

Appendix 1: Major soil units of Entree and their characteristics (FAO/UNESCO, 1990)

Soil units	Origin of the name and its major features
Arenosols	From L. arena, sand; representative of heavy to very light coarse textured soils.
Calcisols	From L. calcis, lime; representative of accumulation of calcium carbonate.
Chromosols	From late L. chromata, to change; representative of change in colour, structure and resistance.
Chrysolobosols	From L. chrysolos, gold; representative of soils with a yellow chromophore.
Gypsisols	From L. gypsum, mineral; representative of accumulation of calcium sulphate.
Leprosols	From Gr. leprose, thin; representative of weakly developed shallow soils.
Lixisols	From L. lixos, to wash; representative of soils with a clay washing horizon.
Lixivisols	From L. lixare, to wash; lessive; representative of soils with accumulation of clay.
Mpudisols	From L. mpudius, short; representative of short profile soils.
Regosols	From Gr. regos, rubble; representative of soils with little or no mineral cover, and the land is not cultivated.
Soloschals	From R. sol, salt, and chos, to wash; representative of soils with salt crusts.
Vertisols	From L. vertere, to turn; representative of soils with deep surface soils.

L = Latin

Gr = Greek

R = Russian

Appendices

Appendix 1: Major soil units of Eritrea and their characteristics (FAO-UNESCO, 1990)

Soil units	Origin of the name and its major features
Arenosols	From L. <i>arena</i> , sand; connotative of weakly developed coarse textured soils.
Calcisols	From L. <i>calx</i> , lime; connotative of accumulation of calcium carbonate.
Cambisols	From late L. <i>cambiare</i> , to change; connotative of change in colour, structure and consistence.
Fluvisols	From L. <i>fluvius</i> , river; connotative of alluvial deposits.
Gypsisols	From L. <i>gypsum</i> ; connotative of accumulation of calcium sulphate.
Leptosols	From Gr. <i>leptos</i> , thin; connotative of weakly developed shallow soils.
Lixisols	From L. <i>lixivia</i> , washing; connotative of accumulation of clay and strong weathering.
Luvissols	from L. <i>luere</i> , to wash, 'lessiver'; connotative of accumulation of clay.
Nitisols	From L. <i>nitidus</i> , shiny; connotative of shiny ped faces.
Regosols	From Gr. <i>rhegos</i> , blanket; connotative of a mantle of loose material overlying the hard core of the earth.
Solonchaks	From R. <i>sol</i> , salt, and <i>chak</i> ; connotative of salty area.
Vertisols	From L. <i>vertere</i> , to turn; connotative of turn over of surface soils.

L = Latin

Gr = Greek

R = Russian

Appendix 2: Lists of requirements of Land utilization types for rainfed crop production (FAO, 1983)

A. Crop Requirement

Energy	-Radiation	
	-Photoperiodicity	
Temperature	-Total requirement	Growth cycle
	-Critical period	
Moisture		
Oxygen (soil drainage)		
Nutrient availability		
Nutrient retention		
Rooting condition		
Conditions affecting germination or establishment		
Air humidity as affecting growth		
Condition for ripening		
Flood hazard		
Climatic hazard	-Frost	
	-Storm	
Excess of salts	-Salinity	
	-Sodicity	
Soil toxicities		
Pests and diseases		

B. Management Requirement

Soil workability		
Potential for mechanization		
Conditions for land preparation and clearance		
Conditions affecting storage and processing		
Conditions affecting timing of production		
Access with in the production unit		
Size of potential management unit location	-Existing accessibility	
	-Potential accessibility	

C. Conservation Requirements

Erosion hazard	
Soil degradation hazard	

Appendix3: Climatic and soil requirements of selected grain, vegetable and fruit crops (Dent and Young, 1981).

Crop	Total growing Period (days)	Mean daily Temperature For growth (°C) Optimum (And range)	Day length Requirements for Flowering	Specific climatic constraints/requirements	Soil requirements	Sensitivity to salinity
Bean (<i>Phaseolus vulgaris</i>)	Fresh: 60-90 Dry: 90-120	15-20 (10-27)	Short day/day neutral	Sensitive to frost, excessive rain, hot Weather	Deep, friable soil, well drained: optimum pH 5.5-6	Sensitive
Banana (<i>Musa spp</i>)	300-365	25-30 (15-35)	Day neutral	Sensitive to frost; temperature <8 °C for longer periods causes serious damage; requires high RH, wind <4 m s ⁻¹	Deep, well drained loam without stagnant water; pH 5-7	Very sensitive
Cabbage (<i>Brassica oleracea</i>)	100-150+	15-20 (10-24)	Long day	Short periods of sharp frost (-10) are not harmful: optimum RH 60-90%	Well drained: optimum pH 6-6.5	Moderately sensitive
Citrus (<i>Citrus spp</i>)	240-365	23-30 (13-35)	Day neutral	Sensitive to frost (dormant trees less), strong wind, high humidity; cool winter or short dry period preferred	Deep, well aerated, light to medium textured soils, free from stagnant water: pH 5-8	Sensitive
Cotton (<i>Gossypium hirsutum</i>)	150-180	20-30 (16-35)	Short day/day neutral	Sensitive to frost, strong or cold winds; temperature required for boll development: 27-32 (20-380°C range); dry ripening required	Deep, medium-heavy textured soils: pH5.5-8 with optimum pH 7-8	Tolerant
Groundnut (<i>Arachis hypogaea</i>)	90-140	22-28 (18-33)	Day neutral	Sensitive to frost; for germination temperature should be >20°C	Well-drained, friable, medium textured soil with loose top soil: pH 5.5-7	Moderately sensitive
Maize (<i>Zea mays</i>)	100-140+	24-30 (15-35)	Day neutral/short day	Sensitive to frost; for germination temperature >10°C; cool temperature causes problem for ripening	Well-drained and aerated soils with deep water-table and without water logging: optimum pH 5-7	Moderately sensitive

Onion (<i>Allium cepa</i>)	100-140 (+30-35 in nursery)	15-20 (10-25)	Long day/day neutral	Tolerant to frost; low temperature (<14-16) required for flower initiation; no extreme temperature.	Medium-textured soil: pH 6-7	Sensitive
Appendix 3 (continued)						
Crop	Total growing Period (days)	Mean daily Temperature For growth (°C) Optimum (And range)	Day length Requirements for Flowering	Specific climatic constraints/requirements	Soil requirements	Sensitivity
Pea (<i>Pisum sativum</i>)	Fresh: 65-100 Dry: 85-120 120-150	15-18 (10-23)	Day neutral	Slight frost tolerant when young	Well-drained and aerated soils: pH 5.5-6.5	Sensitive
Pepper (<i>Capsicum spp</i>)	100-150	18-23 (15-27)	Short day/day neutral	Sensitive to frost	Light-medium textured soils: pH 5.5-7	Moderately sensitive
Potato (<i>Solnum tuberosum</i>)	100-150	15-20 (10-25)	Long day/day neutral	Sensitive to frost; night temperature <15°C required for good tuber initiation	Well-drained, aerated and porous soils: pH 4.5-6	Moderately sensitive
Sesame Sesame indicum syn. S. orientale	80-180	27-33 (17.5-40)	Short day/day neutral	Sensitive to excessive rain and water logging	Moderate fertile, good structured, well drained sandy loam is preferred: pH 5.5-8.0	Sensitive
Tomato (<i>Lycopersicon esculentum</i>)	90-120 (>25-35 in nursery)	18-25 (15-28)	Day neutral	Sensitive to frost, high RH and strong wind; optimum night temperature 10-20°C	Light loam, well drained without water logging: pH 5-7	Sensitive
Watermelon (<i>Citrullus vulgaris</i>)	80-110	22-30 (18-35)	Day neutral	Sensitive to frost	Sandy loam is preferred: pH 5.8-7.2	Moderately sensitive

RH= Relative humidity

Appendix 4: Land qualities that need to be assessed for rainfed crop production (FAO, 1983)

Qualities related to crop growth

LQ1	Radiation regime:	Total radiation Day length
LQ2	Temperature regime:	
LQ3	Moisture availability:	Total moisture Critical period Drought hazard
LQ4	Oxygen availability to roots (drainage)	
LQ5	Nutrient availability	
LQ6	Nutrient retention capacity	
LQ7	Rooting condition	
LQ8	Conditions affecting germination and establishment	
LQ9	Air humidity as affecting growth	
LQ10	Conditions for ripening	
LQ11	Flood hazard	
LQ12	Climatic hazard	
LQ13	Excess salts:	Salinity Sodicity
LQ14	Soil toxicities	
LQ15	Pests and diseases	

Qualities related to management

LQ16	Soil workability	
LQ17	Potential for mechanization	
LQ18	Land preparation and clearance requirement	
LQ19	Conditions for storage and processing	
LQ20	Conditions affecting timing of production	
LQ21	Access within the production unit	
LQ22	Size of potential management unit	
LQ23	location:	Existing accessibility Potential accessibility

Qualities related to conservation

LQ24	Erosion hazard	
LQ25	Soil degradation hazard	

Appendix 5: List of class-determining factors (i.e. as land use requirements or limitations or as land qualities) with some land characteristics, input and land improvements for consideration in setting critical limits for irrigated crop production (FAO, 1985)

Class-determining factors: -land use requirements or limitations -land qualities (where applicable)		Representative land characteristics, inputs, land improvements and other relevant considerations
Agronomic: -crop requirement /limitation -the crop environment		
1.	Growing periods: -growing period requirement -growing period	Growing cycle of crops. Dates and duration (days)
2.	Radiation -radiation requirements -radiation regime	Day length, extra-terrestrial radiation; solar radiation (Rs); photosynthetically active radiation (PAR); actual sun shine hours (n); possible number of sunshine hours (N); net short wave radiation Rns; total net radiation (Rn), mm of evaporation (Rn=cal/cm2/min approximate equivalent to 1 mm water/hr).
3.	Temperature: -temperature requirement -temperature regime	Temperature data. Heat units. frost free periods.
4.	Rooting: -rooting requirement -rooting conditions	Effective soil depth for roots. Root room. Volume % of stones. Penetration resistance or soil Strength.
5.	Aeration: -oxygen & aeration requirement -oxygen supply and soil aeration	Periods with or without adequate aeration during the growth period. (Depth and fluctuation of ground-water)
6.	Water quality: -water requirement -water supply -total water -critical period	Water balance, water storage. yield vs. evapo-transpiration relationships; deficient periods Run-off, run-on, seepage and porcolation, ground water contribution, effective precipitation. Stream flows, diversions, storage releases, aquifer safe yields.

Appendix 5 (continued)

	Class-determining factors: -land use requirements or limitations -land qualities (where applicable)	Representative land characteristics, inputs, land improvements and other relevant considerations
7.	Nutrients (NPK): -nutrient requirement -fertilizer requirements -nutrient supply -fertilizer supply	NPK uptakes by crops & response to NPK. Losses of NPK (leaching, volatilization, fixation, etc.). N fixation. soil nutrients & their retention. CEC fertilizer requirement & availability including manure, etc.
8.	Water quality: -crop tolerance to water quality -water quality	Total salt concentration. Ionic composition. Sodium adsorption ratio (SAR), pH, carbonates and bicarbonates.
9.	Salinity: -crop tolerance to salinity -salinity regime (salt balance)	Plant salt tolerances, present and future soil salinity, inputs of salt through water supply, losses of salt by leaching, salt balance. Seasonal salt movement in profile, salt from groundwater.
10.	Sodicity: -crop tolerance to sodicity -sodicity regime	Predicted pH, ESP and/or SAR of soil solution, predicted effect on soil structure, infiltration and permeability. Sodium toxicity.
11.	pH, micronutrients and toxicities: -crop tolerance, susceptibilities -toxicity or micronutrient regime	On non rice crop land, pH effects and crop tolerances and susceptibilities to excesses or deficiencies of Ca, Mg, Zn Fe, S, B, Cu, Mn, Mo, Al.
12.	Pest, Disease, Weeds: -crop tolerance, susceptibilities -pest, disease, weed hazard.	Crop tolerances and susceptibilities. Wild animals, birds, arthropods etc. Fungal, bacterial, viral pathogens. Weeds. Pesticides, fencing, inputs.
13.	Flood, Storm, Wind, Frost: -crop tolerance, susceptibilities -flood, storm, wind, frost hail hazard	Frequency and severity of floods, storms wind, frost and hail if any.

Appendix 5 (continued)

Class-determining factors: -land use requirements or limitations -land qualities (where applicable)	Representative land characteristics, inputs, land improvements and other relevant considerations
Management: <u>-management requirements and limitations.</u> <u>-conditions affecting management</u>	
14. Location: -location requirement -location	Closeness to markets, processing unit. Access to inputs and services. Access to water (gravity, pumped). Travel & transport problem & cost. Day to day management problems. Accessibility of machinery.
15. Water application management: -limitation of irrigation method -conditions affecting water application management.	Size, shape of management unit. Labour requirement. Availability. Conditions affecting uniformity of Water application, rate, frequency and duration of application.
16. Pre-harvest farm management: -pre-harvest farm management requirements & limitations -conditions affecting pre-harvest farm management	Effects of timing of pre-harvest operations (e.g. soil workability) including land preparation, nurseries, seeding, transplanting, fertilizer application, irrigation, weeding, spraying etc.
17. Harvest and post harvest Management: -requirements and limitations -conditions affecting	Atmospheric wetness, dryness, wind. Soil wetness, dryness. Effects of soil or humidity on the quality of the crop produce.
18. Mechanization -requirements for mechanization -conditions affecting potential for Mechanization and on-farm Transportation	Slope angle, rock hindrances, stoniness, soil depth, soil texture, shape and size of fields. Effects of soil compaction. on-farm transportation.

Appendix 5 (continued)

	<p>Class-determining factors: -land use requirements or limitations -land qualities (where applicable)</p>	<p>Representative land characteristics, inputs, land improvements and other relevant considerations</p>
	<p>Land development and improvement -land development requirements -factors affecting cost of land clearing</p>	
19.	<p>Land clearing: -land clearing requirements -conditions affecting cost of land clearing</p>	<p>Forest: underbrushing, felling, burning stacking; costs, value of timber, charcoal time period to development. Persistent weeds: mechanical cultivation, flooding chemical control; costs, time period to development. Rocks and stones: removal costs.</p>
20.	<p>Land grading and leveling: -grading and leveling requirement -conditions affecting land grading and leveling costs</p>	<p>Slope, microrelief, macrorelief, cover. Field size and shape, cut and fill, earthmoving costs.</p>
21.	<p>Physical, chemical and organic aid and amendments -requirements -conditions affecting costs</p>	<p>Need for deep ploughing, subsoiling, profile inversion, sanding, marling; gypsum, lime, organic matter, costs.</p>
22.	<p>Reclamation leaching: -leaching requirement -conditions affecting leaching</p>	<p>Primary or one-time reclamation leaching requirements mm of water; continuous or intermittent, costs.</p>
23.	<p>Irrigation engineering -irrigation engineering requirements conditions affecting engineering works and costs</p>	<p>Earthwork and other structures for diversion, storage, conveyance, and regulation of water. Topography, substratum conditions, permeability channels, access to construction sites, cost of engineering works.</p>

Appendix 5 (continued)

Class-determining factors: -land use requirements or limitations -land qualities (where applicable)		Representative land characteristics, inputs, land improvements and other relevant considerations
	Conservation and environmental: -conservation and environmental requirements and limitation -conditions affecting conservation and the environment	
24.	Long-term prevention of salinity and sodicity: -requirements and limitations -conditions affecting long-term salinity and sodicity hazards	long-term inputs of salt, water quality water depth, permeability, drainage tidal swamp conditions, intrusion saline water into an aquifer, control measures and their costs.
25.	Long-term control of ground water and surface water: -requirements and limitation -conditions affecting long-term Control	Protection of catchment areas, degra- dation of catchment, sedimentation of reservoirs, control of groundwater, and their cost.
26.	Erosion hazard: -requirements and limitations -conditions affecting erosion	Erosion control. Maximum acceptable soil loss and effects of climate, soil, topography, land use factors costs.
27.	Environmental hazard: -environmental control requirement and limitations -conditions affecting long-term environmental risks	wildlife, water-borne human diseases (e.g. malaria), needs for environmental control of vectors.
	Socio-economic: -socio-economic requirements and limitations -socio-economic conditions	
28.	Farmers' attitudes to irrigation	Will the farmers utilize the irrigation facilities.
29.	Other socio-economic limitations that may be class-determining	Water rights, tenurial and land ownership complications, disincentives of taxation, fragmentation, etc.

Appendix 6: Requirements and limitations of land utilization types for extensive grazing (FAO, 1991).

I. Primary production level	Descriptions
A. Growth requirements	Single, multiple or compound LUTs. Crop grows, cultivars, cropping calendar, cropping intensity. Perennial or spring systems, cultivation factor, cropping index.
1. Radiation 2. Temperature 3. Moisture 4. Aeration (soil drainage) 5. Nutrients 6. Rooting condition 7. Salinity/sodicity 8. Soil toxicities 9. Hazards fire 10. Flood 11. Frost 12. Genetic potential of vegetation	Subsistence, commercial or both, domestic or export, or both. Seasonal supply and quality Structure of the animal production system Extent of mechanization Value of capital investment, amount of labour and cost per ha.
B. Management requirements	Labour and breed labour requirements Seasonal peak periods, holidays
13. Ease of control of undesirable plant species 14. Mechanized operation 15. Size of potential management units	Experience, response to extension and literacy.
C. Conservation requirement	Extent of erosion, soil fertility, soil conservation Soil land reclamation, forest cover.
16. Tolerance to soil erosion 17. Tolerance to vegetation degradation	Which utilization systems are regarded as mechanized
II. Secondary production level	Factors which may be limiting to extensive grazing Grazing and silage production
D. Growth requirements	Freehold, leasehold, communal, state, or other forms of tenure Tenure, and the availability of land for extensive cropping
18. Grazing capacity 19. Drinking water availability 20. Climatic limitation 21. Biological hazard 22. Accessibility for animals 23. Conditions for hay and silage	Communal ownership, crop rotation, livestock farming, village land with rights of pasture State ownership, state farms, national parks
E. Management requirements	
24. Ease of fencing or hedging 25. Location	

Appendix 7: Checklists of headings for description of land utilization types (FAO, 1983)

Headings		Descriptions
I.	Cropping system	Single, multiple or compound LUT. Crops grown, cultivars, cropping calendar, cropping intensity. Perennial cropping systems, cultivation factor, cropping index.
II.	Markets	Subsistence, commercial or both, domestic or export, or both.
III.	Water supply	Seasonal supply and quality.
IV.	Irrigation method	Gravity or lift, runoff-river or storage releases, surface overhead, drip, etc.
V.	Capital intensity	Value of capital investment and recurring cost per ha.
VI.	Labour intensity	Family and hired labour, man-months per ha, seasonal peak periods, festivities and holidays.
VII.	Technical skills and attitudes	Experience, response to innovation and change, literacy.
VIII.	Power	Extent of human, animal and tractor power impact on land preparation, harvesting, etc.
IX.	Mechanization and Farm operations	Which operations are mechanized or partly mechanized.
X.	Size and shape of Farms	Farm size, size by LUTs, fragmentation of holdings, rainfed and irrigated areas.
XI.	Land tenure	Free hold: family farm, corporately owned estate. Tenancy: cash rent tenancy, labour tenancy, share cropping. Communal ownership: cooperative (collective) farming, village land with rights to cultivate etc. State ownership: state farm, national park.

Appendix 7 (Continued)

Headings		Descriptions
XII.	Infrastructure	Assumptions about processing facilities, storage deposits, markets, access to farm inputs. Roads, housing, schools, medical facilities, electricity, domestic water supplies. Research and extension, services and facilities.
XII.	Irrigation infra-Structure	Assumptions about irrigation and drainage infrastructure and access to irrigated land.
XIV.	Cultivation practice	Preparation of land for irrigation including clearing. Tillage operations (including duration for ploughing, leveling etc. Fertilizer application (timing and methods), weeding crop protection, harvesting and processing.
XV.	Material inputs	Prior assumption about quantities and quality of inputs especially for seed, planting material, fertilizers, pesticides, herbicides, etc.
XVI.	Livestock	For traction, milk or meat, manure, forage requirements, including crop by-products, field grazing, zero grazing, stall-fed, etc.
XVII.	Associated rainfed	Influence of LUT of competing rainfed agriculture, shifting cultivation or agro-forestry, timber trade from land cleared for irrigation.
XIII.	Yields and production	Yield per unit area on S1 land (ceiling value for relative yield). yield per unit of water (per m ³) especially during periods of water shortage.
XIX.	Environmental impact	Public health problems (i.e. Bilharzia, malaria, river blindness, diseases transmitted by water). Downstream effects on water supply and quality siltation, flooding, etc. Effects on wildlife conservation.
XX.	Economic information	Market prices, input costs and availabilities, subsidies, credit.