SECTION 3

Vegetation assessment

Introduction

Sites: The sampling sites for the detailed investigations and scoring will have been identified during the transect walk and reconnaissance visit of the study area (section 2). They need to be representative of a specific land use type. It is important that selected sampling sites can be compared with a benchmark of similar vegetation / land use type in good conditions. Digital photographs should be taken of each sampling site and to the extent possible comparative pairs of sampling sites should be assessed (healthy forest versus a degraded forest etc.).

Equipment: In addition to the standard recording materials, GPS, camera and abney level / clinometer for measuring slope and maps used in the transect walk (see Annex 1 in Part 1 (FAO, 2011a)), further tools that may be required include:

- machete to cut through thickets;
- plastic bags and plant press to take any vegetation samples;
- 50m tape measure (marked at 1m, 2m and 10m intervals) to measure distances;
- a conventional quadrat (1 metre metal/bamboo square with 10 cm grids of wire or string);
- calibrated Aluminium Disk Pasture Meter (optional);
- the Abney level will be used for measuring tree height (as appropriate).

Quadrat size: A quadrat is a predetermined sample surface area (usually square) used repeatedly to sample vegetation and measure species presence, frequency, abundance and cover. The quadrat size that should be used depends on the vegetation type and density and should be decided for each particular site:

- for herbaceous cover / grasslands a 1m^2 quadrat divided into grids (e.g. 10 cm^2);
- for dense forest or crops a 5x5m or 10x10m quadrat can be marked out using a tape measure (e.g. with one person or a stake at each corner)
- for shrub land and open grass / wooded savannah a 20x20m to 50x50m quadrat can be used, as above, or a line transect used (see below).

Line Transect: In rangelands and very dry areas with extremely sparse vegetation, a line transect tends to be used rather than a quadrat, this may be 50 or a 100 m long depending on the heterogeneity of the vegetation. For estimating tree density, a 50 to 100m quadrat can be paced out. To ensure a representative sample up to 3 line transects may need to be taken in a 500 m^2 area.

There are three steps in assessing vegetation degradation:

Step 1: Before going to the field, information on changes in vegetation areas and intensity of use can be obtained from time-series aerial photos and satellite images, also from reports of natural resources / vegetation inventories and land cover surveys.

Step 2: Information on vegetation condition and health can be obtained in the field through visual observations of vegetation cover and condition (dominant species, size / growth; mortality and regeneration) backed-up by vegetation sampling using quadrats and measurements to compare vegetation on sites / areas that have been subject to different levels of protection, management and utilisation. Specimens of indicator plants should be collected in plastic bags, (or in a plant press, if available) with labels to record the site and local plant names for later identification with specialists (botanists, foresters, pasture specialists, ecologists, etc.).

Step 3: As with the assessment of other land resources, it is important to supplement and triangulate the data from the vegetation observations with information provided by key informant interviews (see Tool 5.2). This should help provide explanations of changes in vegetation area, intensity of use and products harvested. Household interviews (Tool 7.1) should provide more detail on the quantity and quality of the products harvested from particular areas. Different household members need to be involved, as they may have different information depending on which specific and products they harvest (in particular women may use vegetation resources in very different ways to men).

The following tools are provided:

- Tool 3.1 Vegetation assessment in forests / woodlands
- Tool 3.2 Vegetation assessment in pasture / rangeland
- Tool 3.3 Vegetation assessment in croplands
- Tool 3.4 Degradation effects on cropland productivity

(See also Tool 5.2 Interviews on Vegetation Resources.)

More detail on vegetation assessment and biodiversity indices are given in Table 5 in Part 1.

PHOTO 4 **Natural veld grazed by cattle, sheep, goats and donkeys (South, Africa)**

Vegetation types and indicators

Objectives:

- To compare the vegetation status and trends (degradation / improvement) between different units of land (i.e. protected, well managed vegetation with little evidence of degradation and / or under inappropriate land use or poor practices that are causing degradation);
- To identify / verify indicator plants of land degradation, conservation or improvement;
- To assess vegetation (forest, pasture, rangeland, cropland) in terms of productivity and ecological function and capacity to maintain the range of ecosystem services.
- To identify the direct causes of vegetation degradation and the direct effects of SLM practices.

The observations should generate information that facilitates subsequent analysis to identify drivers and wider impacts of LD / SLM on livelihoods and ecosystem services.

Participants: As with the soil assessment, if possible, the local team should be accompanied in the field by the land owners / land users.

Type of vegetation: The first task is to classify the vegetation:

Forest / woodland type (F): whether the trees are coniferous, evergreen broad-leaved, semi-deciduous, deciduous, or xeromorphic (arid and semi-arid areas) and the density:

- **Forest (FF):** Trees usually over 5m tall with crowns interlocking (generally 60-100% canopy cover). Shrubs, herbs and non-vascular plants may be present with any cover value;

- **Woodland (FW):** Open stands of trees usually over 5m tall with crown not usually touching (generally 25-60% canopy cover). Shrubs, herbs and non-vascular plants may be present with any cover value;
- **Sparse woodland (FS):** Trees usually over 5m tall with widely spaced crowns (generally 10-25% canopy cover). Shrubs, herbs and non-vascular plants may be present.

As described in Table 2 in Part 1, it is also useful to specify the land use type i.e. if the forests/ woodlands are virgin / natural, planted forests/ plantations and or protected such as a forest reserve or wooded savannah in a game park. If the forests are grazed this should also be indicated i.e as in agrosilvopastoral systems

Grazing land type (G): Land that is grazed or browsed by livestock and wildlife may consist of tall /medium / short grassland or forbs, and sparse or dense bush or dwarf bush and a range of trees (evergreen, semi-deciduous, deciduous, or xeromorphic species):

- **Herbaceous (H):** Grasses and/or herbaceous plants (including ferns) generally forming >10% cover. Trees, shrubs, and dwarf shrubs may be present, but with cover 10% or less. Non-vascular plants may be present with any cover value.
- **Bush (S):** Shrubs and or small trees usually 0.5-5m tall with individuals and clumps not touching or interlocking (generally >25% canopy cover). Trees may be present but with cover 10% or less. Herbs and non-vascular plants may be present with any cover value.
- **Sparse Bush (SS):** Shrubs and or small trees usually 0.5-5m tall with individuals and clumps widely spaced (generally 10 - 25% canopy cover). Trees may be may be present with 10% cover or less. Herbs and non-vascular plants may be present with any cover value.
- Dwarf Bush (SD): Low growing shrubs and/or dwarf trees usually under 0.5m tall (though dwarf forms 0.5-1.0m can be included), with individuals and clumps not touching or interlocking (generally >25% canopy cover). Trees and shrubs greater than 0.5m may be present, but with canopy cover 10% or less. Herbs and non-vascular plants may be present with any cover value.
- Sparse Dwarf Bush: As above though low growing shrubs and/or dwarf trees (generally 10-25% canopy cover).

As described in Table 2 in Part 1, it is also useful to specify the land use type i.e. if the grassland or shrubland is essentially unmanaged, extensively managed or intensively managed for grazing by livestock and wildlife and/or if they are protected areas. If available the livestock types and stocking density should also be specified

Cropland type: Cropland may contain natural (maintained) or planted trees, shrubs and grasses in field borders and hedges and as biological soil and water conservation measures such as grassed contour bunds or strips, or alley cropping of useful leguminous or fruit tree species. The cropping system (crop types, rotations, inter or relay-cropping, fallow period, etc.) should be described as well as the natural vegetation.

As described in Table 2 in Part 1, it is also useful to specify if the cropping is perennial trees or shrubs (e.g. vineyards, orchards, coffee, tea, sisal), perennial crops (sugar cane, banana, perennial fodder crops, etc.) or annual crops (food and fodder crops, horticulture) and whether they are irrigated or rainfed. It is also useful to specify if they are mixed agropastoral systems if grazing is also taking place or stall fed animals are kept on the farms

The forest, grassland or crop species may have specific characteristics related to the soil and terrain conditions for example saline resilient species in saline soils, drought resilient species on very shallow and stony soils and water tolerant species in wetland areas.

Vegetation indicators

Vegetation condition is a key aspect of degradation in grasslands, wood/forest lands and croplands. For this range of land uses six key vegetative indicators of degradation are used in the assessment (stability or positive changes would indicate conservation or SLM):

- **Decline in vegetation cover (plant and litter):** reduced cover means increased exposure of the land to sun, wind, rain and wind and water erosion;. Vegetation cover can be divided into basal cover (herbaceous), shrub cover and canopy cover (trees) for a more in depth analysis
- **Changes in vegetation structure and species composition** which determines cover, shade, use and productivity. Change in dominant species is a key indicator of degradation and the share of beneficial / economically valuable species to harmful / unpalatable / invasive species influences productivity and livelihoods;
- **Decline in species and habitat diversity:** reduction or loss of biodiversity is associated with loss of useful products and functions (habitat for wildlife, pollinators) and reduced resilience (e.g. to climate change and to pests and diseases);
- **Changes in abundance of specific indicator species:** the specific species may indicate, for example, low pasture or soil quality (or the converse), invasive species (e.g. leading to bush encroachment or out competition of more palatable species), or specific land degradation concerns such as salinity (halophytes), waterlogging due to soil compaction, fire incidence;
- **Reduced vegetation health and productivity** which includes the vegetation quality or extent of damage of natural and planted species (e.g. to leaves, buds, roots, cambium, branches, trunk) by fire, pests, over-exploitation, etc., and reduced growth/ regeneration capacity of forest, shrubs, trees and herbaceous species (few young plants, many old/ senescent plants);
- **Vegetation management and use:** whether it is intensively or extensively used; the management practices that are used and the use of products harvested from the land.

PHOTO 5 **Photos can be useful to back up observations and measurements**

Tool 3.1 Vegetation Assessment in Forest / Woodland

It is important to understand the history and the stage of the vegetation in natural forests and woodlands (primary, secondary) and to relate the forest condition to pressures on the forest from local and other users of wood and non-wood forest products. This tool is used also for assessing the condition and productivity of trees outside of forests / woodlands (i.e. trees in grazing lands and croplands).

Sampling

An appropriate quadrat size should be selected with the advice of the vegetation specialist ecologist in the team (see Table 7) and used to determine the cover, condition and productivity of trees in woods / forests compared with a benchmark site which is assessed to be in good condition using the following indicators. This draws from FAO National Forest Monitoring and Assessment (FAO, 2009). As a rough guide the quadrat size is normally equal to the height of the tallest vegetation

A field form is provided in Table 9 below to assist with systematic recording and documentation of the various vegetation indicators. This could be adapted as required by the assessment team during an initial pilot assessment

1. Vegetation cover: Each of these indicators should be assessed, as appropriate (none / negligible <5%, little 5-10%, moderate 10-40%, high 40-70%; dense >70% cover)

1.1. Tree canopy cover: estimate the ground surface covered by the vertical projection of the tree canopies, as a percentage of the total ground area;

1.2. Shrub canopy cover: estimate the ground surface covered by the vertical projection of the shrub canopies % of the total ground area; and,

1.3 Ground cover: estimate the ground surface covered by herbaceous vegetation or litter.

2. Species composition
2.1 Tree / shrub species: record either common / local (specifying local language) or scientific species name for all species if there are few, or the three dominant tree species and the three dominant shrub species if the vegetation is diverse. Compare to the benchmark site and ask the local informants / land users to indicate if there has been a change in the dominant species as this is a key indicator of degradation, also ask the reasons (overexploitation – by whom?, specific management practices, climate change etc.);

TABLE 7 **Optimal size of quadrats in vegetation surveys**

Type of vegetation	Vegetation height (m)	Size (m)
Moss / Lichens	< 0.05	0.1 × 0.1
Short grassland (annual grassland))	< 1	1 × 1
Tall grassland (perennial grassland)	< 2	2 × 2
Shrub	< 4	5 × 5
Young forest (sub-forest))	< 8	10 × 10
Mature forest	> 8	20 × 20

Source: http://hosho.ees.hokudai.ac.jp/~tsuyu/lecture/glossary/on_quadrat.html

2.2. Indicator species: identify any species which is an indicator of problems or constraints (e.g. invasive species, weeds, plants that indicate salinity, waterlogging, low fertility etc.) and record the abundance (i.e. whether the number of each indicator species in the quadrat is - abundant (many); medium (common); or rare (few)).

2.3 Useful species and products: compare to the benchmark site and ask the local informants / land users to indicate:

1. If there has been a change in the dominant species, as this is a key indicator of degradation and ask the reasons (overexploitation, management practices, climate change etc.);
2. Which are useful tree / shrub species? What products they provide (timber, charcoal, food and medicinal products, other)? and for whom? (land use group; men or women) and whether there has been a change (i.e. loss of valuable species and products or decline in productivity)?;
3. Whether there has been a change in the share of beneficial / valuable species to harmful / unpalatable / invasive species or in the wildlife (e.g. loss of habitat, feed).

3. Condition and wood productivity

3.1 Growth: measure the average height (h in m) and diameter at breast height (Dbh in cm) for trees and for stumps with: i) a Dbh ≥ 20 cm in forest land; and ii) a Dbh ≥ 10 cm in non-forest land. For stumps lower than 1.3m the diameter is measured at stump height (Dsh). For stumps, ask the land users if they can indicate the time since the tree was cut (<1, 1-5, 6-10, >10 years) as this will indicate recent pressures. Ask local informants / land users the age of planted trees - this is a useful measure of productivity and of carbon stocks.

3.2 Overall tree condition: record the condition where:

- good = no symptoms of disease / other effects on growth and vitality;
- slightly affected = some symptoms;
- severely affected = symptoms that substantially affect the tree's growth and vitality;
- dead / dying = damage that is or will lead to death or the tree has fallen.

3.3. Crown condition / health: good = dense, no dieback; moderate = dense, visible dieback, poor = less dense, significant dieback; dying = sparse, high dieback; dead = already killed.

3.4 Tree stem quality: for species used for timber / building materials, assess if the stem is straight and extent of damage due to fire, pests, diseases, animals, etc. (high: straight tree without visible damage; medium: some slight defects or damage; low: several defects or damage).

3.5 Causes of damage: ask local informant / land users if they know the causes of damage (e.g. due to insect infestation (defoliation, leaf feeding, etc.); presence of fungus (leaf spots, leaf or needle discolouration, etc.); burning; wild or domestic animals; human induced (cuttings, bark damage, logging, etc.); extreme climatic events (e.g. broken branches by wind, snow, lightning, etc.); or other causes).

3.6 Management practices ask local informant / land users what types of management practices are used in the forest / wood land, what is the intensity trend and whether there are any bye laws affecting management practices and use of products (see Photo 6 and Table 8).

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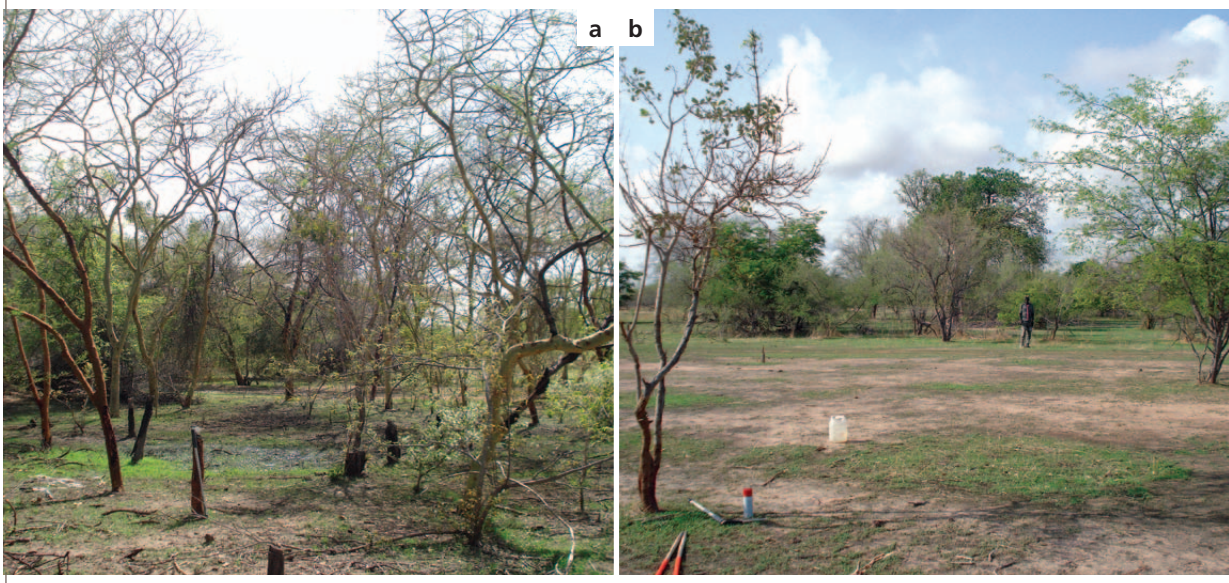

PHOTO 6 **(a) and (b) Assessing grazing land with trees (Touba Ndar Fall, Senegal)**

TABLE 8 **Review of management practices in forest / woodland**

Management practice and measures in forest/ woodland	**Extent of application** (V- Very high; H- high; M- medium; L- low)	**Use of products**	**Effect/Intensity trend** (O - Overuse C - conservation (stable) L- low use)
e.g. thinning / coppicing of trees/ clear felling..., etc.		e.g. use of wood/ wild fruits/nuts/ medicinal plants,	
e.g. byelaws, regulations on access, rights of use			

TABLE 9 **Field form for vegetation assessment (degradation/ SLM) in forest/woodland**

Site No	Species		Growth				Canopy				Health			Products				Users	
	Common name	Scientific name	Av. Diameter Dbh. cm	Av. height m	Year(s) since cut	Tree Stem quality C	Tree canopy cover %	Shrub cover %	Ground cover %		Crown condition C	Tree/shrub condition C	Cause of damage C	Wood and building materials	non wood food and medicinal products	Charcoal		Local use	Commercial use
Tree																			
Shrub																			
Stump																			

Ntes:

Tool 3.2 Vegetation assessment in pasture / rangeland

Visual indicators and methods

An understanding is needed by at least some members of the assessment team of the processes of rangelands degradation and issues of seasonality. This understanding helps in identifying appropriate indicators of vegetation status and trends and assessing interactions between vegetation, soil and water resources degradation.

Whilst it is important to understand all major impacts of degradation on ecosystem services, land users (notably the livestock owners and herders) will be most interested in the effects on rangeland productivity and consequently on livestock carrying capacity.

Changes in grass species composition, notably the decline in the percentage and absolute number of desirable (palatable) species, combined with any decline in plant vigour leading to lower forage biomass production, will result in the affected rangeland having a reduced livestock carrying capacity. This will have an adverse effect on livestock productivity, with livestock owners finding that they can keep fewer animals on a given area of rangeland. The health, condition and breeding success of the animals may deteriorate if livestock numbers exceed the long-term carrying capacity of the range.

A set of proposed indicators is outlined in Table 10 for a visual assessment of pasture / rangeland condition - comparison is the key between well and poorly managed land (see Photos 8a and b.[3] The proposed scoring needs to be tested and adapted / calibrated for each situation. The findings should be integrated with the soil investigations (Section 4).

These methods are subjective, the accuracy depending on the judgement of the operator, but they need no in-depth knowledge of the pasture and can be applied easily. The criteria for calibrating the scoring should be well documented and supported with photographs. This will allow the scoring to be consistently applied by different people at different times, improving their robustness and value for base-line setting and future monitoring.

Sampling

Select an appropriate quadrat size or use a line transect to determine the cover, condition and productivity of the pasture or rangeland for the selected assessment site using the indicators in Table 10. Where possible, repeat the measures to compare the site in the given land use with another site in relatively good condition.

The score sheet (Table 10) should be used for each sample site or for each vegetation group identified. The bigger or more variable the area, the more observations are necessary to get a representative scoring of range quality. Avoid transition areas and make sure the visual assessment represents all major changes that have occurred in vegetation groups and conditions. Additional locally appropriate indicators can be included in the score sheet, or they can be used to make a more informed assessment of the existing indicators.

This scoring system has been calibrated in South Africa and was tested in the five other LADA project countries, but it may need to be re-scaled in other locations.

3 This list of core indicators is adapted from a list of visual indicators for assessing pasture (veld) condition trend on farms and extensive grazing areas used in South Africa with farmers, extension staff and researchers and repeated yearly. (Fourie & Roberts, 1977, as described by Jordaan, 1991). The original list of indicators includes density, basal cover, botanical composition, vigour and the condition of the soil surface.

TABLE 10 **Indicators and classes for assessing pasture / rangeland quality**

Issues and core indicators		Category
1. Vegetation /litter cover		
1.1	**Total bare soil / vegetation cover**	Estimation of % cover- for comparison (using a quadrat or line transect) *[N.B. Cover is critical for soil protection from raindrop impact, high temperature and to reduce runoff volume and rates.]* *Cover can be divided into basal cover (herbacecous), shrub cover and tree canopy cover for a more in depth analysis.*
1.2	**Bare spots**	Spots without vegetation. In savanna - 2m or larger (the agreed size may change per ecological zone)
	None	None can be seen
	Little	Can be seen, but does not characterise of the area
	A lot	Characterises the area
	Dominating	More bare than covered
1.3	Litter cover/Surface organic matter	The more, the better soil surface protection. [Gives an indication of moderate grazing practices.]
	Dense	Covers soil beneath tufts.
	A lot	Bare soil can be seen
	Little	Seen but no notable cover effect.
	None	None seen
2. Vegetation quality and composition		
2.1	**Vegetation height, diameter and vigour for** perennial species (shrubs, trees) **and** herbaceous species (grasses, legumes)	Growth measurements - height and diameter at breast height (DBh) and growth pattern- e.g. stunted, defoliated) and vigour measurements - stem diameter, average shoot length and basal shoot diameter. Using representative quadrat or line transects and comparing between well and poorly managed land or protected areas, taking note of time of year and seasonality.
	Good	Vegetation height, diameter and plant vigour compare very well with representative site and is close to optimal considering the seasonality and climatic conditions (i.e. rainfall and drought).
	Moderate	Vegetation height, diameter and plant vigour slightly lower than the representative site.
	Poor	Vegetation height, diameter and plant vigour significantly lower than representative site and sub-optimal.
	Very poor	Serious reduction in biomass (vegetative production), resulting in stunted and defoliated growth and very little to no plant vigour.
2.2	**Proportion of perennial / annual species**	*Indication of grazing quality and resilience to drought (herbaceous species – lower lignin and higher protein; woody species- higher lignin, lower protein)*
	Dominating	All grasses are perennial
	A lot	Single annuals are present
	Little	Perennials are present but not important
	None	Perennials not seen

TABLE 10 **Indicators and classes for assessing pasture / rangeland quality** *(continued)*

Issues and core indicators		Category
2.3	**Proportion (dominance) of useful species**	*This could include: - Ecological functions (e.g. canopy cover, deep rooting, resilience to drought, recovery after burning); Palatability (browse / grazing); and Products for human use*
	Dominating	All or most species useful
	A lot	Moderate
	Little	Present – some useful species
	None	Not seen
3. Ecological integrity, biodiversity and change dynamics		
3.1	**Proportion of each vegetation strata**	% / proportion of trees, bushes / shrubs, forbs[4], grasses (reflects exploitation and change in habitat)
3.2	**Species that decrease with grazing pressure** (i.e. preferred by livestock)	For each vegetation strata (herbaceous (grasses and forbs); shrubs/bushes; and trees): • Identify preferred species / decreasers - those species that decline with graze / browse pressure e.g. palatable spp. that play an important role in livestock diet (*T.triandra, Panicum. maximum* and *D. eriantha* can be used as key species in South Africa) • Compare with protected sites.
3.3	**Species that increase with grazing pressure** (i.e. resilient to trampling, unpalatable species)	Identify key species that are known to increase with grazing pressure for each vegetation strata including species resilient to trampling (e.g. *Eragrostis* spp. in particular *E. rigidior* can be used as key species in South Africa). Compare with trampled sites; - key species not regularly utilised by livestock (e.g. *E. muticus*, *C. plurinodis* and *Bothriochloa radicans* ("stinkgrass") in South Africa.) Compare with lightly or moderately utilised areas.
3.4	**Poisonous plants**	Identify plants poisonous to livestock; this will differ from area to area (e.g. in South Africa examples include *Homeria* spp., *Senecio* spp., *Lantana camara*, *Dicapetalum cymosum* etc.)
3.5	**Alien Invasive or proliferous weed species**	Identify specific alien invasive or weed species that have reduced pasture / range or crop productivity (e.g. presence (low, moderate, high) or % cover of Prosopis, Lantana etc.).
3.6	**Pest damage**	Indicate extent and severity of damage by termites (defoliated vegetation and termite nests visible), rodents, locusts or others.
	None	Not seen.
	Little	Single localities, no real damage.
	A lot	Damage seen, but not over whole area.
	Dominating	Whole area damaged.
3.7	Damage due to diseases	Evaluate as in pest damage

4 Forbs are herbaceous flowering plants that are not grasses, sedges or rushes.

TABLE 10 **Indicators and classes for assessing pasture / rangeland quality** *(continued)*

Issues and core indicators		Category
3.8	Bush / shrub encroachment	A key factor of pasture / range degradation is an increase in woody, invasive, unpalatable/toxic species. Too many bushes / trees depress grass production (reduce livestock carrying capacity) and may reduce access to water.
	None / sparse	Trees 30m+ apart.
	Open	Present. Visibility 200m and more.
	Dense	Visibility 50m. People and livestock can still move with ease.
	Very dense	Not easy to penetrate.
3.9	Deforestation	Deforestation is the loss of forests, woodland and savanna areas to other land uses due to over-cutting of trees. One consequence is soil erosion, which results in the loss of protective soil cover and water-holding capacity of the soil.
	None	There are no signs of deforestation.
	Some	There are some indications of deforestation, but the process is still in an initial phase. With minor efforts it can be easily stopped and damage repaired.
	Moderate	Deforestation is apparent, but its control and full rehabilitation of the land is still possible with considerable efforts.
	Severe	Evident signs of deforestation. Changes in land properties are significant, or even beyond restoration, and very difficult to restore within reasonable time limits.
3.10	Biomass decline *	Reduced vegetative production for different land use (e.g. on forest land through clear felling, secondary vegetation with reduced productivity). Depending on the time of year, biomass estimates can be made and compared between poorly and well managed / protected sites to give an indication of reduced vegetation production - trees, grasses, shrubs.
	None	There are no signs of biomass decline.
	Some	There are some indications of biomass decline, but the process is still in an initial phase. It can be easily stopped and damage repaired with minor efforts.
	Moderate	Biomass decline is apparent, but its control and full rehabilitation of the land is still possible with considerable efforts.
	Severe	Evident signs of biomass decline. Changes in land properties are significant, or even beyond restoration, and very difficult to restore within reasonable time limits.

* Biomass estimates can be made using a simple hand balance in the field. However, dry weights of biomass samples weighed in a lab. are more accurate and comparable than wet weights in the field.

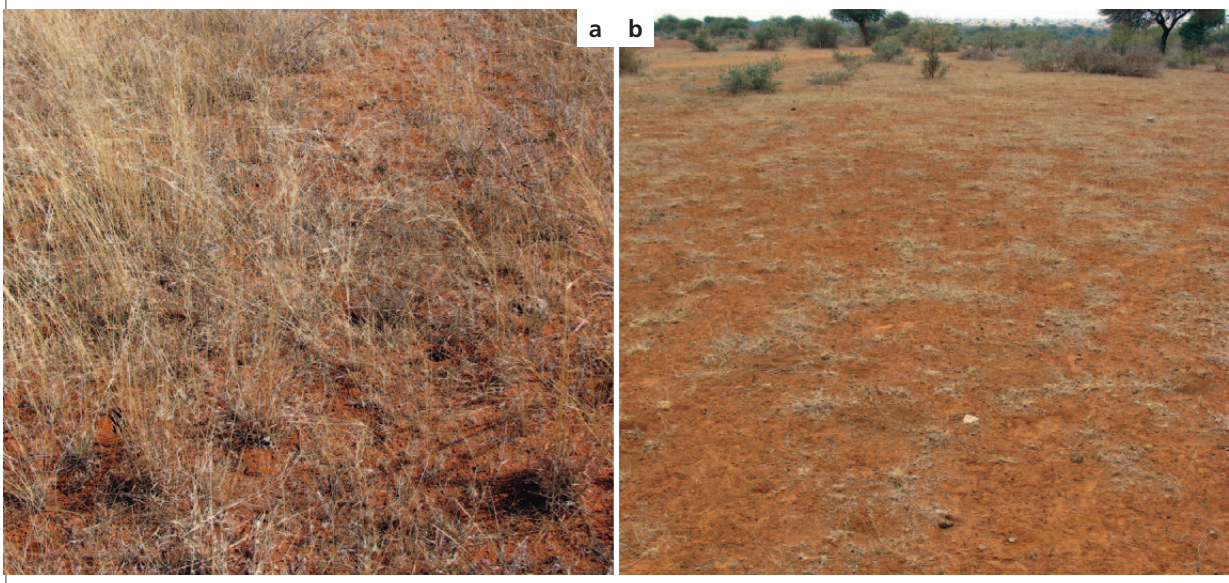

PHOTO 7 **a) Average basal cover (left) and b) low basal cover (right) due to grazing pressure (South Africa) (see Table 10)**

Scoring

Once the class has been assigned for each indicator, the range / pasture condition can now be scored. Using Table 11, for each indicator mark one of the columns. Columns have the following values: column 1 = 5, column 2 = 3, column 3 = 1, column 4 = 0. Sum the number of marks in each column. Multiply it with the value of each column. Sum all to give a total index for each site / pasture.

TABLE 11 **Scoring using visual indicators for assessing range quality**

Range condition indicator	Best class	Moderate	Poor	Worst class
1.1 Total bare soil	None	Little	Lot	Dominating
1.2 Bare spots	None	Little	Lot	Dominating
1.3 Litter cover / surface organic matter	Dense	Lot	Little	None
2.1 Vegetation height, diameter and vigour	Good	Moderate	Poor	Very poor
2.2 Proportion of perennial/annual species	Dominating	Lot	Little	None
2.3 Proportion of useful species	Dominating	Lot	Little	None
3.1 Proportion of each vegetation strata (grasses, shrubs, bushes and trees)	Dominating	Lot	Little	None

TABLE 11 **Scoring using visual indicators for assessing range quality** *(continued)*

Range condition indicator	Best class	Moderate	Poor	Worst class
3.2 Species that decrease with grazing pressure	Dominating	Lot	Little	None
3.3 Species that increase with grazing pressure	None	Little	Lot	Dominating
3.4 Poisonous plants	None	Little	Lot	Dominating
3.5 Alien invasive or proliferous weed species	None	little	Lot	Dominating
3.6 Pest damage	None	Little	Lot	Dominating
3.7 Damage due to diseases	None	Little	Lot	Dominating
3.8 Bush /shrub encroachment	Sparse	Open	Dense	Very dense
3.9 Deforestation	None	Some	Moderate	Severe
3.10 Biomass decline	None	Little	Lot	Dominating
Score	**5**	**3**	**1**	**0**
Sum of scores				

Convert the score to a percentage (score / number of points X 100) and interpret the condition using the following classes:

Score %	Grassland condition	Trend (indicate if it is...)
100 – 90	Excellent	
71 – 90	Good	Stable
70 - 51	Average	Improving
50 - 31	Bad	Deteriorating
0 – 30	Extremely bad	

[NB This scoring system was developed for grassland and grazing animals and should be adapted for browsing animals.]

Management practices in range and pasture lands

Discuss with the local informants / land users and describe the reasons for the current vegetation status (cover, composition, ecological integrity, biodiversity etc.) and where available, also the reasons for change dynamics.

Complement this information with information gathered from the FGD (Tool 1.1) on vegetation and from household interviews (Tool 7.1) on the:

- Management and conservation practices in place (or missing) to ensure sustainable utilization of vegetation resources;
- Use of products: what products are used from the grazing land (e.g. wood from trees for timber or firewood, straw for thatching, wild animals for food etc.);

TABLE 12 **Review of management practices in grazing land**

Management practices / measures in grazing land (indicative examples)	**Extent of use/ Intensity** (H- high; M- medium; L- low)	**Use of products**	**Intensity trend** (O - Overuse; C - conservation (stable); L- low use)
• pasture species management • removal of invasive species • thinning of bush		• use of grass / straw for thatch, medicinal plants, etc.	
• density of livestock (in relation to expected stocking capacity)		• use of manure for fuel, etc.	
• use of trees/shrubs in grazing lands (shade, fodder, felling)		• use of tree wood / wild fruits / nuts etc.	
• specific regulations, bye laws (e.g. stocking rate)		• specific laws (e.g. harvesting rate)	

- Direct pressures, also the socio-economic and bio-physical driving forces that explain the current pasture / rangeland status (e.g. human population, animal numbers, poverty, labour, land tenure / access rights etc. that lead to clearing, fragmentation or conversion of land etc.);
- A description of land users' historical, current and future responses to land degradation, policies, legislation and change dynamics related to vegetation, backed up where possible by photos (see the example of Photo 8).

Table 12 indicates how such information could be recorded and documented

Grazing quality and carrying capacity

Grazed and browsed species vary considerably in their response to management practices as well as in their nutritive value and acceptability to livestock. Such variation exists between- and within-species at different times of the year and in the same species growing in different areas.

With regard to pasture and rangeland productivity and the effects of livestock, information needs to be obtained from individual key informants and the FGD on livestock **stocking density** and variations throughout the year due to mobility, also the potential **carrying capacity**.

Carrying capacity[5] is the potential of an area to support livestock through grazing / browsing / fodder production over an extended number of years without deterioration to the overall ecosystem. Carrying capacity is dynamic and influenced by several factors, including climate, soil, topography and veld / grassland type

5 As defined by Trollope, *et. al.*, 1990; Jordaan, 1991; and Fourie, *et. al.*,1985

(botanical composition, quantity and quality of grazing material).

Carrying capacity can be expressed as **livestock units/ha** (LSU/ha = 1/(ha/LSU), where: 1 LSU = an animal with a mass of 450 kg which gains 0.5 kg per day on forage with a digestible energy percentage of 55% (Meissner, 1982; Trollope *et al*., 1990).

Different livestock species generate different grazing or browsing pressures; for example, goats are hardy and can live on poorer quality grazing than sheep or cattle but cause more degradation because of their feeding habit. A change in livestock species should be noted, as it may be responsible for a decline in vegetation quality.

A pasture / rangeland area under assessment, or a specific farm, usually contains several grassland (veld) types, each with different plant communities and different micro- climate and soil characteristics. Any carrying capacity analysis should be carried-out for each main pasture type. Although mentioned here, this detailed analysis will be beyond the scope of a rapid assessment in most cases. If, however, there is an ongoing programme of measuring climate change or using this as a key indicator of pasture productivity in the area being assessed, the team may want to include these more detailed measurements.

Trees in the grazing landscape

Besides the assessment of vegetation for livestock grazing it is also important to assess the trees on grazing lands as they provide valuable shade for livestock and windbreaks, they help to maintain a cooler microclimate, provide firewood and other products.

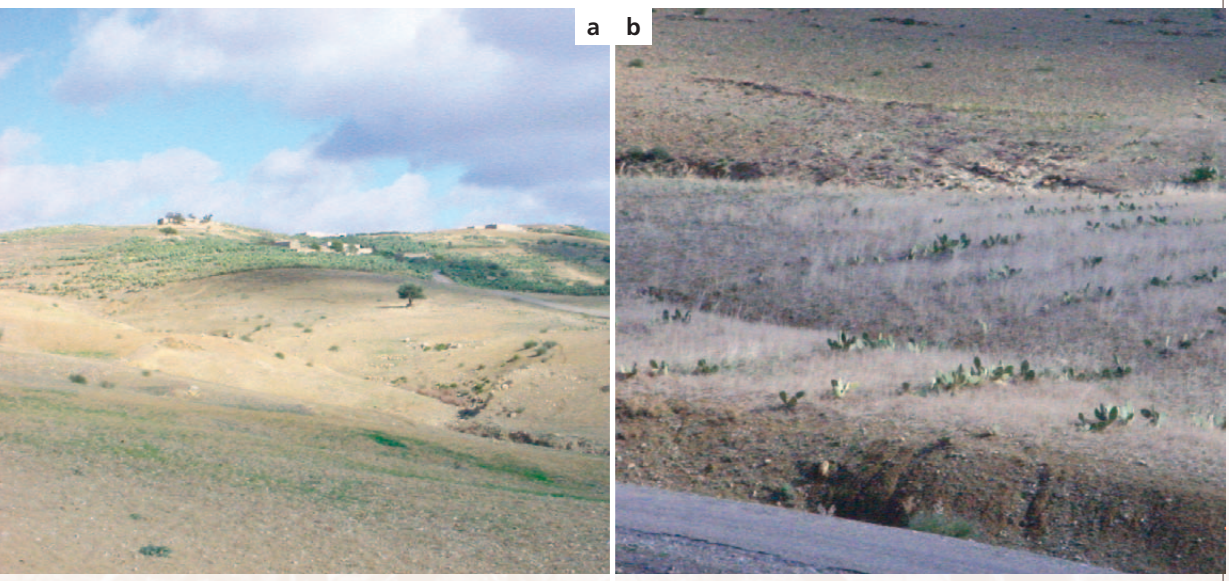

PHOTO 8 **Comparison of a) bare exposed cereal land with b) managed pasture & cactus, Tunisia**

PHOTO 9 **Comparing vegetation and management on different sides of a fence (Bariloche, Argentina)**

PHOTO 10 **Comparing an area before and with project (Fengnin, China)**

– **Density and spatial distribution of trees in the grazing land;** provides a useful indicator of the extent to which trees have been maintained in the environment. (none; scattered / sparse; grouped in blocks; trees in lines (e.g. along fences, roads) in, plantations; other.

– **Tree health, condition and use of products:** where the trees are used for timber, or other non wood forests products the protocol on forest / woodland assessment can be used to assess the trees in the grazing landscape.

Tool 3.3 Vegetation assessment in croplands

Natural vegetation is also important in croplands. In addition to the indicators specified under crop productivity below (Table 13), five other vegetation indicators are included here that should be observed in the field and assessed through the land user and household interviews:

- **Ground cover:** as with pasture and forest land soil, ground cover by live vegetation, mulch (see Photo 11) or crop residues is a key factor in protecting the soil from raindrop impact, soil erosion, high temperatures and excess evaporation;
- **Permanence of the crops or period of cover:** determines exposure of bare soil and erosion risk;
- **Cropping system diversity:** diverse crop systems provide resilience to pests / diseases, capacity to restore and make better use of nutrients / organic matter and reduce erosion risk (e.g. a multi-storey agroforestry system will intercept and make better use of rainwater and the deep soil profile and protect the ground from erosion more than a cereal field; a crop rotation will make better use of nutrients and water in the soil profile);
- **Diversity of natural vegetation within the cropland:** natural vegetation provides habitat for associated species and their beneficial ecological interactions (e.g. pollination). In drier farming systems, there is a need to minimise competition for water between species through the use of appropriate species and management practices;
- **Land fragmentation / proximity to natural vegetation:** increased fragmentation and reduced proximity to natural vegetation will indicate intensification pressure;
- **Use of natural vegetation** for restoring soil protection and organic matter content, also other uses (e.g. wood and non wood forest products etc.

PHOTO 11 **Maize stubble left on soil surface to provide mulch (South Africa)**

TABLE 13 **Indicators of vegetation condition in croplands**

Indicators	Value
Ground cover (inverse of bare soil)	
• cover by crops	%
• cover by mulch	%
• cover by plant residues	%
Permanence of the various crops and cover	
• period of cover	low, moderate, high
• cover in the dry season(s)	low, moderate, high
• cover at start of rainy season (s) when wind and water erosion are greatest risk	low, moderate, high
Crop diversity	
• crop species diversity (number and share of. local /indigenous to introduced species))	no.; low/medium/high
• crop varieties (number for 3 main crops)	no.; low/medium/high
• harvested products diversity (grain, straw, beans, fruit, fibre, etc.)	no.; low/medium/high
Fragmentation/proximity to natural vegetation	
• average farm/field size	ha
• average number of parcels	no.
• extent/share of fallow land	%
Diversity of natural vegetation in / around cropland	
• distance of cropland from natural vegetation (grazing, forest / wood, managed fallow, unmanaged)	none / close / far
• landscape features- presence of hedgerows, trees, grassed bunds/ waterways, windbreaks, etc. -specify	none / few / many
• contribution to household of gathered products (e.g. share of fuelwood, wild foods, charcoal, materials, medicinal plants,...)	low / moderate / high
• reduction/loss of useful species and products	low / moderate /, high
Use of natural vegetation	
• for protective mulch	low / medium / high
• for restoring organic matter management	low / medium / high
• for other products (wood, firewood, etc)- specify	low / medium / high

Assessing crop biodiversity

Simple diversity measurements of richness, evenness and divergence can be used to compare the status and trends in on-farm crop species and varietal diversity. In many countries, biodiversity is of increasing interest and especially its relationship to land degradation / SLM and climate change. The following indicators can be used:

a) Identify and list the **range of species and varieties grown** in a sample of farm households (small, medium, large farms) (e.g. there may be 30 species in total and for one crop species e.g. maize there may be 5 varieties grown etc.);

b) Assess the average **species and varietal richness** for each farm size - the number of different kinds of individuals (regardless of their frequencies), for example:
   – average number of i) plant species and ii) average number of plant varieties per household iii) number and share (%) of traditional plant varieties per household;

c) Assess the **evenness among farms and among the whole community** -

how similar are the frequencies of the different variants (low evenness indicates dominance by one or a few crop types);

d) Assess **divergence** (as a %) (i.e. the partition of diversity between and within farms) this can be measured by the difference between community and farm index values divided by the community value (high divergence may indicate high potential of households in the community to grow different varieties).

Through discussions with land users, explain the findings, for example:

- Crop genetic diversity may continue to be maintained on farm, in the form of many species and / or several traditional crop varieties. Alternatively, crop diversity may be very low, in which case there are few species and few varieties maintained;
- A large part of crop diversity may be held in the larger community, rather than in any one farmer's fields.(i.e. the diversity is spread throughout the community);
- There may be a close relationship between traditional varieties' richness and evenness (i.e. farmers who grow traditional species will also grow several varieties of each crop);
- In some cases, crops may be maintained at farm and community level with one or two dominant varieties and a large number of other varieties that occur at lower frequencies. This suggests that farmers maintain the low frequency varieties as an insurance to meet future environmental changes or for social and / or economic reasons. For other crops that show a more even frequency of distribution of traditional varieties, this implies that farmers are selecting varieties to serve current needs;
- Divergence estimates across crops and varieties may show that small-scale farmers who manage different varieties in different ways are a major force for maintaining crop genetic diversity;
- Climate change and variability may be influencing which crops / varieties farmers grow, as they adapt to reduce risk of crop failure.

Tool 3.4 Degradation effects on cropland productivity

Land users are usually most interested in the impacts of LD / SLM on productivity, as this is directly linked to food and livelihood security. There is a strong emphasis on productivity impacts with the rangeland assessment tools, but some additional focus in this area will be required for cropland.

Information can be obtained on the effects of degradation on cropland productivity through the household interviews and discussions with land users in the field and other informants (e.g. extension / project staff) backed-up by data from agricultural research. There are three main groups of visual field indicators that are useful:

- low or declining yields (actual yields and trends);
- poor growth characteristics;
- plant nutrient deficiencies and toxicities.

Assessing yield and productivity

There are 4 possible sources of information.

- **Historic comparison of yields from records** (review of secondary data) Farm records, local co-operatives, marketing boards or official government statistics can provide useful information on medium to long term trends in

production. By then putting those records alongside statistics on fertiliser use, introduction of new varieties and other production-enhancing factors, a qualitative view may be gained of how far land LD / SLM may have impacted production.

- **Discussions with land users to assess change in yields and land productivity**
  See Tool 5.3 Interview with land users on crop productivity and yield.
- **Assessing change in production costs that may be related to soil degradation**
  Assessing whether production costs have increased because of increased tillage / fertiliser requirements and herbicide / fungicide application over the years can be estimated by farmers' perception or can be calculated using annual farm balance sheets (see Figure 8). (FAO, 2008).
  Ground preparation, fertiliser, herbicide and pesticide inputs can account for some of the main costs in a cropping system and can increase significantly with soil degradation. As degradation increases, the density and strength of the soil increases and, as a result, the soil becomes more resistant to tillage forces. In mechanised systems, plough resistance increases so that larger tractors are required to avoid excessive wheel slip and the need to operate at lower ground speeds in a lower gear. The size, density and strength of soil clods also increase with increasing loss

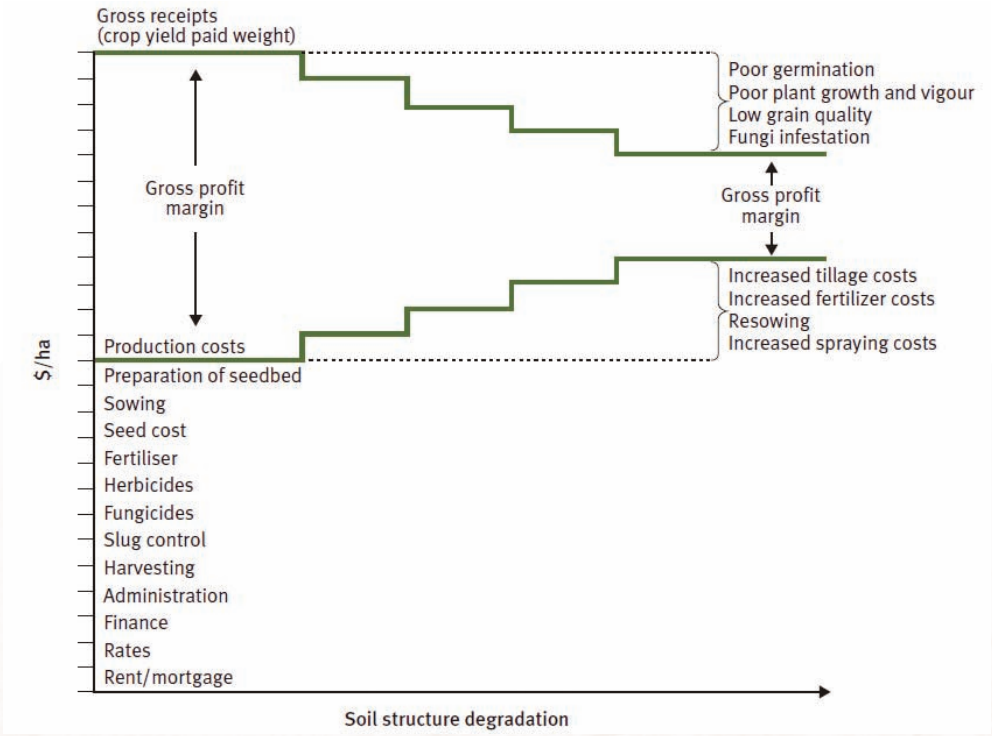

FIGURE 8 **Assessment of production costs**

Visual score (VS)	Production costs
2 [Good]	Production costs including ground preparation, fertiliser, herbicide & pesticide requirements have not increased
1 [Moderate]	Production costs including ground preparation, fertiliser, herbicide & pesticide requirements have increased moderately

of soil structure, therefore careful timing and additional energy is needed to break them down to a seedbed. This energy is generally applied by using more intensive methods of cultivation and by making a greater number of passes. As a result, conventional tillage costs can increase by over 300 percent.

Continuous cropping using conventional cultivation techniques increases the rate of soil organic matter decomposition and damages soil structure. This depletion of soil organic matter reduces soil fertility and the ability of the soil to supply nutrients to crops. Higher amounts of fertilizer are needed to compensate for the loss of these nutrients. Furthermore, the loss of soil organic carbon under continuous conventional cultivation could incur a possible carbon tax in the future.

Reductions in crop yield are often not recognised as the result of the degradation of soil structure. Growers often assume that soil fertility is at fault and increase their production costs by applying extra amounts of fertilisers.

- **Quantitative measures of changes in yield**

Within-field differences in yield are often very significant. It may be possible to directly relate the yield differences to land degradation variables such as soil depth or erosion. Root crops (carrots, sweet potatoes, beet) are especially amenable to this technique. Farmers may also be willing to draw the size of their individual root crops onto paper. An equivalent size of tuber can then be purchased from the market, weighed and the yield estimated by multiplying the number of plants in a fixed area by the estimated average weight. This would depend on the assessment being undertaken at harvest time (which is unlikely) but information could be subsequently collected by the local team members.

Plant growth characteristics

These may include:

- **crop establishment** (germination, plant emergence and root growth are restricted by a crusted soil surface, also compacted soil in the root zone which impedes air and water movement);
- **numbers of tillers in cereals** (this is partly determined by plant genetics and planting density but is also an expression of plant vigour and growth which is regulated by nutrient and water availability and soil condition);
- **plant leaf colour** prior to completion of grain filling provides a good indication of water and nutrient status, also soil condition (crop yellowing due to inadequate formation of chlorophyll occurs as a result of low N, K, S, Fe, Mg, Cu, incorrect pH and / or poor soil aeration; blemishes can result from lack or excess of P, K, S, Mg, Mn, Zn, Cu and B);
- **root growth** determines uptake of nutrients and water (root length and density can be restricted by soil

TABLE 14 **Possible field indicators for assessment of crop production**

Plant growth measurements or observations	Good condition (2)	moderate condition (1)	poor condition (0)
Crop establishment (Plant population/m^2)	Good emergence and crop establishment, with few gaps (due to poor germination) and crop showing a good even height.	Moderate emergence & crop establishment with significant gaps in the crop and variation in seedling height. Emergence may be moderately slow but may recover.	Poor emergence and crop establishment, with many gaps in the crop (e.g. due to crusting) and a large variation in seedling height (e.g. moisture stress, areas of erosion and deposition, variation in organic matter management). Plants may appear sickly thus more vulnerable to pest and disease.
Number of tillers (e.g. wheat, barley and oats) crucial in determining number of ears and hence a proxy for yield	Depending on the cultivar, the plant has 3 well developed tillers with little variability compared to the main stem.	Depending on the cultivar, the plant has 2–3 tillers with moderate variability compared to the main stem.	The plant has 1 or no tillers at all, with significant differences in terms of development to the main stem.
Leaf colour (nutrient uptake is closely linked with soil aeration)	Leaf colour is uniformly deep green. The odd colour blemish on leaves may be apparent within a broad area.	Leaf colour is yellowish green (i.e. has a distinct yellowish tinge). Few colour blemishes on leaves may occur within a wide area.	Leaf colour is quite yellow over a wide area. Colour blemishes on leaves may commonly occur.
Root development and disease	Good root length and root density in the upper 0.25–0.30m of soil. Rare root diseases.	Moderate root length and density in the upper 0.25–0.30m of soil. Common root diseases.	Poor root length and density in the upper 0.25–0.30m of soil with the root system being restricted to limited areas. Very common root diseases.
Plant height and diameter (as proxies of yield) • relative values in relation to resource quality / degradation signs but care as depends on variety	Tall strong cereal and fodder crops Large vegetables e.g. carrot length and diameter, cabbage and lettuce diameter.	Moderate in size.	Small and stunted - may be due to low soil fertility, waterlogging in the root zone, or subsoil compaction limiting the depth of soil from which the roots can obtain water and nutrients.

TABLE 14 **Possible field indicators for assessment of crop production** *(continued)*

Plant growth measurements or observations	Good condition (2)	moderate condition (1)	poor condition (0)
Wilting	No signs of wilting • medium textured deep soils with no compacted layers restricting root growth and with near neutral pH (neither too acid or alkali).	Some signs of wilting.	Evident signs of leaf wilt and moisture stress: • in sandy soil or areas with a stony or shallow profile; • during drought periods in heavier textured soils; • if subsoil is compacted; • if water uptake restricted by very acid or alkaline subsoil.

compaction, hardpans, reduced soil pores and aeration, salinity, sodicity and nutrient deficiencies; root disease and pest damage increase with poor soil structure and poor aeration; good root growth is enhanced by soil organic matter);

- **crop height and diameter** at maturity is a useful indicator of soil condition if agronomic factors have not limited crop development, but is also affected by climate, fertiliser use and size of grain kernels in cereals / numbers and size of tubers.

As with yield, differences in these characteristics may not be entirely due to observed LD / SLM but these simple measurements are very useful in obtaining a farmer-perspective on crop productivity.

Possible field indicators for the assessment of plant growth are given in Table 14. These can be assessed qualitatively or quantitatively using quadrats etc.. However, some of the indicators will be relevant only at certain times of the year.

Plant nutrient deficiencies and toxicities

Nutrient deficiencies are one of the commonest ways in which land degradation affects production (see Annex 2). Expertise is required for reliable identification of nutrient deficiency symptoms in the field as different plants respond in different ways to nutrient deficiencies. For example:

- Deficiencies of different nutrients (or toxicities or other degradation factors) may exhibit the same visual symptom. For example, yellowing of bean leaves can indicate lack of nitrogen, water-logging or even salinity. In maize, accumulation of purple, red and yellow pigments in the leaves may indicate N deficiency, an insufficient supply of P, low soil temperature or insect damage to the roots.
- Disease, insect and herbicide damage may induce visual symptoms similar to those caused by micronutrient deficiencies. For example, in alfalfa it is easy to confuse leaf-hopper damage with evidence of boron deficiency.

Acute nutrient deficiencies can often be identified from the colour of a plant's leaves, whether the older or younger leaves are first affected, whether the terminal bud is affected, and by the plant's growth pattern. Slight or moderate deficiencies seldom show up as foliar symptoms. Similar symptoms can also be caused by damage from machinery or wind. Also one deficiency symptom can mask other deficiency symptoms.

Certain soil types, or soil uses, may be more likely to display nutrient deficiencies than others. The combination of particular soil conditions with visual indicators of nutrient deficiencies makes the conclusions drawn from the latter more robust.

Possible causes of nutrient deficiencies should be investigated with the land users, such as:

- long and / or intensive cropping with insufficient applications of manures or fertilizers to replace the nutrients removed in the harvested products (i.e. nutrient mining);
- unbalanced applications of mineral fertilisers without applying manures;
- large applications of acidifying nitrogen fertilisers (e.g. sulphate of ammonia);
- excessive applications of trace element fertilisers causing other trace element deficiencies (especially in sandy soils); and
- excessive liming with increased soil alkalinity causing nutrient deficiencies.

Where such expertise exists in the assessment team and where crop nutrient stress appears to be a significant form of land degradation then reference should be made to **Annex 2** in which some general and crop specific nutrient deficiency symptoms are provided. In addition, the team may be able to obtain a copy of photographic keys to assist in the field identification of specific nutrient deficiency and nutrient toxicity symptoms from national agricultural research and / or extension services.

Nutrient deficiencies are caused by more than just removal in the processes of soil degradation. The principal cause (up to 100 kg N or more, in intensive cropping) comes from removal in harvested crops and insufficient replenishment through manures or fertiliser. Excess removal through harvesting, although unrelated to soil erosion, is a form of land degradation. Thus, in determining the cause of nutrient deficiencies, the team must judge carefully, tying field evidence with other aspects of farming practice and local knowledge.

The information gathered on maintenance and use of natural vegetation, the cropping system or crop-livestock system and management practices (tillage, nutrients management, organic matter management etc.) of relevance to land degradation and sustainable management can be summarised, in a format as, for example, Table 15 (below).

A field form is provided in Table 16 for recording and documenting the information gathered on cropland in terms of natural vegetation and crop condition and productivity through observations and discussions with farmers or other land users.

TABLE 15 **Field form – Review of management practices in cropland**

Management practice in cropland (indicative examples)	**Practices causing degradation**	**Good management practices**	**Products and their use**	**Productivity trend** (+, 0, -)**	**Intensity trend** (O, C, L)***
Management of natural vegetation, its use and biodiversity	e.g. - overexploitation of trees, loss of wildlife and reduced Carbon stocks	e.g.- biodiversity conservation through management of hedges / maintenance of trees - growth of specific shrubs / trees for organic matter / mulch etc.	e.g. - use of wood / organic materials / other wild products		
Management of the farming system* and species/varietal diversity	e.g nutrient mining due to intensification and fragmentation increased runoff due to bare soils and removal of resides for livestock				

* Farming system is used to denote cropping, agroforestry and crop-livestock integration
** Productivity trend (+) Increasing, (0) stable , (-)decreasing
*** Intensity trend: O - Overuse C - conservation (stable) L- low intensity

TABLE 16 **Field form – Assessment of (natural vegetation and crop condition and productivity in croplands**

				Species (natural vegetation and crop)		**Natural vegetation**					**Crop condition**							**Products and Yield**			
Site No	Av. Farm size (ha)	Av field size (ha)	Av. number of parcels	**Common name**	**Scientific name**	Distance from cropland	Landscape features	Contribution to household	Use for mulch, soil OM	Ground cover	Crop establishment/ vigour	Crop size	Crop species diversity	Crop varietal diversity	Crop cover	Pest / disease incidence above ground and roots	Leaf colour / signs of nutrient deficiencies	Production costs	Y Yield (1ary and 2ary products)	Users of products (share local users to external)	Harvested product diversity
	ha	ha				km	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C

crop size e.g (e.g. ht; or diameter at maturity)