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“Development on the margin”

Marginal Soils

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Abstract

The term “land” refers to the terrestrial bio-productive system that comprises soil, vegetation and other biota, hydrological and ecological processes and entities which provide a range of ecosystem services and functions. Soil is an integral component of land, and is the essence of all terrestrial life. It is the 3-dimensional body on the surface of the earth, and the interface between the lithosphere and the atmosphere. Soil, or the pedosphere, strongly interacts with the hydrosphere and the biosphere, and is the most basic of all natural resources. It affects and moderates gross/net/biome and ecosystem productivity, cycling of water and elements especially that of C (N,P,S), climate and the energy budget, denatures and filters pollutants and thus purifies water, stores germ plasm and influences above and below ground biodiversity, and is also an archive of human and planetary history. World’s soil resources are also finite in extent, unequally distributed among eco regions, prone to degradation by natural and anthropogenic factors, have inherent resilience, and are renewable over the geologic time scale.

Despite their importance to ecosystems health and human civilisation, soils are being marginalised and treated as a global common good. Consequently, the soil resources are degraded by a range of processes such as decline in soil structure and tilth leading to crusting and compaction, accelerated erosion by water and wind, secondary salinisation of irrigated land, depletion of soil organic carbon (SOC) or soil organic matter (SOM) along with that of essential plant nutrients (i.e. N, P, K, Zn, Cu), acidification, elemental imbalance, and reduction in activity and species diversity of fauna and flora (macro, meso, and micro organisms). Thus, soil degradation entails decline in its physical, chemical and biological quality with the attendant adverse effects on ecosystem functions.

Marginal soils are soils of poor quality, and characterised by low ecosystem functions and services. Marginal soils may be created by natural (i.e. too steep, too shallow, too rocky, too dry, too wet, too cold or inaccessible) or anthropogenic (human-induced) factors. The latter (e.g. accelerated erosion, secondary salinisation, depletion of SOC) is caused by land misuse and soil mismanagement.

The Law of Marginality (Lal, 2008b; 2009 a;) states that “marginal soils cultivated by marginal means produce marginal yields and support marginal living”. Yet, the bio-physical process of soil degradation is driven by social, economic, cultural and other Human dimensions. Indeed, when people are poverty stricken and desperate they pass on their sufferings to the land. In addition to poverty, soil degradation is also caused by human greed, short sightedness and cutting corners for quick economic returns. Poor governance and lack of political will power to implement conservation-effective and restorative measures are major factors affecting soil degradation. The vicious cycle and the downward

spiral “lack of investment in soil management % accelerated soil erosion and depletion of SOC and plant nutrients - human malnutrition and food insecurity - political unrest and social/civil strife - severe degradation and desertification of soil and natural resources” reinforce one another, create positive feed back because of perpetual soil mining and use of extractive farming practices. Soil degradation, caused by land misuse and soil mismanagement, is a principal reason for inadequate human nutrition and poor health (Lal, 2009 c).

The SOC amount and its composition in the root zone are important determinants of soil quality which affects soil functions and ecosystem services. There is a threshold level of SOC concentration, 1.0 to 2.0 % in the root zone, below which soil processes and use efficiency of inputs are severely impaired. Marginal soils in developing countries of Sub Saharan Africa, South Asia and other regions, often have SOC concentration of < 0.5 %. Thus, marginal soils of low SOC concentration and low effective rooting depth do not respond to inputs such as improved varieties, fertilisers and irrigation. The yield potential of improved varieties can only be realised if grown under optimal soil conditions. While both traditional breeding and genetic engineering are needed, even the elite varieties cannot extract water and nutrients from marginal soils where these do not exist. The low level of SOC in marginal soils is caused by the negative C budget created by extractive farming practices of removing crop residues for numerous uses (e.g. animal feed, construction of houses and fences), use of animal dung as house hold cooking fuel, and lack of or insufficient input of fertilisers and soil amendments. It is not possible to take more out of a soil than what is put in it without degrading its quality. Only by judiciously replacing what is taken can a soil be kept fertile, productive and countries by 1 t/ha in the root zone can increase food production by as much as 50 million t/yr (Lal, 2006; 2010 b).

Marginal soils can be restored through sustainable intensification. The latter implies improving productivity and ecosystem services (i.e. carbon sequestration) while also restoring environmental quality. The strategy is to produce more from less while reducing the environmental impact and negative externalities. The goal is to create positive ecosystem C (along N,P,S) and water budgets in marginal and degrade soils. While there is no panacea, there is a menu of options to choose from for site-specific situations. Sustainable intensification implies the use of modern innovations built upon the traditional knowledge and wisdom. It is not a question of either or. Those who refuse to use modern science to address urgent global issues must be prepared to endure more sufferings because today's problems (7 billion people increasing at the rate of 75 million per annum and projected to be 9.2 billion by 2050) cannot be solved by yesterday's technology. Some recommended management practices (RMPs) include conservation tillage, mulch farming, cover cropping, integrated nutrient management and manuring, precision farming, water harvesting and recycling through drip sub irrigation, fertigation, deficit irrigation or partial root drying, aerobic rice, bio char etc. Sustainable management of soils is the engine of economic development, political stability and transformation of rural communities in developing countries (Lal, 2004; 2010a).

Marginal soils are a transnational issue. Thus, each country and every land manager and farmer is cause and victim of this global problem, albeit to a varying degree. For example, mining SOC by extractive farming has the same effect on global warming as does fossil fuel combustion. Restoration of marginal soils and adoption of RMPs on soils of managed ecosystems have a technical potential of sequestering 1.2–3.1 Gt C /yr for as long as 50 — 100 yrs until the C sink capacity is filled (2010a). In combination with C sequestration in forest biomass, the draw down capacity of terrestrial ecosystems is about 50 ppm of atmospheric carbon dioxide by 2100 or 2150. This is the most natural and cost — effective strategy of adapting to and mitigating climate changes with numerous ecosystem services. Thus, restoring marginal soils through sustainable intensification is integral to any solution to achieving the Millennium Developmental Goals, mitigating climate change and improving the environment. If marginal soils are not restored, crops will fail even if rains do not; hunger and malnutrition will perpetuate even with emphasis on bio technology and

genetically engineered crops; civil strife and political instability will plague the developing world even with sermons on human rights and democratic ideals; and humanity will suffer even with great scientific strides. Political stability and global peace are threatened because of soil degradation, food insecurity and desperation. The time to act is now (Lal, 2008 a).

Adoption of RMPs for restoration of marginal soils in developing countries has lagged behind because small land holders are resource poor and cannot invest in the inputs required. Thus, adoption of RMPs must be promoted by incentivizing the farming communities. The strategy is to reward land managers through payments for ecosystem services (e.g. carbon sequestration, green water credits, bio diversity enhancement). This must be done by a fair, transparent and a just pricing process. Payments for ecosystem services is a better strategy than the subsidies and handouts. Emergency aids and other knee-jerk approaches have created dependencies, killed initiatives, ruined self esteem, increased corruption, and distorted values. By payments for ecosystem services, farmers must be treated as clients and not as aid recipients.

As agronomic productivity sputters. As food production lags behind the demands, as hunger and malnutrition adversely affect human health and well being, as soils marginalise and degrade, as natural waters pollute and contaminate, as climate warms and biomes shift and cannot adjust, as biodiversity dwindles and environment deteriorates, as ecosystem integrity and its functionality are jeopardised, there will be a growing realisation among policy makers that taking soils for granted has been the root cause of the downward spiral.

The reasons for stalling of the Green Revolution in South Asia and of agronomic stagnation in sub-Saharan Africa is the widespread problem of marginal soils exacerbated by the extractive farming practices, poor governance and lack of political will. The developing countries have the capacity to feed the present and future populations on sustainable basis with judicious management and restoration of marginal soils.

Given the right incentives through payments for ecosystem services, local win-win options are awaiting implementation. Now is the time to usher the soil — based and long — lasting Green Revolution in developing countries while improving the environment and promoting peace and communal harmony.

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