# Soil Resource Management for Sustainable Development

**T. Nagendra Rao***
**Consultant Soils Specialist & Agronomist**
**TNR Soil Health Services**
**#33, Ashok Colony, Kapra, ECIL Post, Hyderabad - 500062**
**(e-mail: tnrao@TNR-SoilHealthServices.com; Tel/Fax: 040 27127377)**

Several studies (Davidson, 1992; FAO, 1989) are pointing towards the degradation of the finite soil resource and question on its continued capacity to provide the quality of life that was assured in the past. Vast growing population accelerated the rate of soil resource use for multiple purposes. This has triggered the degradation of lands with accompanying negative impacts on biodiversity and agricultural productivity and the impending effects of global climate change are all converging to emphasize the point for immediate change in the manner that natural resources are exploited (Eswaran, 1992).

The soil resource and the land are in general put to six main uses:

**Ecological uses:**

1. Biomass production to ensure food, fodder, fuel and fiber supplies as a source of basic needs for human and animal life supported through agriculture as a main activity.
2. Soil as a protective medium thorough filtering, buffering and transformation actions between atmosphere, ground water and plant roots.
3. Soil as a biological habitat and gene reserve that harbors large variety of organisms living in and above the soil.

***Anthropogenic uses*:**

4. Soil as a basis for technical, industrial and socio-economic human activities. *E.g.*, industrial production, housing, transport, recreation, dumping ground for wastes *etc.*,
5. Soil as a source of geogenic energy of raw materials such as clay, sand, gravel, water *etc.*,
6. Soil as sources of geogenic and cultural heritage – paleontological and archeological treasures, landscapes… understanding history of earth.

According to Blum (1993 & 1994), severe competition exists between these six uses thus leading to a need arising out of understanding the concept of "Sustainable Land Use".

Three main types of competition and interactions between these six uses have been identified:

1. Exclusive competition between ecological and technical uses: land as a source of raw material for geogenic and cultural heritage on one hand and for forestry, filtering, buffering and transformation activities, soil as a gene reserve on the other hand.

2. Intensive competition between infrastructural land uses and development on one hand and agricultural, forestry, filtering, buffering and transformation activities, soil as a gene reserve on the other hand, particularly in urban areas.

3. Intensive interactions between three ecological soil and land uses. Land use practices for agricultural purposes and its influence on ground water quantity and quality.

**Sustainable land use is defined as "spatial and/or temporal harmonization of all six main uses of the land, minimizing irreversible ones"**

This has to be attempted in a local or regional approach, depending on the specific uses of land in a given area.

It is becoming increasingly evident that managing the land resource base is important to attain the broader goal of sustainability, equity and environmental soundness (Greenland *et al*., 1994).

**Land degradation – the reality:**

The FAO/UNESCO/UNEP "Global Assessment of Soil Degradation" provides data to quantify the current magnitude of soil degradation problem (Oldeman *et al*., 1992).

Several studies in India also indicate huge face erosion and other forms of degradation (Tables 1-5).

**Table 1.** Soil erosion affected areas due to water in India (Singh *et al.,* 1992)

| Rate of Soil Erosion (t/ha/year) | Class | Area Affected (Mha) |
|---|---|---|
| 0-5* | Slight | 80.1 |
| 5-10** | Moderate | 40.6 |
| 10-20 | High | 80.5 |
| 20-40# | Very High | 16.0 |
| 40-80# | Severe | 8.3 |
| >80 | Very Severe | 3.2 |

*dense forests with >40% canopy, cold desert regions and arid regions of western Rajasthan
**Indo-Gangetic plains including salt affected lands of Punjab, Haryana, UP, Bihar and WB
# Shiwalic hills, north-eastern Himalayan region, ravines, shifting cultivation areas, western coastal ghats and the black cotton soils (Vertisols) of the Peninsular India

**Table 2.** Soil erosion due to wind

| Degree of Sand dunes (% of area affected) | Area Affected (Mha) | Percent of total affected area |
|---|---|---|
| No sand dunes | 8.57 | 41.5 |
| 0-20% | 1.89 | 8.9 |
| 20-40% | 3.98 | 18.6 |
| 40-60% | 3.43 | 14.7 |
| 60-80% | 1.02 | 4.8 |
| 80-100% | 2.49 | 11.5 |
| Total | 21.38 | 100 |

Source: Shankarnarayana *et al.,* 1987

Soil erosion due to wind occurs more in hot arid region occupying nearly 31 Mha. Majority (60%) occurs in Rajasthan.

**Table 3.** Soil loss due to shifting cultivation in north-eastern hill region

| State/Union Territory | Area affected at one point of time (1000ha) | Soil loss (Mt) |
|---|---|---|
| Arunachal Pradesh | 92.0 | 3.76 |
| Assam | 69.6 | 2.85 |
| Manipur | 60.0 | 2.45 |
| Meghalaya | 76.0 | 3.11 |
| Mizoram | 61.6 | 2.52 |
| Nagaland | 73.5 | 3.01 |
| Tripura | 22.3 | 0.91 |
| **Total** | **455.0** | **18.61** |

Source: Goswami & Choudhury (1987)

**In India alone, 174 million hectares (53%) out of total 329 million hectares geographical area is suffering from various illnesses *viz.,* erosion, water logging, acidity, salt injury *etc.*, interfering with life forms. Loss of nutrients from land is 5-8 million tonnes annually, affecting economy and development.**

**Table 4**. Development of Soil Salinity in some irrigation projects in India

| Irrigation Project | State | Soil Salinity('000ha) | Annual Increase |
|---|---|---|---|
| Sriramsagar | AP | 1.0 | 0.17 |
| Tungabhadra | AP, Karnataka | 24.5 | 1.91 |
| Gangdak | Bihar, UP | 400.0 | 36.40 |
| Ukai Kakrapar | Gujarat | 8.3 | 0.30 |
| Mahi Kadana | Gujarat, Rajasthan | 35.8 | 1.70 |
| Chambal | MP, Rajasthan | 40.0 | 3.10 |
| Tawa | MP | 6.6 | 1.10 |
| Rajasthan Canal | Rajasthan | 29.1 | 2.60 |
| Sarda Sahayak | UP | 50.0 | 0.90 |
| Ramganga | UP | 352.4 | 50.30 |

Source: Joshi & Agnihotri (1984)

**Table 5**. Soils affected by physical constraints

| **Kind of physical problem** | **Area (Mha)** | **States Affected** |
|---|---|---|
| Highly permeable soils | 10.77 | Rajasthan(2.37)<br>Punjab(2.5)<br>WB (2.11)<br>Tamil Nadu(1.68)<br>Haryana, Orissa, Kerala, AP and HP(small areas) |
| Slowly permeable soils | 9.43 | MP(9.14), Limited areas of Tamil Nadu |
| Shallow soils | 25.02 | AP(13.6)<br>Maharashtra(5.56)<br>Kerala(1.26)<br>W.B. (1.13)<br>Orissa, Punjab, Haryana and HP (limited areas) |

| | | |
|---|---|---|
| Hardening soils | 20.35 | AP(13.4) Maharashtra(3.43), WB(1.5), Bihar(1.01), Haryana, Orissa, Punjab, HP and Kerala(limited areas) |
| Soils with mechanical impedence at shallow depth | 10.63 | Rajasthan (2.94), Maharashtra(2.16), Punjab(2.0), WB(1.73), Bishar(1.02), Tamil Nadu, AP., HP, and Bihar limited areas. |
| Others | 9.45 | --- |

According to Dent (1990), 19.3% of land in India suffers from soil physical limitations:

10.0% by steepy slopy land

5.7% by shallow soils

1.2% by coarse textured soils

2.4% by heavy cracking clay soils

Land degradation due to mismanagement of land and thus deals with two interlocking, complex system: the natural ecosystem and the human social system. Interactions between the two systems determine the success or failure of resource management programs. To avert the catastrophy resulting from land degradation that awaits in many parts of the world, the following concepts enunciated by Eswaran and Dumanski(1994).

1. Environment and agriculture are intrinsically linked and research and development must address both.
2. Land degradation is as much a socio-economic problem as it is a biophysical problem.
3. Land degradation and economic growth or lack of it (poverty) are intractably linked.
4. Implementation of mitigation research to manage degradation can only succeed if land users have control and commitment to maintain the quality of the resources.
5. Agricultural research focus must shift from increasing productivity to enhancing sustainability, recognizing that agriculture can be a non-degradable force.
6. Land use must match land quality; thus appropriate national policies should be implemented to ensure this to reduce land degradation.

**Land productivity and land use options:**

Sustainable land management (SLM) is the key to harmonizing the environmental and ecological concerns of a society faced with the economic realities of producing adequate food and fiber ensuring a basic minimal quality of life (Dumanski et al., 1992). A Framework for Sustainable Land Management has the potential to emerge as one of the most powerful tools for the sustainable management of land (Eswaran, 1992).

**Site-specific Soil Technologies:**

Several new technologies are emerging out of research, which are worth exploring in managing soil resource base in a sustainable manner.

**(1) Integrated watershed management:** This has been accepted as one of the most rational approach in preventing deterioration of ecosystem, restoration of degraded lands and improving the overall productivity of the rainfed areas for sustained use and conservation.

**(2) Site-specific nutrient management**:

Nutrient management is a major component of a soil and crop management system. Site specific nutrient management is applying those concepts to areas within a field that are known to require different management options from the field average. Site-specific nutrient management is a concept that can be applied to any field and any crop. While most often thought of in relation to use of computer and satellite technology, the site-specific nutrient management does not require special equipment, and does not require a large farming operation. The technology tools certainly expand the capabilities for using site-specific management. Site-specific crop and soil management is really a "repackaging" of management concepts that have been developed and promoted for many years. It is basically a systematic approach to apply sound agronomic management to small areas of a field that can be identified as needing special treatment. The components of site-specific management may not be new, but now we have the capability with new technology to use them more effectively. Site-specific management includes practices that have been previously associated with Maximum Economic Yield (MEY) management, best management practices (BMPs), as well as general agronomic principles. The systematic implementation of these practices into site-specific systems is probably our best opportunity to develop a truly sustainable agriculture system.

**(3) Advances in soil testing services:**

Soil testing is the basis for making scientifically sound management decisions while addressing soil health issues. Soil testing also helps improving the appropriate nutrient application across a field.

**(4) Geo-spatial Soil mapping:**

Use of new GPS/GIS tools is facilitating mapping of precisely the soil health conditions considering spatial and temporal variability. This information could be adequately integrated with several agronomic management practices to achieve desired results in the field.

**(5) Soil management decision support systems**

Technology transfer demands changes, not only in the way materials and people are used in production, but also in the way information is managed. Decision makers, in particularly environmentally-sensitive countries with limited resources, are expected to make technical decisions that are ecologically, economically and socially acceptable (IBSNAT, 1993). The information sources for making such decisions must be easily available, organized, timely, accurate and dependable. Computer aided decision support systems could affectively help field specialists and consultants to make appropriate recommendations in the field.

**Conclusion:**

While soil degradations in continuously occurring, many developing countries are strongly constrained by lack of institutional capability and commitment to undertake the needed soil management activities. There is an urgent need to address this problem at Govt. level. Effective use of currently available technologies through public private partnerships to get desired results is need of the hour. The concept of soil health is being promoted largely by various scientific institutions all over the world. Soil health is the continued capacity of soil to function as a vital living system, within ecosystem and land-use boundaries to sustain biological productivity, maintain the quality of air and water environments and promote, plant animal and human health. Policy makers should pay good attention to see the Sustainable land management is a reality in the field.

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