REVIEW ARTICLE AGROBIOLOGICAL RECORDS
ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

AGRICULTURAL LAND CLEARING IS IMPERATIVE FOR A SUCCESSFUL AGRICULTURAL MECHANIZATION PROGRAM IN NIGERIA

ICE Umeghalu*, CP Nwachukwu, CO Umobi, JI Uba and OF Anonye

Department of Agricultural and Bioresources Engineering, Faculty of Engineering,
Nnamdi Azikiwe University, Awka, Nigeria

*Corresponding author: ic.umeghalu@unizik.edu.ng

ABSTRACT

The rapid increase in population in Nigeria calls for an increase in agricultural production. Farming commences with land clearing. Traditionally, the manual land clearing method is still predominant in Nigeria, where the matchet, hoe and axe are the implement used for the operation. However, this land clearing method can no longer keep pace with the population explosion. The method is ideal for small areas of land with small trees and stumps when surplus labor is available; however, the manual method becomes tedious and costly for mechanized farming. Agricultural land clearing involves removal of natural vegetation from the land, stumping, mechanized tree knockdown, windrowing, wood-cutting and burning, removal of debris and pioneer plowing. The soil structures, crop nutrients, and soil moisturizing content crops need to grow are in the topsoil. Therefore, agricultural land clearing operations should aim at minimum topsoil disturbance—poorly cleared land results in poor yield and frequent damage to agricultural machines and equipment. To achieve adequate agricultural land clearing, special techniques, machines, tools, experienced machine operators, and adequate timing of land clearing operations are necessary. This review aims to offer information on adequate methods of agricultural land clearing, outlining the procedures to be followed, tools to employ and good timing for carrying out various stages of land clearing operations in different agricultural zones of Nigeria. Parameter for assessing good agricultural land clearing is also discussed.

***Keywords*:** Agricultural Mechanization, Agricultural Land Clearing, Top Soil, Assessment, Costing

Article History (2022-190) || Received: 19 Jan 2022 || Revised: 25 July 2022 || Accepted: 20 Dec 2022 || Published Online: 26 Dec 2022

1. INTRODUCTION

Farming commences with land clearing operations. Farmers can use machines to clear and prepare the land and handle and process crops. Land clearing is the foundation on which mechanized agricultural production is based. Farm machinery helps farmers to do work more quickly and with less physical labor. However, land clearing is difficult and delicate and requires special tools and skills (Adama et al. 1999). Stripping off the topsoil on any land destined for agriculture is a catastrophe since it is only in the topsoil that the nutrients the crops need to grow are found, which offers stable conditions for cultivation. If topsoil texture is seriously disturbed by incorrect machinery, its natural structure is destabilized, resulting in uneconomically low agricultural yields, and soil erosion is encouraged (Ogbulafor 2000; Obasi 2013; Umeghalu 2019; Kopittke et al. 2019).

It is, therefore, needful that the factors of climate, vegetation, soil, relief, prevailing drainage, and plant growth are properly understood before a sound land clearing policy is formulated and implemented (Umeghalu 2013). The increasing food shortage in the country, where population growth is rapidly increasing, calls for the expansion of the farms and corresponding increases in farm labor. Unfortunately, agricultural practices in Nigeria are still laden with primitive methods of farming. The use of hand tools is still predominant, which is labor intensive. Again, the drudgery from using these outmoded methods scares the youths away from engaging in the agricultural sector, as they abandon the farms for the elderly and weak people who can produce very little food and migrate to the cities for white-collar jobs (Umeghalu and Alika 2019). In order to replace this shortage of labor required for food production, there is a need to mechanize those operations that require much labor that frightens the youths from engaging in agricultural production (Onwualu et al. 2006).

2 Traditional Methods of Land Clearing Operations in Nigeria

Agricultural production is undoubtedly Nigeria's most critical and widespread line of development. Shifting-field cultivation, the predominant method of agricultural production, is condemned because of its low agricultural

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

yield (Hodder 1973). It may also be responsible for the disappearance and degradation of forests and constitutes an important restriction on development (Baude et al. 2019). Shifting-field cultivation can be defined as an agricultural system that is characterized by a rotation of fields rather than crops, preliminary clearing by 'slash and burn,' and by short periods of cropping alternating with long fallow periods. Only human labor is used - and the chief tools are the hoe, machete, axe, and digger (Okigbo 1986).

Remaining natural vegetation in tropical rain forests containing many trees is an arduous undertaking, and traditionally the practice adopted is to remove only the smaller trees leaving the larger ones. These more giant trees- help in forest regeneration when the land is eventually abandoned, and the ash derived from the burning of the smaller trees and undergrowth helps provide soil rich in phosphorus and potash. Often, the imminence of weed invasion is a standard indicator used by the farmer to ascertain when it is time to abandon his plot. A large part of Nigeria's agricultural practices conforms to the same general technological pattern, the objective of which is to produce carbohydrates, the basis of human food, by shifting cultivation without irrigation (Onokerhoraye 2010; Umeghalu et al. 2012).

The forest trees are felled with axes, and when dry, the vegetation is burnt; after the crop harvest, the patch lies fallow, and the forest regains control until it is once again to be cultivated. The axe is more useful than the hoe; often, the soil is not tilled at all, and no manure is added. The cultivated crops benefit from the fertility given by the wood ash. However, in practice, weeds and shoots of trees, creepers, and ferns are often so abundant that without their removal, cultivation is impossible.

Each planting season, the anxiety of the farmer is great, for if the land is not cleared in time, the trees will not have time to dry, they will not burn; and if the farmer is late with his fire, he runs the risk of being caught by the first rains. The clearing will then be in vain, and famine is inevitable.

In land clearing activities in the southern part of Nigeria, hoeing is not indispensable in the first year but becomes so in the second; it is always necessary for savanna clearing. The fire does not destroy the rhizomes of the giant grasses or woody plants, and the farmer has to take them out with his hoe to prevent them from stifling his crops (Umeghalu et al. 2012).

After the last harvest, the land remains fallow. How long should the fallow period have no precise rule? However, it might last for at least twenty or thirty years in order that may restore soil completely. Too short a fallow can have disastrous consequences for the next harvests. Farmers always prefer forest soils, which can only exist after long fallows. Depending on the nature of the ground or the density of population and tradition, one finds fallow lasting only two or three years and others with a duration of thirty years; between eight and twelve years are necessary to get a good cover of woody vegetation.

2.1 Definition of Agricultural Land Clearing

Land development involves mainly two operations which are land clearing and land forming. Land clearing involves the removal of vegetation such as trees, bushes, stumps and shrubs from the soil with minimum loss of the topsoil. However, land formation involves operations that are important to keep the soil in production, such as the construction of bunds, terraces, and drainage (Adama et al. 1999; Ogunjirin et al. 2018; Ramankutty et al. 2018).

Agricultural land clearing removes natural vegetation from land to a depth of about 30cm; it entails stumping and extraction of roots with minimum topsoil disturbance. While well-cleared land is a perennial asset, poorly cleared land generates problems in agricultural production. Agricultural land clearing can be differentiated from land clearing for road building or land clearing for construction work in that in construction work; the land is cleared without regard to the topsoil. In crop production, topsoil is the reservoir for moisture and crop nutrients and should be protected in agricultural land clearing. Agricultural land clearing is adequately done only when the vegetation is removed with minimum disturbance to the topsoil. It is under these conditions that agricultural mechanization can succeed. Depending on the end use to which the land is to be put, there exist different types of land clearing. For example:

i) To construct highways, railways, roads, swimming pools, etc., total vegetation removal is recommended.
ii) Some big trees and stumps can be left on the ground for cattle grazing.
iii) Removing vegetation up to 10-30cm below ground level is recommended for growing normal crops to avoid disturbing the top soil that houses crop nutrients.

When land is poorly cleared for agricultural production, it will lead to frequent breakdown of farm machinery and poor yields. Soil erosion will accelerate and rebuilding organic matter on tampered topsoil may take a long time and be capital intensive (Nwuba and Fashiwa 1987).

2.2. Factors to be Considered in Land Clearing

It is necessary to consider the following factors which greatly affect land use and the size of the undertaking. These factors can be grouped into four major headings: environmental, social, or institutional, cost/price, and the end use of the land.

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

2.2.1. Environmental

***2.2.1.1. Soils, Geology and Agro-climate*:** An area's soils, geology, and agro-climatic regimes should be given special consideration when dealing with land clearing. This is important because, where the heavy unsuitable mechanical plant is used for land clearing, it will result in shearing off the topsoil, without which cultivation of crops is not possible. Most times, the type of machines used for land clearing is badly selected, especially where machines specifically designated for soil excavation are used for land clearing (Wang et al. 2023). When the vegetation is removed from the tropical environment, the impact of heavy rainfall and high soil temperatures cause many problems which, among them are the following:

a) Reduced water infiltration and loss in moisture retention capability due to the blocking by clay particles of both macro and micropores. Thus, this gives rise to intensive run-off of surface water which causes soil erosion, flooding of flat land and silting-up of the nearby streams and rivers.
b) Excessive leaching, which impoverishes the soil and leads to crop failure due to the sinking of the soil nutrients deep into the subsoil, thus placing the nutrients beyond the reach of herbaceous plants with shallow rooting systems.

***2.2.2. Change in Soil Structure*:** Soil type plays a part when tree felling production is considered. Roots often prop out the ground when trees are felled in sandy loam soils. Methods and equipment choices are affected by the moisture content of the soil. Where vegetation is thick, the layers prevent the sunshine from reaching the soil, thus causing the soil to be damp so that it will not support the weight of equipment in the felling and stacking operations. In areas with embedded rocks or stony outcroppings, equipment employed for land clearing operations is often severely damaged during clearing operations. This causes the repair and maintenance cost of machines to be high. Underfoot conditions are classified into various forms:

i. **Good underfoot conditions:** This condition exists when traction, flotation, and slope are not a problem for the tractor, even after repeated passes on the same track.
ii. Soft underfoot conditions: This exists when more than one or two passes over the same track create moderate to severe impairment of machine performance.
iii. Poor underfoot conditions

a) Topography, size, and shape of the land: The topography of a place is another determinant factor affecting the method and equipment choice for a land clearing operation. Thus, steep slopes, ditches, swamp areas, and hills decrease production and increase maintenance costs. The land size and shape also determine the machine and land clearing method to be adopted in the land clearing exercise.

b) Rainfall, climate, and temperature: Rainfall and the resultant water table affect flotation. Conventional track-type tractors will sometimes sink into the soil due to the amount of rain in an area. It is helpful, therefore, to consider low-ground pressure tractors for such areas. Knowledge of the climate of an area is vital in determining the period best suited for land clearing projects. It so also is the knowledge of the annual temperature extremes and length of the growing season.

c) Institutional factors: The place accorded agriculture by governments is very important in the development of the agricultural sector of a country. Land clearing project is costly, and government must be willing to support agriculture through fiscal and conducive tax policy, providing the enabling infrastructure such as roads, electricity, and water, as well as a favorable land tenure policy to encourage and attract investors into agriculture, reform and settlement project establishment. Governments must be willing to invest in research and employ the result in a practical sense and also be able to avail such information to farmers through extension programs.

d) Low Cost of Production: Without an adequate return on investment, the business will not succeed. A farmer will be in business when he makes a profit on his investment. Cost of inputs like feeds, insecticide, herbicide, fertilizer, cost of land development machinery and tools, hired labor, etc., should be subsidized to assist farmers. Availability of long and intermediate-term credit to finance agricultural projects such as land purchases, construction of buildings, the establishment of plantations, and land clearing will encourage agricultural development.

e) End Use of Land: The end use of land is a very important factor that affects the choice of method and equipment for a land clearing operation. If the land is used for highway or dam construction, it becomes imperative that the total removal of vegetation is necessary. But if the land is for agricultural production, it becomes necessary that the topsoil is preserved. Also, if the land is for grazing, certain larger trees may be left standing on the ground along with the stumps of other trees.

3. Factors to be Considered for Adequate Agricultural Land Clearing

It is necessary to consider the following factors when adequate agricultural land clearing is required:

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

a) The final use of the cleared land
b) The area of the land to be cleared,
c) The type, size, and density of vegetation to be removed,
d) The topography of the land and nature of the terrain - presence of anthill, large stones, streams, gullies,
e) Presence of honeybee hives and snakes,
f) The type and size of equipment, and
g) The agency that will clear the land and experience and skill of the machinery operator.

4. Methods and Equipment for Land Clearing

Some factors govern the methods and equipment to be used in agricultural land clearing. Among these factors are the number of trees, tree size; wood density; roots; vines; and undergrowth. A tree count can determine this. Tree count can be carried out by measuring a straight line of convenience distance, usually 100 meters (328 feet). Tabulation is then taken along this line for a distance of about 5 meters on both sides, thus giving an area of 100 meters by 10 meters (328 feet x 32 feet). This will be repeated a number of times depending on the type of changes in vegetation.

For tree counting, they should first be grouped according to categories such as: Trees with less than 30cm (12in) diameter undergrowth; 30-60cm (12-24inches) diameter; 61-90cm (25-36inches) diameter; 91-120cm (37-48inches) diameter; 121-180cm (49-72inches) diameter; 181cm (73inches) diameter and above. The tree's diameter is measured at diameter-breast-height (DBH), which is usually 1.37meters (4.5feet) from the ground level. When a tree is of buttress type, the measurement should be taken at the top of the buttress, where the tree's trunk begins to run straight.

Counting should be done with the measurement of the tree diameters. It is also good to take records of the following: hard or soft woods (wood density) and the root system (tap or lateral roots). The presence of vines and the undergrowth should be done as well. The presence of high climbing vines binding the three types together should be noted as they inhibit the free fall of trees during feeling.

5. Methods of Selecting Equipment for Land Clearing

According to Elesa (2003) the methods of selecting equipment for agricultural land clearing operations are governed by the following factors. Among these factors are the number of trees, tree size; wood density; roots; vines; and undergrowth. A tree count can determine this.

5.1. Geology, Soils and Agro-climate

An area's geology, soils, and agro-climatic regimes should be given special consideration when dealing with land clearing and its resulting aftereffects (Adefolabi 2004). This is important because where the heavy unsuitable mechanical plant is used for land clearing will result in shearing off topsoil, without which cultivation of crops is not possible. Most times, the type of machines used for land clearing is badly selected, especially where machines specifically designated for soil excavation are used for land clearing (Wang et al. 2023). When the vegetation is removed from the tropical environment, the impact of heavy rainfall and high soil temperatures cause a lot of problems which among them are the following:

a) Reduced water infiltration and loss in moisture retention capability due to the blocking by clay particles of both macro and micropores. Thus, this gives rise to intensive run-off of surface water which causes soil erosion, flooding of flat land, and sitting-up of the nearby streams and rivers.
b) Excessive leaching, which impoverishes the soil and leads to crop failure due to the sinking of the soil nutrients deep into the subsoil, thus placing the nutrients beyond the reach of herbaceous plants with the shallow rooting system.

5.2. Methods of Land Clearing

Generally, land clearing operation is accomplished according to the end use of the land. It may be necessary to desire one or a combination of these types of land clearing:

Complete removal of trees and stumps by physically uprooting and moving them to piles for disposal by burning or other means. Knocking all vegetation down and crushing it to the ground for later burning. Shearing the vegetation at ground level with sharp cutting blades and pilling them into windrows or piles for burning. The stumps and roots may be removed or left in the soil to decay or shattered in subsequent operations by root plowing or harrowing.

Plowing or chopping the vegetation into the top six to eight inches (15 to 20cm) of the soil in a once-over plowing operation. There are several methods and types of equipment which may be used to accomplish each particular case. The problem of land clearing is one of the limiting factors in increasing agricultural productivity. A well-cleared land makes mechanization of agricultural operations easy and cost-effective and enhances bumper

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

harvest if crops are well managed. Experience shows that if land clearing exercise is not properly carried out, it will result in the rapid restoration of the undergrowth. Hence, the prolific root system just below the ground's surface causes severe losses from the breakages of agricultural implements. The cost of repairing, maintaining, and replacing the damaged parts of these machines and implementing them is high, which increases the cost of production. Often, attempts made by firms, individuals, and governments who introduce tractor and equipment hiring schemes to mechanize agricultural practices were discouraged by these implementation damages caused by improperly cleared land (Sanginga 2011; Obasi 2013; Umeghalu 2013).

Land clearing consists of the following operations: stumping or mechanical knockdown; heaping; or windrowing; wood cutting; burning or removal of debris; and pioneer plowing. A farm is said to be well cleared when almost all the natural vegetation is removed to expose the soil to the sun, extracting the roots to a minimum depth of about 30cm, with minimum topsoil disturbance.

Several methods used in agricultural land clearing include the hand method, bush burning, chemical method, explosive blasting and mechanical land clearing method. One or more of these methods can be used in a single land clearing.

5.3. Hand Method

This method is most commonly used by farmers in the tropical world in land clearing operations of slash and burn. In this method, forests are manually slashed, brushed, and fell the trees, usually with tools like an axe, machete, and hoe. Virgin forests require more time to be cleared. Brush and trees are left to dry before burning. With the rapid increase in population and the need for an increase in agricultural production, this system of agricultural practice can no longer keep pace with the current population explosion. This method is ideal for small areas of land with small trees and stumps when surplus labor is available. If the land is to be mechanized, hand stumping becomes tedious and costly.

5.4. Chemical Method

This is very useful for killing stumps of large trees which will be difficult to uproot during land clearing. Arboricides are mostly used as a chemical land clearing method to eliminate undesirable trees in the forest reserve. They are usually applied directly on the cut surface of stumps with a brush. The stump dies and rots away in the soil.

5.5. Explosive Blasting Method

Very large stumps are sometimes encountered in agricultural land clearing. These large stumps can be shattered by using the explosive blasting method. A hole is bored on the stump, and a measured quantity of dynamite or gelignite is poured in and remotely detonated. The shattered stump is raked off during windrowing.

5.6. Mechanical Land Clearing

A mechanical land clearing method involves using various mechanical equipment such as a tree pusher, rolling chopper, bulldozer blade, clearing rake, anchor chain, and shearing blade. The procedure for mechanical land clearing comprises the following: surveying, knockdown of trees, windrowing, burning and removal of debris and pioneer plowing.

6. Surveying

There is a need to determine the area of land to be cleared, the type and density of vegetation, and the topography and terrain of the area, and all these are determined through a survey of the area. The size of the tractor, the type of matched equipment, and the clearing method to be employed are easily established through a survey.

7. Knockdown

The knockdown method of land clearing is accomplished in two ways: single knockdown and chain knockdown. The variant chosen depends on many factors such as; density of the vegetation and size of trees, terrain and topography of the land, available equipment, and operator's skill. In a single tractor knockdown, a crawler tractor is employed with the bulldozer, tree pusher, or clearing rake to knock down trees one after the other.

According to Allan and Akwada (1976), in the Savanna vegetation zone of Nigeria, where vegetation is not dense and the average tree diameter at breast height does not exceed 45cm, the chaining method can be used for land clearing. This method is a very cheap and fast way of land clearing. The procedure involved in the chaining method of land clearing is as follows: Two crawler tractors are linked with a heavy anchor or chain of a length of about 92meters. The crawler tractors move parallel to each other, leaving a space of about 1/3 the length of the chain between them. The chain knocks down the trees one after the other as the tractors move. The power unit of

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

the crawler tractors employed in this operation depends on the average diameter of the trees. It may be necessary at times for a follow-up tractor armed with a tree pusher and a bulldozer blade to be used when heavy, stubborn trees are met. The chaining method is usually employed in the Sahel and upper limits of the Sudan Savanna area, where vegetation is light. This operation may be followed by heavy disking or root plowing to cut the roots, which are removed with the root rake.

Table 1: Mechanical land clearing methods and equipment for different vegetation zones in Nigeria

Vegetation Zone	Clearing Method	Power Unit (Crawler Tractor)	Equipment For Knockdown	Equipment For Raking.	Remarks
Mangrove	Single tractor knockdown	90KW or more depending on tree diameter	Bulldozer blade, Tree Pusher, Clearing Rake	Rake	Lighter Power Units will aid transportation and traction.
Tropical Rain Forest	Single tractor knockdown	200KW	Bulldozer blade, Tree Pusher, Shearing Blade.	Rake, Shearing Blade.	A tractor armed with a shearing blade will aid in cutting where necessary.
Deciduous forest (Derived Savanna)	Single tractor knockdown.	134KW or less depending on tree diameter.	Bulldozer blade, Tree Pusher, Clearing Rake	Rake, Shearing Blade.	In developing secondary forests, chaining can be possible and is economical when the area is large.
Guinea Savanna.	i) Single tractor, ii) Chain knockdown, Choppinging and disking iii) Chain knockdown.	90KW	Bulldozer blade, Tree Pusher, Clearing Rake	Rake, Shearing Blade.	i) For areas of 40ha. ii) For large areas with an average tree diameter of less than 45cm, the tree population
Sudan savanna	Single-tractor knockdown	65KW or two 134kw crawler tractors for chain knockdown.	Bulldozer, rake, tree pusher, anchor chain 92m.	Rake Shear-ing Blade.	The average tree diameter is slightly above 10cm.
Sahel Savanna	Chopping, disking, root plowing	65KW or less	Rolling chopper.	Root rake.	The average tree diameter does not exceed 7.5–10cm.

8. Windrowing

The knockdown operation is followed by windrowing of the debris. The vegetation debris can simply be raked out, but in large areas, especially where vegetation is dense, it becomes necessary to rake them into windrows. A windrow is a row of debris arranged along the direction of the prevailing wind, usually the North-East trade wind. The windrows should be aligned in the direction parallel to the North-East trade wind to aid burning. They are usually pilled at 10 to 15m spacing or wider depending on the density of the debris. According to Umeghalu (2013), wood is combustible and not inflammable; therefore, requires a steady supply of oxygen by the prevailing North-East Harmattan wind for proper burning.

Equipment to be used in the windrowing operation is not advisable to be such that it can scrap the topsoil and form a muddy window. If this occurs, the organic matter on the topsoil will be removed, which will make the soil infertile. Secondly, mud is a fire extinguisher and could prevent proper debris from burning.

For a good burn of the debris, the windrow should be lined along the prevailing wind. The distance between the windrows depends on the vegetation's weight, the crawler tractor's power unit, topography, and the area's terrain (Nwuba 1984). The multi-operation rake, which does not scrap much of the topsoil, is good for windrowing operations. A Shearing blade may also be used to cut tree trunks for easy pushing. The blade must be kept and maintained at a few centimeters above the soil surface, where a bulldozer is the only equipment available for windrowing operation. It is advisable to create some gap when windrowing for passage of machinery and workers.

9. Burning of debris and removal

Orientation of the vegetation debris along the North-East trade Wind aids burning especially during the harmattan period. Firewood is good for cooking and can be sold to wood contractors before burning the windrow. Sometimes, it may be necessary to leave the windrow as wind brakes or wash stops against erosion. After burning, the windrow is cleared off with the rake. The ash adds to the fertility of the soil.

The Imperativeness of Adequate Land Clearing for Mechanization of Agriculture in the Tropical Forest Zone of Nigeria.

Soil and vegetation are in varying proportions in different parts of the world. In Nigeria, for instance, there exist wide variation in ecological conditions based on the amount of vegetation cover on the soil. Land preparation for food production initially involves clearing the land of all bushes and trees so that the possibility of using machinery exists.

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

The tropical forest is complex and complicated to be somewhat bewildering. The traditional method of agricultural production within the zone is bush fallow, sometimes called shifting cultivation. In this method of farming, an area of the forest is prepared for cultivation; the shrubs and small trees are cut down, stacked to dry, and burnt at the bases of the larger trees, which, because of their thin back, are killed (Nwuba and Fashiwa 1987; Elesa 2003; Rondhi et al. 2018). Some trees of economic value are allowed to remain.

Crops mainly grown in this zone are yams, coco yams, cassava, maize, and some semi-perennial crops are also grown for a few years, after which the soil fertility falls, and the farm is abandoned. At this point, plants that have survived the farming period commence rapid growth. Very soon, the area is covered in a tangle of herbs and climbers, which soon overtops any remaining crops. After about five years, the abandoned farm consists of almost impenetrable vegetation made up of young trees, especially species with a short life span. There are masses of climbers and tangles. At this stage, the farmer considers that the forest has followed and regained fertility, and the forest is re-cleared for farming. If the forest is not re-cleared at this stage, the process of recolonization and regrowth is allowed to proceed, and the vegetation gradually changes into the forest.

10. Regrowth on Cleared Land

Regrowth becomes imminent when roots and stumps are not properly extracted from the soil during land clearing operations; therefore, the forest trees easily regenerate from their roots. This is more serious in permanent pastureland on which further cultivation is desirable. Cleared land with poor root extraction encourages weeds' growth, ultimately ending in poor crop yield, and also causes damage to agricultural machines and implements. Regrowth on cleared land can be eliminated by applying Arboricides (Nwuba and Fashiwa 1987; Allan and Akwada 1976).

11. Consequences of Poorly Cleared Land

Poorly cleared land is a perennial problem for agricultural mechanization (Nwuba 1987). In a cleared land where vegetation is removed with excessive excavation and bulldozing of topsoil, the resultant effect is poor yield because the nutrients required by the crops for growth have been removed. This is commonly experienced when an unskilled operator carries out land clearing operations. It is common to see land clearing jobs contracted out to people not properly trained and equipped for the job. They, in turn, hire the services of roadside artisans who employ their road construction bulldozers in what they thought was agricultural land clearing. In the end, the topsoil is excessively excavated and bulldozed, resulting in muddy windows. Mud is a good fire extinguisher; the windrows will hardly burn. Cropping on such land will result in poor yield because the topsoil has been removed, and the subsoil has no nutrients and moisture required by the crops.

According to Nwuba (1987), it takes time for the humus to rebuild and crop yield to improve. Thus, the farmer suffers, and his efforts in agricultural mechanization are automatically in shambles. The farmer may take the option to abandon the farm project due to the high operational cost of machinery needed to turn the windrows, which must be left to decay and level out before any production on the land (Anazodo 1982; Elesa 2003; Odigbo 2008; Obasi 2013).

12. Timing of Land Clearing operations in the Nigerian Guinea savanna

The importance timing of land clearing operation is very important. Tree knockdown operations are best accomplished when there is sufficient moisture in the soil to allow for easy extraction of roots, but the moisture should not be too much to obstruct traction (Obasi 2013; Singh et al. 2018; Pringle et al. 2021). It is, therefore, best to carry out land clearing operations at the beginning and end of the rains (April – May, and September-October) in the Northern parts of Nigeria. However, land clearing operation can be carried out at any period of the year provided that moisture condition is favorable for such.

Nwuba (1984) pointed out that tree knockdown operation should be avoided under dry soil conditions; to do so, the trees will break, and the roots will be difficult to extract from the soil without excessive disturbance of the topsoil and energy consumption. When land clearing is done during the rain, cropping could be done between the windrows. The windrows should be burnt during the dry season after harvesting the crops.

13. Assessment of land clearing Jobs

Land clearing assessment is based on two factors which are cost and quality of work.

13.1. Cost

The cheapest and most effective method should be used. Factors that affect land clearing operations, such as end use, size of the land and vegetation cover, should be considered when choosing the operation's method and equipment.

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

13.2. Quality of work

The quality of work should not be compromised at the altar of cost because it will be too expensive and uneconomical to clear land twice. The quality of land clearing is determined by three conditions: good stumping, good windrowing, and minimum disturbance of the topsoil.

Table 2: Timing guide for various stages of land clearing operations in Nigerian Guinea Savanna

Period	Operation	Approx. month in Northern Guinea savanna
Early rains (about 100mm recorded.	Commence knockdown or stumping. Windrowing, clearing up, and plowing between windrows may commence during this period.	Early June.
Three weeks post rains.	Stop knockdown, complete windrowing and clean up between windrows.	Mid-November.
End of the dry season.	Complete the burning of windrows.	March.
Beginning of rains.	Commence plowing and seedbed preparation.	April/May.
Early rains of about 100mm were recorded.	Commence knockdown for the following year's planting,	Early June.

Source: Allen and Barnes (1985) modifieds

14. Cost calculation for Land Clearing Operations

Two important factors to be considered in calculating the costs of land clearing operation are fixed and operational or working costs.

14.1. Fixed costs

a) Depreciation: This is obtained by dividing the net cost of less 10% by the expected life of the machine in hours. The scrap value is assumed to be 10% of the net cost.
b) Annual interest is at 6% and is usually based on 50% of the net cost.
c) Garage cost is estimated at N20.00 per day.

14.2. Operational cost or working costs

a) Cost of repairs is expressed as a fraction, *r*, of the Depreciation per operating hour. Considering that the rough forest condition may likely increase damage to the tractor and equipment, thus, the value of *r* is taken to be 1.
b) Cost of fuel is estimated at 1 liter of diesel costs N230.00/liter.
c) Cost of lubrication is taken to be 10% of the fuel cost.
d) The cleaning cost is estimated at 5% of the fuel cost.
e) The operator's wage is taken as the Federal Government Salary for artisan grade III, including other benefits such as annual leave, leave allowance, pension, and public holidays.

15. Conclusion

Adequate agricultural land clearing is fundamental to the success of agricultural mechanization projects. A well-cleared land is a perennial asset to agricultural production. It, therefore, requires good planning, special tools, skills, and methods concerning the nature of vegetation. Timing of land clearing operations is imperative. The implication of badly chosen methods, tools, or skills and wrong timing will lead to failed agricultural mechanization projects. Agricultural land clearing operations adequately executed facilitate mechanization, prolong the life of machines and implement and lead to good harvests over the years.

The major problem contributing to failed agricultural mechanization projects in Nigeria are wrong techniques employed in land clearing operations whereby the topsoil is excessively excavated by the wrong choice of machine and equipment, the use of unskilled and ill-experienced operators, and wrong timing of land clearing operations. It is hoped that the information in this review will offer a useful guide in planning, supervision, execution, and assessment of land clearing operations.

REFERENCES

Adama JC, Onwualu AP and Ugwueze GGU, 1999. Tillage Operations in Enugu State under NALDA Programme; An Economic Evaluation Paper Presented at the Conference of Nigeria society of agricultural Engineers; Ikeja Hotel, Lagos, Nigeria. 10-14th November 1999.

Adefolabi DO, 2004. Climate Change and Poultry Epidemic in Nigeria's South-West Zone. Outlook for 2004/2005. Harmattan Season. Press Conference Paper presented at Federal University of Technology, Minna, Nigeria.

Allan TG and Akwada ECC, 1982. Land Clearing and Site Preparation in savanna: Paper Presented at the International Symposium on Savanna Afforestation Kaduna, Nigeria.

ISSN: 2708-7182 (Print); ISSN: 2708-7190 (Online)
Open Access Journal

Allen JC and Barnes DF, 1985. The causes of deforestation in developing countries. Annals of the Association of American Geographers 75(2): 163-184. https://doi.org/10.1111/j.1467-8306.1985.tb00079.x

Anazodo UGN, 1982. Investigative surveys of farm tractors and equipment hiring services in Nigeria. Proceedings of the Nigerian Society of Agricultural Engineering 6: 10-28.

Baude M, Meyer BC and Schindewolf M, 2019. Land use change in an agricultural landscape causing degradation of soil based ecosystem services. Science of The Total Environment 659: 1526-1536. https://doi.org/10.1016/j.scitotenv.2018.12.455

Elesa BY, 2003. Determination of Land Development Rates in 75 NALDA Enclave Projects Nation Wide (1994-1999) and Refurbishing of 41 No. Tractors of DRD in 36 States and Federal Territory Capital. Research Report Submitted to COREN.

Hodder BW, 1973. Economic Development in the Tropics. 2nd Ed. Methuen and Company Ltd., 11 New Felter Lane London, UK.

Kopittke PM, Menzies NW, Wang P, McKenna BA and Lombi E, 2019. Soil and the intensification of agriculture for global food security. Environment International 132: 105078. https://doi.org/10.1016/j.envint.2019.105078

Nwuba EIU and Fashiwa AB, 1987. Agricultural Land Clearing in Nigeria – Problems and Implications. Samaru Journal of Agricultural Education Zaria 1(1):

Nwuba EIU, 1984. Agricultural Land Clearing – A Fundamental Operation in Large Scale Crop Production in Nigeria. Invited paper presented at the NSAE 1984 Symposium on Development and management of Land Resources for Agric Pro., Durbar Hotel, Kaduna.

Nwuba EIU, 1987. Land Clearing: a Prerequisite for Self- Sufficiency in Food. Proceedings of the Nigerian Society of Agricultural Engineering 3: 243-256.

Obasi AA, 2013. Evaluation of Land Clearing Operations in Enugu State Fadama III Project Communities. Paper Presented at the State Fadama III Project Beneficiaries Disbursement and Implementation Workshop, SFCO, Enugu.

Odigbo EU, 2008. Global Food Crisis: Intensification of Agricultural Mechanization Imperative for Nigeria. Lead Paper Presented at the First South-East regional Conference of the Nigeria Institution of Agricultural Engineers held at Nnamdi Azikiwe University, Awka, pp: 12-19.

Ogbulafor VE, 2000. Obasanjo's Economic Direction 1999-2003. Office of the Honorary Minister for Economic Matters. Dawn Functions Nigeria, Limited Lagos Nigeria.

Ogunjirin OA, Farounbi AJ, Ogunjirin OC and Ogini FU, 2018. Agricultural land development: Panacea for food security in Nigeria. International Journal of Scientific & Engineering Research 9(5): 840-845.

Okigbo BN, 1986. Towards a New Revolution from Chemicals to New Biological Techniques in the Improvement of Tropical Agriculture. A paper presented at the International Meeting of the Italian Academy of Science, Rome, Italy.

Onokerhoraye AG, 2010. Land reform and challenges for Vision 20:20:20. Faculty of Environmental Sciences, 4th Annual Lecture 2010. Nnamdi Azikiwe University, Awka.

Onwualu AP, Akubuo CO and Ahaneku IE, 2006. Fundamentals of Engineering for Agriculture. Immaculate Publications Limited, 2 Aku Street, Ogui New Layout, Enugu, Nigeria.

Pringle MJ, Bray SG and Carter JO, 2021. Modelling the disappearance of coarse woody debris, following a land clearing event. Carbon Balance and Management 16(1): 36. https://doi.org/10.1186/s13021-021-00199-y

Ramankutty N, Mehrabi Z, Waha K, Jarvis L, Kremen C, Herrero M and Rieseberg LH, 2018. Trends in global agricultural land use: Implications for environmental health and food security. Annual Review of Plant Biology 69: 789–815. https://doi.org/10.1146/annurev-arplant-042817-040256

Rondhi M, Pratiwi PA, Handini VT, Sunartomo AF and Subhan Arif Budiman SA, 2018. Agricultural land conversion, land economic value, and sustainable agriculture: A Case Study in East Java, Indonesia. Land 7(4): 148. https://doi.org/10.3390/land7040148

Sanginga N, 2011. Ways Nigerian Farmers are Experiencing Low Yield. Business News, Daily Sun Newspapers, Thursday, December 1, page 50.

Singh KK, Madden M, Gray J and Meentemeyer RK, 2018. The managed clearing: An overlooked land-cover type in urbanizing regions? PLoS One 13(2): e0192822. https://doi.org/10.1371/journal.pone.0192822

Umeghalu ICE and DN Alika, 2019. Challenges of tractor and equipment hiring services on mechanization of agriculture in Nigeria: A study case of delta state tractor hiring agency. International Journal of Applied Sciences & Engineering 7(2): 40-44.

Umeghalu ICE, 2013. The Effect of Land Clearing on the Mechanization of agriculture in Nigeria. Unpublished Lecture Note on ABE 413, Land Clearing and Development. Department of Agricultural and Bioresources Engineering, Faculty of Engineering, Nnamdi Azikiwe University, Awka, Nigeria.

Umeghalu ICE, 2019. Involvement of small scale farmers in policy formulation prerequisite for adoption of modern technology in agricultural production in Nigeria. International Journal of Research in Advanced Engineering and Technology 5: 50-52.

Umeghalu ICE, Okonkwo IF and Nwuba EIU, 2012. Modern technology and Nigerian small scale farmers: Constraints and prospect for its adoption. Scientific Journal of Agriculture 1(4): 68-73.

Wang Y, Luo G, Li C, Ye H, Shi H, Fan B, Zhang W, Zhang C, Xie M and Zhang Y, 2023. Effects of land clearing for agriculture on soil organic carbon stocks in drylands: A meta-analysis. Global Change Biology 29(2): 547-562. https://doi.org/10.1111/gcb.16481