COURES CODE: *SOS 518*
COURSE TITLE: Pedology
NUMBER OF UNITS: *2 Units*
COURSE DURATION: *Three hours per week*

COURSE DETAILS:

Course Coordinator: Dr. Bola A. Senjobi. *B.Sc, M.Sc. PhD*
Email: bolasenjobi@yahoo.com
Office Location: Room 236, COLPLANT
Other Lecturers: Dr. G. A. Ajiboye

COURSE CONTENT:

Basic principles of soil classification. Soil morphological characteristics and classification. Soil forming minerals and rocks. Soil survey methodology. Assemblage of maps; use of aerial photographs and topographic maps for soil survey and classification. Type of soil survey, field mapping and soil sampling. Routine laboratory determinations and correlation of soil data. Soil survey report writing and interpretations. Concepts, principles and justification of land-use planning. Historical and present trends in land use. Management problems relating to tropical soils; land –use and soil degradation. Soil and land capability classification.

COURSE REQUIREMENTS:

Compulsory course

READING LIST:

Fitzpatrick, E. A. (1980). Soils. Longman Group Limited, London. 352pp
Young, A. (1980). Tropical soils and Soil Survey. Cambridge University Press, New York.

LECTURE NOTES:

Why classify Soil?

- To organize our knowledge about soils
- To deal with complexity
- To develop principles and guidelines for proper use and management:
    a. to predict behavior
    b. to identify best uses
    c. to estimate productivity
    d. to identify potential problems

- To facilitate easier transfer of information and technology
- To provide a basis for research and experimentation
- To understand relationships among individuals of the population
- To provide an organizational chart or map of the world of soils as we perceive it - the soil survey

Basic principles of classification

- Classification is the grouping of objects into classes or groups on the basis of similarities or differences in their common properties.
- Individual objects make up a population.
- A class is a group of individual or other classes similar in selected properties and distinguished from all other classes of the same population by differences in these properties.
- In any system of classification, those groups about which the greatest number of things can be stated for the chosen objective are generally the best and the most useful classification groupings.

Key concepts of classification

• Types of objects

- Individuals
- Populations
- Sub-populations (strata)

• Issues regarding classes

- Existence of **modal** ('typical') individuals
- Measures of **similarity** in **state space**
- Measures of **compactness** of classes

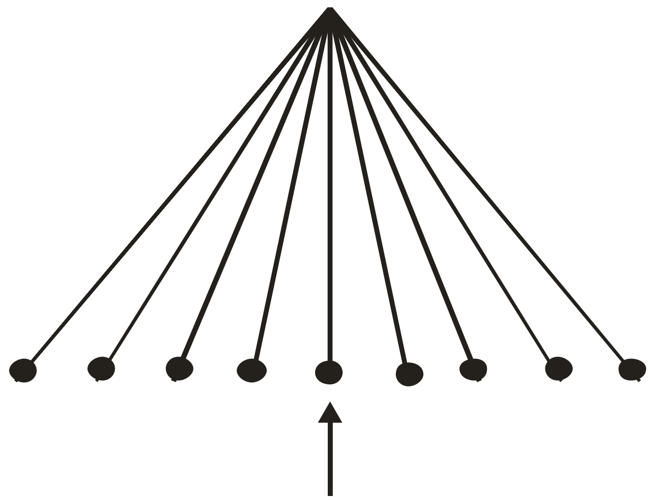
• Types of characteristics

- **Differentiating**: used to defined classes
- **Accessory**: consistently associated with a class;
- **co-variant** with differentiating characteristics

Accidental: not associated with the classes

Attributes of a good differentiating characteristics

- Is important for the objective of classification
- Carry the greatest possible co-varying or accessory characteristics that are also important for the objective of classification.



Principles of differentiation as they affect classes

- A differentiating characteristic must be important for the objective.
- A differentiating characteristic must be a property of the things classified or a direct interpretation for the objective.
- The differentiating characteristics should carry as many accessory properties as possible for the objective.
- The class interval of a differentiating characteristic must provide classes homogenous for the objective.

Principles of differentiation as they affect relationship among categories

- Differentiating characteristics must classify all individuals in any single population (Nikiforrof principle of wholeness of taxonomic categories).
- Greatly different "kingdoms" require different differentiating characteristics at the same level of abstraction.
- All classes of the same category of a single population should be based on the same characteristic.
- A differentiating characteristic in one category must not separate like things in a lower category.

What is different about soils?

- There is really no soil '**individual**' as a self-standing object.
- The emphasis in soil is on defining **mappable** classes

Rather than on optimal classification of individuals.

- There is no true **inheritance** or genetics as it is understood in biology

Concept of the pedon as a discrete object within the soil continuum (Soil individuals)

- The major difficulty in defining soil individuals or basic entities follows from the existence of soil as a continuum.
- The term **pedon** has been proposed as a collective noun for a small basic soil unit that can be regarded as the basic soil entities or soil individual.
- A pedon consists of a small volume of soil which includes the full solum and the upper part of the unconsolidated Parent material. It is usually less than two metres (2m) in

depth, and has a lateral cross-section that is roughly circular or hexagonal in shape and between $1m^2$ and $10m^2$ in area.

Source of criteria for soil classification.

- Different classification system uses different criteria
- For most part, the criteria used to classify soil are those that can be observed or determined rapidly by simple tests on the field.

Marbut (1932) proposed the following properties for differentiating soils at the level of soil type:-

- Number of horizons in the profile
- Colour of various horizons with special emphasis on the surface one or two
- Texture of each horizon
- Structure of the horizons
- Relative arrangement of horizons
- Thickness of horizons
- Thickness of the true soil (profile) Chemical composition of horizons
- Character of the soil material [alluvial, loess, sand]
- Geology of the soil material [parent material]

In addition to the above the USDA make use of:

- Soil Moisture Regimes
- Soil Temperature Regimes

Attributes of a good soil taxonomic system:

- Definition of a class or taxon should carry as nearly as possible the same meaning to each user
- Should be a multi-categoric system (hierarchical)
- lower levels - narrowly defined - large number of differentiating characteristics
- higher levels - broadly defined - few soil properties are used to differentiate
- Classes or taxa should be concepts of real bodies of soil that exist in nature
- Must be capable of providing for all the soils observed in a landscape
- Differentiating characteristics should be properties that are observable in the field or quantitatively measured by reliable techniques
- The system should be capable of modification to incorporate new knowledge with a minimum of disturbance
- The criteria used should keep undisturbed and cultivated soils in the same taxa.

Major ways of classifying soils

There are various ways to organize a soil classification. A major distinction is between **natural** and **technical** approaches:

Natural soil classifications group soils by some intrinsic property, behaviour, or genesis of the soils themselves, without reference to use.

• **Technical** soil classifications group soils by some properties or functions that relate directly to a proposed use or group of uses.

Natural classifications:

• Group by **ecologic region**, e.g. “prarie soils”, “boreal soils”. Geographically-compact but may have diverse properties and function.

•Group by **presumed genesis**, i.e. the development pathway of the soil profile. These are called **genetic** soil classifications. The soil individual is considered as a natural body with its own history and ecology. This depends on the interpretation of landscape and soil genesis.

Group by **similar properties**, working **bottom-up** from a set of individuals, to a set of classes, and then grouping the classes into super-classes. This can be done by:

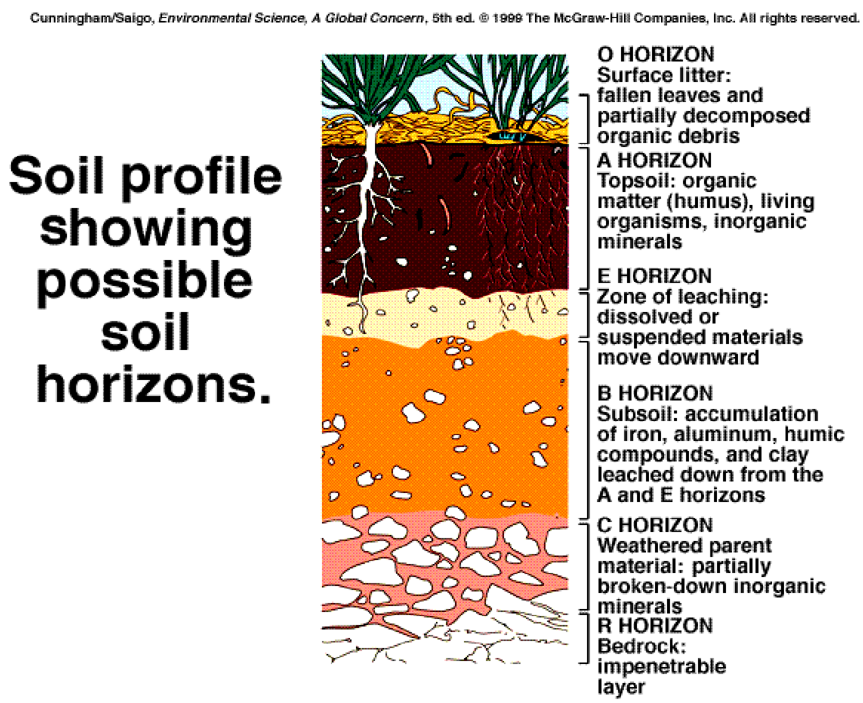
– Subjective judgment of the classifier

– Numerical classification, usually multivariate

Technical classifications:

- *Land* Suitability Evaluation (FAO)
- Land Capability Classification(USDA)
- Fertility Capability Classification (FCC)
- Engineering group
- Hydrologic response

SOIL PROFILE AND HORIZONS: A Source of criteria for soil classification.



MASTER HORIZONS

Horizontal layers of soil called horizons can be described by their different morphological characteristics. Capital letters designate master horizons, which are further subdivided by Arabic numerals.

O Horizon

O horizon is an organic horizon. It is a surface layer characterized by accumulation of organic matter which may be dominated by partially decomposed or undecomposed organic material.

A Horizon

The A horizon is the uppermost mineral layer. It may lie below the O horizon. An A horizon has a high concentration of humus and it is usually regarded as an elluvial surface horizon.

E Horizon

The E horizon is an elluvial surface horizon. It has experience the loss of clay, organic matter, iron and aluminum oxides with the resultant accumulation of quartz and other resistant minerals. It is also characterized by bleached appearance because of loss of materials.

B Horizon

The B horizon is a subsurface mineral horizon showing evidence of illuvial accumulation of silicate clay, iron, aluminum, gypsum, or silica; carbonate removal; residual concentration of sesquioxides and silicate clay; coating of sesquioxides, (etc.).

C Horizon

The C horizon is a layer of minimal alteration. Material may be similar to or unlike that from which the other horizons formed.

R Layer

An R layer refers to hard consolidated bedrock. The R layer is presumed to be the material from which the overlying horizons are developed. But if it is a different material from that of the overlying mantle, it is represented by IIR, indicating what is called ***Lithological Discountinuity***.

TRANSITIONAL HORIZONS

Transitional horizons are dominated by properties of one master horizon but have the subordinate properties of another. These are designated by two capital letters, for example, AB, EB, BE, or BC. The first letter represents the dominant horizon characteristics.

SUBORDINATE DISTINCTIONS

Master horizons are further divided by subordinate characteristics, which usually do not apply to transitional horizons. Subordinate distinctions are identified by lower-case letters, called suffix symbols.

- ***a.*** *Highly decomposed organic material.* ***b****. Buried genetic horizon.* ***c.*** *Concretions or nodules.* ***d****. Physical root restriction.* ***e.*** *Organic material of intermediate composition.* ***f.*** *Frozen soil.* ***g****. Strong gleying.* ***h****.* I*lluvial accumulation of organic matter.* ***i****. Slightly decomposed organic matter.* ***k****. accumulation of carbonates.* ***m****. cementation or induration, km* . Cementation by carbonates; *qm* . Cementation by silica; *sm*. Cementation by iron; *ym.* Cementation by gypsum; *kqm*. Cementation by lime and silica; and *zm*. Cementation by salts more soluble than gypsum. ***n****. Accumulation of sodium.* ***o****. Residual accumulation of sesquioxides* ***p****. Tillage or other disturbance.* ***q****. Accumulation of silica.* ***r****. Weathered or soft bedrock.* ***s****. illuvial accumulation of sesquioxides and organic matter.* ***ss*** *. Presence of slickensides* ***t*** *. Accumulation of silicate clay* ***v*** *. plinthite.* ***w****. development of color or structure.* ***x****. fragipan character.* ***y****. Accumulation of gypsum* ***z*** *. accumulation of salts more soluble than gypsum*

DIAGNOSTIC HORIZONS:

Master horizons describe a soil profile, while diagnostic horizons are used to classify soils. Whereas master horizons are based on appearance, diagnostic horizons are based on soil formation processes. There are two types of diagnostic horizons. These are surface (epipedon) and subsurface horizon (Endopedon).

EPIPEDONS

An epipedon is the surface, or uppermost soil horizon. They are not synonymous to the A horizon. They may be thinner than the A horizon, or include the E or part or the entire B horizon.

Histic epipedon

This organic horizon is water saturated long enough for reduced conditions to occur unless artificially drained. It is 40 to 60 cm thick and has a low bulk density often less than 1 g cm^3.

Mollic epipedon

This epipedon is a soft dark grassland soil. Its organic carbon content is 0.6 percent or more; its base saturation is 50 percent or more; It has a minimum thickness of 18 cmand contains less than 250 ppm P_2O_5.

Anthropic epipedon

While similar to the mollic epipedon, the anthropic epipedon contains greater than 250 ppm citric acid soluble P_2O_5 with or without a 50 percent base saturation.

Umbric epipedon

Mollic-like in thickness, organic carbon content, color, P_2O_5 content, consistence, and structure, this epipedon has less than 50 percent base saturation.

Ochric epipedon

Ochric epipedon is light in colour and low in organic matter and too thin to be any of the other five epipedons. Ochric epipedon is the most common epipedon in Nigerian soils.

Plaggen epipedon

This man-made horizon is 50 cm or more thick and has resulted from centuries of accumulation of sod, straw, and manure, for example. It commonly contains artifacts such as pottery and bricks.

DIAGNOSTIC SUBSURFACE HORIZONS

Diagnostic subsurface horizons can be categorized as weakly developed horizons, as horizons featuring an accumulation of clay, organic matter, or inorganic salts, as cemented horizons, or as strongly acidic horizons.

Agric

The agric horizon is an illuvial horizon that has formed under cultivation and contains significant amounts of illuvial silt, clay, and humus. It is usually formed after prolonged years of cultivation.

Albic

Albic (L. *albus*, white) materials are soil materials with a color that is largely determined by the color of primary sand and silt particles rather than by the color of their coatings.

Argillic (Bt)

An argillic horizon is normally a subsurface horizon with a significantly higher percentage of phyllosilicate clay than the overlying soil material. It shows evidence of clay illuviation.

Calcic

The calcic horizon is an illuvial horizon in which secondary calcium carbonate or other carbonates have accumulated to a significant extent.

Cambic

This horizon shows some evidence of alterations but is very weakly developed between A and C horizons. The cambic horizon has less illuviation evidence than found in the argillic and spodic horizons.

Gypsic (By) accumulation of $CaSO_4$; 15 cm or more thick 5% or more calcium sulfate.

Glossic (B/E) consists of an eluvial part (E - albic) and an illuvial part (Bt - argillic, or Bto- kandic or Btn-natric) sometimes referred to as tounging

Kandic (Bto) - fine textured subsurface horizon that has evidence of clay translocation and is composed mostly of low activity clays (low CEC and ECEC). The CEC (by the 1N NH_4OAC method at pH=7) is 16 cmol(+) or less per kg of clay and the ECEC (by the basic cations displaced by ammonium plus KCl extractable aluminum methods) is 12 cmol(+) or less per kg of clay.

Natric (Btn) - meets all the requirements of the argillic horizon and, in addition, has: a. either prismatic or columnar structure b. either (1) an exchangeable sodium percentage of 15 percent or more or (2) a sodium adsorption ratio (SAR) of 13 or more.

Oxic (Bo) - highly weathered horizon that consists of oxides of iron and aluminum, 1:1 clays and resistant minerals such as quartz. It has a thickness of 30 cm or more; less than 10 percent weatherable minerals; low CEC ($\leq$ 16 cmol(+) per kg of clay

Salic (Bz) soluble salt accumulation - salts more soluble than gypsum 15 cm or more thick EC _>_ 30dS/m in a 1:1 soil water extract

Spodic (Bs or Bhs) - illuvial accumulations of sesquioxides and/or organic matter composed of spodic materials.

Other Diagnostic Soil Features

Abrupt textural change. Ochric or Albic overlies an argillic considerable increase in clay over a short distance in the profile usually double the clay content within a vertical distance of 7.5 cm

Glacic - (Bf). Ice in the form of ice lenses or wedges.

Lamellae - (Bt or Bw). Number of clay-enriched layers separated by coarser textured layers illuvial horizon less than 7.5 cm thick horizontal bands contain an accumulation of oriented clay bridging sand grains lamellae occur in a vertical series of two or more; each lamellae has an overlying eluvial.

Lithologic discontinuity. (Numerical prefix; e.g. 2Bt1) change in parent material geologic process rather than pedogenic possibly indicated by abrupt textural change, contrasting particle sizes, stone lines, mineral composition or orientation of rocks.

Plinthite - (Bv). Humus poor, iron-rich, ironstone hardpan hardens irreversibly after being exposed to repeated wetting and drying in place begins as soft, red iron segregations (mottled appearance) due to oxidation.

Slickensides - (Bss). Polished or grooved clay surfaces produced by one soil mass sliding against another common in shrink-swell clays indicates vertic.

Densic contact - (Bd or Cd). Boundary between soil and underlying densic material (plow pan, glacial till, etc).

Lithic contact - (R). Boundary between soil and consolidated underlying material digging with hand tools is impractical.

Paralithic contact - (Cr). Boundary between soil and weathered bedrock underlying material can be dug with hand tools.

CLIMATOLOGICAL DATA: **A Source of criteria for soil classification.**

Soil Moisture Regimes

The term “soil moisture regime” refers to the presence or absence either of ground water or of water held at a tension of less than 1500 kPa in the soil or in specific horizons during periods of the year.

Classes of Soil Moisture Regimes

Aquic moisture regime. The aquic moisture regime is a reducing regime in a soil that is virtually free of dissolved oxygen because it is saturated by water.

Aridic and torric moisture regimes. These terms are used for the same moisture regime but in different categories of the taxonomy. In the aridic (torric) moisture regime, the moisture control section is dry in all parts for more than half of the cumulative days per year.

Udic moisture regime. The udic moisture regime is one in which the soil moisture control section is not dry in any part for as long as 90 cumulative days in normal years.

Ustic moisture regime. The ustic moisture regime is intermediate between the aridic regime and the udic regime. Its concept is one of moisture that is limited but is present at a time when conditions are suitable for plant growth.

Xeric moisture regime. The xeric moisture regime is the typical moisture regime in areas of Mediterranean climates, where winters are moist and cool and summers are warm and dry.

SOIL TEMPERATURE REGIMES

Classes of Soil Temperature Regimes

Following is a description of the soil temperature regimes used in defining classes at various categoric levels in this taxonomy.

Cryic (Gr. *kryos*, coldness; meaning very cold soils). Soils in this temperature regime have a mean annual temperature lower than 8 ^{oC} but do not have permafrost.

Frigid. A soil with a frigid temperature regime is warmer in summer than a soil with a cryic regime, but its mean annual temperature is lower than 8 ^{oC} and the difference between mean summer and mean winter soil temperatures is more than 6 ^{oC}

Mesic. The mean annual soil temperature is 8 ^{oC} or higher but lower than 15 ^{oC}, and the difference between mean summer and mean winter soil temperatures is more than 6 ^{oC}.

Thermic. The mean annual soil temperature is 15 ^{oC} or higher but lower than 22 ^{oC}, and the difference between mean summer and mean winter soil temperatures is more than 6 ^{oC}.

Hyperthermic. The mean annual soil temperature is 22 ^{oC} or higher, and the difference between mean summer and mean winter soil temperatures is more than 6 ^{oC}.

ISO

If the name of a soil temperature regime has the prefix *iso*, the mean summer and mean winter soil temperatures differ by less than 6 ^{oC}.

SOIL CLASSIFICATION

International Soil Classification Systems

There are two major world soil classification systems. These are the United State Department of Agriculture (UDSA) taxonomic system and the World Food and Agricultural Organization (FAO) World Reference Base System (USDA, 2003; FAO, 2006). These are systems designed for universal application. They should classify any soil, and serve to **correlate** experiences on similar soils all over the world.

USDA SYSTEM OF SOIL CLASSIFICATION

The USDA classification system is a multi- categorical and hierarchical system. Thus the classes in the highest categories are divided into smaller classes in the lower one and continue to the lowest level, which is the soil series.

The USDA system comprise a hierarchy of 6 levels

- Orders (12) (surface and subsurface diagnostic horizons)
- Suborders (55) (Soil temperature. and moisture regimes)
- Great group (238) (subsurface diagnostic horizon)
- Subgroup (1243) (drainage, lithic contact, PM, clay type)
- Family (7504) (Texture of diagnostic surface horizon)
- Series (about 19,000) in U.S.

The most common soil orders in Nigeria are Alfisols, Entisols, Inceptisols, Oxisols and Ultisols.

- The formative name for each order is usually a two or three letter prefix. The prefixes are: Alfisols = ALF, Andisols = AND, Aridisol = ID, Entisols = ENT, Gelisols = EL, Histosils = IST, Inceptisols = EPT, Mollisols = OLL, Oxisols = OX, Spodosols = OD, Ultisols =ULT, Vertisols = ERT.
- **Alfisols:** Alfisols refers to soils with either an argillic B or textural B horizon, kandic, or natric horizon and with a base saturation by sum of cation greater than 35%.
- Andisols: Form from P.M. of volcanic origin. Soil forms by rapid weathering of volcanic ash to produce poorly crystallized aluminosilicates (allophane & imogolite). Andisols are young soils (and they have high OM). In dry climates, can be susceptible to wind erosion and can have unusually low bulk densities
- **Aridisols :** Aridisols are primarily soils of the arid region occurring in area where there is no water in the soil as long as 90 consecutive days when soil temperature is greater than 6°C.
- **Entisols** : They are young soils recently developed and their main characteristic is the lack of any diagnostic horizon.
- **Gelisols:** Presence of permafrost layer within 100 cm of soil surface defines this soil class. Young soils with little profile development, Cold temperatures and frozen conditions for much of the year slow the process of soil formation. May show evidence of cryoturbation, physical disturbance of soil material caused by freezing and thawing.
- **Histosols** : These are soils with high organic matter containing between 20% to 30% organic matter within 80cm of the soil surface.
- **Inceptisols:** Soils with cambic B horizons and with textures finer than loamy fine sands
- **Mollisols:** Typically form under grasslands. They are soils with a mollic epipedon, thick humus-rich surface horizon, high % base saturation throughout profile, slightly leached and very fertile soils
- **Oxisols** : They are soils with oxic B horizon. Usually they are highly weathered and lacking minerals other than quartz, kaolinite and sesquioxides.
- **Spodosols:** *Have a spodic horizon, f*orm in humid, cool climates and occur most often in conifer forests (New England, Mich., Canada), form in acid, coarse, quartz (sandy) bearing P.M. Low fertility
- **Ultisols** : These are soils with argillic B horizons but with base saturation by sum of cation less than 35%

- **Vertisols** : Vertisols are heavy clay soils containing swelling and shrinking montmorillonite or smectite type of clay. The common feature of this soil is cracking but these cracks must be as wide as 1cm and must progress as far as 50cm depth to qualify as a true vertisol. Other noticeable features of vertisols are gilgai and slickensides.

Sub-Order: The sub-orders are the next categories to the soil order and are differentiated from each other within the order on basis moisture and temperature regimes, diagnostic surface horizon (epipedon), parent material, drainage and vegetation effects. Formative elements used at the sub-order level includes: - UD = udic moisture regime; UST = ustic moisture regime; XER = Xeric moisture regime; AQU = aquic moisture regime, HUM= presence of humus etc. Example ustalf = UST + ALF; ALF= Alfisol, UST = Ustic moisture regime; Ustalf= Alfisol under ustic moisture regime.

Great Group: Sub orders are divided into great groups on the basis of close similarities in the kind, arrangement and degree of expression of horizon, close similarities in soil temperature and moisture regimes, similarities in the base status.
regime.
Formative element used at the level of great group includes: Plinth = Plinthite, Cry = cryic temperature regime, Dur = Duripan, Natr = Natric horizon, etc. Example Plinthaqualf = PLINTH + AQU + ALF = Plinthite + Aquic moisture regime + Alfisol. Thus plinthaqualf is an alfisol under aquic moisture regime and has a plinthic horizon.

Sub-group: Sub-groups are sub – division of the great group. Criteria for differentiating the sub groups are:

- presence of diagnostic horizons or features
- properties that are subordinate to those used in differentiating great groups
- properties that tend towards other great groups

The sub group name is derived from the great group name to which an adjective is attached indicating the major property of the sub group;
e.g. calcic Rhodxeralf = Calcic + Rhod + Xer + Alf. Calcic = calcic horizon; Rhod = Red colour (hue 2.5YR or redder); Xer = xeric moisture regime; Alf = Alfisol; Thus, calcic rhoxeralf means a red coloured alfisols having a calcic horizon under xeric moisture.

Family: This is a user oriented category. Thus the criteria for separation are soil properties that influence the response of soil to management and manipulation. These include:

- particle size distribution
- mineralogy of the horizon
- temperature regime
- the thickness of the soil penetrable by plant root
- cation exchange capacity
- presence of cutans
- presence of vertic property
- a few other definitive soil properties.
- For example **clayey calcic rhodxeralfs** means calcic rhodxeralfs with clayey soil texture

Series: It is a sub division of the soil family and is a more user oriented class than the family. Separation of the family into series involves more detailed properties of the soil profile. Soil series is given name after the place where it was first encountered. For example, Ibadan series, Iwo series, Apomu series etc

FAO/UNESCO CLASSIFICATION SYSTEM

The FAO/UNESCO system was developed by a panel set up by UNESCO for providing the basic unit for the soil map of the world. This classification was compiled from diverse systems in term of category and nomenclature. The FAO system has two categories, a higher and a lower one. These categories have not been given name. From their definition, the higher category is equivalent to the great group of the USDA taxonomy while the lower category cannot be fitted into any category of the USDA.

The criteria for classification are similar to those of great group and sub group in the USDA taxonomy. The definition of diagnostic horizons in the FAO system is different from that of the USDA system, although there are many equivalent definitions. For example, argillic horizon in the USDA is the same as argic horizon in the FAO, while Albic, calcic, cambic, duric, histic, melanic, gypsic and nitric horizons has definition similar to those horizons bearing the same nomenclature in the USDA system.

There are 32 reference groups in the FAO (WRB, 2006) system:- Acrisols, Albeluvisols, Alisols, Andosols, Anthrosols, Arenosols, Calcisols, Cambisols, Chernozems, Cryosols, Durisols, Ferralsols, Fluvisols, Gleysols, Cypsisols, Histosols, Kastanozems, Leptosols, Lixisols, Luvisols, Nitosols, Phaeozems, Planosols, Plinthosols, Podzols, Regosols, Solonckak, Solonetz, Stagnosols, Technosols, Umbrisols and Vertisols.

Common group in Nigeria soils are Plinthosols, Ferralsols, Stagnosols (mangrove soils), Alisols (ultisols), Acrisols (ultisols), Luvisols, Lixisols (alfisols), Arenosols, Cambisols and Regosols.

The names of soils are indicated by adding prefix and suffix adjectives from the qualifier lists to the reference group, for example Gleyic Luvisol oxyaquic.

Acrisols : Acrisols are soils that have a higher clay content in the subsoil than in the top soil as a result of pedogenic processes (especially clay migration) leading to an argic (argillic) subsoil horizon. Acrisols have in certain depths a low base saturation and low activity clays. Acrisols correlates with Ultisols with low activity clays (USDA).

Alisols: Alisols are soils that have a higher clay content in the subsoil than in the top soil as a result of pedogenic processes (especially clay migration) leading to an argic (argillic) subsoil horizon. Alisols have in certain depths a low base saturation and high activity clays throughout the argic horizon. They occur predominantly in humid tropical, humid subtropical and warm temperate regions. Alisols correlates with Ultisols with high activity clays (USDA).

Arenosols: Arenosols comprise sandy soils, including both soils developed on residual sand after in situ weathering of usually quartz-rich sediments or rocks, and soils developed in recent deposited sands such as dunes in deserts and beach lands.

Cambisols: Cambisols combine soils with at least an incipient subsurface soil formation. Transformation of parent material is evident from structure formation and mostly brownish discoloration, increase clay percentage, and /or carbonate removal. US taxonomy classifies most of these soils as Inceptisols.

Gleysols: Gleysols are wetland soils that, unless drained, are saturated with ground water for long enough periods to develop a characteristic gleyic colour pattern. This pattern is essentially made up of reddish, brownish or yellowish colours at ped surfaces and/or in the upper soil layer or layers, in combination with grayish/bluish colours inside the peds and/or deeper in the soil. Many of the WRB Gleysols correlate with the aquic suborder in the USDA taxonomy (Aqualfs, Aquents, Aquepts, aquolls etc).

Lixisols: Lixisols comprise of soils that have a higher clay content in the subsoil than in the topsoil as a result of pedogenic processes (especially clay migration) leading to an argic (argillic) subsoil horizon. Lixisols have a high base saturation and low activity clays at certain depths. Lixisols correlates with Alfisols with low activity clays (USDA).

Luvisols: Luvisols comprise of soils that have a higher clay content in the subsoil than in the topsoil as a result of pedogenic processes (especially clay migration) leading to an argic (argillic) subsoil horizon. Luvisols have high activity clays throughout the argic horizon and a high base saturation at certain depths. Luvisols correlates with Alfisols with low activity clays (USDA).

Local soil classification Systems

A number of soil classification systems exist within the country that is native of the country. These includes:-

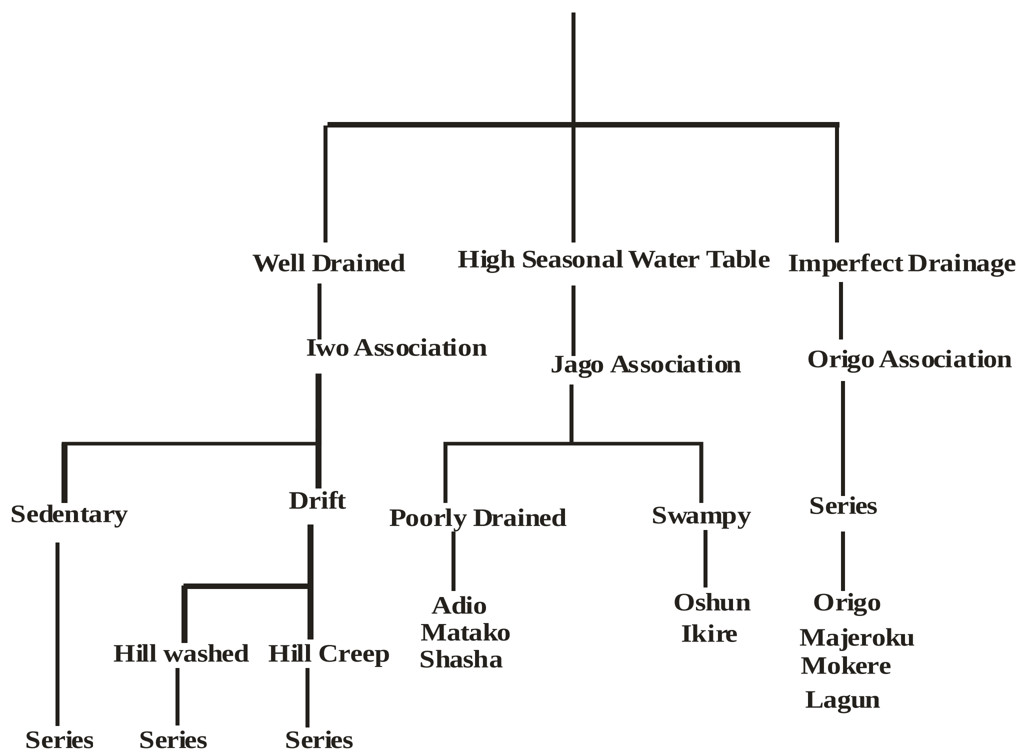
- Smith and Montgomery (1962); Moss (1957); Jungerius (1964) ; Klinkenberg and Higgins (1968)

However, non of these classification can be said to be national, i.e. they are not nationally acceptable and cannot be apply to the nation because each of the system was either developed for the soils of a given locality or of a given parent material.

Soil Classification by Smith and Montgomery

All the soils classified by Smith and Montgomery are within the central southern part of Nigeria. These soils are formed from igneous and metamorphic rocks.

The schematic diagram below depicts the classification pattern adopted by Smith and Montgomery.



Soil survey

Soil survey is a branch of soil science which involves the identification of the different types of soil in a given landscape and the location of their distribution to scale on a map. In addition, soil survey provides information on the quality of the land in terms of their response to management and manipulation.

Mapping Unit

A mapping unit is a geographical unit and it is an area of land within which the greater proportion is occupied by the taxonomic class after which it is named.

Purity of Mapping

The degree of uniformity or heterogeneity in term of kinds of soils within a mapping unit is a measure of its purity. Purity is the proportion of the mapping unit occupied by the profile class after which it is named. Different soil survey organizations have different acceptable purity standards ranging from70 - 85%.

Kind of mapping units

Mapping units have been distinguished based on the amount of inclusion or impurity they contain. Five kind of mapping units have thus been distinguished and these are consociation, association, complex, undifferentiated and miscellaneous/unvisited.

Consociation

A consociation is a mapping unit with very little inclusion or impurity. It is assumed to contain the profile class after which it is named but in practice the purity of such class may range from 70% to 85%.

Association

An association is a mapping unit that contain two or more taxonomic class that are nearly equally represented and in which it is very easy to separate one profile class from the other.

Complex

Complex is a mapping unit where more than two taxonomic classes are equally represented and the components are intricately interwoven so that separation, even at large scale is difficult.

Undifferentiated

This is a mapping unit consisting of a number of taxonomic units that are so intricately interwoven that separation into different units are impossible at any reasonable mapping scale.

Miscellaneous/unvisited

This is a loosely used term by some survey organization. It refers mainly to areas that cannot be mapped because of rock outcrops, thick forests or other impediments.

Principles of soil survey

The principles of survey can be discussed under five points

- A soil survey must have an objective.
- A soil survey is not the only basis for decision on land use and management, it is only an aid
- Land resources do not consist of soils alone
- A soil map must show soils.
- Soil map and report are complementary..

Type of Survey

Soil survey can be classified using the following criteria

Purpose of survey
Regularity of observation
Based on scale of mapping

Classification by purpose of survey

Based on the purpose of survey, there are two types of survey. These are general purpose and special purpose survey.

A general purpose soil survey is one that is done mainly to add to the already existing inventory of soil information.

A special purpose soil survey is done for specific purpose in mind, e.g. survey for irrigation or survey for citrus plantation.

Based on regularity of observation, three kinds of surveys have been distinguished: - free survey, rigid grid and flexible grid.

In **free survey**, there is no rigid pattern of observation.

In **rigid grid survey**, examinations of the soil are done at regular and pre-determined interval.

Flexible grid survey method is a compromise between the free and rigid grid methods of survey. In this system of survey, the number of observation is fixed but the location of the observation points are not pre-determined and can be fixed at will.

Based on the scale of mapping, there are seven kinds of surveys:- compilation, integrated survey, exploratory survey, reconnaissance survey, semi-detailed survey, detailed survey and intensive survey.

Compilation: These are soil maps produced by abstraction from other soil surveys. And where they exist they are filled by inferences. The scale is usually at 1: 100,000 or smaller.

Integrated survey: This is also known as land system survey. It is based on mapping the total physical environment and the scale is 1: 250,000 or smaller.

Exploratory survey: They are usually rapid road traverse made to provide modicum of information about the area that are otherwise unknown. Scale of exploratory survey varies from 1: 2,000,000 to 1,500,000.

Reconnaissance survey: They are the smallest scale of survey where the whole area is still covered using remote sensed imageries and the scale is usually 1:250,000

Semi-Detailed survey: In a semi-detailed mapping units are usually soil association and the scale of mapping varies from 150,000 to 100, 000.

Detailed survey: Detailed surveys are executed using rigid grid method and are usually employed for small area. Scale of observation varies between 1: 10,000 and 1: 25,000. Mapping unit are usually soil series.

Intensive survey uses rigid grid approach and mapping units are soil series and phase of soil series. Scale of mapping varies from 1: 1,000 to 1: 10,000.

Producing soil survey report

Soil survey reports take different forms because of the variation in the purpose of the survey and the interest of the client. However, some basic items are common to all soil survey reports. These are:

(a) The physical environment

(b) Methodology of the survey
(c) Description of the soils in terms of mapping unit and classification
(d) Land evaluation

The physical environment

In the physical environment, the aspects usually discussed are the location and extent, the climate, regional and local relief and topography, geology of the parent materials, vegetation and land use pattern (including mining and agriculture).

Location: The location is given in longitude and latitude or the Eastings and Northings (when using GPS). The site is also indicated by small area on a large map where the area of the project is shaded. The approximate area of the land is also given in hectares.

Climate: Full information is given on the climatic condition of the area. Data on Rainfall, temperature, relative humidity, wind speed and direction are collected and presented either as tables or as graphs.

Relief and topography: Because of the influence of relief on soil formation, the information on it is very vital.

Geology or parent material: Knowledge of the parent rock from which the soil is formed is necessary. The difference between geology and parent material become important where the transported material and the geology are different from each other.

Vegetation

Experience has shown that there is a close association between vegetation and kind of soils. Therefore, information on the vegetation of the project area is important. It is therefore necessary to mention the type, subtype and identification of vegetation.

Land Use

The kind and pattern of land use in the project area must be fully discussed. This include the type of crop cultivated, irrigation practices, area covered, mining activities, constructions if any, and some peculiar characteristics of farming systems e.g. land conservation practices.

Social Economic activities

The social economic environment of the project area also needs to be mentioned. The presence or absence of market and the marketing potentials of the available markets should be described.

Methodology of the survey

Here the method used in carrying out the soil survey is spelt out

The soils

This is the main part of the report. In it a full account of the soils, their properties and distribution over the landscape studied are given. Specifically, the aspect of the soils to be mentioned includes:-

(1) Soil classification: The soil classification systems used are discussed and the criteria of classification are well spelt out. In addition, the categorical level at which the classification was stopped should be mentioned.
(2) Description of the mapping units: The mapping units are described fully in terms of their extent and major soil properties. Also for each mapping unit, the representative profile class is given and the extent of coverage (purity).

Soil Survey interpretation and land evaluation

Land evaluation is the main point most land users are interested in. This is the stage where the potentials of the soils in that area is accessed and their response to management are accessed. The soils can be grouped into:

1. Capability classes (Land capability classification)
2. Land suitability evaluation classes (FAO framework)
3. Irrigation capability classification (US Bureau of land reclamation)
4. Fertility capability classification

Text figures

Here the legend of the soil map and land evaluation map are presented. Each map must have its own legend and this must correlate with the map.

Appendix

Various information from which the report has been summarized but which are too voluminous to be included in the main report are presented here. The data presented here include data on profile description and analyzed data.

REMOTE SENSING

Photogrammetry and Remote Sensing is officially defined as "the art, science, and technology of obtaining reliable information from noncontact imaging and other sensor systems about the Earth and its environment, and other physical objects and processes through recording, measuring, analyzing and representation".

Simply speaking, photogrammetry and remote sensing are sciences concerned with the acquisition of information from images. In photogrammetry the emphasis is acquisition of geometric information through measurement, while in remote sensing the emphasis is on the acquisition of thematic information through interpretation. Both measurement and interpretation could be achieved either manually or automatically.

Foundations of Remote Sensing

The Electromagnetic Spectrum

Electromagnetic spectrum is defined as "electromagnetic radiation is energy propagated through space between electric and magnetic fields. The electromagnetic spectrum is the extent of that energy ranging from cosmic rays, gamma rays, X-rays to ultraviolet, visible, and infrared radiation including microwave energy."

Electromagnetic Waves

Electromagnetic waves may be classified by Frequency or wavelength the velocity of ALL electromagnetic waves is equal to the speed of light, which we (along with Einstein) will refer to as c.

Wave Phenomena Concepts

Electromagnetic waves are *radiated* through space. When the energy encounters an object, even a very tiny one like a molecule of air, one of three reactions occurs. The radiation will either be reflected off the object, absorbed by the object, of transmitted through the object. The total amount of radiation that strikes an object is referred to as the *incident radiation*, and is equal to:

reflected radiation + absorbed radiation + transmitted radiation

In remote sensing, we are largely concerned with REFLECTED RADIATION. This is the radiation that causes our eyes to see colors, causes infrared film to record vegetation, and allows radar images of the earth to be created.

The electric field and the magnetic field are important concepts that can be used to mathematically describe the physical effects of electromagnetic waves.

The electric field vibrates in a direction transverse (i.e. perpendicular) to the direction of travel of the electromagnetic wave.

The magnetic field vibrates in a direction transverse to the direction of the wave AND transverse to the electric field.

POLARIZATION: Polarization is defined by the orientation of the electrical field E. It is usually described in terms of HORIZONTAL POLARIZATION and VERTICAL POLARIZATION. Polarization is most important when discussing RADAR applications of remote sensing.

Aerial Photography

Introduction

Aerial photography has two uses that are of interest within the context of this course:

(1) Cartographers and planners take detailed measurements from aerial photos in the preparation of maps.

(2) Trained interpreters utilize aerial photos to determine land-use and environmental conditions, among other things.

Although both maps and aerial photos present a "bird's-eye" view of the earth, aerial photographs are NOT maps. Maps are orthogonal representations of the earth's surface, meaning that they are directionally and geometrically accurate (at least within the limitations imposed by projecting a 3-dimensional object onto 2 dimensions). Aerial photos, on the other hand, display a high degree of radial distortion. That is, the topography is distorted, and until corrections are made for the distortion, measurements made from a photograph are not accurate. Nevertheless, aerial photographs are a powerful tool for studying the earth's environment.

Because most GISs can correct for radial distortion, aerial photographs are an excellent data source for many types of projects, especially those that require spatial data from the same location at periodic intervals over a length of time. Typical applications include land-use surveys and habitat analysis.

This unit discusses benefits of aerial photography, applications, the different types of photography, and the integration of aerial photographs into GISs.

Basic Elements of Air Photo Interpretation

Novice photo interpreters often encounter difficulties when presented with their first aerial photograph. Aerial photographs are different from "regular" photos in at least three important ways:

- objects are portrayed from an overhead (and unfamiliar) position.
- very often, infrared wavelengths are recorded, and
- photos are taken at scales most people are unaccustomed to seeing

These "basic elements" can aid in identifying objects on aerial photographs.

Tone (also called Hue or Color) -- Tone refers to the relative brightness or color of elements on a photograph. It is, perhaps, the most basic of the interpretive elements because without tonal differences none of the other elements could be discerned.

Size: The size of objects must be considered in the context of the scale of a photograph. The scale will help you determine if an object is a stock pond or Lake Minnetonka.

Shape: refers to the general outline of objects. Regular geometric shapes are usually indicators of human presence and use. Some objects can be identified almost solely on the basis of their shapes.

Texture: The impression of "smoothness" or "roughness" of image features is caused by the frequency of change of tone in photographs. It is produced by a set of features too small to identify individually. Grass, cement, and water generally appear "smooth", while a forest canopy may appear "rough".

Pattern *(spatial arrangement):-* The patterns formed by objects in a photo can be diagnostic. Consider the difference between (1) the random pattern formed by an unmanaged area of trees and (2) the evenly spaced rows formed by an orchard.

Shadow: Shadows aid interpreters in determining the height of objects in aerial photographs. However, they also obscure objects lying within them.

Site: refers to topographic or geographic location. This characteristic of photographs is especially important in identifying vegetation types and landforms. For example, large circular depressions in the ground are readily identified as sinkholes in central Florida, where the bedrock consists of limestone. This identification would make little sense, however, if the site were underlain by granite.

Association: Some objects are always found *in association with* other objects. The context of an object can provide insight into what it is. For instance, a nuclear power plant is not (generally) going to be found in the midst of single-family housing.

Advantages of Aerial Photography over Ground-Based Observation

Aerial photography offers an improved vantage point.

Aerial photography has the capability to stop action.

It provides a permanent recording.

It has broader spectral sensitivity than the human eye.

It has better spatial resolution and geometric fidelity than many ground-based sensing methods.

Types of Aerial Photography

- Black and White
- Color (True color or false color)
- Color Infrared

LAND USE PLANNING

Soil Survey information and land use planning

Land comprises the physical environment, including climate, relief, soils, hydrology and vegetation, to the extent that these influence potential for land use. It includes the results of past and present human activities.

Planning is the process of allocating resources, including time, capital, and labor, in the face of limited resources, in the short, medium or long term, in order to produce maximum *benefits* to a defined group.

Land use planning is the process of allocating uses to land areas, and resources to those uses.

The function of land use planning is to guide decisions on land use in such a way that the resources of the environment are put to the most beneficial use for man, whiles at the same time conserving those resources for the future.

Land evaluation is concerned with the assessment of land performance when used for specified purposes.

Why plan land use?

- To provide maximum *economic benefit* to the individual land owner or operator (e.g. farm planning)
- To prevent or solve *conflicts* between individuals and other individuals or with the needs and values of society as a whole.

Land use planning process involves:-

- recognition of a need for change;
- identification of aims;
- formulation of proposals, involving alternative forms of land use, and recognition of their main requirements;
- recognition and delineation of the different types of land present in the area;
- comparison and evaluation of each type of land for the different uses;
- selection of a preferred use for each type of land;
- project design, or other detailed analysis of a selected set of alternatives for distinct parts of the area; This, in certain cases, may take the form of a feasibility study.
- decision to implement;
- implementation;
- monitoring of the operation.

Concept, Principles and Justification of Land-Use Planning

Decisions on land use have always been part of the evolution of human society. The need for land use planning is frequently brought about, however, by changing needs and pressures, involving competing uses for the same land. The function of land use planning is to guide decisions on land use in such a way that the resources of the environment are put to the most beneficial use for man, Land evaluation is concerned with the assessment of land performance when used for specified purposes.

The aims of land evaluation

Land evaluation may be concerned with present land performance. Frequently however, it involves change and its effects: with change in the use of land and in some cases change in the land itself.

Evaluation takes into consideration the economics of the proposed enterprises, the social consequences for the people of the area and the country concerned, and the consequences, beneficial or adverse, for the environment. Thus land evaluation should answer the following questions:

- How is the land currently managed, and what will happen if present practices remain unchanged?
- What improvements in management practices, within the present use, are possible?
- What other uses of land are physically possible and economically and socially relevant?
- Which of these uses offer possibilities of sustained production or other benefits?
- What adverse effects, physical, economic or social, are associated with each use?
- What recurrent input levels are necessary to bring about the desired production and minimize the adverse effects? What are the benefits of each form of use?

If the introduction of a new use involves significant change in the land itself, as for example in irrigation schemes, then the following additional questions should be answered:

- What changes in the condition of the land are feasible and necessary, and how can they be brought about?
- What non-recurrent inputs are necessary to implement these changes?

The evaluation process does not in itself determine the land use changes that are to be carried out, but provides data on the basis of which such decisions can be taken.

Land evaluation and land use planning

Land evaluation is only part of the process of land use planning. Its precise role varies in different circumstances. In the present context it is sufficient to represent the land use planning process by the following generalized sequence of activities and decisions:

i. recognition of a need for change;
ii. identification of aims;
iii. formulation of proposals, involving alternative forms of land use, and recognition of their main requirements;
iv. recognition and delineation of the different types of land present in the area;
v. comparison and evaluation of each type of land for the different uses;
vi. selection of a preferred use for each type of land;
vii. project design, or other detailed analysis of a selected set of alternatives for distinct parts of the area; this, in certain cases, may take the form of a feasibility study.
viii. decision to implement;
ix. implementation;
x. monitoring of the operation.

Land evaluation plays a major part in stages iii, iv and v of the above sequence, and contributes information to the subsequent activities. Thus land evaluation is preceded by the recognition of the need for some change in the use to which land is put; this may be the development of new productive uses, such as agricultural development schemes or forestry plantations, or the provision of services, such as the designation of a national park or recreational area.

Recognition of this need is followed by identification of the aims of the proposed change and formulation of general and specific proposals. The evaluation process itself includes description of a range of promising kinds of use, and the assessment and comparison of these with respect to each type of land identified in the area. This leads to recommendations involving one or a small number of preferred kinds of use. These recommendations can then be used in making decisions on the preferred kinds of land use for each distinct part of the area. Later stages will usually involve further detailed analysis of the preferred uses, followed, if the decision to go ahead is made, by the implementation of the development project or other form of change, and monitoring of the resulting systems.

Principles

Certain principles are fundamental to the approach and methods employed in land evaluation. These basic principles are as follows:

- Land suitability is assessed and classified with respect to specified kinds of use
- Evaluation requires a comparison of the benefits obtained and the inputs needed on different types of land
- A multidisciplinary approach is required
- Evaluation is made in terms relevant to the physical economic and social context of the area concerned
  Suitability refers to use on a sustained basis
- Evaluation involves comparison of more than a single kind of use

Basic concepts

Certain concepts and definitions are needed as a basis for the subsequent discussion. These concern the land itself, kinds of land use, land characteristics and qualities, and improvements made to land.

Land

Land comprises the physical environment, including climate, relief, soils, hydrology and vegetation, to the extent that these influence potential for land use.

A land mapping unit is a mapped area of land with specified characteristics. Land mapping units are defined and mapped by natural resource surveys, e.g. soil survey, forest inventory.

Land use

Suitability evaluation involves relating land mapping units to specified types of land use.

Major Kinds of Land Use and Land Utilization Types

A major kind of land use is a major subdivision of rural land use, such as rainfed agriculture, irrigated agriculture, grassland, forestry, or recreation.

A land utilization type is a kind of land use described or defined in a degree of detail greater than that of a major kind of land use. In detailed or quantitative land evaluation studies, the kinds of land use considered will usually consist of land utilization types.

Some examples of land utilization types are:

i. Rainfed annual cropping based on groundnuts with subsistence maize, by smallholders with low capital resources, using cattle drawn farm implements, with high labour intensity, on freehold farms of 5-10 ha.

ii. Farming similar to (i) in respect of production, capital, labour, power and technology, but farms of 200-500 ha operated on a communal basis.

iii. Commercial wheat production on large freehold farms, with high capital and low labour intensity, and a high level of mechanization and inputs.

iv. Extensive cattle ranching, with medium levels of capital and labour intensity, with land held and central services operated by a governmental agency.
v. Softwood plantations operated by a government Department of Forestry, with high capital intensity, low labour intensity, and advanced technology.
vi. A national park for recreation and tourism.

Multiple and Compound Land Use

Two terms, multiple and compound land utilization types, refer to situations in which more than one kind of land use is practiced within an area.

A multiple land utilization type consists of more than one kind of use simultaneously undertaken on the same area of land, each use having its own inputs, requirements and produce. Example is a timber plantation used simultaneously as a recreational area.

A compound land utilization type consists of more than one kind of use undertaken on areas of. land which for purposes of evaluation are treated as a single unit. Mixed farming involving both arable use and grazing is an example.

Land utilization types are defined for the purpose of land evaluation. Their description need not comprise the full range of farm management practices, but only those related to land management and improvement.

Land characteristics, land qualities and diagnostic criteria

A land characteristic is an attribute of land that can be measured or estimated. Examples are slope angle, rainfall, soil texture, available water capacity, biomass of the vegetation, etc.

A land quality is a complex attribute of land which acts in a distinct manner in its influence on the suitability of land for a specific kind of use. Land qualities may be expressed in a positive or negative way. Examples are moisture availability, erosion resistance, flooding hazard, nutritive value of pastures, accessibility. Where data are available, aggregate land qualities may also be employed, e.g. crop yields, mean annual increments of timber species.

A diagnostic criterion is a variable which has an understood influence upon the output from, or the required inputs to, a specified use, and which serves as a basis for assessing the suitability of a given area of land for that use. This variable may be a land quality, a land characteristic, or a function of several land characteristics. For every diagnostic criterion there will be a critical value or set of critical values which are used to define suitability class limits.

Land suitability and land capability

The term "land capability" is viewed by some as the inherent capacity of land to perform at a given level for a general use, and suitability as a statement of the adaptability of a given area for a specific kind of land use; others see capability as a classification of land primarily in relation to degradation hazards, whilst some regard the terms "suitability" and "capability" as interchangeable.

Land suitability classifications

Land suitability is the fitness of a given type of land for a defined use. The land may be considered in its present condition or after improvements.

Structure of the suitability classification

i. Land Suitability Orders: reflecting kinds of suitability.
ii. Land Suitability Classes: reflecting degrees of suitability within Orders.

iii. Land Suitability Subclasses: reflecting kinds of limitation, or main kinds of improvement measures required, within classes.

iv. Land Suitability Units: reflecting minor differences in required management within subclasses.

Land Suitability Orders

Land suitability Orders indicate whether land is assessed as suitable or not suitable for the use under consideration. There are two orders represented in maps, tables, etc. by the symbols S and N respectively.

Order S Suitable: Land on which sustained use of the kind under consideration is expected to yield benefits which justify the inputs, without unacceptable risk of damage to land resources.

Order N Not Suitable: Land which has qualities that appear to preclude sustained use of the kind under consideration.

Land Suitability Classes

Land suitability Classes reflect degrees of suitability. The classes are numbered consecutively, by Arabic numbers, in sequence of decreasing degrees of suitability within the Order.

Class S1 Highly Suitable:	Land having no significant limitations to sustained application of a given use, or only minor limitations that will not significantly reduce productivity.
Class S2 Moderately Suitable:	Land having limitations which in aggregate are moderately severe for sustained application of a given use; the limitations will reduce productivity or benefits and increase required.
Class S3 Marginally Suitable:	Land having limitations which in aggregate are severe for sustained application of a given use and will so reduce productivity or benefits, or increase required inputs.

In a quantitative classification, both inputs and benefits must be expressed in common measurable terms, normally economic. Differences in degrees of suitability are determined mainly by the relationship between benefits and inputs.

Within the Order Not Suitable, there are normally two Classes:

Class N1 Currently Not Suitable:	Land having limitations which may be surmountable in time but which cannot be corrected with existing knowledge at currently acceptable cost.
Class N2 Permanently Not Suitable:	Land having limitations which appear as severe as to preclude any possibilities of successful sustained use of the land in the given manner.

Quantitative definition of these classes is normally unnecessary, since by definition both are uneconomic for the given use.

Land Suitability Subclasses

Land Suitability Subclasses reflect kinds of limitations, e.g. moisture deficiency, erosion hazard. Subclasses are indicated by lower-case letters with mnemonic significance, e.g. S2m, S2e, S3me.

Land Suitability Units

Land suitability units are subdivisions of a subclass. All the units within a subclass have the same degree of suitability at the class level and similar kinds of limitations at the subclass level. Suitability units are distinguished by Arabic numbers following a hyphen, e.g. S2e-1, S2e-2.

Conditional Suitability

The designation Conditionally Suitable may be added in certain instances to condense and simplify presentation. This is necessary to cater for circumstances where small areas of land, within the survey area, may be unsuitable or poorly suitable for a particular use under the management specified for that use, but suitable given that certain conditions are fulfilled.

Conditionally Suitable is a phase of the Order Suitable. It is indicated by a lower case letter c between the order symbol and the class number, e.g. Sc2. The conditionally suitable phase, subdivided into classes if necessary, is always placed at the bottom of the listing of S classes. The phase indicates suitability after the condition(s) have been met.

Conditionally Suitable phase may only be employed if all of the following stipulations are met:

i. Without the condition(s) satisfied, the land is either not suitable or belongs to the lowest suitable class.

ii. Suitability with the condition(s) satisfied is significantly higher (usually at least two classes).

iii. The extent of the conditionally suitable land is very small with respect to the total study area.

Qualitative and Quantitative Classifications

Qualitative classification is one in which relative suitability is expressed in qualitative terms only, without precise calculation of costs and returns.

Qualitative classifications are based mainly on the physical productive potential of the land, with economics only present as a background. Quantitative classifications normally involve considerable use of economic criteria, i.e. costs and prices, applied both to inputs and production.

Classifications of Current and Potential Suitability

A classification of current suitability refers to the suitability for a defined use of land in its present condition, without major improvements.

A classification of potential suitability refers to the suitability, for a defined use, of land units in their condition at some future date, after specified major improvements have been completed where necessary.

The results of land suitability evaluation

The results of an evaluation will usually include the following types of information, the extent to which each is included varying with the scale and intensity of the study.

i. The context, physical, social and economic, on which the evaluation is based.

ii. Description of land utilization types or of major kinds of land use which are relevant to the area.

iii. Maps, tables and textual matter showing degrees of suitability of land mapping units for each of the kinds of land use considered, together with the diagnostic criteria.

iv. Management and improvement specifications for each land utilization type with respect to each land mapping unit for which it is suitable.

v. Economic and social analysis of the consequences of the various kinds of land use considered.
vi. The basic data and maps from which the evaluation was obtained.
vii. Information on the reliability of the suitability estimates. Such information is directly relevant to planning decisions.