

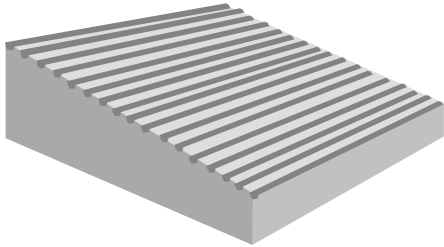
WOCAT-Categorisation System

1. Land Use Type
2. Conservation Measures
3. Degradation Types
4. Main causes of Land Degradation

1. Land Use Type

<i>Land use type</i>	<i>Subcategory codes</i>
Cropland: Land used for cultivation of crops (field crops, orchards).	<ul style="list-style-type: none"> • Ca: Annual cropping: land under temporary / annual crops usually harvested within one, maximally within two years (eg maize, paddy rice, wheat, vegetables, fodder crops) • Cp: Perennial (non-woody) cropping: land under permanent (not woody) crops that may be harvested after 2 or more years, or only part of the plants are harvested (eg sugar cane, banana, sisal, pineapple) • Ct: Tree and shrub cropping: permanent woody plants with crops harvested more than once after planting and usually lasting for more than 5 years (eg orchards / fruit trees, coffee, tea, grapevines, oil palm, cacao, coconut, fodder trees)
Grazing land: Land used for animal production	<ul style="list-style-type: none"> • Ge: Extensive grazing land: grazing on natural or semi-natural grasslands, grasslands with trees / shrubs (savannah vegetation) or open woodlands for livestock and wildlife • Gi: Intensive grazing/ fodder production: improved or planted pastures for grazing/ production of fodder (for cutting and carrying: hay, leguminous species, silage etc) not including fodder crops such as maize, cereals. These are classified as annual crops (see above)
Forests / woodlands: land used mainly for wood production, other forest products, recreation, protection.	<ul style="list-style-type: none"> • Fn: Natural: forests composed of indigenous trees, not planted by man • Fp: Plantations, afforestations: forest stands established by planting or/and seeding in the process of afforestation or reforestation • Fo: Other: eg selective cutting of natural forests and incorporating planted species
Mixed: mixture of land use types within the same land unit.	<ul style="list-style-type: none"> • Mf: Agroforestry: cropland and trees • Mp: Agro-pastoralism: cropland and grazing land (including seasonal change between crops and livestock) • Ma: Agro-silvopastoralism: cropland, grazing land and trees (including seasonal change between crops and livestock) • Ms: Silvo-pastoralism: forest and grazing land • Mo: Other: other mixed land
Other:	<ul style="list-style-type: none"> • Oi: mines and extractive industries • Os: Settlements, infrastructure networks: roads, railways, pipe lines, power lines • Ow: Waterways, drainage lines, ponds, dams • Oo: Other: wastelands, deserts, glaciers, swamps, recreation areas, etc

2. Conservation Measures



Agronomic measures such as conservation agriculture, manuring / composting, mixed cropping, contour cultivation, mulching, etc.

- are usually associated with annual crops
- are repeated routinely each season or in a rotational sequence
- are of short duration and not permanent
- do not lead to changes in slope profile
- are normally independent of slope

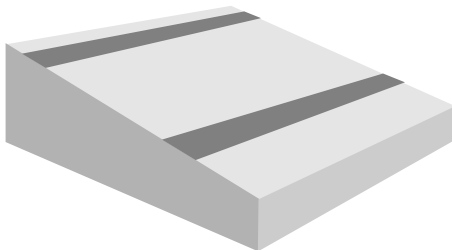
A1: Vegetation / soil cover

A2: Organic matter / soil fertility

A3: Soil surface treatment

A4: Subsurface treatment

A5: Others



Vegetative measures such as grass strips, hedge barriers, windbreaks, agroforestry etc.

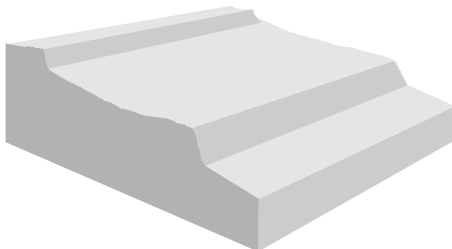
- involve the use of perennial grasses, shrubs or trees
- are of long duration
- often lead to a change in slope profile
- are often aligned along the contour or against the prevailing wind direction
- are often spaced according to slope

V1: Tree and shrub cover

V2: Grasses and perennial herbaceous plants

V3: Clearing of vegetation (eg fire breaks/reduced fuel)

V4: Others



Structural measures such as terraces, banks, bunds, constructions, palisades, etc.

- often lead to a change in slope profile
- are of long duration or permanent
- are carried out primarily to control runoff, wind velocity and erosion and to harvest rainwater
- often require substantial inputs of labour or money when first installed
- are often aligned along the contour / against prevailing wind direction
- are often spaced according to slope
- involve major earth movements and / or construction with wood, stone, concrete, etc.

S1: Bench terraces (slope of terrace bed <6%)

S2: Forward sloping terraces (slope of terrace bed >6%)

S3: Bunds / banks

S4: Graded ditches / waterways (to drain and convey water)

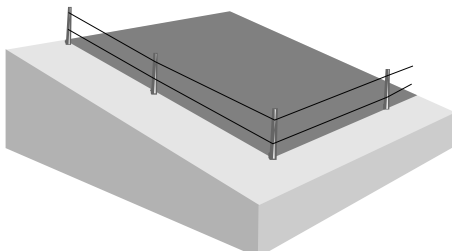
S5: Level ditches / pits

S6: Dams / pans: store excessive water

S7: Reshaping surface (reducing slope)

S8: Walls / barriers / palisades

S9: Others



Management measures such as land use change, area closure, rotational grazing, etc.

- involve a fundamental change in land use
- involve no agronomic and structural measures
- often result in improved vegetative cover
- often reduce the intensity of use

M1: Change of land use type

M2: Change of management / intensity level

M3: Layout according to natural and human environment

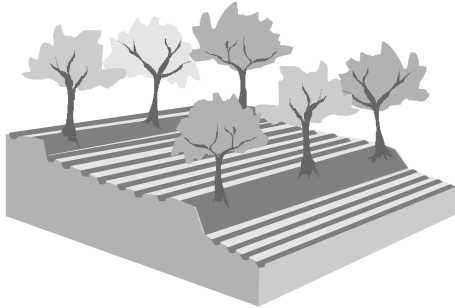
M4: Major change in timing of activities

M5: Control / change of species composition (if annually or in a rotational sequence as done eg on cropland -> A1)

M6: Waste Management: Any measure which includes recycling, re-use

or reduce: includes both artificial and natural methods for waste management

M7: Others



Combinations in conditions where different measures are complementary and thus enhance each other's effectiveness.

Any combinations of the above measures are possible, eg:

- **structural:** terrace with
- **vegetative:** grass and trees with
- **agronomic:** ridges

Example: **S1, V1, V2, A3:**

Main types and subtypes of conservation measures: (as defined above):

A: Agronomic / soil management

- A1: Vegetation / soil cover
- better soil cover by vegetation (selection of species, higher plant density, replacing annual with perennial crops)
 - early planting (cropland)
 - relay cropping
 - mixed cropping / intercropping
 - contour planting / strip cropping
 - cover cropping
 - retaining more vegetation cover (removing less vegetation cover)
 - mulching (actively adding vegetative / non-vegetative material or leaving it on the surface)
 - temporary trash lines (and in A2 as “mobile compost strips”)
 - others
- A2: Organic matter / soil fertility
- legume inter-planting (crop and grazing land; induced fertility)
 - green manure (cropland)
 - applying manure / compost / residues (organic fertilisers), including “mobile compost strips” (trash lines)
 - applying mineral fertilizers (inorganic fertilizers)
 - applying soil conditioners (eg use of lime or gypsum)
 - rotations / fallows (associated with M)
 - others
- A3: Soil surface treatment
- breaking crust / sealed surface
 - breaking compacted top soil: ripping, hoeing, ploughing, harrowing
 - conservation tillage: zero tillage, no till, minimum tillage, non-inversion tillage and other tillage with reduced disturbance of the top soil
 - contour tillage
 - contour ridging (crop and grazing land), done annually or in rotational sequence
 - furrows (drainage, irrigation)
 - pits, redone annually or in rotational sequence
 - others
- A4: Subsurface treatment
- breaking compacted subsoil (hard pans): deep ripping, “subsoiling”, ...
 - deep tillage / double digging
 - others
- A5: Others

V: Vegetative

- V1: Tree and shrub cover
- dispersed (in annual crops or grazing land): eg Faidherbia, Grevillea, Sesbania
 - aligned (in annual crops or grazing land): eg live fences, hedges, barrier hedgerows, alley cropping
 - Subcategories:
 - on contour
 - graded
 - along boundary
 - linear
 - against wind
 - in blocks
 - Subcategories:
 - woodlots
 - perennial crops (tea, sugar cane, coffee, banana)
 - perennial fodder and browse species
 - Further subcategories for dispersed, aligned and in blocks:
 - natural reseeding
 - reseeding
 - planting
- V2: Grasses and perennial herbaceous plants
- dispersed
 - aligned (grass strips)
 - Subcategories:
 - on contour
 - graded
 - along boundary
 - linear
 - against wind
 - in blocks
 - Further subcategories for dispersed, aligned and in blocks:
 - natural reseeding
 - reseeding
 - planting
- V3: Clearing of vegetation
- clearing / reducing of undergrowth (reduce fuel load for fire: eg prescribed fires, grazing, cutting back)
 - fire breaks cutting of aisles / strips through vegetative cover
- V4: Others

S: Structural:

Structures constructed with soil or soil enforced with other materials (S1-S7) or entirely from other materials such as stone, wood, cement, others (S-8)

- S1: Bench terraces (<6%)
- level (incl. rice paddies)
 - forward sloping /outward sloping
 - backward sloping / back-sloping / reverse
- S2: Forward sloping terraces (>6%)
- S3: Bunds / banks
- level
 - tied

- non-tied
 - graded
 - tied
 - non-tied
 - semi-circular
 - v-shaped
 - trapezoidal
 - others
- S4: Graded ditches / waterways (to drain and convey water)
- cut-off drains
 - waterways
 - spillways
- S5: Level ditches / pits
- infiltration, retention
 - sediment / sand traps
- S6: Dams / pans: store excessive water
- S7: Reshaping surface (reducing slope, ...) / top soil retention (eg in mining storing top soil and re-spreading)
- S8: Walls / barriers / palisades, (constructed from wood, stone concrete, others, not combined with earth)
- S9: Others

M: Management:

- M1: Change of land use type:
- enclosure / resting
 - protection
 - change from crop to grazing land, from forest to agroforestry, from grazing land to cropland, etc.
- M2: Change of land use practices / intensity level:
- from grazing to cutting (for stall feeding)
 - farm enterprise selection: degree of mechanisation, inputs, commercialisation
 - from mono-cropping to rotational cropping
 - from continuous cropping to managed fallow
 - from "laissez-faire" (unmanaged) to managed, from random (open access) to controlled access (grazing land forest land eg access to firewood), from herding to fencing
 - adjusting stocking rates
 - staged use to minimise exposure (eg staged excavation)
- M3: Layout according to natural and human environment:
- exclusion of natural waterways and hazardous areas
 - separation of grazing types
 - distribution of water points, salt-licks, livestock pens, dips (grazing land)
- M4: Major change in timing of activities:
- land preparation
 - planting
 - cutting of vegetation
- M5: Control / change of species composition (not annually or in a rotational sequence: if annually or in a rotational sequence as done eg on cropland -> A1)
- reduction of invasive species
 - selective clearing
 - encouragement of desired species
 - controlled burning / residue burning

- M6: Management: Any measure which includes recycling, re-use or reduce: includes both artificial and natural methods for waste management
- M7: Others

Often there are combinations: list them according to priorities: eg Ge/Wt/A3V2

3. Degradation Types

W: *Soil erosion by water*

Wt: **Loss of topsoil / surface erosion**

Loss of topsoil through water erosion is a process of more or less even removal of topsoil, generally known as surface wash or sheet / interrill erosion. Wt also includes tillage erosion. As nutrients are normally concentrated in the topsoil, the erosion process leads to impoverishment of the soil. Loss of topsoil itself is often preceded by compaction and/or crusting, causing a decrease in infiltration capacity of the soil, and leading to accelerated runoff and soil erosion.

Wg: **Gully erosion / gullying**

Development of deep incisions down to the subsoil due to concentrated runoff.

Wm: **Mass movements / landslides**

Examples of this degradation type are landslides and mudflows, which occur locally but often cause heavy damage.

Wr: **Riverbank erosion**

Lateral erosion of rivers cutting into riverbanks.

Wc: **Coastal erosion**

Abrasive action of waves along sea or lake coasts.

Wo: **Offsite degradation effects**

Deposition of sediments, downstream flooding, siltation of reservoirs and waterways, and pollution of water bodies with eroded sediments.

E: *Soil erosion by wind*

Et: **Loss of topsoil**

This degradation type is defined as the uniform displacement of topsoil by wind action. It is a widespread phenomenon in arid and semi-arid climates, but it also occurs under more humid conditions. Wind erosion is nearly always caused by a decrease in the vegetative cover of the soil. In (semi)arid climates natural wind erosion is often difficult to distinguish from human-induced wind erosion, but natural wind erosion is often aggravated by human activities.

Ed: **Deflation and deposition**

Uneven removal of soil material by wind action. Leads to deflation hollows. It can be considered as an extreme form of loss of topsoil, with which it usually occurs in combination.

Eo: **Offsite degradation effects**

Covering of the terrain with windborne sand particles from distant sources ("overblowing").

C: *Chemical soil deterioration*

Cn: **Fertility decline and reduced organic matter content**

Aside from loss of nutrients and reduction of organic matter as a result of topsoil removal by erosion, a net decrease of available nutrients and organic matter in the soil may also occur due to "soil mining": nutrient outputs (through harvesting, burning, leaching, etc.) are not or insufficiently compensated by inputs of nutrients and organic matter (through manure / fertilizers, returned crop residues, flooding). This type also includes nutrient oxidation and volatilisation.

Ca: **Acidification**

Lowering of the soil pH, eg due to acidic fertilisers or atmospheric deposition.

- Cp: Soil pollution**
Contamination of the soil with toxic materials. This may be from local or diffuse sources (atmospheric deposition).
- Cs: Salinisation / alkalinisation**
A net increase of the salt content of the (top)soil leading to a productivity decline.
- P: Physical soil deterioration**
- Pc: Compaction**
Deterioration of soil structure by trampling or the weight and/or frequent use of machinery.
- Pk: Sealing and crusting**
Clogging of pores with fine soil material and development of a thin impervious layer at the soil surface obstructing the infiltration of rainwater. Development of a water-repellent layer (eg beneath surface ashes after forest fire).
- Pw: Waterlogging**
Effects of human induced water saturation of soils (excluding paddy fields).
- Ps: Subsidence of organic soils, settling of soil**
Drainage of peatlands or low lying heavy soils.
- Pu: Loss of bio-productive function due to other activities**
Some land use changes (e.g. construction, mining) may have implications for the bio-productive function of the soil and hence a degradation effect.
- H: Water degradation**
- Ha: Aridification**
Decrease of average soil moisture content (reduced time to wilting, change in phenology, lower yield).
- Hs: Change in quantity of surface water**
Change of the flow regime: flood / peak flow, low flow, drying up of rivers and lakes.
- Hg: Change in groundwater / aquifer level**
Lowering of groundwater table due to over-exploitation or reduced recharge of groundwater; or increase of groundwater table e.g. due to excessive irrigation resulting in waterlogging and/or salinisation.
- Hp: Decline of surface water quality**
Increased sediments and pollutants in fresh water bodies due to point pollution (direct effluents eg from industry, sewage and waste water in river water bodies) and land-based pollution (pollutants washed into water bodies due to land management practices eg sediments, fertilizers and pesticides).
- Hq: Decline of groundwater quality**
Due to pollutants infiltrating into the aquifers. Human induced pollution is mainly caused by inappropriate land management practices or deposition of waste.
- Hw: Reduction of the buffering capacity of wetland areas**
To cope with flooding and pollution.
- B: Biological degradation**
- Bc: Reduction of vegetation cover**
Increase of bare / unprotected soil.
- Bh: Loss of habitats**
Decreasing vegetation diversity (fallow land, mixed systems, field borders).
- Bq: Quantity / biomass decline**
Reduced vegetative production for different land use (eg on forest land through clear felling, secondary vegetation with reduced productivity).
- Bf: Detrimental effects of fires**

On forest (eg slash and burn), bush, grazing and cropland (burning of residues). This includes low severity ("cold") fires (only understorey burns, trees survive) and high severity ("hot") fires (reach the crown of the trees and may kill them).

Bs: Quality and species composition / diversity decline

Loss of natural species, land races, palatable perennial grasses; spreading of invasive, salt-tolerant, unpalatable, species / weeds.

Bl: Loss of soil life

Decline of soil macro-organisms (earthworms and termites) and micro-organisms (bacteria and fungi, ...) in quality and quantity.

Bp: Increase of pests / diseases, loss of predators

Reduction of biological control.

If subcategories are not specified, a "-" should be added instead of a letter.

4. Main causes of Land Degradation

Direct causes of land degradation

Various types of human activities and natural causes may lead to land degradation. The emphasis in the degradation inventory is on human-induced degradation, but sometimes natural degradation also necessitates measures to be taken. More than one of the following causes (direct pressure indicators) may be entered in the matrix table.

- s: Soil management:** improper management of the soil this includes:
 - (s1) cultivation of unsuitable soils
 - (s2) missing or insufficient soil conservation measures/ runoff and erosion control measures
 - (s3) heavy machinery
 - (s4) tillage practice (ploughing, harrowing, etc.)
 - (s5) others

- c: Crop management:** improper management of annual, perennial (e.g. grass), shrub and tree crops. This includes a wide variety of practices:
 - (c1) reduction of plant cover and residues (including burning, use for fodder, etc.)
 - (c2) inappropriate application of manure, fertilizer, herbicides, pesticides and other agro-chemicals or waste (leading to contamination and washing out (non-point pollution))
 - (c3) nutrient mining: excessive removal without appropriate replacement of nutrients
 - (c4) shortening of the fallow period in shifting cultivation
 - (c5) inappropriate irrigation (full and supplementary): inefficient irrigation method, over-irrigation, insufficient drainage
 - (c6) inappropriate use of water in rainfed agriculture (eg excessive soil evaporation and runoff)
 - (c7) others

- f: Deforestation and removal of natural vegetation:** extensive removal of natural vegetation (usually primary or secondary forest), due to:
 - (f1) large-scale commercial forestry,
 - (f2) expansion of urban / settlement areas and industry
 - (f3) conversion to agriculture
 - (f4) forest / grassland fires
 - (f5) road construction
 - (f6) othersDeforestation is often followed by other activities that may cause further degradation.

- e: Over-exploitation of vegetation for domestic use:** in contrast to "deforestation and removal of natural vegetation", this causative factor does not necessarily involve the (nearly) complete removal of "natural" vegetation, but rather degeneration of the remaining vegetation, thus leading to insufficient protection against land degradation. It includes activities such as:
- (e1) excessive gathering of fuel wood, (local) timber, fencing materials
 - (e2) removal of fodder
 - (e3) others
- g: Overgrazing:** usually leads to a decrease in plant cover, a change to lower quality fodder, and/or soil compaction. This may in turn cause reduced soil productivity and water or wind erosion. It includes:
- (g1) excessive numbers of livestock
 - (g2) trampling along animal paths
 - (g3) overgrazing and trampling around or near feeding, watering and shelter points
 - (g4) too long or extensive grazing periods in a specific area or camp leading to overutilization of palatable species
 - (g5) change in livestock composition: from large to small stock; from grazers to browsers; from livestock to game and vice versa
 - (g6) others
- i: Industrial activities and mining:** includes all adverse effects arising from industrialisation and extractive activities, such as loss of land resource and their functions for agriculture, water recharge, etc.. It includes land used for:
- (i1) industry
 - (i2) mining
 - (i3) waste deposition
 - (i4) others
- u: Urbanisation and infrastructure development:** includes all adverse effects arising from industrialisation and extractive activities, such as loss of land resources and their functions for agriculture, water recharge. It can cause considerable run-off and erosion, as well as other types of degradation (eg pollution). It includes land used for:
- (u1) settlements and roads
 - (u2) (urban) recreation
 - (u3) others
- p: Discharges** leading to point contamination of surface and ground water resources, or excessive runoff in neighbouring areas:
- (p1) sanitary sewage disposal
 - (p2) waste water discharge
 - (p3) excessive runoff
 - (p4) poor and insufficient infrastructure to deal with urban waste (organic and inorganic waste)
 - (p5) others
- q: Release of airborne pollutants from industrial activities and urbanisation** leading to:
- (q1) contamination of vegetation/ crops and soil
 - (q2) contamination of surface and ground water resources:
 - (q3) others
- w: Disturbance of the water cycle** leading to accelerated changes in the water level of ground water aquifers, lakes and rivers (improper recharge of surface and ground water) due to:
- (w1) lower infiltration rates / increased surface runoff

(w2) others

o: Over-abstraction / excessive withdrawal of water:

- (o1) irrigation
- (o2) industrial use
- (o3) domestic use
- (o4) mining activities
- (o5) decreasing water use efficiency
- (o6) others

n: Natural causes: many occurrences of degradation are not caused by human activities. Although this assessment places the emphasis on human-induced degradation, natural causes may be indicated as well. They include:

- (n1) change in temperature
- (n2) change of seasonal rainfall
- (n3) heavy/extreme rainfall (intensity and amounts)
- (n4) windstorms / dust storms
- (n5) floods
- (n6) droughts
- (n7) extreme topography
- (n8) other natural causes (avalanches, volcanic eruptions, mud flows, highly susceptible natural resources, etc.)

Indirect causes of land degradation

Socio-economic factors are often crucial in order to understand why land degradation occurs. They are underlying causes - the driving forces of the direct causes of land degradation. More than one of the following indirect pressure indicators may be entered in the matrix table:

- p: Population Pressure:** density of population can be a driving force for degradation. High population pressure may trigger or enhance degradation, e.g. by competing for scarce resources or ecosystem services, but a low population density may also lead to degradation, for instance where it leads to a lack of labour force.
- t: Land Tenure:** Poorly defined tenure security / access rights may lead to land degradation, as individual investments in maintenance and enhancement can be captured by others and land users do not feel “owner” of the maintenance investments. Tenure systems are particular important factors when conservation practices have a long lag between investment and return, such as terracing and tree planting.
- h: Poverty / wealth:** poor people cannot afford to invest in resource conserving practices, so instead they continue to use inappropriate farming practices (such as ploughing hillsides and overgrazing), which again will lead to increased land degradation and worsen poverty. Whether poverty plays a role in land degradation needs to be assessed.
- l: Labour Availability:** Shortage of rural labour (eg through migration, prevalence of diseases) can lead to abandonment of traditional resource conservation practices such as terrace maintenance. Off-farm employment opportunities may, on the other hand, help to alleviate pressure on production resources, in the sense that land users can invest more in conservation infrastructure as income increases.
- r: Inputs and infrastructure** (roads, markets, distribution of water points, etc.): inaccessibility to, or high prices for key agricultural inputs such as fertilizers, may render it difficult or unprofitable to preserve soil fertility or water resources. Access to markets and prices and good infrastructure may improve this. On the other hand, a road through a forest can lead to overexploitation and degradation.

- e: Education, access to knowledge and support services:** investing in human capital is one of the keys in reducing poverty (and thus land conservation practices). Educated land users are more likely to adopt new technologies. Land users with education often have higher returns from their land. Education also provides off-farm labour opportunities.
- w: War and conflict:** they lead to reduced options to use the land or to increased pressure.
- g: Governance / institutional:** laws and enforcements, organization, collaboration and support: government induced interventions may set the scene and be indirect drivers for implementation of conservation interventions.
- o: Others (specify)**