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Review Article

SOIL AND ITS ECONOMIC IMPLICATIONS IN INDIA

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ABSTRACT

Soil is a complex media formed by a porous matrix, in which air, water and biota occur together and its severe degradation is another reality that depends on several factors. Soil problems are influenced by the diversity, distribution and specific vulnerability of soils. They also depend on geology, relief and climate and in India, soil conditions are no good and are even further worsen by human activities. The different ways to categorize impacts includes the on-site and off-site impacts, cost of suffered damage and damage avoidance cost, direct & indirect use values and the non-use values (not quantified). The five major cost categories are: PC, RC – on-site costs, SC, DC – off-site costs & NC – non-use costs. Assessment of economic impacts of soil degradation have revealed that off-site costs (SC+DC) exceed on-site costs (PC+RC) by 12:1 and the cost of suffered damage (PC+SC) was higher than damage avoidance cost (RC+DC). In the present scenario, we have already realized the fact of "Down to earth, down to basics" – solving soil problems will help solve other problems at the National and global levels. As soil has multiple users, consideration of soil has to be integrated at different levels. There is a need for administrative (from local to National and global), sectoral (sectors and other environmental issues) and geographical integration (landscapes, urban, rural, mountain and coastal areas) of both soil assessment approaches and soil protection policies. There are appropriate actions to be taken at all administrative levels, from land planning at the local and sub-national levels, to the set-up of environmental and sectoral policies at the national levels, and the launch of initiatives on a global scale.

Keywords: Soil, Soil degradation, physical chemical and economic impacts, Indian scenario.

INTRODUCTION

In the coming years sustainable soil use and management will be a great challenge to both users and policy-makers globally. The diverse and potentially conflicting demands on the soil resource and its interrelations with climate change, biodiversity and trade will require appropriate action in order not to compromise either its quality or use by future generations. Present policies and laws and their enforcement mechanisms may prove inadequate for sustainable soil management, unless provision is made for their wise use in perpetuity.

As there is an urgent need to stimulate and enhance discussion on the role of soil related to the global ecological and economic issues of climate change, industrial development and trade; UNEP (United Nation Environment Programme) aims to focus attention on the status of soils, and to promote discussion on the need for a global policy on soil, as a basis for the development of legislation and systems for monitoring and managing soil resources.

In many parts of the world, many organizations are now testing the limits of the resilience and multi-functional capacities of soil. Globally, nearly 2 billion hectares of land are affected by human-induced degradation of soils. The food needs of increasing populations is leading to even greater intensification of agriculture, stretching thereby the capacity of soils to release and absorb nutrients and chemicals.

Expansion of built-up areas and infrastructure, particularly in large urban agglomerations, is sealing off the soil from productive uses. Each year an additional 20 million hectares of agricultural land become too degraded for crop

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production, or are lost to urban sprawl. Soils are being degraded physically and chemically due to erosion, exhaustion (nutrient depletion) and pollution. Soil's diverse living organisms are being reduced, and consequently the cleaning and filtering capacities of soils in many localities are being damaged beyond repair. At the same time, abuse of soil organic matter continues to compromise the potential of soils to sequester and provide interim storage for atmospheric carbon.

Eventually, it is a matter of people and the influence they have on the natural resources and the limited space available. The problem calls for new policies, including fair pricing, fiscal policies, and strategic planning concerning the use of land and natural resources. There is resistance from economic interest groups for such measures as it is seen as limiting liberalization and reducing speculative expectations. This may become the biggest challenge for sustainability. If we do not get a proper sustainable use of territory and soil, as well as the water and other natural resources that go with them, the chances of sustainable development is bleak.

What is Soil

Soil is a three-dimensional body performing a wide range of socio-economic and ecological functions. It is a complex media formed by a porous matrix, in which air, water and biota occur together with the fluxes of substances and fluids between these elements.

Soil resource is being irreversibly lost and degraded at an unprecedented rate as a result of increasing and often conflicting demands coming from nearly all economic sectors, including agriculture, households, industry, transport and tourism. Pressures are generated by the concentration of population and activities in restricted spaces, as well as changes in climate and land use. Since soil is a limited and non-renewable resource, damage to soil is not easily recoverable, unlike air and water. Fig.1 below provides a schematic overview of the soil and its associated functions to mankind.

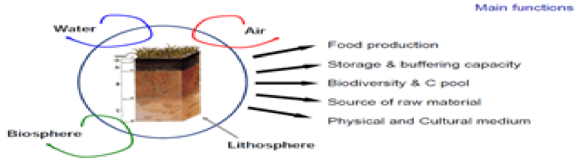

Fig.1: Soil shown with O,A,B,C horizons, its interaction with other spheres and its main functions

Types of Soil

Although no two soils are alike, there are roughly six main soil types:

- Clayey
- Sandy
- Silty
- Peaty
- Chalky
- Loamy

Soils of any region are usually a combination of these ingredients in varying quantities.

Fig.2: General physical view of soil

Clayey Soil

When clay soils are wet they are very sticky, lumpy and pliable but when they dry they form rock-hard clots. Clay soils are composed of very fine particles with few air spaces, thus they are hard to work and often drain poorly - they are also prone to water logging in spring. Blue or grey clays have poor aeration and must be loosened in order to support healthy growth. Red colour in clay soil indicates good aeration and a "loose" soil that drains well. As clay contains high nutrient levels plants grow well if drainage is adequate.

Sandy Soil

Sandy Soils have a gritty texture and are formed from weathered rocks such as limestone, quartz, granite, and shale. If sandy soil contains enough organic matter it is easy to cultivate, however it is prone to over-draining and summer dehydration, and in wet weather it can have problems retaining moisture and nutrients.

Silty Soil

Silty soil is considered to be among the most fertile of soils. Usually composed of minerals (predominantly quartz) and

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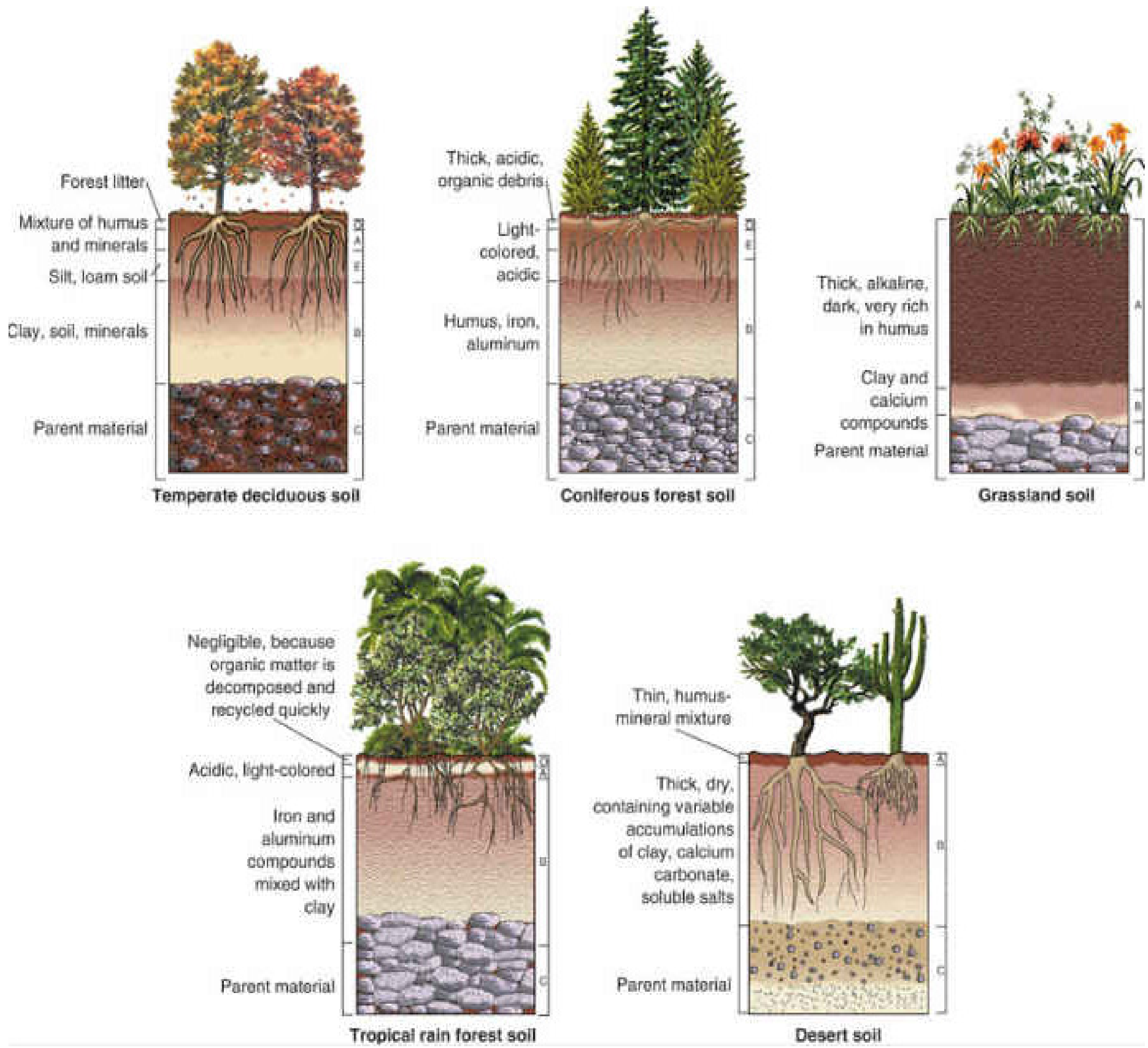

Fig.3: Different soil types of varying composition

fine organic particles, it has more nutrients than sandy soil yet still offers good drainage. When dry it has rather a smooth texture and looks like dark sand. Its weak soil structure means that it is easy to work with when moist and it holds moisture well.

Peaty Soil

Peaty soil contains more organic material than other soils because its acidity inhibits the process of decomposition. This type of soils contains fewer nutrients than any other soils and is prone to over-retaining water. Through good management and use of fertiliser and artificial drainage excellent plants can be grown.

turn causes poor growth and yellowing of leaves. Chalky soil is extremely poor quality and needs regular, substantial addition of fertilizers and other soil improvers.

Loamy Soil

Considered to be the perfect soil, Loamy soils are a combination of roughly 40 % sand, 40% silt and 20% clay. Loamy soils can range from easily workable fertile soils full of organic matter, to densely packed sod. Characteristically they drain well, yet retain moisture and are nutrient rich, making them ideal for cultivation.

Accordingly, there are myriad of soil types depending upon their location. The fig.3 above represents few of them.

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Soil Horizons

A soil horizon is a specific layer in the soil which measures parallel to the soil surface and possesses physical characteristics which differ from the layers above and beneath. Horizon formation is a function of a range of geological, chemical, and biological processes and occurs over long time periods. Horizons are defined in most cases by obvious physical features, colour and texture being chief among them. Main horizons (fig4) are as follows:

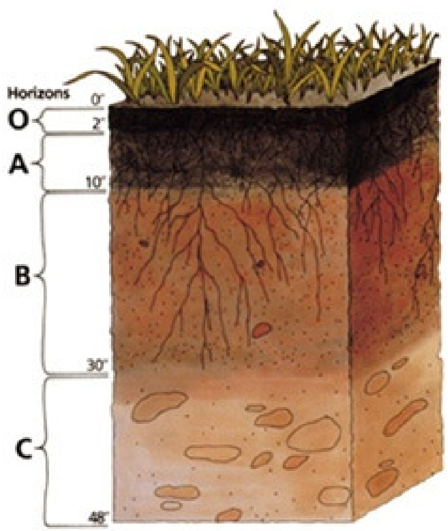

Fig.4: Soil Horizons

- **Organic matter** – Litter layer of plant residues in relatively undecomposed form.
- **A Surface soil** – Layer of mineral soil with most organic matter accumulation and soil life.
- **B Subsoil** – Layer of alteration below "A" horizon. This layer accumulates iron, clay, aluminum and organic compounds, a process referred to as illuviation.
- **C Substratum** – Layer of unconsolidated soil parent material. This layer may accumulate the more soluble compounds that bypass the "B" horizon.

There are several other horizons as well that are not easily conspicuous and rarely found. These are D, E, P and R horizon.

Relevance of Soil Resource: Multiple Functions and Threats

Soil is a multi-functional medium: Soil is not only the basis for 90 % of all human food; livestock feed, fiber and fuel, but also provides services beyond productive functions. Soil form the spatial dimension for the development of human settlements, the building of houses and infrastructures, recreation facilities and waste disposal. It provides raw materials, including water, minerals and construction materials. It forms an essential part of the landscape. It conserves the remains of our past and is itself a relevant part of our cultural heritage.

Soil is non-renewable: Soil has a very high spatial variability: more than 320 major soil types have been identified. Each of these types supports a different range of functions and has a different vulnerability to the various pressures. Soil is, however, a limited resource, and while limited remediation of some functions can be made, soil is not renewable within the time span needed for its regeneration. With a very slow rate of soil formation, any soil loss of more than 1 t/ha/y can be considered irreversible within a time span of 50-100 years

Soil's resilience is perhaps soil's worst enemy: Soil's buffering capacity; its resilience and its capability to filter and absorb contaminants mean that damage is not perceived until it is far advanced. This is perhaps a major reason why soil protection has not been promoted to the same extent as the protection of air and water. Now, after many years of misuse, the signs and the impacts are showing more clearly and responses are required, both corrective and preventive, so that the problem does not continue to be transferred to future generations.

This concept is further clarified with desertification process, which is an extreme example of how ongoing soil degradation – due to the interaction of various factors such as climate and unsustainable use of water and land resources can lead, under certain circumstances, to the gradual and progressive reduction in the capacity of the soil to support human and animal communities, vegetation and economic activities. A correct response to the problem would therefore involve different levels of actions, at the local, national and global levels, as well as actions to integrate environmental policies into sectoral policies.

Major Soil Problems

Some of the major soil problems (Fig5) that are routinely encountered are discussed below:

1. **Sealing -** The rate of real soil loss due to surface sealing through growth in urbanization and transport

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infrastructure is very high. This process is linked with the development of nation and tourism and the pressure is likely to increase in the coming years. The rates of soil loss due to surface sealing through growth in urbanisation and transport infrastructure (roads, airports, railways, ports, etc.) are high and similar in several countries. In most countries, loss of soil due to urbanization and industrial development has been modest in the past decades. However, some areas are so heavily transformed by mining and heavy industry, as to give rise to the term "industrial desertification".

2. **Erosion** - Soil erosion by water and wind is a major problem. It is caused by a combination of harsh climate, steep slopes, thin vegetation cover and poor agricultural practices. Soil erosion by water and wind is a severe and well-recognized problem where impacts are exacerbated by soil contamination due to former and future industrial operations. Although less severe and thus less perceived, erosion is an increasing problem in the agricultural areas where high-quality and easily erodible soils are subject to more intensive agriculture. Soil erosion leads to both on-site impacts (e.g. loss of soil organic matter and loss of soil functions) and off-sites impacts (e.g. contamination and loss of soil's capacity to sequester atmospheric carbon).

3. **Retrogression & degradation** - These are two regressive evolution processes associated with the loss of equilibium of a stable soil. The retrogression is primarily due to erosion and corresponds to a phenomenon where succession reverts back to pioneer conditions (such as bare ground). Degradation is an evolution, different of natural evolution, related to the locale climate and vegetation. It is due to the replacement of the primitive vegetation by secondary vegetation. This replacement modifies the humus composition and amount, and impacts the formation of the soil. It is directly related to human activity.

4. **Contamination** - Contamination is high in restricted areas or hot spots (urban areas and industrial compounds), due to both diffuse and localized sources. Although there has been a reduction in emissions and use of some hazardous substances, mainly due to application of policy measures, these are countered by a general increase in economic activity. Based on available data, losses deriving from industrial activities and former waste sites are the major causes of local contamination. Severe soil degradation is currently observed in specific areas, due to contamination by heavy metals, persistent organic pollutants and dioxins around industrial sites and urban areas as well as

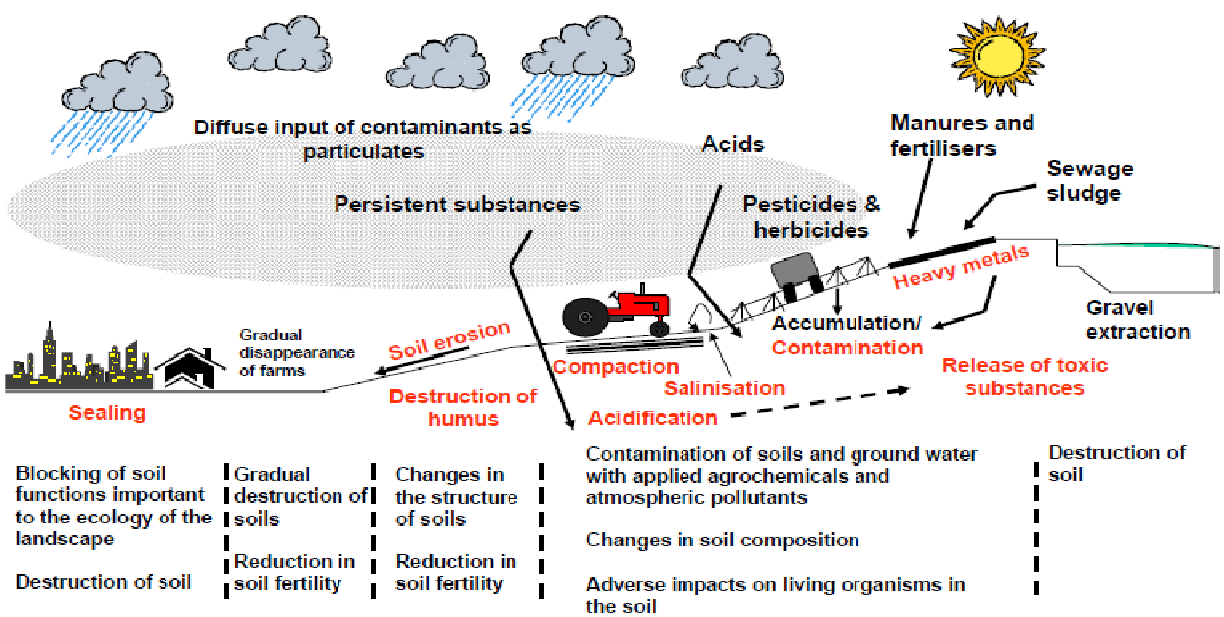

Fig.5: Major types of soil problem

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kind of contamination in the soil is chemical contamination.

5. **Acidification** - Through deposition from the air is a continuing problem. Soil acidification occurs as a result of emissions of acidifying pollutants from transport, industry and natural biogeochemical cycles, re-depositing onto the soil surface mainly via dry depositions and rainfall. Exceedances of critical loads for acidification and eutrophication on terrestrial ecosystems are at present mostly dominated by nitrogen deposition. However, soils under severely acidified conditions are difficult if not impossible to rehabilitate

Soil Degradation – The Physical, Chemical and Biological Decline of Soil

Soil degradation – An area of major concern

In the present scenario, the prevalence of soil degradation is on a very large scale. The figure 6 below represents almost all the disastrous effects of soil degradation on our ecosystem.

The challenges of climate change which may bring wetter, stormier winters and drier summers and possible feedbacks as carbon dioxide is released from drier soils, then soil degradation is a significant problem now and in the future. Soil degradation is not just a rural problem: urban soils can be degraded by pollution, removal, burial or sealing of the surface which can exacerbate flooding. The Single Payment Scheme, an initiative that replaced the old Common Agricultural Policy, provides subsidies on the basis that land is maintained in good agricultural and environmental condition, and includes a review of soil protection measures. Under voluntary agreements such as Environmental Stewardship, an incentive-based initiative that goes further than the Single Payment scheme in protecting the environment, around 40 percent of the 20,000 participants to date have chosen to complete a soil management plan which protects soil from physical erosion. Urban soil protection generally lags behind, but policy makers are now developing policies to address urban soil degradation, for instance in the planning system, where sustainability appraisal and environmental impact assessment explicitly require consideration of impacts on soils.

Physical Decline of the Soil

The following characteristics, identified during the field examination, are used to characterize the 'soil degradation features' present and based on these, each site is allocated to a soil structural degradation class according to specific combinations of features. Fig.7 depicts one such site.

- Surface soil condition – the presence of slaked or capped topsoil indicating that the natural infiltration capacity of the soil surface has been reduced.
- Presence of wheeling or tramlines – the passage of vehicles over the soil surface deforms and compacts the upper parts of the topsoil, leading to a reduced infiltration capacity and the creation of preferential pathways for rapid water movement off the land.
- The extent of poaching – overstocking or grazing when soil is too wet, leads to poaching and compaction of the upper topsoil.

Fig.6: ILL effects of soil degradation

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- The presence of structural change within, or at the base of the topsoil – the ill-timed use of some cultivation practices, especially ploughing, can result in the formation of compacted layers within, or at the base of the topsoil. The overall permeability of the topsoil and/or the topsoil/subsoil junction is reduced, promoting topsoil saturation and lateral water movement.
- The presence of erosion and deposition features – indicating that runoff has been sufficiently great to cause the movement of detached soil particles.
- Vertical wetness gradients within the soil profile – in naturally well-drained, permeable soils it would be expected that during the winter months, except shortly after intense rainfall events, the soil profile would be of approximately similar wetness throughout. An indication of structural degradation is provided when such soils are significantly drier in the subsoil, compared to the topsoil

Fig.7: Landmass showing physical degradation of the soil

Chemical decline of the Soil

Alkalinity - Alkalinity is the total content of substance in soil that causes an increased concentration of **OH** ions either upon in dissociation or as a result of hydrolysis is called the alkalinity of soil. Alkaline soil causes heavy leachates and is not suitable for cultivation.

Chemical compounds

Sulphate (SO_4^{2-}) is widely distributed in nature and may be present in natural soil in concentration ranging from a few to several thousand mg/gm. Similarly, if fluoride is present in soil then even its low concentration causes harmful effects on human health but some of the chemical compounds like nitrates, potassium and phosphorous decides the fertility level of any soil. The ratio of these three chemicals is referred to as NPK ratio.

Presently, soil is degraded both due to alkalinity and high concentration of chemicals by excessive human activities. Vast areas in the otherwise productive Indo-Gangetic plain cutting across the states of Haryana, Punjab, Uttar Pradesh and some coastal regions of Gujarat have lost their productivity due to soil salinity–alkalinity. These soils are characterised by excess soluble salts with sodium carbonate in substantial quantity. Consequently, the soils accumulate sodium on the exchange complex thus resulting in poor physical properties including low infiltration rates. In many areas a layer of calcium carbonate concretion (kankar pan), which is normally found at a depth of 1 m, acts as a barrier for root penetration into the soil. The soil pH is high adversely affecting germination, plant growth, and nutrient availability to plants. The process of salinisation sets in due to (a) irrigation with ground water containing excess of carbonate and bicarbonate ions (secondary salinisation), (b) runoff from adjoining undrained basins, and (c) rise in ground water table as a consequence of mismanagement of irrigation command. This is a man-made problem. In addition, there is natural salinity in depressions in landscaping of lower elevations.

Biological Decline of Soil

- **Carbon sequestration and soil degradation**

  Conservation-effective land use and soil management systems offer a potential for carbon sequestration in soil and terrestrial ecosystems through decrease in losses of soil organic carbon and increase in biomass production, among other benefits. Within this context, there is a clear economic linkage between fossil fuel burning, climate change, dryland degradation and carbon flux. Carbon sequestration may be viewed as the key to reversing soil degradation; as degradation is reversed, so carbon sequestration increases and vice-versa. The projected opportunities for carbon sequestration in drylands over the next five to 50 years suggest that if conservation and rehabilitation measures were implemented in the world's drylands, this would lead to an annual carbon sequestration between 1.0 to 1.3 Gt per year. These considerations will become relevant once the Kyoto Protocol 5 is ratified by allowing trading of carbon credits and cooperation between Annex I (developed) and non-Annex I countries in reducing net emissions through the Clean Development Mechanism (CDM).

- **Soil and climate change**

  The interrelations between climate change and changes in soil quality are complex. Assessments of the impacts of climate change on soil properties and performance, as well as the influence of soil on global change, are mostly based on hypothetical scenarios and data obtained under controlled conditions. Thus, predictions are rather more qualitative than quantitative. Many soil alterations occur slowly over a long term, while others will occur very quickly, such as loss of soil organic carbon (SOC). Loss of SOC causes rapid decreases in the quality of many soil properties such as soil structure and biodiversity. The worldwide amount of SOC bears directly on changes in atmospheric carbon. Modest changes in SOC, whether positive or negative, may have an appreciable effect on the content of atmospheric carbon, whose yearly change is only a small percentage of the total SOC.

- **Soil as Carbon Sink**

  The capability of soil to sequester atmospheric carbon could be exploited to offset greenhouse emissions due to the burning of fossil fuels, and is currently under discussion in the framework of the United Nations Framework Convention on Climate Change (UNFCCC). It has been estimated that terrestrial carbon sinks represent an average net sequestration of 2.3 Gt of carbon per year (the same amount of carbon is sequestrated by ocean sinks), against 6.3 Gt emitted from fossil fuels and industrial activity, 1.6 Gt emitted from land-use changes (mainly deforestation) and 3.3 Gt of carbon which accumulates in the atmosphere every year. Terrestrial sinks are part of an active biological cycle, so that a substantial fraction of the fossil fuel carbon sequestrated currently by terrestrial ecosystems could return to the atmosphere in one hundred years or so. Thus, terrestrial sinks are best viewed as important but temporary reservoirs that can buy valuable time to reduce industrial emissions, but they are not permanent offsets to these emissions.

  Within terrestrial ecosystems, current carbon stocks are much larger in soil than in vegetation, particularly in non-forested ecosystems in middle and high latitudes. Moreover, below-ground carbon generally has a slower turnover than above-ground carbon. Thus, carbon storage can be maintained over a longer period of time. Below-ground carbon is normally more protected than above-ground carbon during fires and other disturbances. Agricultural practices have a significant influence on the amount of carbon stored in soil over time. Changes in agricultural practices and inputs - notably changes in crop varieties, application of fertilisers and manure, rotation and tillage practices - influence how much and at what rate carbon is stored in or released from soils.

Geographical dimension of Soil Degradation

The geographical distribution of soil degradation depends on several factors. Soil problems are influenced by the diversity, distribution and specific vulnerability of soils. They also depend on geology, relief and climate. A further factor is the distribution of driving forces across the continent and within each region or climatic zone. The figure 8 represents worldwide scenario and figure9 gives the Indian scenario of soil degradation for comparing the extent of soil degradation in India on global scale.

Soil loss and deterioration will continue and will probably accelerate if proper and prompt measures are not taken to de-couple the progress of economic sectors and their pressures on the soil resource through the integration of soil protection measures with sectoral policies.

Economic Impact of Soil degradation in India

Soil provides living things with food, fibres and fuel. It supports wildlife and rural and urban activities. From the end of the 1940s to the beginning of the 1990s, over 90% of the

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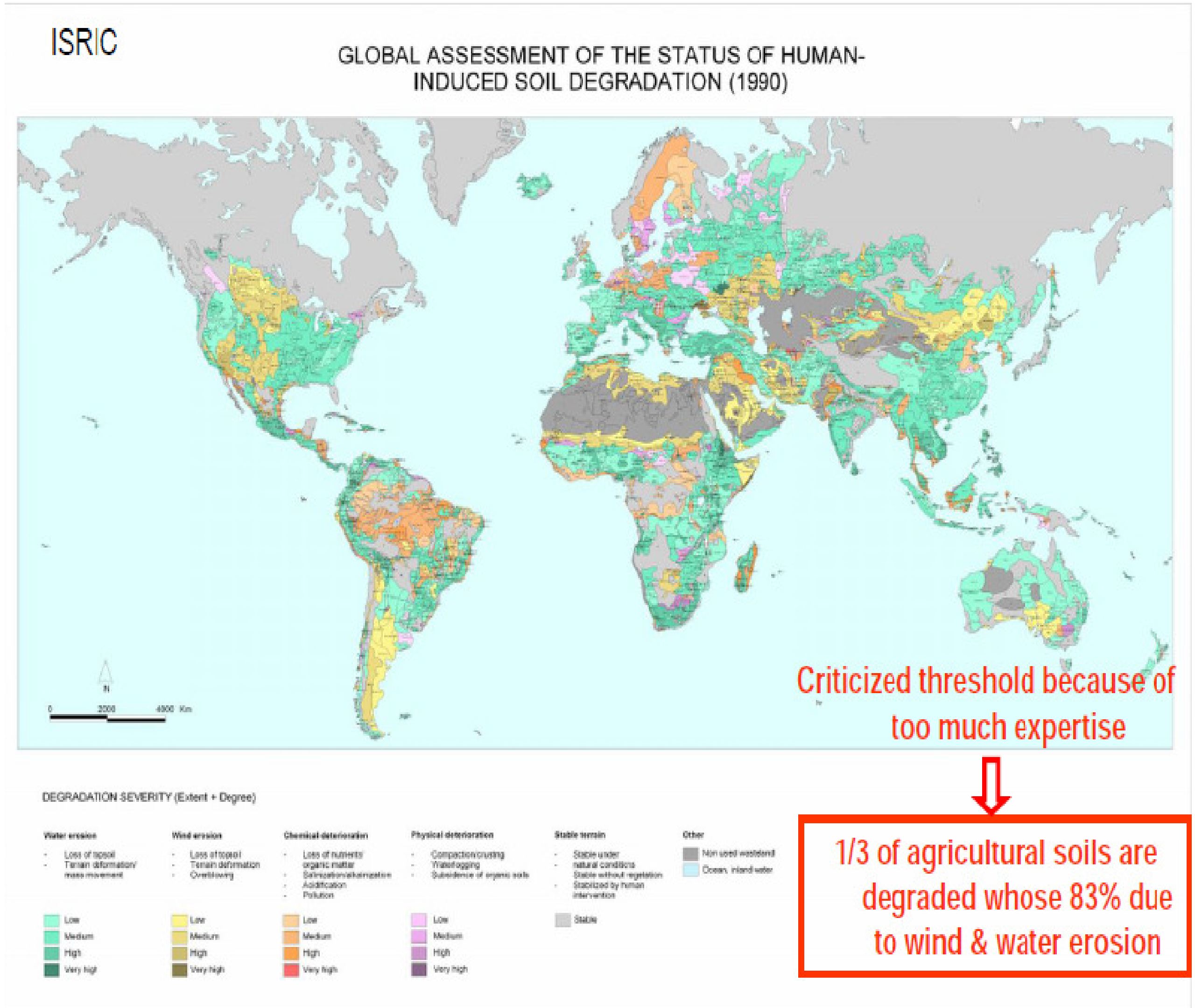

Fig.8: Worldwide dimension of soil degradation

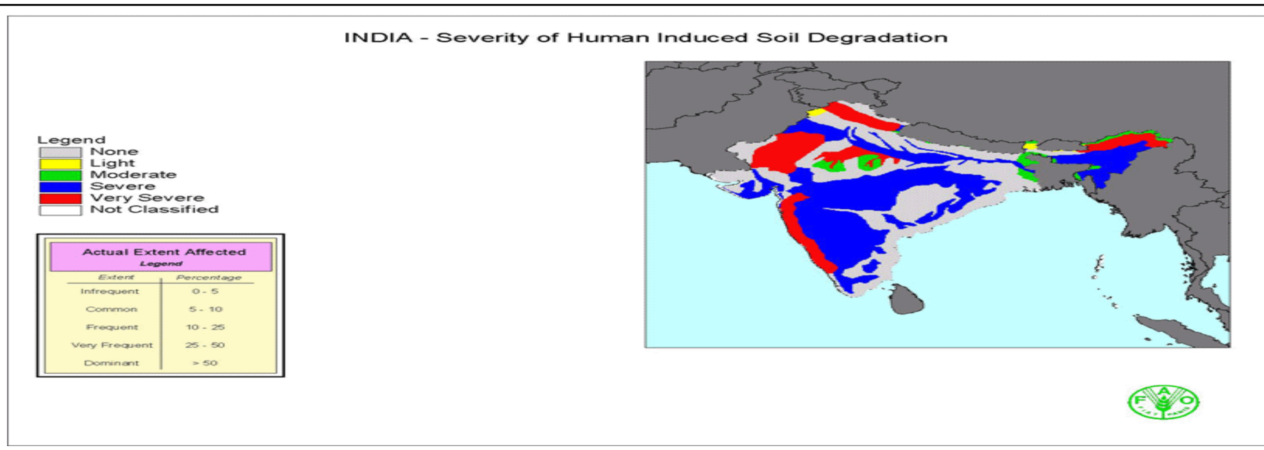

Fig.9: Indian Scenario of Soil Degradation

degradation of productive land was due to overgrazing, deforestation and inappropriate agricultural practices. These changes in the soil affect over 2 billion people, most of the 852 million people suffering from hunger in particular. Soil can therefore not be ignored in ecosystem mechanisms. Also, by 2050 the world population will have reached 9 billion; Soil has therefore become a fundamental resource that must be protected as a matter of urgency.

The major causes of soil degradation in the country are deforestation, unsustainable agricultural and water management practices, land use changes for development, and industrialisation. The major process of soil degradation is soil erosion (due to water and wind erosion), contributing to over 71% of the land degradation in the country. Soil erosion due to water alone contributes to about 61.7% and that by wind erosion 10.24%. The other processes include problems of water logging, salinity-alkalinity. The process of desertification is impacting every aspect - loss of agricultural productivity, loss of natural resources (forests and vegetative cover, biodiversity, soil changes), socio-economic conditions (economic losses, problems of sustenance, decline in quality of life), etc.

Runoff induced erosion is quite prevalent in most States of India located in the arid, semi-arid and dry-sub humid regions. The annual water erosion rate ranges from less than 5t/ha/yr (for dense forests) to more than 80 t/ha/yr in the Shivalik hills. Sheet erosion affects red soils comprising Alfisols, ultisols, and oxisols (4-10 t/ha/yr) and black soils constituing Vertisols and Vertic soils (11-43 t/ha/yr). Gully erosion severely affects hilly areas (more than 33 t/ha/yr), while hill slope erosion affects 13 mha (more than80 t/ha/yr).

The motivation for the assessment of soil's economic value is the fact that soil degradation imposes real costs and the fact that healthy soils have public good aspects. Assessment of economic impacts of soil degradation is carried out by Ecological dept. and is commissioned by DG Environment. Their views do not necessarily represent the position of DG Environment but was a study on scoping of what can be assessed. The different ways to categorize impacts includes the on-site and off-site impacts, cost of suffered damage and damage avoidance cost, direct & indirect use values and the non-use values (not quantified). The five major cost categories are: PC, RC – on-site costs, SC, DC – off-site costs & NC – non-use costs. Assessment of economic impacts of soil degradation have revealed that off-site costs (SC+DC) exceed on-site costs (PC+RC) by 12:1 and the cost of suffered damage (PC+SC) was higher than damage avoidance cost (RC+DC). It negatively impacts the economy at a rate of 3-7% of agricultural GDP. According to the Tata Energy Research Institute (TERI), New Delhi, the economic losses caused by lower crop yields, and reduced reservoir capacity has been estimated to be in the range of 89-232 billion rupees, as a result of loss of 11-26% of agricultural output. According to a World Bank study, India loses 1.2-6.0 million tonnes of foodgrain production every year due to water logging; another major factor for degrading soil.

There is a close link between poverty and land degradation. The poverty-degradation link is particularly evident where there is a lack of diversification of alternative livelihoods and the ability of land managers to invest in mitigation is limited. The policy environment is critical. Policy can cause or reduce land degradation through directly targeting proximate mitigation efforts such as terracing and re-afforestation, which may or may not elicit positive responses from land managers, and through its indirect impact on the economic and social context within which land degradation is embedded.

Requirements for Coping Up with Soil Problems

The development of a policy framework which recognizes the role of soil, taking account of the problems arising from the competition among its concurrent uses (ecological and socio-economic), and aiming at the maintenance of soil's multiple functions, could have multiple benefits and achieve a consistent improvement of environment as a whole. There are appropriate actions to be taken at all administrative levels, from land planning at the local and sub-national levels, to the setting up of environmental and sectoral policies at the national level and the launch of initiatives on a global scale.

Unless the soil problems are catered properly and effectively, no nation can rise with a sustainable development. The presence of a good quality soil is not only a need but a necessity as well, as the development of the nation depends upon the type of soil it holds and harness.

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Legal Instruments

Within more than 200 multi-lateral treaties, agreements, conventions and protocols established in the field of environment, covering flora and fauna conservation, pollution management, regional conservation protection, protection of world cultural and natural heritage, landscape protection and many others, only a few of them are directed towards the protection of soil. Among them, the World Soil Charter (1972) and the World Soil Policy (1982) need to be mentioned. These instruments have contributed to raising the profile of soil conservation as a major international environmental management issue, but have not resulted in operational programmes to protect soil. Moreover, a number of international conventions addressing soil issues have been ratified since the 1992 Rio Declaration on Environment and Development. These include climate change (UNFCC), biodiversity (UNCBD), desertification (UNCCD), as well as the International Forum on Forests with its International Forest Principles (IFF) and the Global Plan of Action on Land Based Pollution (GPA). In particular, the UN Convention to combat desertification (1994) addresses the impacts of land degradation in arid, semi-arid and sub-humid regions as well regions affected by serious drought. The convention invites the countries to prepare national action plans (NAPs) as well as a regional action plan to combat desertification in the area. Fig.10 below depicts some of them.

Obstacles to Strong Soil Policy

Data on soil has been gathered by different organizations for different purposes. There are, however, important data gaps and access to relevant data and information is difficult. Few existing data can be directly used for policy purposes and most covers small geographical areas. This may be a consequence of absence of legal requirements for data collection, monitoring and reporting on most soil aspects at the national levels. The specific situation about soil data can be summarized as follows:

- A mass of data exists at the local level, but few data are of direct use and there are data gaps at the regional level;
- There is a lack of harmonization of monitoring and data collection activities at the national and regional levels;
- Data flows, between data collectors and the organizations responsible for reporting, have not been established at the national levels.

Improving data and information on the state and trends of soil would require a coherent framework for monitoring and assessment of soil, including the establishment of a data flow/reporting mechanism on soils, which will enable a greater knowledge of the policy relevant issues and streamlining of existing activities/ collaboration of relevant

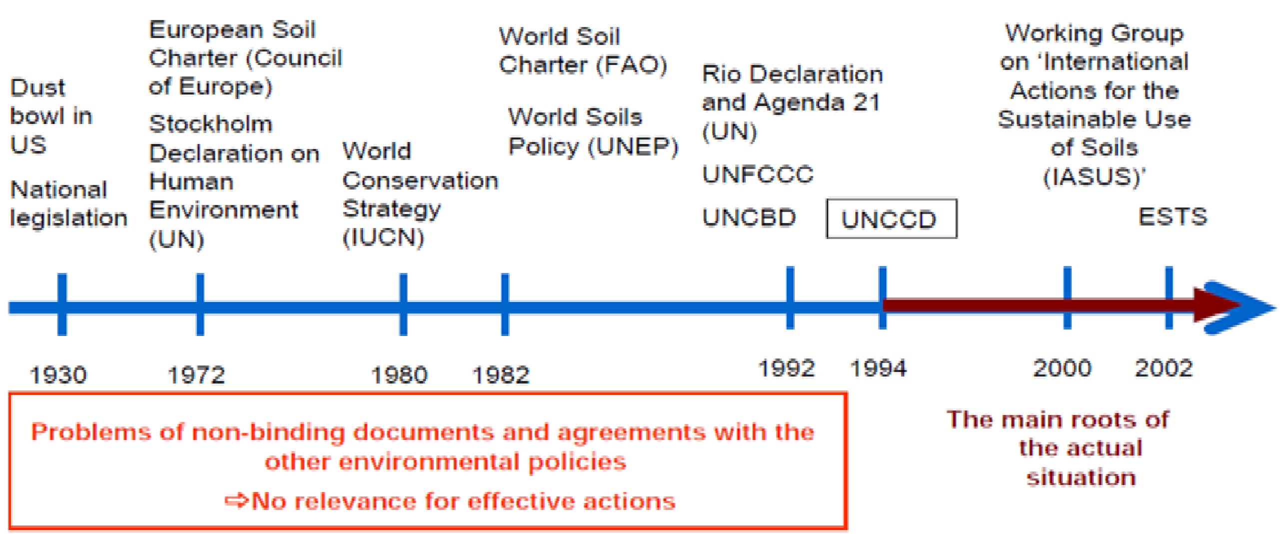

Fig.10: Various policies and framework designed by the national and international authorities

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stakeholders. This should include the development of a work program for soil for the years to come and integration of soil issues into environmental and sectoral policies as shown in fig.11.

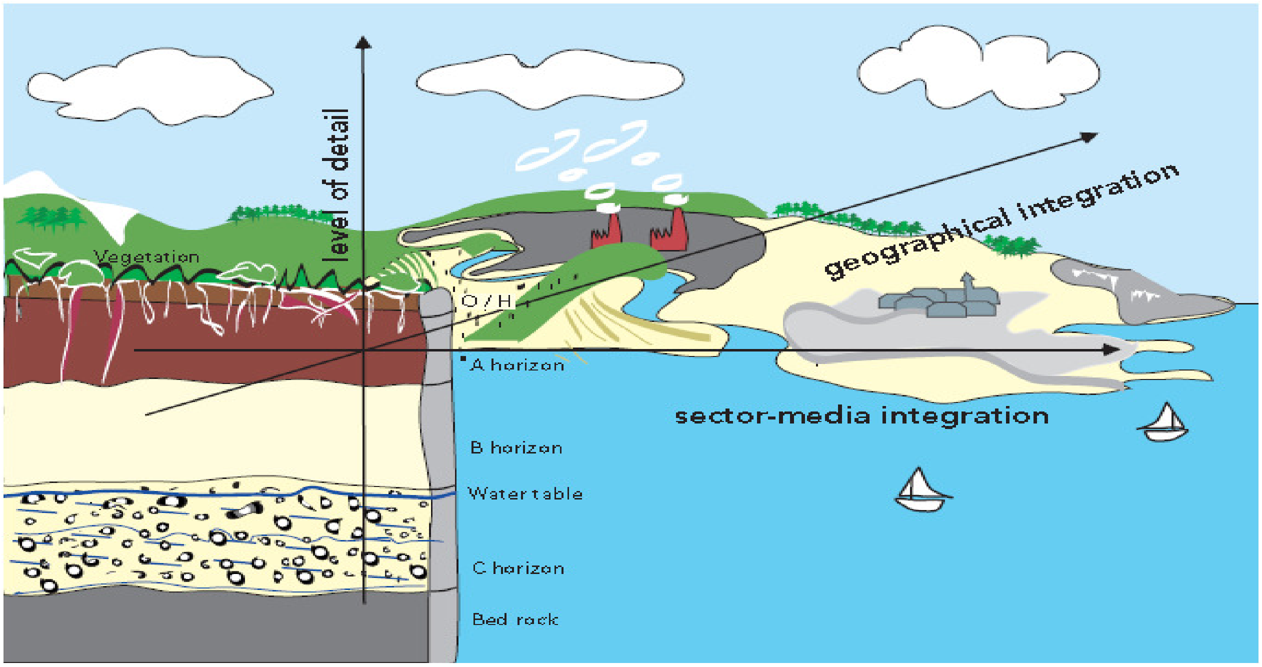

Fig.11: Schematic representation of integration of soil issues with other

Current Initiative for Soil Protection

The role of the media and new information tools in increasing public awareness of soil problems is rising for the good. Recently there has been an increasing interest in soil problems from the mass media. In general, reported concerns are related to loss of revenue and property caused by contamination or identified environmental risks. Cases taken up by the press are usually concerned with local contamination, where a more direct link between the source of contamination and the contamination itself exists, as well as cases involving important economic losses. However, people still underestimate the risk or the real cost of living in an area at risk (whether this is an area close to a landfill or to a factory releasing substances causing cancer, or an area subject to natural risks, such as flooding, landslides or natural radiation). Public awareness campaigns are implemented to develop the public's understanding of risk. In most of the cases, this may be in part explained by psychological reasons as well as by the fact that the effects on human health and ecosystems are often delayed. When such impacts occur, it is generally difficult to make a clear link between causes and effects. Moreover, the impacts of soil degradation are often shown indirectly through, for example, the effects on other resources such as the contamination of groundwater. Nevertheless, public awareness is growing.

Catastrophic events such as the recent floods, earthquakes and landslides have contributed to the public being increasingly aware of the need for a more rational use and a more effective protection of soil and land resources. The causes of these disasters have been clearly identified and reported in the media as stemming from the competition of concurrent uses of land due to a high concentration of population and activities and not simply due to natural hazards. This awareness is perhaps related to the increasing attention provided by the media to soil problems and to the fact that public authorities, NGOs and private companies (e.g. insurance companies) are providing more effective tools to inform the public. For instance, it is possible to access

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on-line information on the risks affecting a particular property.

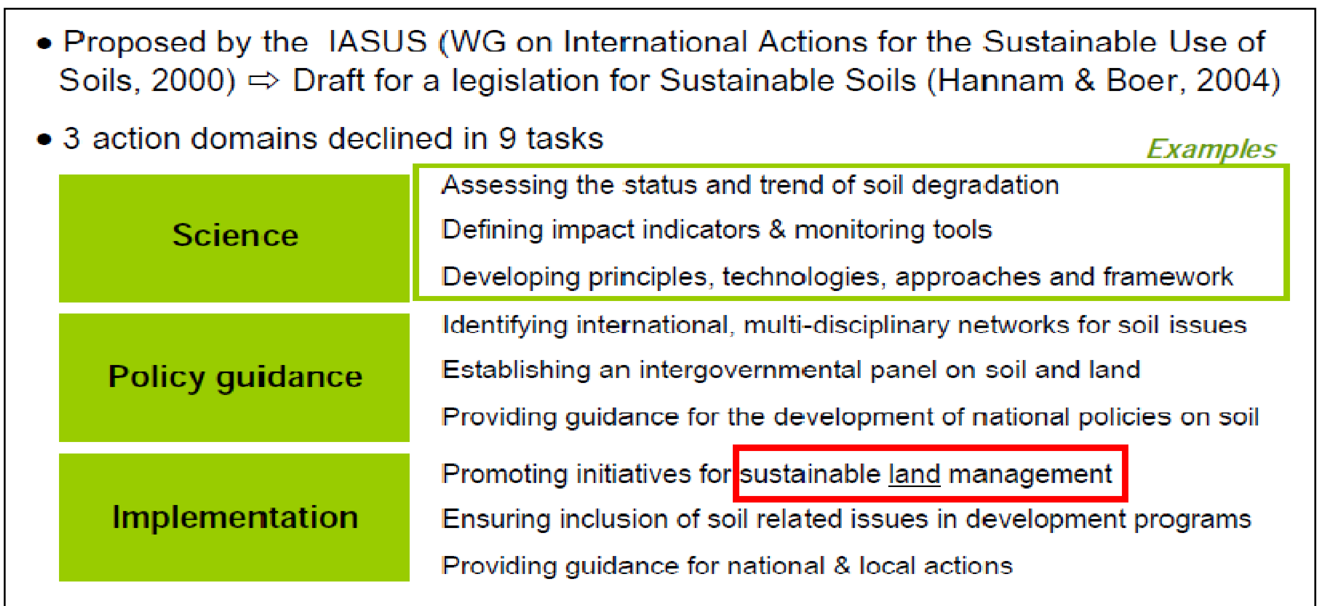
Sincere efforts such as promoting peoples participation in sustainable development and natural resource management; improving knowledge on drought and desertification, management of natural resources leading to sustainable development, improving the socio economic environment, improving basic infrastructure, promotion of alternative livelihood, intensification of agriculture, promotion of awareness, improving institutional organization and capacity will certainly lead to judicious utilization of soil as resource.

Brownfield redevelopment, i.e. the re-use of abandoned industrial areas for new urban development, has been identified as a response to the increasing demand for land resources. However, soils of former industrial sites can be heavily polluted and their remediation could be economically or technically infeasible. Sustainable management of soil as a natural resource, together with air and water, is among the challenges and priorities mentioned in the Fifth Environmental Action Programme (5EAP).

Soil, Agricultural Policy and the World Trade

Negotiations within the World Trade Organization (WTO) are also contributing to the increasing relevance of soil protection. Current debate shows that very different and contrasting views on the importance of soil for agricultural groups of countries. For example, the Unites States and the Cairns Group (Australia, Argentina, Brazil, Canada and others) look at soil mainly as a substrate for agricultural production, more or less neglecting the environmental importance of soil for the protection of groundwater, biodiversity and other environmental targets. In contrast, the EU, Japan and India are among other countries that strongly aim at a multi-functional use of soil, regarding agriculture as one of several important uses. These contrasting viewpoints are very understandable given the different spatial distributions of agricultural soils in relation to urban, industrial and transport systems in which agricultural soils simultaneously fulfill different important functions. All these different functions of soils are of concurrent importance, due to the concentration of activities in a small space and the high competition arising from ecological and socio-economical uses of soil resources. This is not the case in the United States, Canada, Australia and other members of the Cairns Group, because the amount and distribution of agricultural land with regard to other land uses, e.g. urban settlements, industrial premises and transport routes, is spatially very different.

Keeping these facts in mind, World Trade Organization (WTO), has put forth world Soil Agenda and is as follows:



World Soil Agenda

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Soil Protection and Sustainable Development

Soil and plants, interactively with air and water and the biological resources they support, control environmental quality, human health, and global ecosystem sustainability. Soil resources serve as the foundation for agricultural development and are the long-term "capital" on which any nation builds and grows. Soils undergird the biosphere and its complex biophysical interconnectivity. Soils, along with plants, serve as receptors for waste, function as biological filters that govern water quality, and determine the fate and transport of chemicals.

Public awareness of soil quality is important because: (1) protection of the soil resource is essential to ensure the safety and security of our food supply, the quality of our air and water resources, and the biodiversity of life; (2) the soil resource is finite in extent and varies in productivity, quality and resilience over the landscape, and the soil resource requires site-specific and landscape-scale planning for its use and management; and (3) poor management of vulnerable soils through inappropriate cultural practices and misapplication of irrigation water, municipal and industrial by-products, or animal manures can impair soil quality by depleting soil organic matter, compaction, acidification, salinisation, or chemical over-loading. Information about soils is therefore critical and should be used for ecosystem-based, land-use decision making, site-specific planning, and preservation of biodiversity.

Soil scientists, agronomists, and agricultural specialists have been leaders in addressing environmental concerns. However, the public mandates a new focus on issues of environmental research i.e. earth scientists should play a pivotal role. These environmental challenges include (1) enhancing and conserving renewable natural resources including plants, soil, air, and water quality; (2) quantifying soil quality characteristics and their resilience to degradation; (3) quantifying climatic change and its impact on complex natural and agricultural ecosystems; (4) calibrating biodiversity with soil physical, chemical and biological attributes; (5) protecting wildlife habitats and ecosystem restoration including wetlands preservation and use; (6) managing waste products as a useful resource; (7) fostering pollution abatement; (8) establishing land carrying capacity; (9) developing alternative energy sources; (10) discovering environmental technologies; and (11) employing best soil management strategies to sustain food, feed, and fiber production systems for an ever expanding global population in an economically viable and environmentally defensible manner. Fig.12 below depicts a scheme for sustainable management of soil.

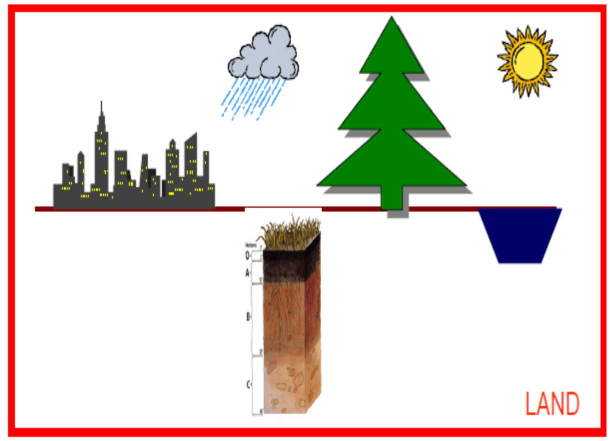

Fig.12: As sustainability deals with socio-economic sustainability, dealing with land management is more appropriate than dealing with soil management (better soil management is lead by a better land management)

Since, the survival and well being of developing nations depend largely on sustainable development and for this there is a need for a paradigm shift from 'throw and forget' approach to recycling in the form of 'waste to wealth' approach for waste management. In this regard, the importance of public – public partnership is more valued than public – private partnerships as the worldwide experience has shown that where community have a sense of ownership of their resources, they take care of them.

An important consequence of soil multifunctionality and the limited availability of the resource – and one of the main causes of soil degradation – is competition between concurrent uses of land and soil (food production, living space, infrastructure and industrial production) due to concentration of activities in a small space. There are also conflicts between private and public use of soil resources. These competing demands, if not properly managed in a sustainable manner, will result in more degradation (unsustainable agricultural practices, soil contamination, sealing, etc), which ultimately will lead, in a vicious circle of decline, to a gradual reduction in the available resource. **There is a clear link between climate change, sustainable**

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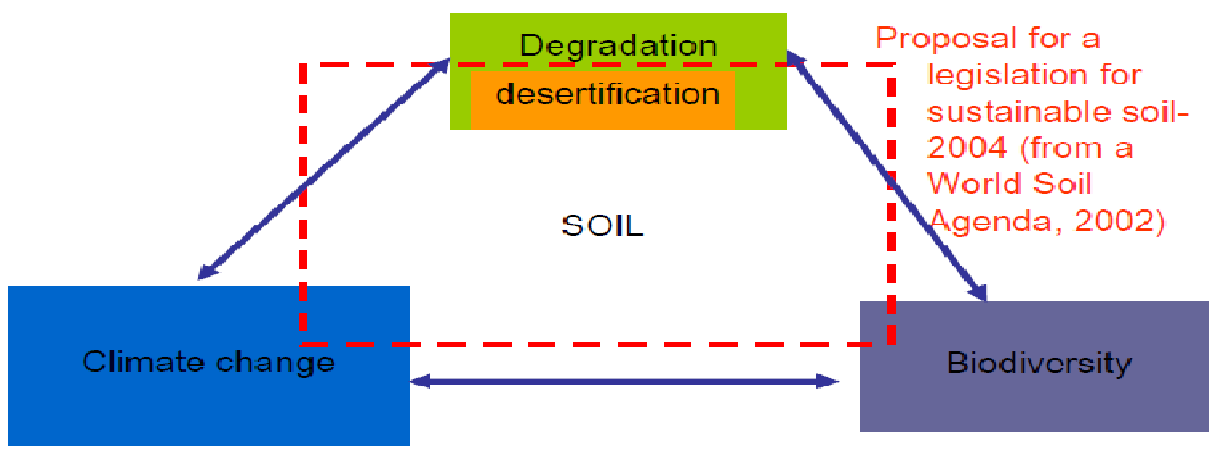
development, environmental quality and soil degradation. Soil is affected by climate change and changes in climate could lead to further soil degradation and this very fact has infact lead to the establishment of various soil laws (fig.13). At the same time soil plays an important role in the sequestration of atmospheric carbon, through the dynamic process affecting the content of soil organic matter (SOM). SOM is lost through soil degradation (and soil organic carbon with it) and so is the capacity of soil to act as a carbon sink. In developing countries, soil degradation reduces food supplies and contributes to an increase in the number of the so-called "environmental refugees". Soils which are wet during critical times for land management operations, such as for ploughing or harvesting, can be prone to compaction and structural damage. Soil structural damage leads to a reduction in soil water storage and infiltration capacity, which reduces the inherent ability of the soil to absorb rain, leading to increased runoff.

Soil is a cross-cutting issue. As soil has multiple users, consideration of soil has to be integrated at different levels. There is a need for administrative (from local to National and global), sectoral (sectors and other environmental issues) and geographical integration (landscapes, urban, rural, mountain and coastal areas) of both soil assessment approaches and soil protection policies. There are appropriate actions to be taken at all administrative levels, from land planning at the local and sub-national levels, to the set-up of environmental and sectoral policies at the national levels, and the launch of initiatives on a global scale. In India, DPSIR framework is utilized to address the issue of developing responses towards a stress, what are stresses, driving forces, impacts, etc and are schematically represented in fig.14.

Conclusions

Soil loss and deterioration will continue and will probably accelerate if proper and prompt measures are not taken to de-couple the progress of economic sectors and their pressures on the soil resource through the integration of soil protection measures into sectoral policies.

Fig.13: Vicious circle of soil degradation, climate change and loss of biodiversity



"Down to earth, down to basics" – solving soil problems will help solve other problems at the National and global levels. Soil protection will have multiple benefits. At the national level, as the diversity and multi-functionality of soil contribute to nation's cultural and natural diversity, protecting soil will help to preserve its resources, identity and ability to cope with change. At the global level, combating soil degradation will help offset greenhouse gas emissions, will provide a better environment, will guarantee more food to an increasing population and will contribute to the economic progress of future generations.

As soil is a cross-cutting issue, soil assessment approaches and soil protection policies need to incorporate a wide perspective. This means that it would be necessary to integrate assessment and responses at the administrative (from global to local), sectoral (economic sectors and other environmental issues) and geographical levels (landscapes, urban, rural, mountain and coastal areas).

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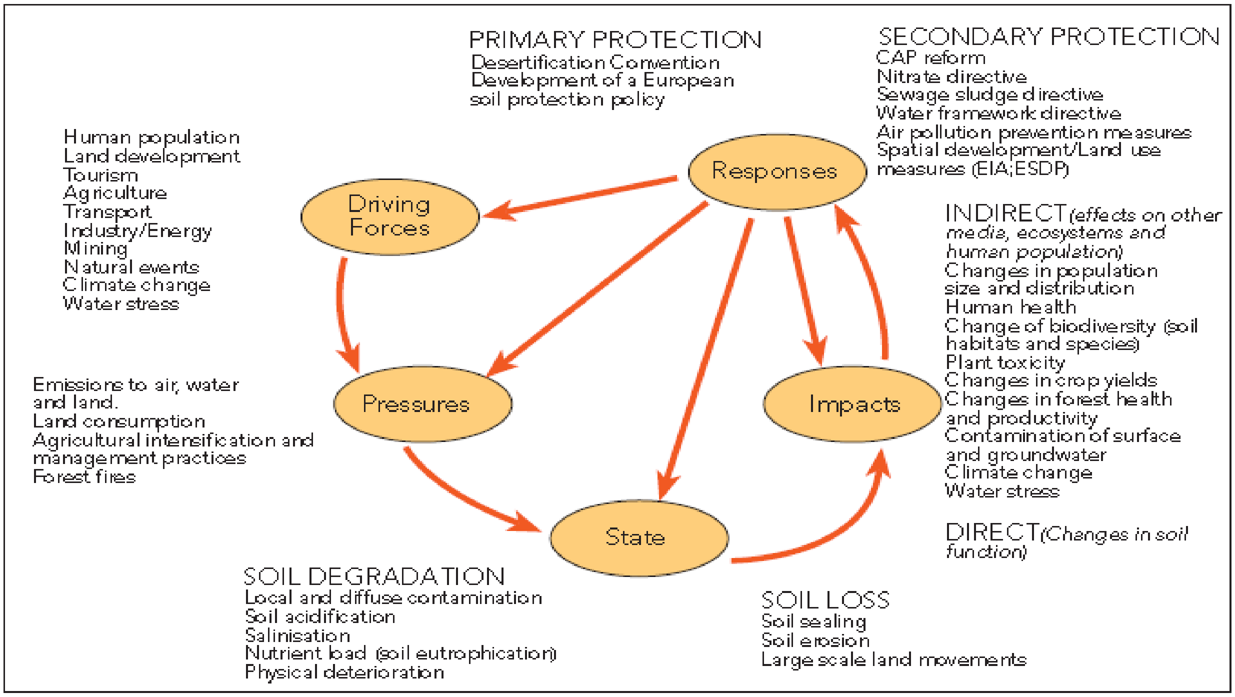

Fig.14: DPSIR Framework Applied To Soil

The effects on soil of the implementation of existing measures need to be analysed and monitored. Ideally such results should be communicated on a regular basis through, for example, a soil reporting mechanism and assessment framework. This would require a closer collaboration among administrations in order to improve access to data and data comparability, and to avoid duplication. Such assessments would also help identify what else may be necessary but is not covered by existing legislation.

Development of Community level Action Plan and implementation is very essential for combating desertification and to mitigate the effects of drought. Effective institutional coordination among the relevant stake holders (NGOs, CBOs, Govs, Donor communities, etc) is the need of the hour and also promotion of the synergistic implementation of the three RIO Conventions can serve our purpose to great extent. In the decades to come, the sustainable use of soil will be a great challenge, comparable and closely interrelated with the global concerns about changes in climate and biodiversity. This would require that the necessary actions are taken in order to meet today the diverse and potentially conflicting demands on the soil resource, without compromising its use and availability to future generations.

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