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Evolving concepts and opportunities in soil conservation [☆]

Julian Dumanski

Consultant, Sustainable Land Management, Ottawa, Canada

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Abstract

The terrestrial landscape has changed considerably compared to that of the early 20th century when soil conservation was first institutionalized. Large portions of the land are already intensively managed, and the remainder is increasingly receiving human interventions. Previous work on soil conservation focused attention on technological innovations, particularly control and mitigation of soil erosion. However, land degradation has continued and actually accelerated in many parts of the world, due mainly to demands for continued economic development, using technologies that are highly exploitive. In many cases, this has been facilitated by highly inadequate and unsympathetic institutional, legislative, and policy environments.

The paper discusses some of the new driving forces, new international programs, and new potential partners in soil conservation. Increasingly, international efforts to mitigate land degradation are shifting from studies of the biophysical processes to improving the global, national and local enabling policy environment, as well as mainstreaming of soil conservation into national and regional policies and programs. Also, increased emphasis is placed on economic instruments and international markets, such as carbon trading, and incorporation of non-market values in ecosystem investment, such as payment for ecosystem services, certification schemes, etc. The paper discusses some of the opportunities for soil conservation that accrue from these new driving forces.

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Keywords: Land degradation; Environmental goods and services; Driving forces

1. Introduction

Soil conservation has its roots in historical antiquity, but the institutionalization of the movement began with the major droughts and environmental devastations which occurred in the early part of the 20th century. The approaches to soil conservation that emerged from these experiences focused on prescriptive technological and engineering approaches to prevent or mitigate the impacts of soil erosion on crop yields, farmer income, and food security. However, after almost a century of soil conservation, the world has changed. Agriculture is now less natural resource based, and more strongly affected by globalization, production subsidies and other safety nets. Over the past decades,

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E-mail address: jdumanski@rogers.com

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new land management technologies have progressively improved crop yields, and until very recently, the accepted evidence was that food security was no longer a concern.¹ However, events of the recent past bring this into question

Although the importance of soil conservation to national agricultural GDP varies from country to country, the global importance of soil conservation and the control and mitigation of land degradation² are more highly recognized now than at any time in the past. This is because rising populations and rising incomes in the middle classes, as well as increased capacity of human interventions to cause ecosystem degradation, are now of such magnitude that for the first time in history how we manage the land can impact directly on global environmental goods and services. This concern on environmental values is the major driving force on the geopolitical agenda for soil conservation, and this is expected to increase in the future as society better understands the important linkages between soil quality and the environment.

1.1. Linking land degradation and global environmental goods and services

Land degradation is an integral part of the environment cycles³ that support all types and quality of terrestrial life on the planet. Thus, in thinking about the processes and impacts of land degradation on society, we must increasingly focus not only on agricultural yields, farmer income, and food security, but increasingly on the impacts of land degradation on provision of environmental goods and services. The driving forces of rural land use change are shifting from agriculture, forestry and other extractive services, to provision of environmental goods and services and global life support systems, and the major decisions in this are being made by people in urban fora, with often little understanding of agriculture.

Most ecosystem changes are the result of rapid growth in demand for food, water, timber, fiber, and fuel. In the recent past, food production increased by two and a half times, water use doubled, timber harvesting increased by more than half but tripled for pulp and paper production, and installed hydropower doubled. These changes have contributed to substantial net gains in human well-being and economic development, but at growing costs of ecosystem degradation, increased risks of extreme events, and exacerbation of poverty for some groups of people. The degradation of ecosystem services represent losses of natural capital, and while this can sometimes be justified to produce greater gains in other services, often more degradation of ecosystem services takes place than is in the best interest of society.

There are direct and indirect linkages between ecosystem services and components of human well-being, and land degradation affects these linkages in different ways. Knowledge of these impacts provides evidence of the extent to which these can be mitigated with socioeconomic and technological interventions. For example, if it is possible to purchase a substitute for a degraded ecosystem service, then there is a high potential for mitigation, but if there is no substitute, or if the substitute is very expensive, or if degradation of the ecosystem service is beyond rehabilitation, then that service may be lost forever. The strength of the linkages and the potential for mitigation are shown in Fig. 1.

Changes in drivers that indirectly affect ecosystem goods and services can lead to changes in drivers that directly affect ecosystems, such as changes in local land use and cover, the application of fertilizers, etc. (Fig. 2). These result in changes to ecosystems and the services they provide, thereby affecting human well-being. These interactions can take place at several scales and can cross geographic and time scales. For example, an international demand for meat products may lead to regional deforestation, which may increase flood magnitude, loss of soil organic matter, and soil erosion.

A discussion of the current state of the global environment is given in the Appendix to this paper.

2. Global trends influencing the geopolitical agenda for soil conservation

The human footprint on global terrestrial ecosystems is very large and growing exponentially. Currently, fully 83% of the world's land area is directly influenced by human interventions⁴; 50% of the terrestrial earth's surface has

¹Although food security is reasonably assured, about 2 M people go hungry every day, due more to problems of internal security and distribution.

²Land degradation involves the processes of degrading the quality of land, whereas soil conservation normally refers to remedial or mitigation measures. Although the terms are sometimes used interchangeably in this paper, they are not the same.

³Discussions on global environmental degradation include dimensions of land degradation. Although the terms have different meaning, in most cases, environmental degradation cannot occur without considerable degradation of land resources.

⁴Cited in Karieva et al. (2007).

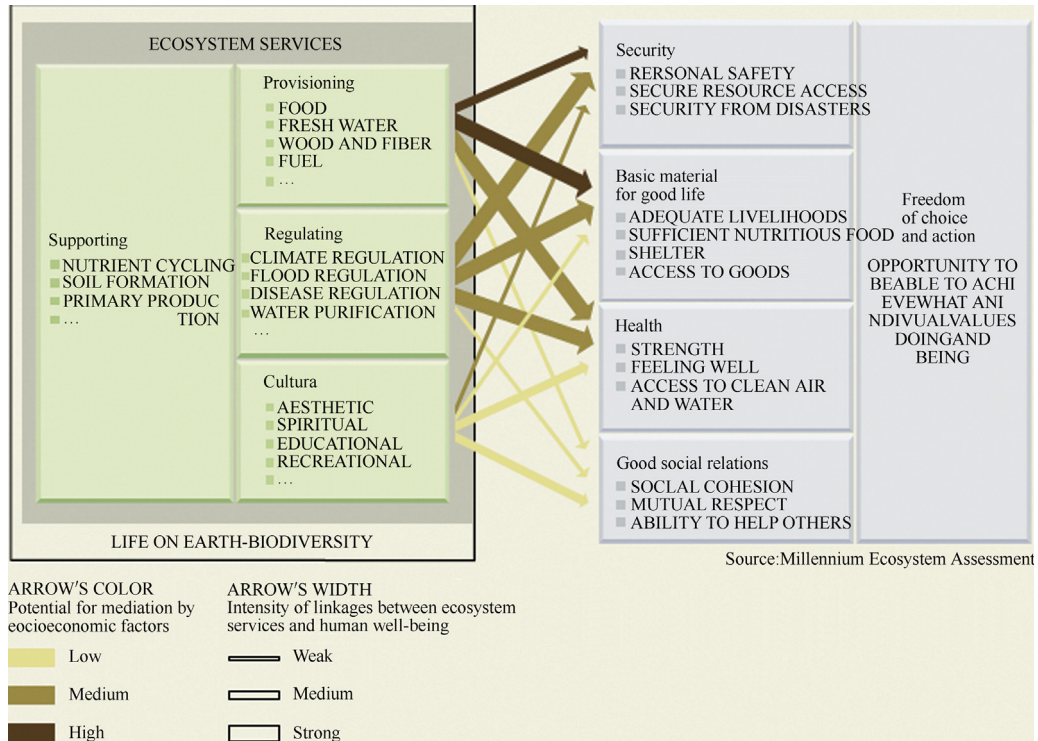


Fig. 1. Linkage between ecosystem goods and services and human well-being (UNEP, 2005).

been converted to grazing land and cultivated cropland, and 25% is intensively managed in agriculture, natural and plantation forests, or managed nature preserves (UNEP, 2005). Estimates are that by early in the next century, all land will be under some degree of management (Vitousek, 1994).

The current driving forces on terrestrial ecosystems result from our continual initiatives for improved incomes and life styles.

2.1. Increasing human footprint on the environment

The development of the extensive human footprint began under the rubric of settlement and our attempts to domesticate nature, in which we have been extremely efficient. Originally, nature was domesticated (tamed) to enhance productivity, ensure food security, and control predators, but more recently this was promoted to enhance commerce and provide protection from storms and diseases (Karieva, Watts, McDonald, & Boucher, 2007). This process was fundamentally one of tradeoffs, i.e substituting some natural environmental goods and services for others that are considered to be more useful. Thus for example, we plowed up grasslands and cut down native forests to create land for settlement and cultivation. In the process, we suppressed wildfires, eliminated predators, fortified shorelines, and controlled rivers for irrigation and hydroelectric power. Already the earth's dams hold nearly six times as much water in storage as occurs in free-flowing rivers (UNEP, 2005). These are all positive interventions in the process of domesticating nature, but the resulting trade-offs are of lower resilience than those originally provided by nature, and the consequences are often land degradation, desertification, poverty, and increasing marginalization of the world's disadvantaged.

There is a general impression among policy makers that a reserve of spare land exists for further settlement and cultivation. Although this was once the case, current estimates are that we are effectively at the limits of cultivable land, except for selected areas of central Africa and central Latin America (Young, 1999).

2.2. Urbanization

The continued, rapid urbanization of the worlds' population also strongly promotes the continued domestication of nature. By 2030, there will be 1.75 billion more urban residents, representing new urban land cover totaling about

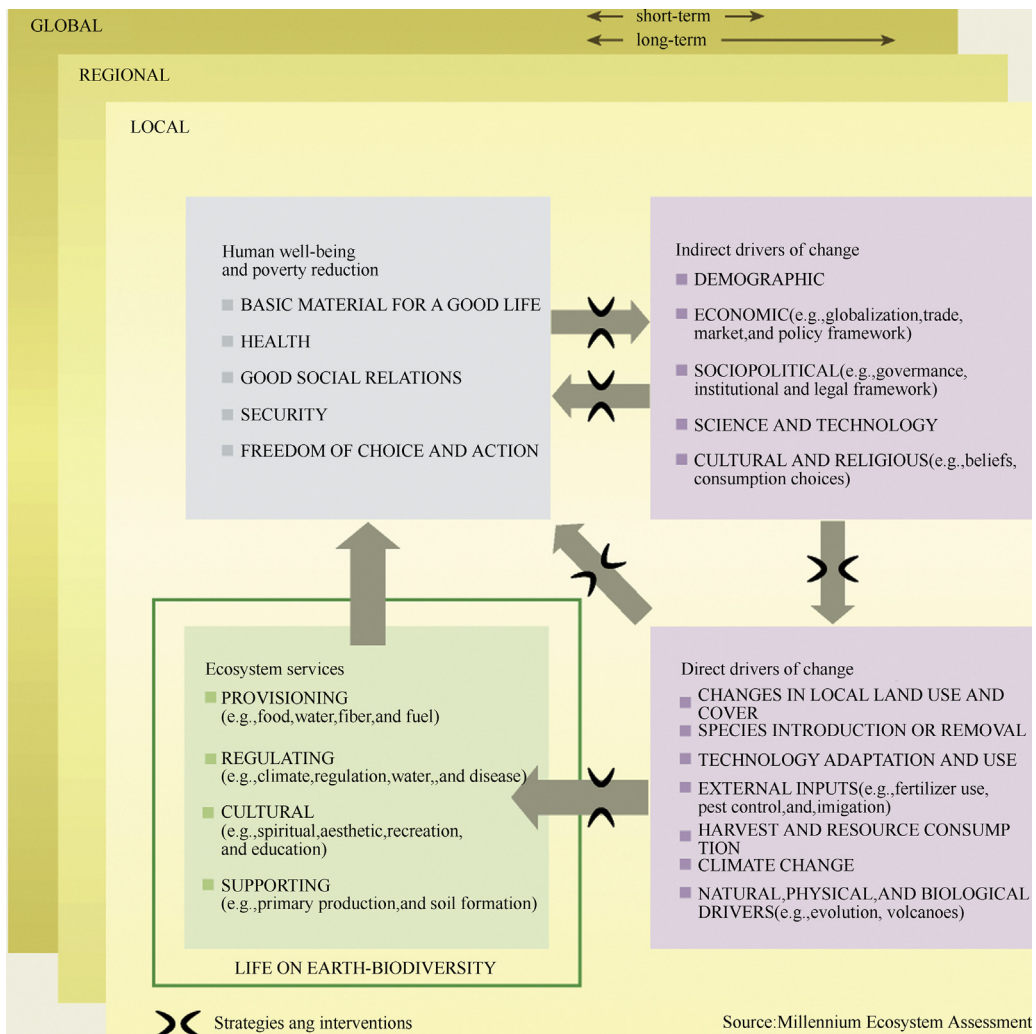


Fig. 2. Linkages among direct and indirect drivers of land use change, ecosystem services, and human well-being (UNEP, 2005).

42.4 M ha. These ecosystems are very different from those of rural areas, and because cities are the main consumers of most ecosystem services, the per capita ecological footprints will increase dramatically as incomes and consumptions increase. The choices and actions of urban dwellers are more powerful than those of rural populations, and these will influence policies and action far beyond their boundaries. Unfortunately, urbanites are generally unaware of the impacts of their decisions on environmental goods and services, and they are generally not knowledgeable on the trade-offs possible to provide for an improved environment. Regardless, future political discussions on the environment will be increasingly controlled by these urban influences, and further conversions of nature are expected. On the positive side, and with the higher education of urban populations, future discussions will increasingly focus on the trade-offs that we wish to impose on an already domesticated landscape, and soil conservationists must be ready to play increasingly important roles in these strategic discussions.

2.3. Globalization

Globalization is the chief process driving our age. It is a relatively recent phenomena, but one with potentially significant impacts on soil conservation policies. This is because of the new driving forces on the use and consumption of natural resources, namely income growth, (normally) high energy prices, rapidly escalating food prices, emerging biofuel markets, and climate change. Since 2000, world demand for cereals increased by 8%, but

prices more than doubled (Von Braun, 2007). This dramatic rise was due to a series of inter-related factors, including increased global populations (expected to increase a further 30%), high economic growth, particularly in China and India,⁵ shifting rural–urban populations,⁶ growth of the middle class with higher incomes and changing consumption habits,⁷ reduced cereal stocks,⁸ the search for alternate fuels, and climate change⁹. Another significant factor is the growing power and leverage of international corporations on the production and marketing chain (Von Braun, 2007)¹⁰, including the horizontal consolidation that has occurred across the agri-input industry, with the top three agri-chemical companies accounting for roughly half of the total market.

The full impacts of globalization are yet to be identified, but they are likely to vary among countries. There are emerging observations that the high food prices will result in reduced application of conservation technologies in food exporting countries, as farmers react to the higher prices. For example, in the USA in the early part of this century, up to 50% of farmers planned to reduce their commitment to the Conservation Reserve Program to capture the benefits of higher market prices. This was opposed by urban interests such as the nature NGOs and environmentalists, but supported by other urban interests such as bakers and food suppliers.

On the other hand, the high food prices may result in increased recognition of the value of conservation in food importing countries, as governments try to minimize the costs and impacts of high food prices. High fuel prices make agriculture more expensive, but may also help to promote zero tillage, as farmers move to minimize operating costs. On biofuels, there is growing consensus that they are neutral in terms of greenhouse gas contributions, but highly distorting of market conditions due to extensive farm subsidies.¹¹ At the same time, there are concerns on the potential negative impacts on soil conservation if crop residues are used for biofuels.

The concentration of marketing power in the hands of international corporations is not likely to benefit soil conservation since these companies emphasize food quality, food safety, and guaranteed supply at the required time, rather than global environmental benefits. However, these companies may be useful partners in promoting certification schemes for soil conservation, such as has happened for organic producers. Regardless, the soil conservation community must recognize that there are new players on the field, and that they wield considerable consumer and political power.

2.4. Information power

The age of information and the age of globalization are parallel driving forces. Whereas the latter is driven by trade, the former is driven by new technologies and the evolution of new and improved skills and understanding. Whereas once nation states derived national policies on issues such as the environment, the evolving approaches are to move toward international solutions on global environmental problems. This is best illustrated by the growing influences of the international environmental conventions, administered under the UN. These are increasingly powerful instruments, with highly effective convening powers, centered primarily on the urban constituency. For example, in 2007, the IPCC shared the Nobel Prize with former Vice President Al Gore for their work on Climate Change. This was achieved through the collaboration of hundreds of scientists from many countries in the space of only about 15 years. Such impact has never been achieved before.

3. New opportunities for promoting soil conservation

3.1. The international environment conventions

Several important international environment conventions have been developed and ratified by the global community since the Rio Earth Summit. The conventions emphasize international responsibilities for global

⁵Real GDP in these regions increased by 9% per annum between 2004 and 2006.

⁶Sixty one per cent of global populations are expected to live in urban areas within the next three decades.

⁷In South Asia, per capita consumption of rice is expected to decline by 4% by 2025, but consumption of milk and vegetables is expected to increase by 70% and meat, eggs, and fish by 100%.

⁸In 2006, global cereal stocks were the lowest since the early 1980s.

⁹World agricultural GDP is projected to decrease by 16% by 2020 due to climate change.

¹⁰Between 2004 and 2006, total global food spending increased by 16% to \$6.4 trillion; growth for the top food processors and traders increased by 13%; the top 10 producers of agricultural inputs increased by 8%; sales of the top food retailers increased by 40%.

¹¹The US imposes a duty of \$0.51 per litre of biofuel imported from Brazil, but subsidizes US corn production for biofuel.

environmental management, but recognize that there are corresponding local and national issues. While all deal with complex issues of land management, only the United Nations Convention to Combat Desertification and the United Nations Framework Convention on Climate Change, and its subsidiary, the Kyoto Protocol, specifically mention soil and land management, although this is increasingly being recognized also in the Convention of Biodiversity

The major international conventions and their relationships to agriculture are summarized as follows:

3.2. *Biodiversity and agriculture*

Biodiverse ecosystems have a fundamental role and importance in sustainable development, providing many important benefits. They often contain a variety of economically useful products that can be harvested or serve as inputs for production processes, as well as providing habitats for flora and fauna, and many key ecological services including those associated with nutrient cycling, disturbance regulation, availability and quality of water for agriculture, industry, or human consumption, etc. Agriculture is dependent on many biological services, and conversely, sustainably managed agricultural landscapes are important to the conservation and enhancement of biodiversity.

3.3. *Desertification and agriculture*

The objectives of the United Nations Convention to Combat Desertification (UNCCD) are to combat desertification, land degradation, and the effects of drought in arid, semi-arid, and dry sub-humid areas. Efforts to combat desertification are integrated with strategies for poverty eradication, and they are guided by the principles of stakeholder participation, international cooperation, and consideration of the specific needs of affected developing countries. National Action Programs (NAPs) are developed to define and promote preventive measures, enhance climatologic, meteorological, and hydrologic capabilities, strengthen institutional frameworks, provide for effective stakeholder participation, and review implementation regularly. The Convention gives priority to Africa while not neglecting other regions. It has no independent financing, but a Global Mechanism (GM) was established to mobilize and coordinate funds for combating desertification.

3.4. *Climate change and agriculture*

The linkages among land-use dynamics, management of rural landscapes, and greenhouse gases (GHGs) are identified in the United Nations Framework Convention on Climate Change (UNFCCC). During previous periods of rapid agricultural expansion, primarily in temperate regions, there was widespread conversion of native lands for agriculture, with concomitant huge emissions of CO₂ to the atmosphere due to oxidation of organic carbon in vegetation and soils. In recent years, deforestation in temperate regions has been reversed, but land conversions in the tropics has expanded considerably, and this has become a major source of CO₂ emissions to the atmosphere. Annually, about 20% of total anthropogenic CO₂ emissions are due to land conversions, and a further 5% is contributed from continual carbon losses from cultivated soils. Also, agriculture contributes around 50% of anthropogenic CH₄ emissions globally, primarily from the rumen of livestock and from flooded rice fields, and about 70% of anthropogenic N₂O, largely as a result of nitrogen inputs from synthetic fertilizers and animal wastes, and biological nitrogen fixation.

3.5. *International waters and agriculture*

Almost half of the world's land surface and 80% of the fresh river flows exist in major basins which cross or form international boundaries. Many of these shared watercourses are subject to alarming rates of environmental degradation, with strong linkages to land and water management. Deforestation and land degradation in international watersheds such as the Nile, Niger, Parana, and Indus affect rainfall patterns, increase the range of local temperatures, and cause major variations in water flow and quality. Soil erosion leads to siltation and sedimentation of lakes and reservoirs, shortens their lifetimes, destroys aquatic environments, reduces the productivity of their ecosystems, and diminishes the flood control capacity. Approximately 75% of global pollution of marine waters is from land-based activities, including pollutants such as pesticides, nutrients from fertilizers and sewage, sediments and solid wastes.

Pollution from nitrates and phosphorus is growing rapidly due to overuse of fertilizers, increased domestic and industrial sewage, and increased aquaculture.

3.6. The Ramsar convention

The Convention on Wetlands is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. It came into force in 1975, with a mission for “the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world”. Wetlands provide fundamental ecological services and are regulators of water regimes and sources of biodiversity at all levels – species, genetic and ecosystem. Soil conservation has an important role in the rehabilitation and preservation of wetlands, and prevention of serious and sometimes irreparable damage to provision of ecosystem services.

3.7. The impacts of the environment conventions on soil conservation

The international environmental conventions, particularly the UNFCCC and the UNCCD, illustrate the new dynamics in the geopolitical evolution of soil conservation. These conventions do not guide activities in soil conservation, but they focus discussions on linkages between land degradation and the environment, identify objectives to be achieved and procedures to be followed, identify new opportunities including new market based opportunities, and identify new partnerships and new money to fund the programs. Negotiations under Kyoto are illustrative of how new financial instruments (carbon credits) and market mechanisms (carbon trading) under the international conventions can be used to promote soil conservation. The general acceptance of these approaches indicate that market based opportunities will become available for the other international conventions, thus cementing good business practices with provision of environment goods and services.

The conventions on Climate Change and Desertification have highlighted the importance of soil conservation to the urban community and to the world. The importance of soil conservation vis-à-vis global environmental benefits is now recognized on a par with air and water quality. This provides opportunities to promote soil conservation on levels that have never been available before.

4. New international initiatives to mitigate land degradation

4.1. The global environment facility (GEF)

The GEF is the major funding agency for the international environment conventions. The GEF supports six focal areas and two cross-cutting areas with interest in land degradation. These include Land Degradation, International Waters, Climate Change, and Biodiversity. Each focal area is defined by long term Strategic Objectives, and supported by sets of Strategic Programs and expected outcomes (GEF, 2007). The GEF focal area on Land Degradation is designed to foster system-wide change to control the increasing severity and extent of land degradation and to derive global environmental benefits. Its tool is Sustainable Land Management (SLM). The focal area addresses the three major direct drivers for terrestrial ecosystem degradation, namely land use change, natural resources consumption and climate change. All project proposals incorporate the effect of climate change as an integral part of measures for sustainable land management. The GEF emphasizes that investing in SLM to control and prevent land degradation is an essential and cost-effective way to deliver other global environmental benefits, such as maintenance of biodiversity, mitigation of climate change, and protection of international waters.

The program takes a holistic view of land degradation, and works towards capturing synergy among the GEF focal areas as these relate to land degradation. Sustainable land management takes a landscape approach, which requires integration among all major issues involved in natural resources management, including the various factors influencing decisions about land use at the local, national, and regional level. This program invests in projects that integrate sustainable land management into national development priorities, strengthen human, technical, and institutional capacities, bring about needed policy and regulatory reforms, and implement innovative sustainable land management practices.

The GEF emphasizes and promotes development of appropriate enabling policy environments and institutional capacity to support sustainable land management (SLM), particularly in least developed countries which may lack such infrastructure. Related activities include harmonizing relevant planning and policy frameworks, integrating land use planning, and establishing institutional mechanisms for the management of trans-boundary resources. An essential part of the GEF's work in SLM is supporting on-the-ground investments in sustainable agriculture, rangeland, and forest management to address land degradation, such as packages to restore ecosystem health while improving local livelihood and the flow of goods and services they provide.

4.2. *TerrAfrica – the new alliance to combat land degradation in Africa*¹²

This program is based on the principles of Sustainable Land Management (SLM)¹³, giving it distinct advantages to pursue joint objectives in land degradation, poverty reduction, and environmental management. The focus of TerrAfrica is to ensure that SLM is mainstreamed more at the center of governments' and other stakeholders' priorities, attract new investment, scale-up successful programs, improve national and international knowledge on policies, advocacy, and investment packages for SLM. Intentions are not to promote new research and new technologies, but rather to focus on root causes of land degradation, including indirect impacts and socio-economic drivers, institutional and policy barriers, and markets for inputs and produce. It also provides support and capital to invest in land improvements, dissemination of knowledge, and support to analytical underpinnings to guide decision-making and to assess socio-economic costs and benefits. It also works to improve cooperation and harmonization among stakeholders including donor agencies, researchers, civil society, and farming communities.

The TerrAfrica program is being developed by a partnership of donors and governments, including the GEF and the World Bank, and operates in Sub-Saharan Africa at country and regional levels.

4.3. *MENARID – integrated natural resource management for the middle east and north Africa*

The objective of MENARID is to (i) to promote integrated natural resource management (INRM) in the production landscapes of the MENA region and (ii) improve the economic and social well-being of the targeted communities through the restoration and maintenance of ecosystem functions and productivity. In this program, investments are coordinated to: (i) promote enabling environments and mainstream the INRM agenda at national and regional scales, and (ii) generate mutual benefits for the global environment and local livelihoods through catalyzing INRM investments for large-scale impact. The program supports the GEF focal areas for land degradation, international waters, biodiversity, and climate change while contributing at the same time to improving livelihoods and reducing poverty. The operational objectives are to promote INRM in the production landscapes, while improving the economic and social well-being of the targeted communities through the restoration and maintenance of ecosystem functions and productivity.

The MENARID program provides technical assistance, and associated investments necessary to coordinate and harmonize INRM activities, in an effort to integrate IWRM, biodiversity conservation measures, and climate responses in the MENARID countries. The program promotes policy and institutional reforms to mainstream INRM and IWRM, biodiversity conservation measures, and climate responses in national policies, planning processes, and legal frameworks. The program invests in restoration of arid and semi-arid ecosystems, rehabilitation and restoration of degraded lands (including farmlands, rangelands and watersheds), as well as stimulates income-generating

¹²This program was developed because past investments and research on land degradation in Africa have been inadequate compared to the scale of the threat, land degradation continues to accelerate, and it is recognized as a genuine constraint to economic growth (World Bank, 2005). Currently, about 65% of Africa's population is directly and indirectly affected by land degradation. Agriculture generates about one-third of the continent's Gross National Income, but agricultural production has been falling at about 3%/yr as a result of land degradation and other causes. The loss in gross annual income due to land degradation is estimated at USD 9 billion for Africa (GTZ, Fact Sheet Desertification in Africa). As a consequence, food insecurity in Sub-Saharan Africa was expected to increase by 25% between 2000 and 2010.

¹³The pillars of SLM are the application of agro-ecological principles to farming; an emphasis on human resource development and knowledge based management techniques; a participatory, decentralized and farmer centered approach; the value placed of natural and social capital enhancements in addition to economic efficiency gains, and the role of strong and self reliant rural institutions (Smyth & Dumanski, 1993).

activities for the local populations, including increased adaptation to climate change. The fourth component emphasizes knowledge management, sharing, and up-scaling best practices.

The program is delivered through targeted technical assistance and associated investments to strengthen institutional and human resource capacity for improved coordination at the national level, as well as on-the-ground operational capacity at the local level.

4.4. The European Union Thematic Strategy on soil protection

The Environment Commission of the EU is working on a strategy to provide EU member states with a framework within which to protect soil and use it in a sustainable way. For the first time, they are treating soil protection on the same level as water and air. The objectives are to harmonize legislation, policies and programs to ensure an adequate level of protection for all soil in Europe. These are the first steps in the development of a Thematic Strategy to protect soils in the European Union

4.5. Conservation Agriculture: an international movement of farmer associations

Conservation Agriculture (CA) is a new, farmer driven, international movement that is gaining acceptance because of the potentials to enhance farm profits, while concurrently improving environmental services, soil quality, and mitigate land degradation. CA emphasizes the use of modern technologies that enhance the quality and ecological integrity of the soil, but the application is tempered with traditional knowledge of soil husbandry gained from generations of successful farmers. This holistic embrace of knowledge, as well as the capacity of farmers to apply this knowledge, and innovate and adjust to evolving conditions, ensures the sustainability of those who practice CA. CA provides direct benefits to environmental issues of global importance, including control and mitigation of land degradation, mitigation of climate change, improved air quality, enhanced biodiversity including agrobiodiversity, and improved water quality. It is achieved through community driven development processes whereby local, regional and national farmer associations, working through community workshops, farmer-to-farmer training, and on-farm experimentation, but with technical backstopping from conservation professionals, decide on the technical innovations for adoption and the best procedures for implementation.

An international working group has developed a comprehensive definition of CA to clarify relationships between CA and no-tillage (Dumanski, Peiretti, Benetis, McGarry, & Pieri, 2006). This identifies the principles of CA to include maintaining permanent soil cover, promoting a healthy, living soil, promoting balanced application and precision placement of fertilizers, pesticides, and other crop inputs, promoting legume fallows, composting and organic soil amendments, and promoting agroforestry to enhance on-farm biodiversity and alternate sources of income. The FAO definition of CA centers on avoiding mechanical soil disturbance, maintaining continuous soil cover, and adopting diverse cropping systems (Kassam, Derpsch, & Freidrich, 2014).

No-tillage remains the main stay of CA, and adoption of these technologies has expanded rapidly over the past several decades (Derpsch, 2005). No-tillage is now used on more than 125 M ha worldwide, primarily in North and South America. Approximately 45% of no-tillage technology is practiced in South America, 32% is practiced in the United States and Canada, 14% in Australia and New Zealand and about 9% in the rest of the world, including Europe, Africa and Asia. Using these technologies, grain production has increased, soil carbon has been enhanced, water quality improved, and consumption on-farm of fossil fuels has decreased (Kassam et al., 2014).

5. Mobilizing market based initiatives for land degradation and soil conservation

5.1. The Kyoto protocol and soil conservation¹⁴

The Kyoto Protocol focuses on controlling and reducing GHG emissions, primarily from industrial and transportation sources, but it also recognizes the corresponding opportunities to be gained through better management of carbon reservoirs and enhancement of carbon sinks (sequestration) in forestry and agriculture. The latter are

¹⁴The Kyoto Protocol is currently being renegotiated.

achieved through soil conservation, improved local land management practices, such as crop rotations and zero tillage, and management of land use change (conversions).

Global, national, and regional C markets are evolving in the US, Europe, and Asia. However, the prices being offered for a certified C credit (one t CO₂ equivalent) are highly variable, indicating that the market is still very immature.

Although governments have major roles in developing the market by regulating policy and directly and indirectly setting the price through incentive payments and other interventions, the current action of governments in the evolution of these markets is not clear. Thus, it is uncertain whether current market prices will be sufficient to entice many farmers to make the necessary changes in land management to ensure sufficient sequestration to meet Kyoto requirements, particularly in North America.

5.2. *Payment for environmental services (PES)*

In Latin America, water-related PES schemes are gaining popularity as instruments to finance activities of natural resources management for improving water availability and quality (Kiersch, Hermans, & Van Halsema, 2005). Schemes range from local initiatives with or without external financing to national programs financed through cross-sectoral subsidies. Most PES schemes are negotiated directly between participants, with payments to providers based mostly on available funds and opportunity costs.

While these are promising mechanisms to improve natural resource management, providing there are adequate numbers of water users willing to pay, it would be more useful to expand such schemes to include other environmental services such as carbon sequestration or biodiversity conservation. Such expansion, however, would require new institutional mechanisms to combine local and global markets for environmental services, and the development and monitoring of new technologies which simultaneously provide these services.

5.3. *New partners in soil conservation – the nature NGOs*

The nature NGOs are emerging as important partners in soil conservation. The potential for this partnership is illustrated in the highly successful North American Waterfowl Management plan and the programs of Ducks Unlimited Canada (DUC).

DUC is part of the larger North American Ducks Unlimited family, with a mission to conserve, restore and manage wetlands and associated habitats for North America's waterfowl, providing benefits to wildlife and people. DUC is a private, non-profit, Canadian owned and governed, charitable association. The vision of DUC is to achieve a mosaic of natural, restored and managed landscapes capable of perpetually sustaining populations of waterfowl and other wildlife.

Ducks Unlimited Canada, with its partners in the USA and Mexico, started the North American Waterfowl Management Plan in 1986. This has since expanded to become one of the most successful conservation programs in the world. This international agreement unites federal, provincial/state and municipal governments, non-governmental organizations, private companies and many individuals. The program has generated over \$3.2 B, and successfully conserved over 5 M ha of wetlands, particularly the important areas of the flyover in North America.

DUC puts major emphasis on forming partnerships with private land owners in joint ventures where there are mutual benefits. For example, they promote and facilitate establishing conservation easements, where payment or tax benefits accrue to landowners who agree to manage their land using conservation based technologies. In particular, they promote zero tillage and other soil and crop conservation practices which concurrently enhance soil quality, conserve habitat, and improve biodiversity. These popular initiatives have secured over 17,000 landowners as members in the joint ventures in the prairie region of western Canada. More recently, DUC has begun work to broker agreements between farmers and governments in marketing carbon sequestration credits under the Kyoto Protocol.

6. **Conclusions**

The global terrestrial environment consists of a mosaic of ecologically linked, natural and human land use ecosystems, and the health and integrity of these ecosystems depends on the mix and the synergy of processes that pass between them to produce a steady flow of production and environmental goods and services (GEF, 2004). The

links among ecosystem integrity, human welfare, and human health are increasingly being realized, and it is recognized that land degradation affects selected portions of these linkages. These degradation processes must be more carefully controlled if the ecosystem components, functional cycles, and services that flow there-from are to be ensured into the future.

Understanding the components, processes, and synergy within and between natural and converted (managed) ecosystems requires a landscape approach rather than single factor studies. Landscape studies promote understanding of ecological and socio-economic interactions, linking local benefits to global environmental goods and services. Agro-ecosystems and other managed ecosystems experience pressures, energy flows, and dynamics that differ from natural systems, and these have to be understood not only in terms of capital return (yield, etc.) but also in terms of their influence on ecosystem services (Dumanski et al., 2002).

There are new driving forces that will influence the geopolitical agenda for soil conservation. These include the rising consumerism of the global middle classes, including the rapidly urbanizing populations of China, India, and Latin America. The processes of globalization, modern technologies of knowledge management, and the rising influence of urbanites have the potential to considerably change the way we promote soil conservation. We must be cognizant of these driving forces, and react to capture the opportunities they present. At the same time, there are new and increasingly powerful players on the soil conservation scene, including the nature-based NGOs which are emerging as influential players in soil conservation. We should pursue partnerships with these to ensure balanced focus on production, economic, and environmental goods and services. The nature-based NGOs have considerable convening power and considerable capacity for fund raising, but more importantly, they are increasingly influential in developing financing schemes for non-market goods and services from the environment. These are important initiatives for soil conservation.

There are many promising, new opportunities for soil conservation, as illustrated in the international environment conventions, the evolving, new programs under sustainable land management, and the evolving international trading schemes. This will require some shifts in focus for the soil conservation community, a move from defining the processes of erosion and developing technological fixes, towards more involvement in the social and political processes of community led soil conservation. More attention must also be given to removing the barriers and bottlenecks to soil conservation. Also, the soil conservation community must be more proactive in mobilizing and empowering the farmers and herders of society in the fight against land degradation, since they are the immediate direct beneficiaries of improved land management and those who suffer the most from land degradation. The international environment conventions provide guidance and opportunities for such shifts, and some successes achieved with international institutions, such as the International Union for the Conservation of Nature, Ducks Unlimited, and other environmental NGOs, provide guidance on approaches.

Thus, the world has changed and the science of soil conservation must also change. The soil conservation community must stop looking at what has worked in the past, but look forward to what is needed in the future. It must move from perennial studies of erosion and prescriptive approaches, to more holistic and participatory (social) approaches. It must move to procedures which integrate soil conservation, rural landscape management, and technological innovation, with profit generating activities and market opportunities. We must get on board with the new driving forces and new program opportunities; we must catch the wave, think beyond the box. The soil conservation community has much to offer, and much can be achieved in partnerships in environmental management, soil conservation, and human well-being.

Appendix. The Millennium Ecosystem Assessment

The state of the global environment: the impacts of environmental degradation were assessed in the Millennium Ecosystem Assessment report (UNEP, 2005). This identified the following:

- Approximately 15 out of 24 major ecosystem services are being degraded or are used unsustainably. These include such life support services as fresh water, air and water purification, regulation of climate, natural hazards and pests, and capture fisheries. Many such services are being degraded to increase supply of other services, such as food production.
- Evidence is increasing that the ecosystem changes are increasing the likelihood and frequency of potentially irreversible changes, such as creation of dead zones in coastal environments, shifts in regional climates, abrupt alterations in water quality, collapse of fisheries, etc.

- The harmful effects of ecosystem degradation are disproportionately born by the poor, thereby contributing to growing inequalities and sometimes social conflict.

The consumption of ecosystem services is expected to grow as a consequence of an expected three to six-fold increase in global GDP by 2050, regardless of an expected leveling off of global population growth (UNEP 2005).

In terms of land use and ecosystem degradation, the report cites the following:

- More land was converted to cropland since the Second World War, than in 150 years between 1700 and 1850. Medium and intensively managed agricultural lands now occupy about 25% of global terrestrial surface.
- Approximately 20% of coral reefs were lost and a further 20% degraded, and 35% of mangrove swamps were lost in the last decades of the 20th century.
- Fresh water withdrawals from lakes and rivers doubled (70% for agriculture), and water impoundments behind dams quadrupled.
- Since 1960, flows of biologically available nitrogen have doubled, and flows of phosphorus have tripled. Almost half of all synthetic fertilizers ever used, has been used since 1985.
- Since 1750, atmospheric concentration of CO₂ has increased by 32% (from 280 to 376 ppm), due to fossil fuel use and land use changes. Approximately 60% of this has taken place since 1959.
- Human activities are resulting in significant losses of global biodiversity, and changing the diversity of life on earth.
- Frequency and risks of floods and fires has increased 10 fold in the last 50 years; natural catastrophes now account for 84% of insured losses.

Mitigation of ecosystem degradation: ecosystem degradation and land degradation can rarely be reversed without attention to the direct and indirect drivers of land use change. Both economic growth and population pressures result in increased consumption of ecosystem services, but the harmful environmental impacts of any type and level of intervention depend on the efficiency of technologies used. Many changes in ecosystems services involve privatization of what were formerly common pool resources. e.g water user rights, land user rights, etc. In the process, some groups become marginalized and often lose their traditional access to these resources. An example is the loss of grazing rights for indigenous peoples with the privatization of rangelands. It is estimated that the important drivers of ecosystem change are unlikely to diminish in the first half of this century, but two main drivers, climate change and nutrient loading, will become more severe (UNEP, 2005), and increasingly this will occur within the context of globalization.

Impacts of ecosystem degradation on society: ecosystem degradation affects wealthy as well as poor populations, but the impacts on wealthy populations are minimized and mitigation is easier because they can afford substitutes and other measures that often are out of reach for the poor. However, substitutes are not available for all services, and mitigation can be prohibitively expensive beyond the threshold of collapse, and substitutes can have other negative environmental impacts. On the other hand, poor populations suffer more, and land and ecosystem degradation are sometimes principle factors contributing to rural poverty (World Bank, 2005). The pattern of winners and losers in ecosystem change, particularly for those most vulnerable and those most poorly equipped to cope with the major changes in ecosystem services, such as the rural poor, women, indigenous populations, etc., is not normally considered in management decisions. The reliance of the rural poor on “free” ecosystem services, such as soil fertility, harvesting of NTFPs, are rarely measured and thus not reflected in national statistics, but for certain societies, these benefits can be substantial.

Ecosystem resilience: ecosystems have a large capacity to absorb impacts and abuse, and the impacts of degradation may not be readily apparent. However, once a threshold is crossed, the systems change to a very different state. This change can occur quickly, it can be extensive and large in magnitude, and it can be difficult, expensive, or impossible to reverse. Thus, degradation of ecosystem processes may be slow to be observed, or the impacts may be experienced at some distance from the source of damage. For example, it takes decades for the full impacts of phosphorus loading to become apparent through erosion, eutrophication, etc. Similarly, it takes centuries for loss of soil organic carbon to become apparent through climate change.

This delayed reaction in ecosystem degradation is increasing the likelihood of nonlinear, potentially irreversible global change with important implications for human welfare, e.g. climate change. One of the major driving forces causing nonlinear change is the loss of biodiversity, including soil biodiversity. This is because the soil is a living body, maintained through the ecological interactions and balance of its biological constituents, and the loss of genetic diversity in the soil decreases the resilience of this ecosystem.¹⁵ The loss of resilience is also caused by the continued, direct impacts of multiple drivers, such as over-harvesting, nutrient loads, climate change, etc. Our capacity to identify and predict such changes and the thresholds when they occur are still very imperfect.

The value of ecosystem services and natural capital: natural capital consists of natural resources, ecosystem resources, and land. These resources are assets that yield goods and services over time that are essential to the sustained health of our environment and the economy. Protection and enhancement of natural capital will sustain food production, improve water quality, increase recreational opportunities, mitigate flooding, decrease net greenhouse gas emissions, improve air quality, provide habitat, and produce many more tangible and intangible benefits to society. The degradation of ecosystem services represents a loss of capital assets. Many ecosystem services are available freely, and degradation is not reflected in standard economic value systems. Non-market values of ecosystem services are often allowed to degrade, because resource management decisions are mostly influenced by those ecosystem services that enter the market system.

Agriculture is often the cause of ecosystem degradation. For example, damage from agriculture in the UK to water sources, air quality, off-site soil erosion, and biodiversity was \$2.6 billion, or 9% of gross farm receipts. In addition, reduced value of waterfront and recreational uses, water treatment costs, tourism, etc. was estimated at \$100–150 M per year, with additional \$77 M per year in mitigation costs (UNEP, 2005).

The value of protecting or rehabilitating natural capital often exceeds by several fold its use in production.¹⁶ For example, in Canada, the estimated net value of conserving or restoring natural areas is about \$195/ha/yr in the Grand River Watershed of Ontario, about \$65/ha/yr in the Upper Assiniboine River Basin in eastern Saskatchewan and western Manitoba, and about \$126/ha/yr in the Mill River Watershed in Prince Edward Island (Oliweler, 2004). In the Catskill Mountains, New York, an investment of \$1–1.5 billion to restore ecosystem functions in watersheds for New York City, resulted in a saving of \$6–8 billion in water treatment plants (Chichilnisky & Heal, 1998). The annual environmental value of C sequestration in the U.S. Great Plains is estimated at US\$200, four times as great as the net private returns to farmers for meat, wool, and milk, and about half the market value of the land (Pretty et al., 2001). In New Zealand, the value of extra organic matter gained through C sequestration is estimated at \$16.50–\$91.50/ha/yr. The environmental services of sequestering C and N to mitigate air and water pollution is 42–73 times higher than the lost agricultural production value due to land degradation (Sparling, Wheeler, Vesely, & Schipper, 2006).

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¹⁵Resilience is the disturbance that a system can absorb without crossing a threshold to a different structure and functions.

¹⁶Overall, land degradation probably affects more than 2.6 billion people in more than 100 countries. The economic cost is generally estimated to range between 1 and 9% of agricultural (cropping) gross domestic product (GDP) in selected countries in Africa, resulting in an annual cost of approximately \$10–90 billion (Requier-Desjardins & Bied-Charretton, 2006).

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