. to be a sustainable carbon sink for its long-standing time and purpose. The time-averaged carbon sequestration rate is one accounting option for agroforestry; it accounts for periodic woody biomass harvests using Schroeder's (1992) "average storage technique". Carbon is removed from the atmosphere by trees and forests when actively growing. Their growth, however, slows and eventually stops as they age, and they are no longer a net carbon sink (although they continue to store it)49~~[48]~~. The principal uses for forest wood are pulp and paper products, from which most of the carbon is returned to the air via incineration. When a forest is cut down, much, or perhaps all, of its carbon is released into the atmosphere in a short period49~~[48]~~.

Regarding the perspective of A.F.S., carbon sequestration mainly implicates the uptake of air carbon dioxide during photosynthesis and fixation in plant components and stored in the soil for secure stocking 50~~[49]~~, which happens in two principal sections: above and below grounds. The aboveground considers the aerial parts of the plant like stems and leaves of herbaceous and trees components. While the belowground are roots and soil profiles 51~~[50]~~.

The heightened notion of carbon sequestration is built on the effective use of resources by the various functionally, structurally, and complex plant populations in agroforestry systems compared to grass systems or monocrop52~~[5~~1;53~~52]~~. A.F.S. practices amass more carbon than silviculture and grazing lands due to both "components" (forest and grazing), sequestration and storing active schemas 54~~[53~~;53~~52]~~.

In A.F.S., species often have diverse physical requirements for specific nutrients in quantity at certain times and use various mechanical or functional means to acquire them 54~~[54]~~. Trees in agroforestry

Comment [MS4]: Link with your finding

Comment [MS5]: Absorbed from the atmosphere and sequestered to the soil

Comment [MS6]:

provide organic matter (O.M.) to the soil 56[55;5756] and could therefore improve the stocks of organic carbon in Soil (S.O.C.). Leaf litterfall and pruning residues are left on the soil, where organic matter formed from the root and root exudates can be integrated deeply into the soil due to the deep-rooted system of A.F.S. trees to diminish the competitiveness with the annual crop 58[57].

The carbon sequestration potential of agroforestry systems confers to its massive potential in terms of mitigation strategy to climate variability due to its multi-purposes of tree species and soil59[58]. In alley cropping systems, the distance within the tree rows is generally sheltered by native or sowed herbaceous plants; moreover, soil in between tree rows is generally not tilled, favouring organic carbon stocking 60[59]. Additionally, straight carbon inputs to the soil can be likely augmented by a few agroforestry uses; these comprise (a) restoring to the soil as mulch pruning of woody species and permitting copious tree litter to decay on-site, (b) permitting livestock to graze and add manure to the soil, (c) during crop fallow periods, allowing woody species to grow and add surface, (d) incorporating trees and their litter input in animal production systems, (e) benefiting from soil carbon inputs of crops grown in the early steps of the implementation of forestry 43[42]

Comment [MS7]: Please add some trees species used in AFS and how much carbon sequestering per year

Air pollution from GHG emissions is estimated to have reduced Saudi Arabia population life expectancy by 1.5 year**Error! Reference source not found.**[60]. The Saudi Green Initiative (S.G.I.) aimed to raise vegetation cover, reduce carbon emissions, combat pollution and land degradation, and preserve marine life.

Comment [MS8]: Not clear

4. CONCLUSION

The ancient technique of A.F.S., which attempted to achieve the maximum agronomic values by utilizing nutrients, light, and water, has recently gained greater attention for its role in climate risk reduction through the sequestration of soil organic carbon, which is part of the aims of S.G.I to reduce the impact of fossil fuels combustion by reducing GHG emissions and protecting the environment**.**

Nevertheless, the adoption of A.F.S. in arid regions is encouraged to rehabilitate degraded land due to human activities and demographic pressure, increase available farmlands productivity, conserve the natural resource, and increase the forest cover.

To improve food security, the establishment of A.F.S. in arid regions should be the mainstream farming technique. Also, growing plants and crops in arid areas will help stop desertification and dune encroachment, which many arid regions face.

Furthermore, A.F.S. can supply other benefits for rural development by helping rural people diversify their source of income and supplying them with fuel, firewood, fodder, and timber that comply with S.G.I goals by reducing the pressure exerted on the forest and protected areas for timbers and firewood. Increasing vegetation cover, boosting Saudi Arabia reforestation program through S.G.I and reducing land degradation. Moreover, A.F.S. positively impacts soil micro-climate by reducing wind velocity and soil evapotranspiration, affecting moisture content and temperature. Considerably

Comment [MS9]: I suggest to add some adaptation strategy for AFS reducing one of the most challenging issues of Saudi Arabia related to the harsh and tremendous windblown of its arid and desert environment.

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