Silviculture of *Acacia senegal* for Climate Change Mitigation and Economic growth: An imperative towards Achieving the Sustainable Development Goals in Yobe state.

ABSTRACT.

The need to mitigate the effect of climate change arising from over exploitation of natural resources and to improve the economic wellbeing of the common populace in Sub - Saharan Africa particularly the northern Sahelian state of Yobe. Acacia is one of the trees adapted to the Sahelian climate of Yobe that provides a lot of social and economic benefits, and it's exploited in wild state. This paper highlights the domestication of the tree using silvicultural practices and silvics of the tree by elucidating the origin, climatic and soil requirement, product they produce diseases and control methods. Findings reveal the following information based on cited literatures. The plant grows in drier Sahelian climates of Africa, parts of Arabia and parts of India and Pakistan. It produces gum Arabic, fodder for livestock and other medicinal products. Findings implies that Acacia Senegal is suitable for agro forestry based on the fact that Acacia is a nitrogen fixer and produce no thick canopy making it possible for crops to thrive well underneath their canopy.

Key words: Silviculture, *Acacia senegal*, Climate change, economic growth and Yobe State

1.0 Introduction

Sub-Saharan Africa has been inhabited by people for thousands of years. The area is characterized by dry and harsh climate with little rainfall which is around 800mm throughout the year (Becky Hayward, 2004). In many parts of the region the major contributor to survival is the *Acacia* tree which is found across the continent(Hayward, 2004).Climate variability and human activities are the two major factors threatening

forestry in Sudan Sahelian Africa. in this region half of the forest region are threatened (Diatta *et al.*, 2021). In African context the major problems facing communities is deforestation of trees particularly *Acacia species* in northern States, Yobe inclusive. This has a negative impact on the life of farming communities in four major areas: - Lack of fuel, Shortage of income, Shortage of livestock fodder and Land degradation. Since 1980s, rural development agencies have been making efforts to encourage people to plant and manage local tree species that are beneficial particularly Acacia species. The major problems curtailing this effort include lack of information on the most appropriate species, variety or seed source for a particular locality, Lack of adequate knowledge of the silvicultural and silvics of the Acacia species.

The objective of this paper is to highlight the use of a tree-based rural development using taxonomy, ecology and variation of Acacia species which are appropriate for rural development in the Sudano - sahelian region of Yobe State. The potentials of Acacia tree in addressing climate change mitigation and economic development are clearly demonstrated by adopting the silviculture and silvics of this multi-purpose Sudano-sahelian tree. Acacia can survive under extreme harsh conditions and give out the following benefits: -

- They act as natural repair -kits for depleted soils.
- They stabilized the microclimate by providing shade under which plants can grow and animals can feed.
- They provide pods for animal fodder, fuelwood, seeds, timber and gums which can all be used for domestic purposes and export for generating income for smallholder farmers and their families ‘

Table 1. Poverty indicators in Nigeria

Variable	**Value**
Population living on less than $1.00/day	70%
Population living on less than $2.00/ day	91%

Poverty Gap $1.00/day	35%
Poverty Gap $2.00/day	35%
Access to improved sanitation	59%
Access to improved water source	62%
Life expectancy (**both sexes**)	52 years

Source: Ibrahim (2012)

Table 2: Trends in poverty level by zones (1980-2010)

Zone	1980	1985	1992	1996	2004	2010
South South	13.3	45.7	40.8	58.2	35.1	63.8
South East	12.9	30.4	41.0	53.5	26.7	67.0
South West	13.4	38.6	43.1	60.9	43.3	59.1
North Central	32.2	50.8	46.0	64.7	67.0	67.5
North East	35.6	54.9	54.0	70.0	72.2	76.3
North West	37.7	52.1	36.5	77.2	71.2	77.7

Source: Ibrahim (2012)

2.0 Poverty in the study area

2.1 Poverty indices and economic growth in Yobe State.

Nigeria is blessed with huge mineral and natural resources and despite the abundance of the resources in the country, the poverty level is very alarming with nearly 100 million people living in abject poverty such that the country is referred to as the poverty capital of the World(Jaiyeola & Bayat, 2019) .The poverty rate in the North east and North West is 77.7 % and 76.3% respectively. The 10 worst states (Fig 1) with high incidence of poverty in Nigeria are in the northern part of the country with Yobe appearing among the top ten with highest incidence of poverty(Jaiyeola & Choga, 2020) . Paradoxically, the country is rich, but the people are poor. Despite the abundance of mineral and natural resources, over exploitation and total mismanagement is the major problem (Edoumiekumo *et al.*, 2014).

Yobe is susceptible to environmental challenges, including desertification, erosion and flooding. Land degradation attributed to deforestation, over-grazing by livestock, increasing demand for firewood and increased agricultural intensity has led to soil breakdown. Additionally, sand dune build up has resulted in a reduction of plant growth and productivity in the state (Hunger, 2019). One third of the World population uses fuelwood as a source of energy and the highest uses are from rural parts of Africa particularly northern Nigeria where it accounts for 80% of the total energy consumed (Norizah, 2019).

In line with the Millennium Development Goals benchmark for minimum standard of livelihoods. One of the roles played by the Yobe state SDGs is to ensure that poverty is eradicated through wealth and job creation and sustainably harnessing the natural and mineral resources abound in the state. This is in consonant with the views of Abbas and Ogiri, (2017) that raising income is paramount tool in poverty reduction and overall wellbeing in any meaningful society. Yobe and Borno states have the best climate for *Acacia species* growth in Nigeria(Ibrahim, 2012). Based on this reason investing in Acacia domestication is a good idea.

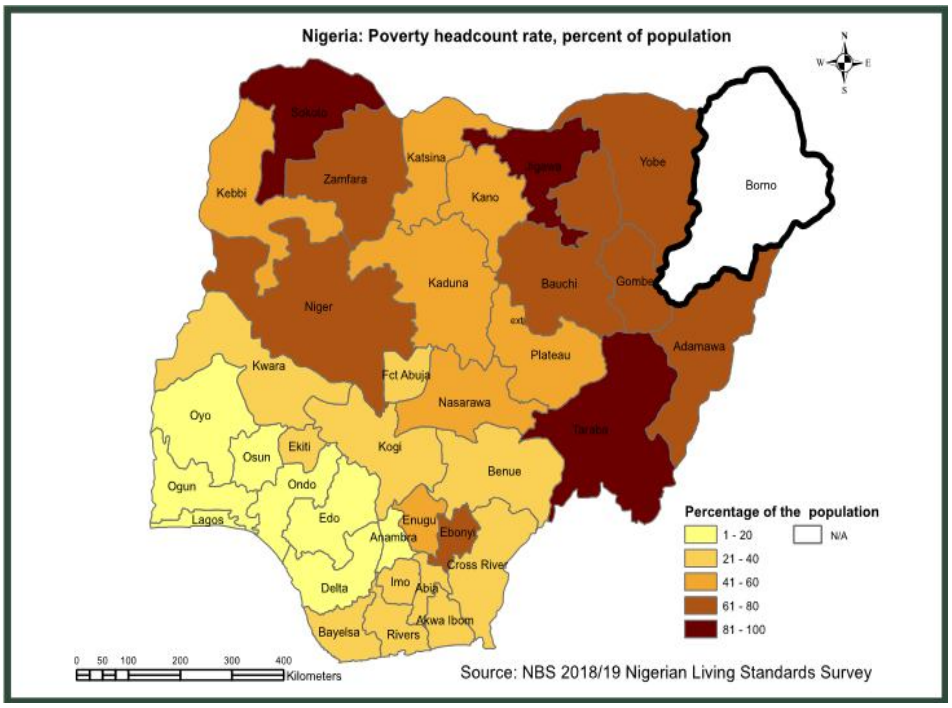

Fig 1. **Map of Nigeria showing poverty count rate with no data for Borno as result of insecurity during the data collection time.**
Source National Bureu of Statistics, (2020)

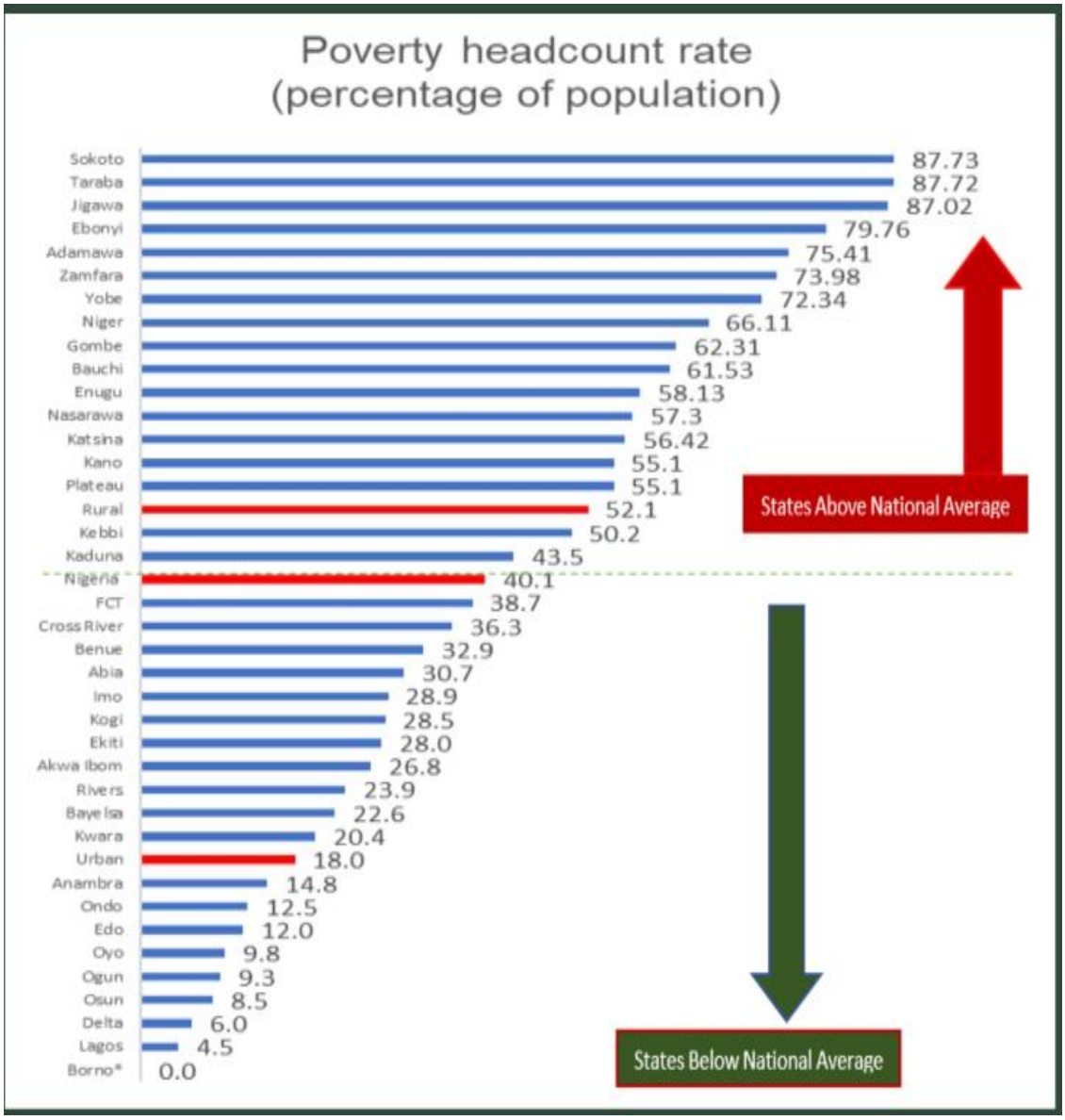

Fig. 2. Poverty headcount showing Yobe state among the top ten in the list

2.2 Silviculture and silvics of *Acacia senegal*

The Northern state of Yobe is facing environmental degradations such as desert encroachment, flooding and drought. In addition, the global economic meltdown of 2009 and 2015 recession is another reason why we must diversify the economy (Yk *et al.*, 2022). Instability in the price of petroleum products, the negative impacts arising from the use of fossil fuel as a major cause of global warming and climate change necessitate

the governments to focus on diversifying our economy by harnessing our natural products. In this case harnessing Acacia and its related product is seen as a way of diversifying our economy.

Silviculture of *Acacia* is synonymous to domestication of *Acacia* trees. The tree is multi-purpose considering the wide number of uses it offers to people. Silviculture is the science and art of managing forest communities based on knowledge of tree silvics. More particularly, the theory and practice of controlling the establishment, composition and growth of forest vegetation (Forestry, 2015). Silviculture can be defined as the science of organising growth and development processes in trees and forest ecosystem to ensure environmental sustainability and optimise management objectives on a prescribed area of forest land. It can also be defined as applied forest ecology. In other words, Silviculture is the art and science of cultivating forest crops for all their diverse range of uses. It is concerned with the growing of trees just as agriculture is concerned with the growing of food crops in fields. (Savill *et al.,* 1997) A generally accepted definition is that it is the study of the life history and general characteristics of trees with particular reference to environmental factors. Silviculture in forest development is charged with the responsibility of evolving appropriate techniques required for the formation of new and regeneration of old forests.

3.0 Origin and Introduction of *Acacia senegal*

Acacia senegal is a multipurpose African tree of the family *Leguminosae* and subfamily *Mimosoideae*. The trees function as " keystone" species in the arid and semi-arid regions of Africa and middle East (Agea *et al.*, 2005). It is highly valued for centuries for gum, fodder and timber production (Jibo, 2021). Today *A. Senegal* is grown primarily for gum, but plays a secondary role in agricultural systems, restoring soil fertility and providing fuel and fodder. Acacia are regarded as a forgotten resource. About 170 species are native to Africa (Becky Hayward, 2004; Githae *et al.*, 2013). The species is indigenous to Africa countries which appear in different variation and morphological characteristics. *Acacia senegal* is found in Western, Central, Eastern and Southern Africa, Oman, Pakistan and India. It has been introduced into Egypt, Australia, Puerto Rico and the Virgin Island (Gary *et al.*, 2002).

2.4 Climatic and soil requirements of *Acacia senegal*

Acacia senegal is very drought resistant (Danthu, 1992). It grows on sites with annual rainfall between 100-950mm, mainly between 300-400mm, and 5-11-month dry periods or more), dry wind, and sandstorms. Generally, it cannot withstand frost(Becky Hayward, 2004). Acacia *Senegal* prefers coarse-textured soils such as fossil dunes, but it will also grow on slightly loamy sands and skeletal soils such as Lithosols (Qadir, 1973). Although generally soils are drained, there are exceptions: in Kayers region, south-Kordofan, East Sudan, *Acacia Senegal* grows on heavy clay soils with approximately 800mm annual precipitation. The best sites have pH of 5 to 8. The tree ranges from 100-1700m elevation in the Sudan to 1950m around Nakuru in Kenya. Distribution of gum trees in Chad is located between latitudes 11^0 and 17^0 north and rainfall of between 150mm and 900 mm per year (Daakkreo *et al.*, 2019). *Acacia spp* is seen as an agricultural asset because it produces green leaves, which are in full growth during the dry season which are dropped unusually during the rainy season. For this reason they provide shade to cattle and farmworkers during hot sun at the same time do not obstruct the light needed by the growing crops during the rainy season (Becky, 2004). This makes it a good choice for agroforestry practices.

3. 0 RESULTS

3.1 Propagation methods in *Acacia senegal*

Propagation in *Acacia senegal* is achieved both by direct sowing using seeds planted in nursery and by vegetative means using cuttings, grafting, layering and aerial layering. In Acacia propagation by using seeds, they should be harvested before pods have dried for easy collection and to avoid insect attack. Seed is easily extracted by hand. Freshly extracted seed should immediately be dusted with an insecticide.

Furthermore, one of the most notable examples of direct sowing for raising plantations is *Acacia nilotica* and *A. Senegal* in the Sudan. But nearly all tropical plantations are planted rather than direct sown , and at maturity , clear felled and replanted rather than naturally regenerated (Julian, 1996). Vegetative propagation is also possible in *Acacia*

senegal as fragments taken from crown of mature trees that are at least 13 years old. cuttings can be taken from branches 50 cm long.

3.2 Seed Production and Nursery in *Acacia senegal*.

Acacia seeds are dormant and hard and needs to be given some sort of pre-treatment for them to germinate faster. This has been reported by Mohammed *et al.*, (2017) , that generally members of the Leguminosae family have hard seed coat and contain less moisture. Adequate and dependable supply of water is needed during nursery sittings for adequate growth of the seedlings. Plants must be watered morning and evening daily by hand or irrigation system (Shettima *et al.*, 2017).

Plate1 Supervision of planted seedlings in a nursery
Source NAGAPPEN (2002)

Plate 2 Seed of *Acacia senegal*
Source Mohammed *et al.*, (2017)

A. *Senegal* is usually raised in the nursery in polyethylene pots, 2-4 seeds per pot, thinned to one seedling after 4-6 weeks. Direct seeding (5-8seeds in 30 times 30 cm pits or larger) can also be used (Alkali, 2010). The planting stock can be kept in a wetted jute cloth to make the cuttings at the time of establishing nursery(P. Danthu, 1992). treatment by dilute Tetraoxo sulphate (vi) acid also greatly enhanced germination in *Acacia senegal* as reported by (Bosah, 2007). Experiment was conducted to assess different seedlings accessions of *Acacia*

senegal in Bauchi Nigeria, eight different seedlings four from Borno and 4 from Yobe were collected. Seedling no eight from Yobe had the desirable seedlings characters namely fast growth habit highest seedling girth and could be transplanted within 57 days of sowing (Ibrahim *et al.,* 2014). Shade are constructed to protect seedlings from direct sunlight for two to three weeks after pricking out (Shettima *et al.,* 2017). In south Western highlands of Saudi Arabia Acacia species takes a significant portion of the floral composition and is significant for beekeeping production in the country. Despite the degraded condition of the vegetation of the region. It was pointed out that planting nursery grown seedlings is one of the best methods for successful restoration of the degraded land. Apart from environmental and climate change mitigation it also help in evaluating nursery level performances of selected native Acacia species in apicultural land restoration (Al-ghamdi *et al.,* 2020).

3.3 Wood and other Uses of *Acacia senegal.*

Gum: *Acacia Senegal* and its close relatives are the defined source of commercial gum Arabic food purposes. *A. Senegal* produces the only acacia gum evaluated toxicologically as a safe food additive (Anderson, 1991). Result of an experiment conducted by E. Muita et al shows that gum arabic from *A. senegal* var *kerensis* can be used as a stabilizer in low-fat yoghurt formulations and this increases consumer acceptability (Muita et al., 2020). The phytochemical analysis of Gum Arabic have been carried out by Ibrahim and co-workers and was found to be rich and valuable in the food and other commercial industries(Gashua *et al.,* 2013). The gum from other *Acacia species* (*A. seyal* etc.) is available commercially as gum tahla (approx. 10% of au acacia gum marketed) for technological applications. Gum Arabic has been used for at least 4,000 years by local people for preparation in food, in human and veterinary medicine, in crafts and as a cosmetic(Mokwunye, 2010). Today, gum Arabic application is manifold. Formerly the international trade market largely absorbed all gum available. In Armania a trial was conducted of the coppicing ability of *Acacia nilotica* in order to cover the deficit for the high demand for biomass which is around 90% of the energy consumed. The specie

coppiced well and is a medium to fast growing in comparison to other indigenous species. though recently international demand has declined together with gum prices(Gessesse *et al.*, 2015). *Acacia senegal* is the only tree that produces Grade 1 (Highest quality) gum Arabic. Sudan is the leading exporter of grade 1 gum Arabic. Nigeria has less than 5% of the World's gum Arabic market. Sudan and Chad makeup about 95% (Gary Harrison and Ryan Roberge ARD, 2002). About 70 to 85 of the World total consumption of gum Arabic is produced in the Sudan (Mustafa and Elamin, 1965). World production of gum arabic potential is estimated at around 60,000 tons per annum , out of which 50% or more originate from Sudan (Mujawamariya, 2012). Gum Arabic is used in the food industry as a flavour fixative and emulsifier; stabilizer in frozen dairy products, for its viscosity and adhesive properties in bakery products, and as a foam stabilizer and clouding agent in beer (Studer, 2018).

In pharmaceutics, it is used as a stabilizer for emulsions, binder and coatings for tablets, and as an ingredient in cough drops and syrups (Hamouda, 2017). A soothing and softening agent, gum Arabic is extensively employed in folk medicines. Among many other uses it is used internally for coughs, diarrhoea, dysentery, hemorrhage, and externally to cover inflamed areas. Gum arabic is a dietary supplement for improving nutrition of type 2 diebetic patients, it exhibit an excellent property on improving their poor glycemic control (Babiker *et al.*, 2017). Gum Arabic is used in cosmetics as an adhesive for facial masks and powders, and to give a smooth fell to lotions. Industrially, gum Arabic is applied as an adhesive, as a protective colloid and safeguarding agent for inks, sensitizer for lithographic plates, coating for special paper, sizing agent for cloth to give body to certain fabrics, and coating to prevent metal corrosion. Gum Arabic is used in the manufacture of matches and ceramic pottery(NFTA, 1991). Many studies reported the use of acacia arabica as an effective against variety of diseases including diabetes, skin disease and cancer. Fresh parts are considered as astringent, demulcent, aphrodisiac, anthelmintic, antimicrobial, antidiarrheal with good nutritional value in Indian traditional medicine system (Abduljawad, 2020; Amadou *et al.*, 2020). Many studies reported the use of *Acacia arabica* as an effective against variety of diseases including diabetes. Fresh parts are considered as astringent, demulcent, aphrodisiac, anthelmintic, antimicrobial,

antidiarrheal with good nutritional value in Indian traditional medicine system (Rajvaidhya *et al.*, 2012).

3.4 Tapping techniques for gum Arabic.

The gum Arabic tree has erected rigid and strong stems and measures up to 13m in height. It is thorny and low branching. It requires moderate pruning of lower branches from the main stem up to 150 cm above ground level foe easy access to the stem for tapping (Aghughu and Wuranti, 2005). Tapping is an important management tool for enhancing gum productivity. The best time to tap a tree for high output is about 9:00 am and 5:00 pm (Yau *et al.*, 2016). Tappable girth size in gum Arabic lies between 25cm and 50cm atabout100cm above ground. The correct sign for tapping is after rains are over when about 50% of the leaves are shedded. This continuous up to the next rain. Higher temperature encourages exudation of gum. exploitation can be natural through cracks on the stem or by the use of small axe or cutting knife (Aghughu and Wuranti, 2005)

There is a significant relationship between applied gum Arabic tapping techniques by using sunk and increasing gum yield and quality at (p= 0.05) (Hamad *et al.*, 2021). The gum is obtained as dry exudate from the stem and branches of the tree after the plant is injured. The nature of the injury can be organized and controlled (tapping). Injuries could be natural cracks/stem burst or injury as a result of pruning or cutting a stem or branches for fencing or animal fodder (Alkali, 2010; Mokwunye, 2010). Research was conducted to find out whether there is a difference in yield between tapped and untapped *Acacia senegal* trees. Result show that tapping increases the gum Arabic yield by 77.42% (Wekesa *et al.*, 2009). Tapping date significantly ($P < 0.05$) produce a difference in Acacia senegal gum yield (g/ picking) giving higher yield when tapped in the 15th of October and give out lesser yield when tapped on the 1st of September as reported by Ilu and coworkers (Ilu *et al.*, 2020).

3.4.1 Wood- *Acacia Senegal* is locally valued for fuel wood and charcoal although biomass yield per unit land area is not sufficient to plant *A. Senegal* purely for fuel wood. Wood is used in local construction for poles and fence posts, the light- coloured wood for tool handles and dark heartwood for weaver's shuttles. Strong ropes are made from the bark fibres of the tree's long surface roots (Mohammed *et al.*, 2022).

3.4.2 Food and fodder- Dried and preserved seeds of *A. Senegal* are used by people as vegetables. The foliage and pods are browsed by sheep, goats, camels, impala, and giraffe. Leaves contain 10% - 13% digestible protein and 0.12% -0.15% phosphorus, while the pods contain 15% digestible protein and 0.12% - 0.14% Phosphorus (Mohammed *et al.*, 2022).

3.4.3 Dune stabilization- *Acacia Senegal* is important for desertification control through sand dune stabilization and wind breaks.

3.4.4 Pests and diseases of *Acacia senegal*.

One of the commonest pests of *A. senegal* is the buffalo tree hopper (*Stictocephala babulus*) which may destroy seed crops. Other pest includes the spiders (Cyclops sp.) which can smother young growing apices. Larval stage of *coleopterans* (*bruchids*,) Lepidoptera, and Hymenoptera damages the seed. Locusts (*Aecidium melanorhodon*) can defoliate vast areas overnight. *Acacia senegal* is also attacked by the fungi cladosporium herbarium, Fusarium sp, *Ravenelia acaciae- senegalae* and *R. acaciocola* (Orwa *et al* 2009)

3.4.5 *Acacia senegal* for Agroforestry

It is a multipurpose nitrogen- fixing legume. They maintain and improve soil productivity and is the reason why they are adopted in agroforestry systems. Farmers cut trees and sell that are more than 20 years old which resulted in yield increase (Bargali and Bargali, 2009)

Acacia Senegal is grown in agro forestry systems especially in the Sudan and Uganda in "gum gardens' for gum as well as to restore soil fertility (Agea *et al.*, 2005; Mohamed, 2005; Temgoua *et al.*, 2018). Five-year- old trees are ready for tapping, and production peaks between 7and 15 years. In Sudan, a traditional bush-fallow system is followed with a 20-year rotation during which time *Acacia senegal* is grown for 15 years. Agricultural

crops are grown for five years (sesame, millet, sorghum, groundnuts), followed by five years with young, unproductive *A. Senegal* trees, which latter produce gum during the last 10 years of the rotation (Temgoua *et al.*, 2018). Corresponding to this rotation, ¼ of the land is kept in agricultural crops, ¼ in unproductive young trees, and ½ in productive trees. Controlled grazing is practiced after the trees have reached age four and under productive trees after the gum has been harvested. Wild trees are harvested during the dry season for gum exuded from cracks in the bark. Strict protection from fire and livestock grazing, and efficient control of weed competition during at least the first two years is important to seedling survival. Minimum spacing for block planting is 4 times 4m. At 10 times 10m spacing, agriculture inter cropping is possible, for example interplanting with millet, beans, or groundnuts.

4.0 Conclusion

In conclusion, Yobe is an agrarian state known with marginal agricultural soil as a result of population expansion, land degradation and desert encroachment. It may here be seen that the northern state of Yobe is an agrarian state, as a result of population expansion the marginal agricultural soil is over cultivated and trees were cleared massively for fuel wood all resulting in land degradation and desert encroachment. Poverty index is very high in the state with over 70%, one of the highest in the country. Domestication of Acacia species (silviculture and silvics) is pointed by this paper as a way forward for improving the economy (income generation of the masses) and improving the harsh Sahelian climate of the state. *Acacia senegal* is a legume and a nitrogen fixer. Acacia produce seeds in a pod. Acacia is a plant of dry tropical climate, *Acacia Senegal* produce gum Arabic and fuel wood, *Acacia* is mostly grown in underdeveloped African nations and some developing Asian countries. Acacia is planted through seed with little chance of natural regeneration because of grazing animals. The tree can also be propagated by vegetative means.

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