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# LAND CAPABILITY CLASSIFICATION OF THE SOILS OF GHANA

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SUMMARY

In this paper an attempt is made to classify the soils of Ghana under seven capability classes based on the degree of their limitation to mechanized farming and management with the aim of ensuring proper land-use and efficient crop and livestock production.

The classification involves a critical evaluation of the following characteristics of the soils - depth, drainage, texture, slope (topography), permeability, water-holding capacity and inherent fertility to determine the degree of their limitation.

Soils within capability classes I to IV are recommended for mechanized cultivation of crops, pasture, woodland or wild life, whereas those under classes V to VII are recommended only for grazing, woodland or wild life.

## Introduction

The Soil is the most valuable asset in any country. If it is well conserved, its productivity cannot only be maintained but also improved considerably. If soil is misused, however, it can be rendered permanently unproductive and in extreme cases irretrievably lost. (1)

Agriculture will continue to contribute immensely to the economy of Ghana. It is, therefore, essential to develop a sound programme with a view to ensuring continuous production of agricultural and forestry commodities. This can be accomplished by a systematic increase in production on existing small, co-operative and state farms as well as by the development of virgin lands capable of economic production.

Such a sustained agricultural production cannot be achieved without an expansive programme of mapping the soils of the country as rapidly and as cheaply as possible with a view to supplying needed information on potential arable, irrigable, pasture and forestry lands.

Since the commencement of Soil Surveys in Ghana some seventeen years ago, considerable basic data have been accumulated. These are available in the form of soil maps and reports. They cannot in their present form be widely used without being interpreted in such a way as to be understood by the majority of those they are intended for.

Soils can be interpreted in many ways depending on the objectives for which they are to be used. In agriculture, the most primarily objective is the production of crops. In engineering, soils are required to provide materials mostly for building and highway construction. In hydrology, the objective is to locate suitable areas for wells and dams with a view to retaining water for the use of mankind and livestock.

In this paper, an attempt is made to interprete the soils of Ghana for agricultural purposes only. This is in the form of a land capability classification patterned on the system widely used in the soil and water conservation programme in the United States of America. The authors hope that with the co-operation of engineers from the National Construction Corporation it will be possible in the near future to prepare another paper on the interpretation of soils for engineering purposes.

The Land Capability Classification being employed is based on the degree of limitation of the soils of Ghana to mechanized farming and management and involves three major categories of soil groupings. These are (1) capability class, (2) capability sub-class, and (3) Capability Unit.

In the first category the soils of Ghana have been grouped under seven general capability classes. The degree of limitation to mechanized farming and management becomes progressively greater from class I to VII.* Soils in classes I to IV are considered suitable for mechanized cultivation of both field and forage crops as well as for the production of tree crops and, for woodland and wild life purposes.** Soils in classes V to VII are considered unsuitable for mechanized cultivation of field crops and are recommended for the production of tree crops, grasses and legumes for pasture, and for woodland and wild life purposes. Field crops can be grown on class V soils, but only when they are hand cultivated. Like class VI soils, however, soils within class V are best suited to tree and pasture crops. Class VII soils have the greatest risks to management and are suited only for woodland and wild life purposes.

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* See Fig.1A, 1B and 1C on pages 3, 4 and 5

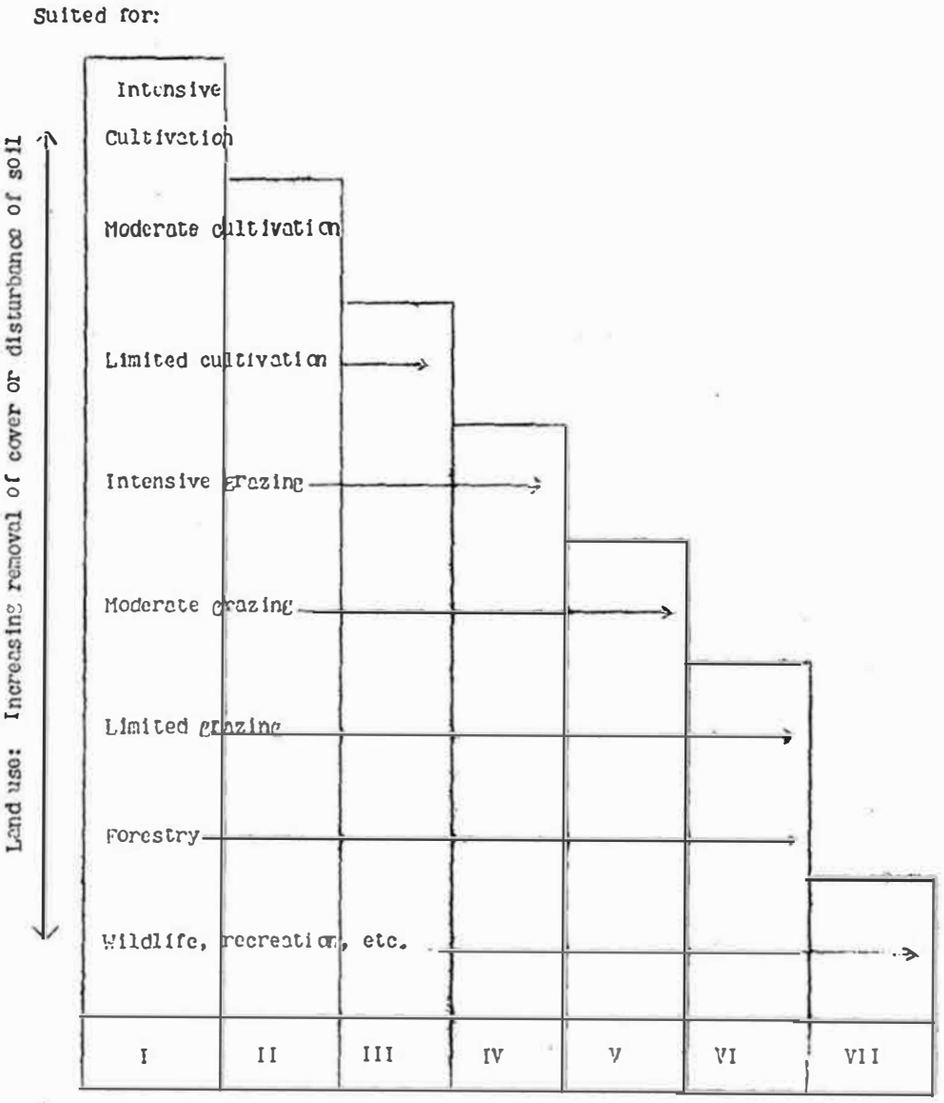
** Soils within classes I to IV are also safe to be cultivated by hand or bullock farming where the necessary farm machinery is unavailable.


FIGURE 1A A LANDSCAPE SHOWING HOW CAPABILITY FITS THE LAND.

## Outline of the land-capability classification

| Broad land use suitability (Broad grouping of limitations) | Land-capability class (Degree of limitations) | | Land-capability subclass (Grouping of land-capability units according to kind of limitation This table shows examples only.) | Land-capability unit (Land - management groups based on permanent physical characteristics. This table shows examples only.) |
|---|---|---|---|---|
| Land suited for Cultivation | I | Few limitations. Wide latitude for each use. Very good land from every standpoint. | | |
| | II | Moderate limitations or risks of damage. Good land from every standpoint. | | |
| | III | Severe limitations or risks of damage. Regular cultivation possible if limitations are observed. | Limited by hazard of water erosion; moderately sloping land. | Moderately sloping, slightly acid soils. |
| | | | | Moderately sloping, highly acid soils on sandstone or shale. |
| | | | Limited by excess water; drainage needed for cultivation. | |
| | | | Limited by low moisture capacity; sandy land. | |
| | IV | Very severe limitations. Suited for occasional cultivation or for some kind of limited cultivation. | | |
| Land not suited for cultivation | V | Not suited for cultivation because of wetness, stones, overflows, etc. Few limitations for grazing or forestry use. | Grouping of sites according to kind of limitation. | Sites significant in management of ranges, pastures, forests etc. |
| | VI | Too steep, too shallow too stony, too droughty, and too wet etc. for any type of cultivation. Moderate limitation for grazing or forestry. | | |
| | VII | Marshes, bovals, scarp phases, rough, stony, barren lands. Not suited for cultivation grazing or forestry. Suited for wildlife, watersheds or recreation | | |

Relation of land limitations and land-capability classes to safe land use




Land-capability classes: Increasing limitations and hazards; decreasing adaptability and freedom of choice of uses

Within each capability class as defined, except class I, sub-classes are set up according to the dominant limitation factor that determines the class. Four kinds of limitations are recognized within the sub-class grouping, namely: runoff or risk of erosion (e), wetness and need for drainage (w), root zone and cultivation limitation (s), and climatic limitation (c).

The capability unit is the most detailed and specific soil grouping of the Capability Classification. It consists of soils that have about the same responses to systems of management of common cultivated field crops, forages and tree crops. Soils in any one capability unit are adapted to the same kinds of common cultivated crops and plants and require similar alternative system of management. (3)

Although, this land Capability Classification system is aimed at ensuring efficient use of land, it is not an economic classification. Thus for example, a farmer on class I land will not necessarily derive more economic benefit from his land than a colleague on either a class IV or V land. It simply means that a Class I land is more suited to mechanized cultivation and can be made to produce more and different crops than a class II or III land and in that order down to class VII with the most limitation to mechanized cultivation and management. A particularly valuable and economic crop for example cacao, may do well only on a class V or VI land and thereby give more financial returns than all the crops on a class I land.

Factors affecting the capability and Use of Land

Soil surveys supply basic data on depth, drainage, texture, slope and hazard of erosion, permeability, water holding capacity, inherent fertility and other chemical soil properties which together with climate determine the capability of a land to successfully produce cultivated crops and/or grasses and trees.

(a) Climate is a limiting factor in land use classification wherever the rainfall is not enough or the temperature is not suitable for increased production of specific crops and other useful plants. The above-mentioned permanent soil characteristics vary widely with climate. They are, therefore, considered in land capability classification in respect of broad areas with similar climatic conditions.

(b) Soil Depth: is one of the factors in land capability classification which is important not only as a medium for the movement of air, moisture and roots but also as a reservoir for storing water and nutrients which are necessary for moderate to high production of crops. Any restirction to the movement of water, roots and air due to an impervious soil layer such as clay pan, cemented concretions or iron pan, therefore, will affect the extent to which the land can be used profitably. Six main soil depth classes are recognised in land capability classification. These are: (1) very shallow (0-10"), (2) shallow (10-20"), (3) moderately shallow (20-36"), (4) moderately deep (36-48"), (5) deep (48-60") and (6) very deep (over 60").

(c) Soil Drainage: which refers to the rapidity and extent of the removal of water from the soil by runoff and flow through the soil to underground spaces or in another sense, to the frequency and duration of periods when the soil is free of saturation, is very important in dertermining the type of crop plants that can be successfully grown on a land without risks of damage. For example, in well-drained to moderately well-drained soils, water is removed readily but not rapidly thus sufficient moisture is usually available for the use of wide variety of economic crop plants. In poorly to very poorly drained soils, however, the root zone is waterlogged for such long periods that roots of ordinary crop plants are unable to procure enough oxygen for healthy and abundant growth. Other soil drainage conditions which are taken into consideration in land capability classification are excessively well-drained, in which condition water is so rapidly and completely removed that most crop plants suffer from lack of water and imperfectly drained condition where water is removed from the soil slowly enough to keep the soil wet for a significant period of the year.

(d) Soil Texture is a permanent soil characteristic which strongly affects land use and management requirements. The term "texture" is a collective word which refers to the proportions of sand, silt and clay in soils. Soil texture is closely associated with drainage, water holding capacity and permeability of a soil, since it determines the amount of water that can flow or be retained by a soil at a given period of time. The various soil textural classes in land use groupings are:

(1) Heavy textures - clay and silty clay grades.
(2) Moderately heavy textures - light clay, clay loam, and sandy clay grades.
(3) Medium textures - silt, loam and silt loam grades.
(4) Light textures - fine sandy loam and sandy loam grades.
(5) Coarse textures - sands and loamy sands.

(e) Slope and hazard of erosion: The steepness, length and shape of slope (concave or convex) have a direct effect not only on the amount of soil and water losses from a land but also on the intensity to which the land can be used. For example, the loss of organic matter and nutrients by sheet erosion especially in the Interior Savannah Zone of Ghana can be so large as to render the land completely unproductive without any dramatic signs of gullying. If a land is too steep, it becomes unsafe for any type of cultivation or the production of economic trees. The only use which can be made of such a land is to devote it to woodland or watershed protection or for the production of firewood. In Ghana, the slope of the land as recognised, varies from nearly level flat summits and valley plains to very steep hills. The various classes of slope and erosion hazards are defined as follows:

| (a) Topography | Percent slope |
|---|---|
| 1. Nearly level to gently sloping | 0 - 2 |
| 2. Gently sloping or gently undulating | 3 - 5 |
| 3. Moderately sloping or moderately undulating. ..... ..... | 5 - 10 |
| 4. Sloping to undulating ..... | 10 - 15 |
| 5. Hilly to steep or rolling ..... | 15 - 30 |
| 6. Very steep ..... ..... | 30 - 50 |

(b) Erosion Hazards.

1. Slight ... none to 25 per cent of surface eroded.
2. Moderate ... 25-50 per cent of surface eroded.
3. Severe ..... over 50 per cent of surface eroded.
4. Very severe ... deep gullies and bovals.

(f) Soil Permeability refers to the quality of a soil horizon that enables water or air to move through it. It is associated with structure, texture, porosity, and the type of clay mineral in a soil. Permeability is important in each soil horizon since the rate or speed at which water passes through a soil is governed by the slowest rate within a total soil profile. This in turn governs the amount of water that a soil may rapidly absorb. The closer a slowly permeable layer such as clay pan, cemented concretions and iron pan, is to the surface, the more restricted are plant roots to absorb water, air and nutrients and the more chance there is for runoff to take place. Soil permeability can be measured quantitatively in terms of rate of flow of water through a unit cross section in unit time under specified temperature and hydraulic condition. The variations associated with soil permeability are defined as follows:

| Permeability | rate in inches of $H_2O$ per hour |
|---|---|
| 1. Slow .... .... .... | 0.05 - 0.20 |
| 2. Moderately slow .... .... | 0.20 - 0.80 |
| 3. Moderate ... .... .... | 0.80 - 2.50 |
| 4. Moderately rapid .... .... | 2.50 - 5.00 |
| 5. Rapid .... .... .... | 5.00 -10.00 |
| 6. Very rapid .... .... | over 10.00 |

(g) The Water holding capacity of a soil is an important physical property that affects the capability and use of land. It is influenced by a number of other soil properties, such as depth, texture, type of clay mineral, structure and organic matter. Soils with limited water holding capacity are droughty and thus restrict the type and number of crops that can be grown profitably under good management. The water holding capacity of a soil can be quantitatively measured and is often expressed in inches of water per foot depth of soil. The different degrees recognised are as follows:

| | inches per foot depth |
|---|---|
| 1. Very low (poor) | 0.50 or less |
| 2. Low (fair) | 0.75 - 1.20 |
| 3. Moderate (Very fair) | 1.50 - 1.75 |
| 4. High (good) | 1.80 - 2.50 |

(h) The Inherent Fertility of a soil is that quality of the soil that enables it to provide adequate amounts of plant nutrients in proper balance for the production of specific crops. This quality of a soil is usually inferred by the sum total of all the permanent physical soil characteristics mentioned above coupled with chemical soil properties such as organic matter content, cation exchange capacity, per cent base saturation and soil responses to added plant nutrients in the form of fertilizers.

The degree of limitation of a soil to cultivation and management as a result of climate and/or one or a combination of the soil properties discussed above will determine to a great extent the capability class and sub-class under which that particular soil is to be appropriately classified.

Land-use classification of the soils into capability classes and sub-classes:*

Land suited to Mechanized cultivation and other uses

Class I land (Fig.2).

This class consists of very good soils with minor or no physical limitations to mechanized cultivation. The soils are deep to very deep, well drained and medium textured on nearly level to very gently sloping topography. They are moderately permeable and have a moderate to high water-holding capacity, medium inherent fertility but a good capacity to utilise added fertilizers. They are subject to no more than slight erosion and are not subject to damaging overflows.

Class I soils are suitable for intensive agriculture involving any crop which the climate of the area allows and can sustain moderate to high crop production with few management practices such as maintenance of fertility through mulching, manuring, addition of commercial fertilizers, the establishment of a legume in the rotation and contour ploughing.

Class I soils are very limited in Ghana. Some of the major class I soils are Damongo, Nimi, Ejura and Bediesi series from the Interior Savannah and Transitional zones of Ghana, Akumadan and Boamang series from the Forest zone and Toje series from the Coastal Savannah zone. Such soils are suitable for the production of food crops, tobacco and other cultivated cash crops.

Class II land (Fig.3).

Class II land is made up of good soils with few physical limitations which can be easily corrected. The soils are suited to cultivated crops, pasture, and for woodland and wild life purposes.

The possible limitations which make Class II soils not quite as good as those of Class I may be generally sub-divided on the basis of (1) erosion - denoted by IIe, (2) wetness - denoted by IIw, (3) other soil properties - denoted by IIs, and (4) Climatic limitations denoted by IIc. The first sub-class commonly relates to upland soils and the second to lowland soils. Properties coming under the third category may be found on either topographic site. The limitations may include one or more of the following effects within each of the under-mentioned sub-classes:

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*Examples of capability grouping of soils from various parts of Ghana are shown on Maps 1, 2, and 3 at the back

FIGURE 2. CLASS I LAND - Very good for any type of Cultivation

2A. Level to nearly level land with only slight erosion hazard

2B. Deep, well-drained, medium textured soil (Toje Series)

2c. Urena lobata on Class I land near Ejura (Damango sandy clay)

RE 3. CLASS II LAND - Good land for cultivated crops and/or pastures

3A. Nearly level and moderately deep soil with slight to moderate erosion hazard

3B. Avocado Pear on class II soil, Mangoase Co-operative Farm. (Kokua clay loam)

(a) Sub-class IIe.

1. Moderate erosion hazard.
2. Gentle slopes.

(b) Sub-class IIw.

1. Moderately wet soils (internally).
2. Heavy textured soils.
3. Presence of salts.
4. Occasional overflows.

(c) Sub-class IIs

1. Moderately deep soils - often associated with erosion and sub-class IIe.
2. Moderately well-drained soils - often associated with sub-class IIw.
3. Either moderately rapid or moderately slowly permeable soils.
4. Either low or moderate water holding capacity.
5. Low inherent fertility.
6. Fair capacity to utilize added fertilizers.

The limitations of class II soils restrict the selection of crops, time and ease of cultivation and the amount of water and frequency of irrigation. Moderate productivity can best be maintained on class II land by (1) raising the fertility level through mulching, manuring, addition of commercial fertilizers, liming and the inclusion of legumes in the rotation, (2) terracing, (3) stripcropping, (4) contour ploughing, and (5) water control structures.

Class II soils occur extensively in the Forest, Transitional, and Coastal Savannah Zones of Ghana. They are, however, somewhat limited in extent in the Interior Savannah Zone. Major soils of Ghana falling within this class are Afrancho, Suko, Korangsang, Nurugu, Oyarifa, Varempere and Balcufili Series.

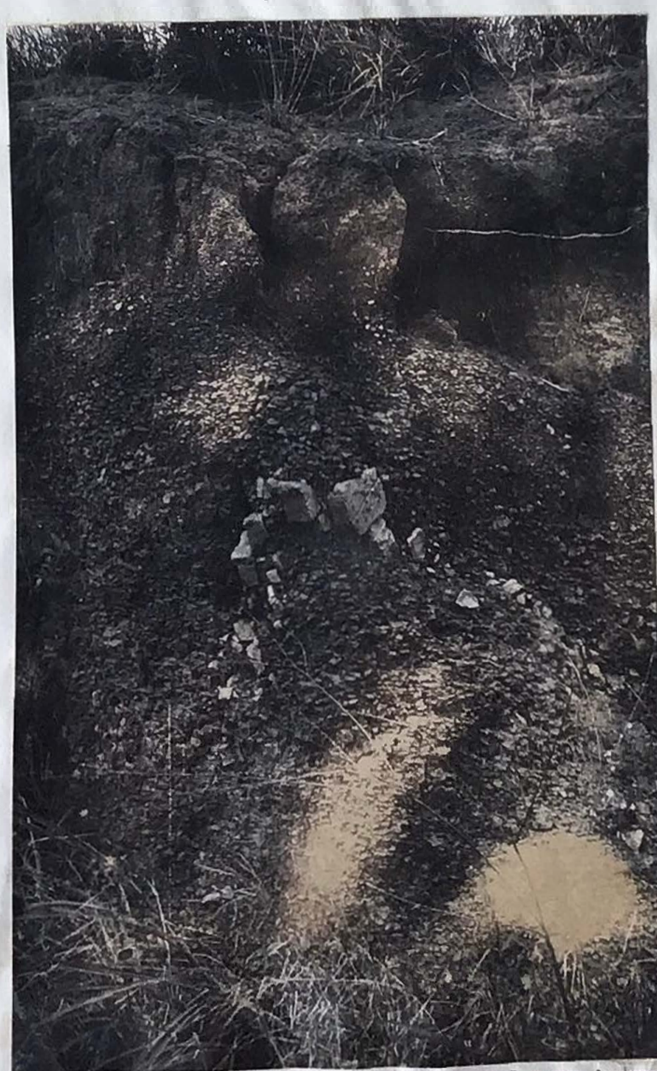
Class III land (Fig.4).

Class III soils are moderately good but have more limitations to mechanized cultivation than class II land. When used for cultivated crops, conservation practices are usually more difficult to apply and maintain. They are suited to cultivated and pasture crops and, for woodland and wild life purposes.

The limitations of soils in class III that restrict the degree of clean cultivation, choice of crops and the time of planting and harvesting, may include one or a combination of the following effects of the under-mentioned sub-classes.

FIGURE 4. CLASS III LAND - Very fair land for c ltivated crops and / or pasture

4A. Nearly level, deep but heavy textured, poorly drained soil. Moderate to severe drainage problem. IIw.



4B. Moderately shallow, medium textured so l over impervious parent rock. Moderate to severe erosion hazard. IIIs.

(a) Sub-class IIIc

1. Moderate to high erosion hazard.
2. Sloping or undulating topography.
3. Gravelly or stony texture.

(b) Sub-class IIIw

1. Imperfect to poor internal drainage.
2. Excessive wetness.
3. Heavy textures.
4. Presence of salts.
5. Moderate overflow hazard.

(c) Sub-class IIIs

1. Moderate to shallow depth to bedrock, indurated layer, concretions or ironpan - often associated with IIIc.
2. Low moisture holding capacity.
3. Excessive wetness - associated with (IIIw).
4. Shallow depth to claypan - associated with (IIIw).
5. Slow to very slow subsoil permeability associated with (IIIw).
6. Either very slow, rapid or very rapid permeability.
7. Low inherent fertility.
8. Fair or low capacity to utilize added fertilizers.

Moderate productivity of Class III soils can best be maintained by following the recommendations for Class I and II lands with additional elaborate water control measures as grass water-ways, close strip cropping and broad based contour terraces or bunds.

Class III soils are very extensive in Ghana. Examples of a few of the major soils are Amo, Hake and Akuse series from the Accra plains; Kokofu, Akroso and Kakum series from the Forest region; and Bawku, Mimi and Tolon series from the Interior Savannah Zone.

Class IV land (Fig.5).

Class IV land consists of fairly good soils best suited for perennial vegetation. They can with great care be mechanically cultivated to field crops. Hand cultivation and/or bullock farming can be practised. The possible limitations that may singly or in combination render class IV soils not as good as Class III, may generally be described under sub-class IVc, IVw and IVs as follows:

URE 5 CLASS IV LAND: Fairly suited for cultivation. Best suited for pasture grazing

5A. Fairly productive Soil. Limited in use due to moderate depth to gravelly subsoil (Tanina sandy clay)

5B. Gully erosion on class IV land (Sello-Tuni land Planning Area, near Wa).

(a) Sub-class IVc

1. Moderate to high erosion hazard.
2. Sloping to hilly topography.
3. Very gravelly or stony textures.

(b) Sub-class IVw

1. Either poor or excessively drained soils.
2. Heavy textured soils.
3. Moderate overflow hazard.

(c) Sub-class IVs

1. Shallow depth to bedrock, ironpan, concretionary layer or clay pan.
2. Poor drainage often associated with sub-class IVw.
3. Light textured and/or gravelly or stony soils.
4. Either very rapid or very slow subsoil permeability.
5. Low water holding capacity.
6. Low inherent fertility.
7. Low capacity to utilize added fertilizers.

The productivity of class IV soils may be maintained by following more intensely the same practices recommended for Class II but rotations to be practised should include long periods of forage or tree crop production. Class IV soils are very extensive in Ghana and are mainly cultivated to food crops and tree cash crops. Some of the representative major soils are Dentenso, Tanina, Kupela, Lima, Volta and Pale series from the Transitional and Interior Savannah Zones; Birim, Kokofu (shallow) and Oda series from the Forest Zone; and Agawtaw and Pejeglo series from the Coastal Savannah Zone

B. Land Limited in use-Generally not suited to mechanized cultivation*

Class V land (Fig.6)

Soils in class V are not suited to mechanized cultivation because of severe limitations. They are best suited to limited clearing, grazing and hand cultivation for the production of perennial crops. These soils commonly occupy hilly to steep topography and are subject to moderate or severe erosion. Deep, heavy textured and poorly drained soils on nearly level topography which are very difficult to drain will also fall within this class. Upon draining, however, the heavy textured soils can be raised to Class III or IV levels and thus be suitable for the production of rice, irrigated pastures, etc. Mechanized

* Certain soils grouped under classes V, VI and VII may be made fit to be cultivated to crops, through major earth moving or other costly reclamation measures.

URE 6. CLASS V LAND NOT SUITABLE for Mechanized cultivation but may be hand Cultivated. Recommended for the production of pasture for grazing purposes.

6A. Shallow gravelly soil. Subject to severe erosion. Best suited for livestock grazing.

6B. Nearly level but shallow and gravelly soil. Showing proper land-use (livestock grazing) being practised. (Sello-Tuni Land Planning Area near Ne).