Why manage land?

- Land is the terrestrial surface of the earth including the soil, underlying parent material, vegetation patterns, shallow water bodies and near-surface ground water reserves.
- It supports many life forms (terrestrial) and offers habitats for plants, animals and humans.
- It forms the basis for human settlements, transport/movement and economic activities.
- It provides not only living space, but connectivity and routes for movement/migration of terrestrial organisms.
- Hitherto, land is the only viable means for meeting most of the food, fibre and raw material requirements for the majority of human populations.
What does land mgmt involve?

• Land can broadly be grouped into 4 major components:
  – Soil and underlying rock material
  – Vegetation (patterns & distribution)
  – Water (surface and ground)
  – Fauna (terrestrial animals, both above and below ground)

• Hence, land management involves management of:
  – Soil condition and properties (physical, chemical & biological)
  – Vegetation quality & density (trees, shrubs, grass & agric. crops)
  – Surface and near surface ground water (quality & quantity)
  – Animals (wild & livestock), rodents/pest control & soil fauna

• All the above should be managed optimally to meet human requirements food, fibre and other natural resources in a sustainable manner (w/o irrev. decline).
Why manage soil?

- Soil is the main productive component of land; plants, herbivores, carnivores and ultimately omnivores (people) depend on soil:

  Producers $\rightarrow$ 1º consumers $\rightarrow$ 2º consumers $\rightarrow$ 3º consumers $\rightarrow$ decomposers

- Without good soil, the basis for terrestrial life would be jeopardized.

- Hence, there is a need to balance the use & productivity of soils so as to maintain long-term soil “health” & quality.

- Soil management involves 4 broad, interrelated sectors:
  - Soil erosion control
  - Soil moisture regulation
  - Soil fertility maintenance (chemical balance)
  - Enhancement of soil biological activity & OM retention
Soil erosion control

• Soil erosion involves 3 main processes:
  – Detachment of soil particles and/or aggregates
  – Transport of detached material
  – Deposition of transported sediment load

• Erosion may be induced by water, wind, ice or gravity.
  – On arable land, water is the main agent of erosion; wind may also be significant in dry climates with sandy soils.

• Erosion is a highly destructive phenomenon causing loss of not only water and plant nutrients, but ultimately the soil itself.

• Eroded sediment has adverse down stream impacts, like water quality decline, siltation of reservoirs, and destruction of property.
Estimated accelerated erosion losses for selected countries.

<table>
<thead>
<tr>
<th>Country</th>
<th>Total cultivated land (million ha)</th>
<th>Accelerated erosion (metric t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>167</td>
<td>1,524</td>
</tr>
<tr>
<td>Soviet Union</td>
<td>251</td>
<td>2,268</td>
</tr>
<tr>
<td>India</td>
<td>140</td>
<td>4,716</td>
</tr>
<tr>
<td>China</td>
<td>99</td>
<td>3,628</td>
</tr>
<tr>
<td>Others</td>
<td>607</td>
<td>11,201</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1265</strong></td>
<td><strong>23,337</strong></td>
</tr>
</tbody>
</table>

Sediment loads of some world rivers and erosion from corresponding drainage areas.
(Source: El-Swaify & Dangler, 1982)

<table>
<thead>
<tr>
<th>River</th>
<th>Countries</th>
<th>Ann. Sed. Load (mill. t)</th>
<th>Erosion (t/ha drained)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow</td>
<td>China</td>
<td>1600</td>
<td>479</td>
</tr>
<tr>
<td>Ganges</td>
<td>Nepal, India</td>
<td>1455</td>
<td>270</td>
</tr>
<tr>
<td>Amazon</td>
<td>Brazil, Peru, etc.</td>
<td>363</td>
<td>13</td>
</tr>
<tr>
<td>Irrawaddy</td>
<td>Myanmar</td>
<td>299</td>
<td>139</td>
</tr>
<tr>
<td>Kosi</td>
<td>Nepal, India</td>
<td>172</td>
<td>555</td>
</tr>
<tr>
<td>Mekong</td>
<td>Vietnam, Thailand</td>
<td>170</td>
<td>43</td>
</tr>
<tr>
<td>Mississippi</td>
<td>USA</td>
<td>300</td>
<td>93</td>
</tr>
<tr>
<td>Nile</td>
<td>Sudan, Egypt</td>
<td>111</td>
<td>8</td>
</tr>
<tr>
<td>Red</td>
<td>China, Vietnam</td>
<td>130</td>
<td>217</td>
</tr>
</tbody>
</table>
Water erosion

• Involves detachment of soil by raindrops or flowing water
  – On initially dry & bare soil, raindrops are the main cause of detachment, as well as transport (sloping areas) of soil particles & microaggregates (this is known as splash erosion).
  – When infiltration rate is exceeded by rainfall rate, and when all surface storage has been filled, additional water will begin to runoff (flow overland) on sloping areas.
  – On smooth and gently sloping surfaces, the overland flow (aided by turbulence from impacting raindrops), tends to remove a thin layer soil fairly uniformly – this is called sheet erosion (interrill).
  – On undulating land with moderate to steep slopes, runoff tends to concentrate in low-lying (depressional) areas and cause channelized flow & scouring leading to rill erosion.
  – When rills grow and coalesce (combine) forming channels of 1 m or more in width and depth, then they are called gullies.
Examples of water erosion

(a) Sheet Erosion
(b) Rill Erosion
(c) Gully Erosion
Control of water erosion

• Involves controlling raindrop impact, runoff, and the soil’s susceptibility to erosion (erodibility).
1. Managing soil cover (protect surface) – vegetation or mulching
2. Managing water – enhancing infiltration & surface detention
3.Managing runoff – surface roughness; sub- & surface drainage

• These may be achieved by a combination of practices:
  – Minimize soil disturbance: conservation or zero tillage
  – Vegetation management to increase soil cover:
    • Residue retention (maintain crop stubble)
    • Cover crops (e.g., vetch, beans, other minor crops) during dry period
    • Straw mulching (spreading crop straw or other dead veg. over surface)
Water erosion control cont’d.

• Reducing runoff amount & velocity + inc. surface storage:
  – Terracing and contour tillage (plowing across-slope)
  – Ridge & furrows, tied-ridges
  – Ditches and pits to trap sediment & water
  – Grassed waterways, culverts, check-dams & drop structures (stone masonry or gabion)

• Management of soil OM and biological activity:
  – Composting, manuring, straw mulching & returning residue to soil
  – Minimize soil disturbance & tillage – enhances soil organism diversity and activity
  – Choice of crops & crop rotations
    • Incorporation of green manures
    • Inclusion of cover crops
Wind erosion

- Wind erosion is most common in arid & semiarid areas, but may also be significant in other areas:
  - Areas with seasonal rain & prolonged dry season
  - Areas with sandy & silty soil, low OM and poor soil structure.

- Mechanics: [also involves detachment & transport]
  - Initially the lifting and abrasive action of wind dislodges tiny soil particles from aggregates or clods at the surface.
  - Once wind is laden with small soil particles, its abrasive action (erosive power) is greatly increased.
  - Impact of these particles further detaches larger particles.

- Detached particles may move by:
  - Saltation – bouncing of medium sized particles (2-3.75 mm)
  - Creep – rolling & sliding of larger particles along soil surface (due to force of the wind & enhanced by saltation).
  - Suspension – fine sand or silt and finer particles lifted & moved great distances (up to several km high and hundreds of km far).
Effects & mechanics of wind erosion

Saltation of soil particles
Control of wind erosion

• Wind erosion is affected by factors such as:
  – Wind velocity & turbulence
  – Soil surface conditions
  – Soil characteristics & moisture
  – Nature and orientation of vegetation

• Hence control measures must address these factors:
  – Wind breaks, shelterbelts; increased surface roughness (plowed fallow during dry periods); stubble retention – all reduce wind velocity
  – Surface conditions may be modified by: tillage, watering, residue retention, mulching & vegetative cover.
  – Soil characteristics may be improved by enhancing OM content and maintaining soil moisture.
  – Use of soil conditioners/amendments to bind and hold soil particles together – e.g., sludges; PAM (poly-acrilamide); etc.
Wind breaks & shelter belts
8. Land Use Management Approaches & Principles

ENVS 334: Applied Soil Science & Land Management
INSTR.: Dr. R.M. Bajracharya
How does land management differ from soil management?

- Land management is a somewhat broader concept than soil management.
  - Soil management considers many aspects of production, such as, water use & availability, crop rotations & nutrient management, erosion control, etc.
  - Land management goes beyond agricultural uses of soil or land.
- Other aspects dealt with in land management include:
  - Grazing and rangeland management: pasture species, stocking rates
  - Forest management: timber quality, species composition, fodder production, non-timber products, etc.
  - Water harvesting and flood control: ponds, reservoirs, levees, barrages, dams, canals, stream/river bank stabilization.
  - Construction: roads, trails, settlements and other infrastructure.
Approaches to land management and rehabilitation

• Previous top-down (central) planning approaches proved to be ineffective at best and disastrous at worst in LM.
• Modern approaches all embrace the participatory concept.
• Often “participatory” approaches are not entirely so:
  – Only partial involvement (of ‘privileged’) of local end-users, or
  – Only involvement in some aspects of the LU planning, design and implementation process.
• There is no doubt, however, that effective & lasting mgmt. of land or any other natural resource must fully involve the local users/stakeholders themselves.
• Hence, the concept of land husbandry has been proposed as an effective holistic approach to LM emphasizing soil & water conservation.
Land Husbandry

• Objectives of land husbandry:
  – Better management of crops, pastures, forests and soil (i.e., in an integrated manner) so as to retain more water for increased production and maintained stream flow.

• Three basic ideas are central:
  – **Farmers**: must be given focus; i.e., identify, engage, develop and encourage the farmers and local farming communities in improving agricultural production activities.
  – **Husbandry**: establishing, producing, improving and maintaining dense and long-lasting soil cover with useful plants and their residues. This means effective soil cover & protection and increased stability & fertility through enhanced OM and biological activity.
  – **Runoff**: proper control and safe disposal of overland flow (which is unavoidable) to minimize erosion damage to the land.
• Proper land husbandry must be preceded by **planning** for the best use of land resources.

• Planning must be done as various **levels** to address the different **scales** of land resource use:
  – National → Regional → District → Village
  – National → Basin → Catchment → Individual farm

• National and regional level planning is done at the central gov’t. level – according to national policies & goals.

• District or catchment (watershed) level LU planning should be done by local gov’t.s in close collaboration with local user groups and communities.
  – This is to ensure that the plans are in accordance with the best interest of both the local stakeholders, as well as, national strategies.
Individual holdings

• At the individual holding (farm) level, the farmers themselves are the planners and decision-makers.
  – Their needs, aims, perceptions and motivations must be understood and kept in perspective.

• The basic motivation of all farmers is to increase production and maximize returns.
  – Yet, in order to do so on a continuing basis (sustainably), they must safeguard the very source of productivity/returns – the land.
  – Thus, soil/water conservation & fertility management is a necessary consequence, rather than main objective of LM.

• Hence, concept of land husbandry emphasizes:
  – Creating conditions for enhancing/improving production for the long-term (as the main objective), the reducing soil erosion follows as a natural consequence.
  – Managing the rainfall & runoff (water being a major factor for production), then automatically soil too will be conserved.
Basic principles of land husbandry

1. Soil conservation should be an integral part of any farming system rather than a separate activity.
2. Loss of soil productivity is more important than the amount of soil loss.
3. Rain water management is more important than soil conservation *per se*.
4. Biological measures are more significant than mechanical measures in preventing erosion and runoff.
5. Reduction of runoff should precede attempts to control its flow.
6. Bottom-up action programs involving local communities & technical staff are more effective than top-down planning.
Conservation & husbandry

- Conservation = “prolonging the useful life of resources”
- Husbandry = “active understanding, managing & improving the productive capacity of resources”
- Hence, crop-, animal-, and land-husbandry all imply:
  1. Understanding the characteristics, potentials, and limitations of different types of plants, animals and land.
  2. Predicting the likely positive and negative effects on their productivity resulting from a given change in management, or of severe but rare events (disease or rain storms).
  3. Working out how they can be strengthened to resist the negative effects of such events.
  4. Adopting systems of management that maintain their productivity and usefulness.
  5. Improving quality & quantity of output in a given time (“productivity”).
  6. Active and central role of the farmer as a steward of the land.
Illustration of the farmer’s and soil conservation’s common interests but differing viewpoints.

Source: Shaxson et al. (1989)
Matching land uses to land types: land suitability

- Land evaluation and assessment is a prerequisite to effective LU planning & LM, as different types of land vary in their ability to support different uses.
- Thus, land suitability classification establishes and recommends ranges of land uses for particular land types:
  - Uses may be ranked according to the intensity or demand upon the land of specific uses.
  - E.g., crop farming, grazing, agro-forestry, horticulture, forestry, wildlife and recreation.
  - Cropping is usually the most intensive of land uses.
  - Reserves for wildlife or recreational uses is least intensive.
- Suitability is based on criteria such as: slope & aspect, geology & soil type, climate (temperatures) and rainfall, etc.
Land use practices

Conservation farm pond

Contour planting and grassed waterways
Hedgerows & terracing

Hedge-rows; hedge-layering

Terracing
Reference texts