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1 ORGANIZATION

1.1 Long-term Strategy of ISRIC

There is an increasing demand for a user-oriented interpretation of natural resource information. This information forms a basis for an improved understanding of the dynamics of soil and terrain characteristics under changing land use. Natural resource information provides essential components for an assessment of the potentials and constraints of soils for food production, and thus has significant implications for food security.

Food security is threatened by the rapidly increasing world population (80 million people annually in the coming decades), and the alarming extent of soil degradation (1.2 billion hectares are affected according to the World Resources Institute, quoting GLASOD estimates). These conditions are largely responsible for an increasing deficit in aggregate cereal output. IFPRI (The International Food Policy Research Institute) has predicted that this deficit may increase from 80 million tons in 1988 to almost 250 million tons by the Year 2020.

Terrestrial eco-systems play also a role in regulating global atmospheric conditions. They are important sources of a number of greenhouse gases. Good quality, up-to-date information on natural resources is urgently needed for an improved quantified interpretation of the impact of the terrestrial eco-system on global climate change.

Historically, ISRIC's mission has been the collection and dissemination of scientific knowledge about the soils of the world, aimed at their suitability and utilization for various agricultural and non-agricultural purposes. In particular, the establishment of an international collection of soil monoliths in Wageningen, and support for national and regional soil reference collections in the developing countries, formed the core of the Centre's work. With the rapid emergence of information technology, ISRIC has developed methodologies for the systematic storage of data on natural resources (i.e. soils and terrain data) in a computer-compatible electronic format. Until recently, ISRIC was considered as a provider of soil and terrain information, either in the form of soil profile databases (ISIS), or as geographically referenced soil and terrain digital databases (SOTER). Through its services as a documentation centre about soils of the world (reports, maps and other information with emphasis on soils of the developing countries). ISRIC also has played an important role as an educational centre for young soil scientists through the display of its unique collection of soil monoliths representing the major soil groups world-wide as shown on the FAO-Unesco Soil Map of the World.

In 1993, ISRIC's Scientific Advisory Council recommended that the Centre should shift its emphasis to include providing information for non-soil scientists and policy-makers. A similar opinion was also expressed by the future proposed activities of the ISSS: "to seize opportunities for soil science and its applications in the 21st century". Their declaration of intent, drafted at the XVth World Congress of Soil Science, states that communication between professional soil scientists and the users of soil science expertise requires strong improvement, because generally there is a narrow perception of soil science as a restricted discipline lacking dynamic inter-action with other sciences.

ISRIC intends to play a continuing role in the improvement of communication between producers and users of soil information and the inter-action between them. There is a need to develop user-friendly products/information derived from primary soil and terrain data to satisfy the user needs. This was the central theme to emerge during an international workshop held at ISRIC in 1995, bringing together existing and potential collaborators of ISRIC's programme on National soil Reference Collections and Databases (NASREC). They concluded that the apparent gap between users of land and producers of information on natural resources may be bridged by linking indigenous knowledge with nationally and internationally accepted scientific expertise. Institutions dealing with land resource data should initiate approaches to the users of soil and terrain information to participate in maintaining and upgrading their role of providing user-oriented information at different levels of aggregation.

ISRIC's mission statement can be summarized as follows: "To collect, store and process soil and terrain information with emphasis on soils of the developing countries with the objective to contribute to research efforts on sustainable utilization of the land, with an emphasis on the impact of land degradation on food productivity, and on efforts to better quantify global change processes. ISRIC will promote the inter-action between producers and users of information through programmes strengthening the capacity of soil institutions in developing countries, through developing strategic alliances with user-oriented national and international agricultural research organizations, and through enhancing the accessibility of soil and terrain information".

ISRIC's long-term strategic plan will focus on the following programmes:

1) ***Assessment of soil and terrain resources for sustainable utilization of the land***
   In close collaboration with international and national research institutes, ISRIC will use its soil and terrain information databases in combination with information produced by other partners (e.g. on climate, land use, socio-economic attributes) to assess the quality of soil and terrain resources (its potential, limitations and its spatial variability), to obtain a better understanding of the impact of soil degradation on biomass production, to assess the impact of land use changes on the soil conditions, and to provide information to better quantify global change processes. These activities are the core of ISRIC's research and development programme.

2) ***Collection, storage and processing of information on soil and terrain resources***
   In joint programmes with international organizations and with catalytic support from various donor agencies ISRIC will continue to collaborate in the development of soil and terrain databases and methodologies to harmonize databases from various international and national resource institutions.

3) ***Strengthening natural resources institutions in developing countries***
   Training and technical support assistance in land resources information technologies, such as the establishment and use of soil reference collections, development of national pedon databases, establishment and use of geo-referenced soil and terrain databases, and the use of soil laboratory management systems to improve data quality.

4) ***Enhancement of the accessibility of soil and terrain information***
   ISRIC will continue to serve as a centre for documentation about the soils of the world, and to assemble soil monoliths, reports, maps and other relevant information on soils of the developing countries. ISRIC's World Wide Web home-page will not only provide meta-information on its collection of soil information, including its own in-house developed databases, but will also provide information on how to access published soil and terrain resources.

ISRIC's long term strategic programme has been reviewed in 1996 by its Scientific Advisory Council and other soil and natural resources scientists world-wide through the dissemination of discussion note: "The Future of ISRIC". Most respondents were users of soil information. They stressed the importance of ISRIC's soil profile database programme and its georeferenced Soils and Terrain Database programme and stressed the need for higher donor awareness. "Keep hammering on the need to update the global geographic soil database (through SOTER), until people see the light" was the most significant part of their advice, even though funding this sort of work is not glamorous in the short run.

In order to attract donors, ISRIC believes that partnerships ("strategic alliances") should be established with institutes or organizations who need derived information from base-line data on land qualities and changes in land qualities as a result of human intervention. The various eco-regional initiatives of the CGIAR (Consultative Group for International Agricultural Research) are examples of programmes that could make use of ISRIC's information. Although "small is beautiful", ISRIC as a relatively small research and development centre, should further strengthen alliances with other organizations and natural resources institutions, whether producers or users of information, through joint programmes and with adequate funding. Such partnerships will avoid competition and duplication of efforts and be mutually beneficial.

1.2 Programmes and Activities

ISRIC's programmes and activities are directly related to the four pillars of the Centre's long-term strategy. They have in common the provision of accessible, useful and user-friendly information about soil and terrain resources. This information is targeted to a wide and diverse group of users including policy makers, land resource managers, scientific community (both earth scientists and no-earth scientists) and indirectly the ultimate users of the land.

Detailed information on various activities for each area of activity may be found in subsequent sections.

Collection, Storage and Processing of Information on Soils and Terrain Resources

This programme forms the core of ISRIC's activities. Primary data on natural resources form the baseline for the assessment of land qualities and for monitoring changes of these qualities as a result of human action. The demand for accurate up-to-date and readily accessible data on natural resources is repeatedly expressed and is also heard in recently formulated international research and development initiatives such as the Global Terrestrial Observatory System initiative (GTOS); the Soil, Water and Nutrient Management Initiative (SWNM); the FAO Strategy for Planning of Sustainable Use of Land Resources:towards a New Approach; the Land Quality Initiative (LQI); and various activities of the International geosphere-Biosphere Programme (IGBP).

Provision of data and information is essential for a successful implementation of Agenda 21 and is a recurring paragraph in almost all chapters of that document. As formulated in Chapter 14 (Promoting Sustainable Agriculture and Rural Development), paragraph 10b states "Examine and undertake surveys and research to establish baseline information on the status of natural resources related to food and agricultural production". Section 4 of Chapter 10 is entirely concerned with the bridging of the data gap. "In sustainable development the need for information arises at all levels, from that of senior national and international decision-makers to the grass roots and individual levels". In a final statement it is observed that there is a wealth of data and information that could be used for sustainable development. "Such information is not adequately managed because of lack of personnel, funding, technology and often the awareness that the information is valuable".

These observations provide ample rationale for ISRIC to continue its efforts to collect, store and process information of soils and terrain resources. The Centre's activities related to this programme include the ISRIC Soil Information Systems database (ISIS, Section 3.1.1), the World Inventory of Soil Emission Potentials (WISE, Section 3.1.2); the World Soils and Terrain Digital Database (SOTER, Section 3.1.3) which comprise geographically referenced soil and terrain databases at continental scale (1:5 million). Under a joint programme with UNEP and FAO, ISRIC has developed a soil degradation status database for South and Southeast Asia in cooperation with national institutes of 16 countries (Section 3.1.4). This study can be considered to be a sequel to the earlier published Global Assessment of Soil Degradation survey (GLASOD). ISRIC is also an active partner in the World Overview of Conservation Approaches and Technologies (WOCAT) programme which is coordinated by the Centre for Development and Environment of the University of Berne (Section 3.1.5).

Assessment of Soil and Terrain Information for Sustainable Utilization of the Land

The various socio-economic and environmental conditions, which are driving-forces for land degradation, loss of biodiversity and contamination of soils, rivers and ground-water. Despite the overwhelming influence of terrestrial ecosystems, their characteristics have been subject to perturbation by human-induced changes of the global environment. Within this field there exists a wide range of possibilities for applied research and development where ISRIC can participate. Already, ISRIC has contributed to programmes to better quantify the present status of human-induced soil degradation; to assess the risks of land degradation, as in the case study in Kenya (Section 3.2.2), based on the Kenya SOTER database; to assess the impact of land degradation on food production in the framework of UNEP's Pilot Global Environmental Outlook Programme (Section 3.2.3).

At the grass roots level, ISRIC has collaborated with the Information Centre for Low External Input and Sustainable Agriculture (ILEIA) to carry out a number of soil investigations in three agro-ecological zones. Three countries were chosen, Ghana, Peru and Philippines, in which contrasting potentials exist for development and where agricultural advisory institutes have as one of their main objectives the integration of farmers' knowledge of soil and land suitability with national and international systems of suitability classification. (Section 3.2.4).

In the framework of a detailed EC-funded STD-3 Biodiversity project entitled "An integrated study of land properties, their floristic indicators and appropriate farming systems in an acknowledged biodiversity centre in Amazonian Peru", ISRIC has undertaken soil analytical work and written the text of a chapter on the containing sections on soil formation, characterization, classification and land evaluation (Section 3.2.5).

At the opposite end of the scale, ISRIC staff have prepared a number of global studies using the WISE database (Section 3.1.2). These include an analysis of soil pH by FAO-Unesco Soil map of the World Major Soil units, a computation of total carbon and nitrogen stocks in the soils of the world and a study of soil water-holding capacity. In another WISE-related development, ISRIC prepared a uniform dataset for pedotransfer functions at the request of the Global Task Force of the IGBP-DIS (Details are given in Section 3.2.1).

Strengthening the Capacities of Soil Institutions in Developing Countries

Traditionally published information on soil resources, mostly in the form of soil maps, reports and complementary soil analytical data are difficult to interpret by non-soil scientists. In its programme to strengthen the capacity of institutes in Developing Countries, ISRIC has played and will give more emphasis in the future to the development of user-oriented information derived from primary data. This reflects the need to improve links between policy, research and practice, particularly between (national) research organizations, (users) and national soil institutions (producers).

One of ISRIC's main programmes in this field was the NASREC programme which came to an end in 1993. This programme was evaluated by an international panel at the request of the Directorate General of International Cooperation (DGIS), the funding body. The panel recommended that an international workshop be held, bringing together existing and potential collaborators of NASREC (Section 3.3.1). The theme of the workshop was "Users and their demands for soil information". ISRIC staff edited and published the proceedings of the workshop and developed a project proposal for a continuation of the NASREC work, based on the advice of the evaluation panel and the opinions expressed by the workshop participants.

Requests for training sessions using SOTER have been received from many countries. At the conclusion of the Kenya SOTER project (KENSOTER), March 1995, (Section 3.1.3), ISRIC organized an East African workshop on SOTER at the request of UNEP. One reason for UNEP's interest in SOTER is that the world is rapidly becoming internationalized. Many issues are not confined within national boundaries, so UNEP sees the need for standardization of information enabling policies to be formulated easily, and that decisions and action can be taken at an international level based on sound information for an entire subregion. "By illustrating a wide variety of applications from the KENSOTER database we should be able to convince others, including the funding agencies of the enormous value of a well-structured, electronic database like SOTER" (SOTER Report 9, Opening Statement by UNEP).

At the conclusion of the Hungarian SOTER project, a regional workshop and training programme was organized by RISSAC (Budapest) for countries in Central and Eastern Europe. Following the conclusion of this reporting period, a new project was formulated using SOTER techniques, for development of a Soil Vulnerability Assessment for Central and Eastern Europe (SOVEUR).

The analytical laboratory of ISRIC developed a Good Laboratory Practice (GLP) manual for the proper documentation and management of laboratory data, supported by a Laboratory Information Management System (LIMS). A special version has been developed to serve small- to medium-sized laboratories dealing with soil, plant and water samples (Section 3.3.3). Training in the use of GLP/SOILIMS has been provided by ISRIC staff within the Soil and Plant Analytical Network for Africa programme (SPALNA). ISRIC was commissioned by DGIS to assist in the establishment of a soil, plant and water laboratory in the Fayoum basin of Egypt (Section 3.3.4).

Enhancement of the Accessibility of Soil and Terrain Information

There is an urgent need to improve the public image of soil science and its standing in the scientific community. Soils are taken for granted by the majority of the population, but despite the image of being "just dirt" soils are an extremely important component of the environment. The pressing need to make soil and terrain information more accessible calls for communication using many different techniques. Modern technology has revolutionized the means of transfer of information and it can be applied to enhance the interaction between pedologists and farmers, extension workers, planners, regulatory agencies and decision makers as well as keeping the man in the street well-informed (ISSS, 1994).

Since its establishment some 30 years ago, ISRIC has had, as one of its central programmes, the collection and analysis of soil profiles representative of the units of the FAO-Unesco Soil map of the World. A selection of these soil profiles are on permanent display in ISRIC's exhibition hall. The profiles, originally arranged according to the FAO System of soil classification, have been re-arranged according to major soil-ecological zones, making the exhibition more accessible to non-soil scientists (Section 3.4.1).

ISRIC's documentation facilities, a systematic collection of books about soils, including the "grey literature" of soil reports, soil maps and other related thematic maps, and slides are consulted regularly by scientists, publishers, consultants and students. In order to make ISRIC's documentation more accessible, all books and 2000 (out of 5000) maps have been entered into the database using the Cardbox Plus Program (Section 3.4.2).

In 1992 the draft World Reference Base for Soil Resources (WRB) was presented at the 15th World Congress of Soil Science. The WRB is intended to provide scientific depth and background to FAO's Revised Legend of the Soil Map of the World. During the period 1994-1996, comments were sought, and a first edition will be ready for presentation at the 16th World Congress of Soil Science, to be held in Montpellier (Section 3.4.3). From the inception of this project, ISRIC has been an active partner in its development.

ISRIC participated in the Land Quality Indicators Initiative of the World Bank, FAO, UNEP, and the CGIAR. ISRIC was commissioned to develop a metadatabase describing data sets relevant to land qualities. An alliance was formed with the Consortium for International Earth Science Information Networks (CIESIN) for the development of the LQI information systems software. The metadatabase thus developed will further enhance the accessibility of natural resource information (Section 3.4.4).

ISRIC shares the concern of the Scientific Community about copyright restrictions in the use of databases. The concept of freeflow of information in accordance with the principle of reciprocity and equity. The Centre adheres to its policy of being an active partner in any project in which its own baseline data are utilized, whether in funded activities, or through non-funded activities if they are relevant to ISRIC's aims. Access to its own databases on soil and terrain resources is provided once these are peer-reviewed and published. Access to databases developed in cooperation with national programmes require permission from the national institutions involved. Through participation in international workshops, conferences and symposia and through the provision of lectures for the MSc programme at ITC, ISRIC further enhances the accessibility of its informational resources.

1.3 Institutional Developments

The reporting period 1995-1996 coincides with the first two years since the formal act of establishment of the ISRIC Foundation in December, 1994. Simultaneously, a document outlining the continuing framework of cooperation between ISRIC and ITC was signed by the Chairman of the Boards of ITC and ISRIC. In 1995, the Board of ISRIC requested that the Chairman of the Scientific Advisory Council of ISRIC convene a meeting to provide the ISRIC Board with the strategic choices for ISRIC's future research and development programme. As it is not possible to bring together all the international and Dutch members of the Scientific Advisory Council for a council meeting, it was decided to submit a discussion paper entitled "The Future of ISRIC" to all council members. The discussion note was also sent to selected soil and environmental scientists world wide. Responses were received from 40 individuals and their opinions were taken into consideration by the ISRIC management staff in their development of ISRIC's long-term strategy. This document, outlined in Section 1.1, was approved by the Board of ISRIC in November, 1996.

In common with many other research and development organizations, ISRIC relies increasingly upon external funding. In its own efforts to obtain financial support, ISRIC seeks to develop strategic alliances with other institutions in order to strengthen its range of expertise and to avoid competition or duplication of effort. In addition to the cooperative agreement established between ITC and ISRIC in 1994, ISRIC has formulated an agreement with the Consortium for International Earth Science Information Network (CIESIN) (Section 3.4.4), and has a working arrangement with the Centre for Development and Environment of the University of Berne in the framework of the WOCAT programme (Section 3.1.5), and with FAO and UNEP through a formal collaboration to develop the SOTER programme. Initial talks have been held with the European Soils Bureau, and the possibilities of a joint programme with the International Board for Soil Research and Management (IBSRAM) are being explored. ISRIC has improved its communication facilities through the installation of an internal network which is linked with electronic mail systems, and by inserting a "home page" on the Internet (http://www.isric.nl).

2 ARTICLE

Soil: An Overlooked, Undervalued and Vital Part of the Human Environment*)

E.M. Bridges and J.H.V. van Baren

Summary

Soils are taken for granted by the majority of the human population, but despite the image of being "just dirt" soils are an extremely important component of the environment. Soils can be observed to have a complex structure, with unique biological, chemical and physical characteristics. They support plants, the primary producers, and supply them with moisture and nutrients, so providing all other terrestrial ecosystems with the basis of the food chain. With the exception of small contributions from aquatic sources, virtually all human food is produced either directly from crops grown in soils, or from animals which graze upon herbage itself rooted in the soil. Soils are under considerable threat from over-exploitation, pollution and miss-use. Many decisions about land use are made without consideration of the underlying soils, and for any serious proposals for sustainable use of the land, soil properties and functions should be recognized. Soils participate in the hydrological cycle, as well as the cycling of carbon, nitrogen, sulphur and phosphorus. They intercept, absorb and inactivate pollutants, but also produce "greenhouse" gases. Soils have long been recognized as a major natural body, worthy of investigation in its own right, and it is now also being seen as a major participant in global cycles of the environment.

Introduction

The relationship between human beings and the environment is complex with interacting social, economic, legal and traditional activities but ultimately, all terrestrial life depends upon the natural resources of the earth. The food for our sustenance is mostly derived from the produce of the land, with smaller contributions from aquatic environments. Up to 95 per cent of all human food comes either from crops directly, or from grazing animals which in turn are dependent upon plants growing in the soil. All terrestrial ecosystems have as their basis the soil, a medium which provides nutrients, moisture and support enabling the plants, through photosynthesis, to trap solar energy.

Although climate is largely outside the control of mankind, the manner in which the other natural resources, including soils, are used or misused is subject to human decisions and so falls

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largely within our control. However, before considered decisions can be made about how any particular part of the environment should be used, it has to be first recognized and accepted before action can be taken. From experience and from the evidence of the last two issues of the Environmentalist even environmentally-aware people have yet to appreciate that the soil is a vital part of the life support system of the earth upon which they and all other people depend.

What is soil?

Soil has been described as *a natural body of animal, mineral and organic constituents, differentiated into horizons of variable depth which differ from the material below in morphology, physical make-up, chemical properties and composition and biological characteristics* (Joffe, 1948). This definition combines the physical, chemical and biological constituents of soils and gives the right weight to the morphology and other components of the soil. A second definition has been adopted recently by a Council of Europe document (1990): *Soil is an integral part of the Earth's ecosystems and is situated at the interface between the earth's surface and the bedrock. It is subdivided into successive horizontal layers with specific physical, chemical and biological characteristics.* These definitions are quoted, because it is important to establish clearly that the thin surface layer of the Earth which we call soil, is a natural entity with its own structure, composition and organisation. This allows different types of soils to be identified, their distribution to be mapped and their relationships to other natural systems investigated. Only with a full appreciation of these complex inter-relationships between the different aspects of the natural environment can the most effective, sustained use for any particular piece of land and its soil be determined.

Level land with deep, fertile, freely draining soil is a highly valuable natural resource which is in great demand for all types of land use. As well as being pre-eminently suitable for food production and forestry, such areas are sought out for high-return industrial activities, for housing and recreational purposes. Urbanization throughout the world is resulting in the loss of many thousands of hectares, usually of the most agriculturally productive land, as cities expand, motorways and airports are constructed, and new "out of town" commercial and industrial enterprise zones are created from "greenfield" sites. During the past 300 years, the population of the 40 largest urban areas has increased 25-fold with an even greater increase in estimated urban area (Silver, 1990). In Western Europe, 2 per cent of agricultural land is being lost per decade to urban growth and in the United States 2.5 million hectares of prime farmland per decade is lost to urbanization (Tolba and El Kholy, 1992). Urban and rural settlements now cover some 4 million km^2. In other words, a discussion of land use and the environment for food production cannot be separated from other claims on the land for non-food production, shelter and services.

There is only a finite amount of land suitable for food production. The shrinking of all natural habitats as human population increases, threatens to result in the collapse of many terrestrial and marine ecosystems as encroachment occurs, with an accompanying loss of biodiversity. This can be avoided if an integrated, holistic approach is taken to the use of the land for food production. Already, virtually all of the most suitable land for agriculture is now in use for food production and this amounts to some 11 per cent of the total world land area. The remainder of the earth's surface is too dry, too wet, too cold, too infertile or too mountainous for any significant agricultural production (FAO, 1993). Expansion on to land less suited to agriculture implies greater inputs (energy, fertilizers, weed control, labour) are required to obtain similar yields and with greater risks of environmental degradation. The second key issue is that food production should, wherever possible, concentrate in the more favourable areas so as to avoid expansion onto unproductive marginal lands which would not be cost-effective and lead to a further destruction of natural habitats and biological diversity.

The role of soil

In addition to the obvious use of soils in agriculture, horticulture and forestry, there are four inherent soil properties which have proved vital for life on earth. These are:

filtration: soils can filter many elements from the downward percolating rainwater, transform their chemical state making them innocuous and re-cycling them.

adsorption: soils have the capability to retain plant nutrients against the leaching effects of rainwater.

storage: soils have the capability to hold moisture and nutrients and release them when needed by plants.

buffering: soils can retain certain chemical elements against leaching and this means that soils can resist the effects of environmental (climate) change.

These processes of filtration, adsorption, storage, and buffering are also used to good effect in the fight against degradation of the environment (ISSS, 1994).

The human threat

Opinions are sharply divided between socio-economists who see no bounds to human ingenuity and therefore no future problems in supplying an increasing population with sufficient food, and the environmental scientists who see a limit to the population which the earth can support. A third group sees practical problems of distribution and supply as limiting the ability of the world to feed its population (Homer-Dixon, 1995). Scientific constraints to the supply of technical ingenuity include human inability to manage the complex of ecological and social systems. These problems become more serious when human capital is in short supply as has occurred in some African states through the impact of AIDS. The cost of research is such that poor societies cannot afford it and even more affluent countries are reluctant to support long-term research investigations. There is also an inability to increase the pace of scientific research in Developing Countries and the speed with which new findings are propagated. In the unstable conditions of many Developing Countries, science is vulnerable where social turmoil exists. Many of these problems were brought to the fore in the forthcoming FAO World Food Summit, held in Rome in November, 1996 and in other discussions organized nationally, for example in the meeting of the Royal Society of London reported by Greenland, Gregory and Nye (1997).

Between 1990 and 2020 the world population is forecast to rise to a total of 8.2 billion by 2020, an increase of 52 per cent. It is an inescapable fact that the per capita area of land to support the human population is steadily decreasing. In 1972 the figure was 0.36 ha; by 1982 it had fallen to 0.31 ha and in 1992 stood at only 0.26 ha. Regionally the pressure will be even greater as in southeast Asia where the ratio of area cultivated per person will decline to 0.09 hectare by 2020. Approximately 0.07 hectares is estimated to be the minimum amount of land to provide a person with a vegetarian diet on a sustainable basis without intensive use of fertilizers and pest control. Whatever the dietary pattern, the key issue in the future will be how best to use scarce land and soil resources, and in direct relation to this, the use of increasingly scarce water resources. Studies by FAO have highlighted the suitability and extent of land resources in developing countries from which greater yields could be obtained by the use of more efficient means of production. However to do this there is a need to appreciate that the resilience of all soils is not the same.

Soil resilience is defined as the ability of a soil to restore its living systems after disturbance (Lal, 1994). If the disturbance is too profound the soil may undergo irreversible damage and the system is jeopardized. Although human activities are concentrated mainly in cultivating the surface horizons or topsoil, heavy equipment developed during the 1950s has enabled some soils and soil materials to be completely mixed so that the processes of soil formation have to begin again, effectively with a new parent material. Some natural soils have had their surface horizons greatly thickened by human activity and have become so modified by human actions to become Anthrosols; in other cases soils have been eroded away completely. Industrial activities have caused soil contamination through atmospheric fall-out and waste materials which have been added to soils.

The impact of mankind on soils

Soils which have been modified by the effects of fertilizers, ploughing and other slight changes may be distinguished from Anthrosols, the profile of which has been completely transformed. These Anthrosols have been estimated to cover about 0.5 million hectares in Europe alone, with areas present in all continents. They are soils in which human activities have resulted in profound modification or burial of the original soil horizons through removal or disturbance of surface horizons, by cuts and fills, secular additions of organic and mineral materials, and long-continued irrigation etc. Some of the actions of mankind may be described as beneficial in that they improve soils; others are deleterious in that they cause soil degradation.

Agricultural practices which may have a beneficial impact on soils include deep cultivation, liming of acid soils, fertilizer applications, sedimentary additions during irrigation, drainage, checking soil erosion, additions of organic materials, and creation of poor drainage for wet cultivation of rice. Deep cultivation of soils has the effect of increasing the depth to which plant roots can easily penetrate by breaking consolidated layers. At the same time, compaction is reduced, downward percolation of water is encouraged and anaerobic conditions curtailed. Liming is necessary to bring the pH of arable soils into the range where food crops will be able to maximize their potential. The impact of adding mineral fertilizers to soils in order to increase the yields of crops has been dramatic and without them current crop yields cannot be maintained. Many soils in southeast Asia, have been made impermeable to enable the cultivation of paddy rice. This agricultural practice has produced a number of features in the soil profile referred to as a "hydragric horizon sequence" (Spaargaren, 1994). It comprises a grey puddled layer, a plough pan with a characteristic platy structure and a subsurface illuvial horizon with iron/manganese concretions. The combination of the presence of organic matter and saturated soil conditions are suitable for the growing rice plants, but also may result in undesirable emissions of methane.

Under natural vegetation, there is a circulation of plant nutrients. Nutrients are taken up from the soil by the plants and returned to the soil when the plants die or, if the plants are eaten by animals, they are passed along the food chain but eventually return to the soil. When natural vegetation is removed in preparation for growing crops, it may be burnt, liberating nutrients onto the soil surface which is then cultivated to provide satisfactory germination and rooting conditions for crops. Cultivation mixes the surface horizons spreading the superficial organic materials through 20 or 30 cm of what has become a topsoil (an Ap horizon). A case is currently being made for increasing the organic content of soils in order to counter the increase of carbon dioxide in the atmosphere. Techniques are available for increasing carbon incorporation in soils. They include slope stabilization, afforestation, agroforestry, conservation tillage in association with cover crops, use of green manures, greater use of mulches, closer management of soil fertility, liming and acidity control and adapting crop rotations to provide increased incorporation of residues (Sombroek, 1995).

Deleterious agricultural practices include removal of plant nutrients by crops without replacing them, the addition of toxic materials, salinization, accelerating erosion, burning organic layers, reducing organic matter content, destruction of soil structure, compaction by farm machinery and grazing, acidification and urbanization.
The degradation of soils, unlike many other environmental problems, is not a phenomenon of recent origin. Throughout history soils have been influenced and changed for better or worse by human beings; indeed many soil scientists would add the activities of mankind to the classic list of five soil forming factors described by Jenny (1941). In the past, soil degradation consisted mainly of the loss of soil through water or wind erosion, induced by cultivation and deforestation, but at the present time problems of chemical, physical and biological degradation are of increasing concern.

Soil erosion

Much effort has been expended upon erosion and its measurement, duplicating work done in the 1930s when most of the effective methods for counteracting soil erosion were worked out and demonstrated to be effective. The significance of erosion is that it is frequently a symptom that something else is wrong, and so it is necessary to look at the management of the land, its physical and chemical conditions rather than spending too much time on measuring yet another example of soil erosion. If the underlying cause or causes are addressed, rather than the effects, the problem of soil erosion falls into the correct perspective.

Water erosion is not only apparent in rills and gullies, but may also occur as an insidious loss of a few millimetres of topsoil each year. Worldwide, 1094 million hectares have suffered human-induced erosion by water and a further 548 million hectares erosion by wind. All the evidence points to the continued increase of erosion on cultivated lands, despite the availability of technology to limit its impact being known for the last 60 years and traditional methods for much longer. The erosion of 1 cm/ha of topsoil is a loss of between 100 and 150 tons of soil, and each 100 tons of soil lost per hectare represents a total loss of 2,000 to 2500 kg/ha of humus, 200-300 kg/ha of nitrogen, 100-200 kg/ha phosphate and between 500 and 1000 kg/ha of potash. These nutrients have to be replaced if yields are to be maintained (Lal, 1994: 1995).

Simulating the effects of soil erosion by artificially removing topsoil has recently been undertaken on plots in Nigeria where dramatic reductions of maize yields were observed. Soil was experimentally removed to depths of 5, 10, and 20 cm giving crop reductions which ranged between 30 and 100 percent. Yields of cassava were not so drastically affected with reductions of between 14 and 31 per cent. Under field conditions, fertilizer amendments did not appear capable of restoring the yields where 10 and 20 cm of topsoil had been removed. In Cameroon and Burkino Faso similar results were observed when strongly acidic, compacted subsoils were exposed. Extrapolating the results of these experiments with observed rates of soil erosion suggests a yield reduction of 2 to 5 per cent for each millimetre of soil lost, and that the overall yield reduction caused by past erosion stands at 9 per cent in Africa as a whole. If erosion remains unchecked at the present rates, yield reductions of 16.5 per cent of present values are forecast for the next 25 years (Lal, 1995)

Erosion by wind is experienced throughout the arid regions and seasonally dry agroecological zones, as well as on sandy and silty soils of other regions in drought periods. World-wide human-induced wind erosion occurs on 548 million hectares, the largest extent occurring in Africa and southwest Asia. Overgrazing has resulted in wind erosion spreading into non-arid areas of New South Wales and Queensland. Wind erosion is responsible for the loss of an annual 850 million tons of soil from the western United States of America alone. Overall in the USA, it was estimated in 1982 that 1.2 billion tons of soil were removed from cropland, 609 M tons from rangelands and 8 million tons from pastureland with smaller amounts from other land uses. This erosion is equivalent to a loss of 2.4 kg/ha/yr of N and 0.6 kg/ha/yr of P (Fryrear, 1995). Grazing by excessive numbers of cattle also initiates degradation. Cattle browse preferentially, leaving unpalatable shrubs. In semi-arid zones, such vegetation is subject to fires in which the vegetation is destroyed and subsequently, the unprotected soils are eroded. In periods of drought, the natural herbage may be grazed until it is killed and then the protective role of the plants is lost and soils become vulnerable to wind and water erosion. Over-expansion of herds in moister periods should be avoided, and the use of additional wells carefully balanced with the long-term environmental impact.

Chemical degradation

Two main problems occur in the chemical degradation of soils; depletion and contamination. Natural depletion of all soluble elements occurs from soils through the process of leaching by rainwater, but this form of degradation also occurs whenever soils bear crops or are grazed. Depletion of plant nutrients from soils has been an obstacle to increasing food production since mankind began to practise settled forms of agriculture. At the present time, insufficient returns for their produce is forcing many farmers throughout Africa to literally "mine" the fertility of their soils (van der Pol, 1992). Loss of fertility has caused farmers to extend the area cultivated to make up for reduced yields. In the process they are moving on to less suitable lands and rapidly destroying the natural environment with its natural biological diversity.

Chemical pollution of soils, which may be dispersed or concentrated, is usually the direct result of human activity and has increased dramatically in recent years (Bridges, 1989). Dispersed pollution results from acid deposition and atmospheric fallout of other toxic elements and compounds. Many agricultural soils have been contaminated by the addition of sewage sludge containing toxic metals such as cadmium or zinc. In their bio-toxic forms, these metals inhibit the soil fauna, decreasing the numbers of micro-and meso-fauna by up to 50%, and the effect may be seen for more than 40 years after the soil was originally contaminated (McGrath, 1986). The toxicity of metals varies greatly with pH and the redox state of soils. Use of phosphatic fertilizers containing cadmium has also been responsible for raising the concentration of this metal in arable lands.

Many studies have shown that the fall-out of copper, lead, zinc and cadmium to soils as a result of human activities is widespread (Alloway, 1990; Bridges, 1993). All these elements are retained by the soil by linkage to organic matter and clay minerals. This leads to an interesting situation whereby the soil can gradually accumulate toxic metals. Up to a critical point, the soil can absorb these without harm, this is the buffering function, and so the environment is protected temporarily against the impact of the toxic metals. Unfortunately, the soil's capacity to store these toxic metals is not infinite, nor is it of a fixed amount. For example, if the pH of the soil is decreased by acidification as is widely occurring, it is possible for some metallic elements to be catastrophically released in what has become known as a "Chemical Time Bomb" (Stigliani, 1988; Batjes and Bridges, 1991; ter Meulen *et al* 1993).

Concentrated forms of soil pollution by chemicals are usually smaller in extent being the result of accidental spillage, ignorance or deliberate dumping of toxic substances to avoid paying for their safe disposal. Regrettably, even when supposedly disposed of safely in licensed landfills, leakages have caused problems for the adjacent ecosystems and deep percolation has reached aquifers with an unfortunate impact on drinking water supplies.
Although measures can be taken to reclaim polluted soils, the expense is usually great and it is better to avoid the problem in the first place (Bridges, 1992).

Physical degradation

Compaction of soils has become a problem in recent years as the size and weight of farm machinery has increased. Subsoil compaction may occur below the plough-layer through frequent use of heavy machinery; this may be difficult and expensive to rectify. Nearer the surface a combination of compaction and tractor wheel-spin may limit the extent to which plant roots can exploit the soil for moisture and nutrients and the free movement of gases between soil and the atmosphere. Such compaction is frequently met upon sites which have been restored after opencast mining, but can also occur on normal agricultural soils which have been subject to heavy traffic, particularly in wet years.

Compaction decreases infiltration capacity, porosity and increases bulk density and resistance to plant root penetration. In soil with a reduced infiltration capacity, saturation is reached quickly and surface flow is generated which can cause erosion and carry pesticide residues from the soil before they have been degraded by the soil bacteria (Harrod, 1992). Crusting or surface sealing can occur, especially in silty soils, where the organic matter content has been lowered by oxidation through long-term cultivation; again this results in decreased infiltration and a greater likelihood of run-off and erosion (van Lynden, 1995).

Biological degradation

Soils also are effectively the agents for decomposition of organic matter and its conversion into an innocuous, semi-stable, material referred to as humus. In the process, it is estimated that the amount of carbon stored in the world's soils is two to three times higher than the carbon stored in the natural vegetation and standing crops. Soils are important as they sequestrate carbon removed from the atmosphere, thereby buffering the "greenhouse effect". Soil scientists are concerned about the fate of fauna and flora within the soil under the barrage of toxic chemicals which are used in high technology agriculture. The significance of the soil fauna in the bio-geo-circulation of elements has been stressed already. The creatures involved in this activity are at risk from application of pesticides to crops and also from residues which fall directly onto the soil. Although soil fauna are rarely obvious, most are of microscopic size, they play an important role in the breakdown of organic substances. Their unspectacular lives have not attracted much current scientific interest, but it is worth recalling that it was not beneath the dignity of the great Charles Darwin to study the humble earthworm's contribution to soil formation.

Natural ecosystems contain a great diversity of biological activity which is the natural biological 'capital' of the earth, and soils are no exception. In particular, the soil microbial biomass deserves special attention in the discussion on biodiversity. Breakdown of organic debris in the soil is one of the critical soil functions, for many interacting microbial species are required. The processes of organic breakdown is only known in outline but the activity of any one group of bacteria is difficult to separate from the others as it is stimulated by the waste products of other groups. Microorganisms are mainly responsible for the recycling of plant nutrients, carbon, nitrogen, sulphur, phosphorus from plant debris, detoxification of pollutant and complex wastes (organic and inorganic) and suppression of pathogenic organisms. Nitrification is seen to be a critical biological function in which soils, plants and microbial activity are involved. Several experiments suggest that natural nitrogen additions through symbiotic and non-symbiotic fixation were sufficient to counteract the N lost annually through harvesting. Comparable processes explain the nitrogen fixation in rice fields that allows continual cropping. Most natural soils are efficient at recycling plant nutrients derived from plant debris. However, when chemical fertilizers are over-used, the soils cannot retain the excess which is leached and this can cause problems in the aquatic environment. In summary, any chemical, physical and biological deterioration of soils is likely to seriously affect these species of bacteria and their functions.

Conclusions

The survey of human-induced soil degradation (Oldeman *et al.,* 1991) sounded a warning to international and national administrators that the soil is being damaged world wide as a result of human activities. This survey, the Global Assessment of Human-induced Soil Degradation (GLASOD), revealed that considerable damage has already occurred on 1965 million hectares (15 per cent of the world's soils) and of the factors responsible, water erosion was most widespread with 1094 million hectares (55 per cent), followed by wind erosion, 548 million hectares (28 per cent) followed by nutrient decline 7 per cent, salinization 4 per cent and physical compaction 3 per cent. It is almost inevitable that as population increases, so the impact upon the world's soils will increase.

Clearly, problems of soil degradation can be solved only by the close co-operation of soil scientists with other experts in a concerted holistic manner, soil science alone cannot do it as the use of the land is involved with facets of social, legal and economic life. Since the Rio Conference on Environment and Development and the publication of *Agenda 21* there has been much written about the adoption of a sustainable approach to land utilization. The pages of *The Environmentalist* have recently been filled with earnest contributions upon this theme. The omission of any reference to soil management in your reports highlights the lack of appreciation of the significance of soils in our lives.

To soil scientists, it seemed incredible that the soil, as such, was not given specific mention in the UN Conference on Environment and Development held in Rio de Janeiro (United Nations, 1992). Although implicit in chapter 10 of *Agenda 21,* it is not made explicit that soil is one of, if not the, most important constituents of land. Sadly, policy-makers often do not even appear to know who to ask or where to find answers to environmental problems concerning soils. As ecologists have eloquently demonstrated, life in its various forms is intimately inter-related in complex ecosystems, but all too often the point is omitted that ultimately all ecosystems depend upon the soil for moisture, nutrients and support. The soil, itself a complex ecosystem, is a vital part of the "earth support system" and a critical link between the inanimate rocks and minerals of the lithosphere and the living plant and animal organisms of the biosphere. Soil scientists have an onerous task to reverse the negative attitudes held about soils.

There is at present no global strategy for research on the problems of sustained land management, but the field of soil science does form a very satisfactory basis for an integrated or holistic approach to soil, water and nutrient management (Greenland *et al.*, 1994; Bridges and Catizzone, 1996). However, it is our contention that it is not simply the problems of soil and soil management which have to be solved; they have to be solved within the social, educational, legal, financial and governmental framework of different countries. There is also a tendency to think of soil problems as occurring in the developing countries; many developed countries have problems which are equally a result of the combination of economic and social conditions which favour exploitation for immediate gain, as opposed to the old adage of "live today as if you were going to die tomorrow, and farm as though you were going to live for ever"!

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3 ACTIVITIES

3.1 Collection, Storage and Processing of Information on Soil and Terrain Resources

3.1.1 ISRIC Soil Information System (ISIS)

Background

When ISRIC was established as International Soil Museum in 1966 its main objective was to assemble soil monoliths, soil samples and associated information to illustrate the units of the FAO-Unesco Soil Map of the World. At present, the world soil collection consists of over 900 monoliths from 64 countries. This is accompanied by soil profile and environmental data. In addition, the collection is supported by a soil map collection, soil report library and a slide collection. To facilitate the storage and management of the soil and environmental data a computerized database management system, called ISRIC Soil Information System (ISIS), has been operational since 1986.

The following data are stored in ISIS:
site data: about 60 attributes on location, geology, landform, soil surface properties, hydrology, land-use and vegetation;
climatic data: average monthly data of meteorological elements of one or more meteo-stations relevant to the site;
soil data:

- 11 attributes for soil classification in FAO-Unesco Soil Map of the World Legend, USDA Soil Taxonomy and a local system,
- soil profile description according to FAO guidelines;
- 103 physical, chemical and mineralogical attributes;

Activities

The input of soil data into the ISIS database in 1995/96 was less than in previous years, but in view of the NASREC Workshop more focused on the dissemination of ISIS held data. A summary of the main activities:

1) At the end of 1996 information of over 689 reference soil profiles were available in ISIS database (see table below). This means an increase of 70 reference soil profiles in comparison to the situation at the end of 1994. This expansion of the ISIS database is result of: i) transferring field information of reference soil profiles, from manual archives to the database. Verification, completion, coding and input of the coded information in the database were the main activities; ii) appending of field information of new reference profiles acquired through NASREC countries.
2) Work on the ISIS programme resulted in a) development of a ISIS version 4, and b) the presentation and distribution of version 4, including updated manuals, to all NASREC project participants during the NASREC workshop at the end of 1995.
3) Dissemination of information held in ISIS database in the form of Country Reports. A Country Report contains all data on reference soils and associated information of a specific country in ISIS database. ISRIC staff members prepared draft versions of Country Reports which were sent for verification and completion to collaborating national institutions. During the compilation of a draft Country Report the required final consistency and quality checks on the combination of field and analytical data is effectuated by ISRIC staff members. Country Reports are jointly published by the national institution involved and ISRIC. Draft versions are available of the following countries: Botswana, Brazil, Colombia, Costa Rica, Cuba, Ecuador, Gabon, Germany, Ghana, Greece, India, Indonesia, Italy, Ivory Coast, Kenya, Malaysia, Mali, Mozambique, Namibia, Nicaragua, Nigeria, Peru, Rwanda, South Africa, Spain, Thailand, Turkey, Zambia and Zimbabwe.
4) Further dissemination of the in ISIS held database was realized with a correlation study of 324 reference soils of the humid and seasonally dry (sub)tropics, based on ISIS data. This study was published as part I in volume 2 of the NASREC Workshop Proceedings.

Ongoing and future work

- To continue the expansion and improvement of the field and analytical information in ISIS database with the activities mentioned before under activity 1. In ISRIC monolith archives there is still information of about 250 reference soil profiles which were studied and sampled before 1986. Depending on availability and quality of information and soil samples, the information of a part of these profiles will be transferred to ISIS.
- To continue the dissemination of ISIS information by publications such as Country Reports.

Database status

The following table summarizes by country the status of data of reference profiles stored in ISIS (as of December 1996).

Table 1. Data status of reference profiles

Country	ISIS	Archive
Australia	3	36
Belgium		4
Botswana	7	
Brazil	28	1
Cameroon	1	
Canada	1	21
China	51	
Colombia	18	1
Costa Rica	12	
Côte d'Ivoire	7	
Cuba	22	
Czech Republic		8
Denmark		8
Ecuador	20	
Finland	1	5
France	11	1
Gabon	6	
Germany	14	3
Ghana	6	
Greece	15	
Greenland	1	
Hungary	20	
India	12	18
Indonesia	46	
Ireland	3	7
Italy	17	
Jamaica	4	
Japan	4	
Kenya	68	3
Malawi	1	
Malaysia	18	
Mali	8	1
Mozambique	9	
Namibia	3	6
Netherlands	10	
New Zealand		5
Nicaragua	11	
Nigeria	28	
Norway	2	1
Oman	4	
Pakistan	6	
Peru	21	
Philippines	6	
Poland	14	8
Romania	11	
Rwanda	10	
Samoa	5	
South Africa	12	9
Spain	20	
Sri Lanka	4	
Sweden	5	14
Switzerland		1
Syria		4
Thailand	13	
Turkey	20	
United Kingdom		11
Uruguay	10	
USA	7	18
former USSR	2	60
Venezuela	1	
Yugoslavia		3
Zaire	2	
Zambia	11	
Zimbabwe	13	
TOTAL (1996)	687	261
TOTAL (1994)	652	296
Total (1992)	*375*	*440*

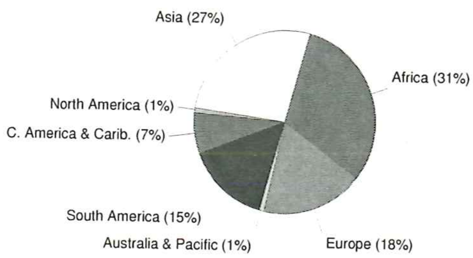


Figure 1. Soil profiles in database

3.1.2 World Inventory of Soil Emission (WISE) potentials database

In September 1991, staff at the International Soil Reference and Information Centre (ISRIC) started developing a digital database to permit a better quantification of the role of soils in controlling processes of global change. This database is now known as the World Inventory of Soil Emission Potentials (WISE) database. WISE is a combination of soil area-data and soil attribute-data. The area-data, based on a digitized and edited version of the 1:5 M Soil Map of the World prepared by the Food and Agriculture Organization (FAO), specify the type and relative extent of the main soil units for each ½° latitude by ½° longitude grid. The properties of the soil units shown on the map have been characterized using a set of representative soil profiles, which are held in the WISE profile-attribute database. The geographical distribution of the profiles currently held in WISE is: Africa (1799); South West and North Asia (522); South East Asia (553); Australia and the Pacific Islands (122); Europe (492); North America (266); and, South America and the Caribbean (599). Important geographic gaps are in China, the New Independent States, and the Northern Territories of Canada. Similarly, a number of soil units are under-represented in the profile database; these legend units account for about 28 percent of the terrestrial globe of which total Lithosols account for about 40 percent. Although it would have been useful to continue compiling additional profiles from the under-represented geographic regions and taxonomic units, the focus during the period under review has largely been on testing and using WISE for a range of applications (see 3.2.1).

3.1.3 World Soils and Terrain Database

1 Methodology Development

After testing several working versions in pilot areas during the previous years, the SOTER methodology was officially published in 1993 as a Procedures Manual in English and Spanish. FAO simultaneously issued the English version in their World Soil Resources Reports series.

A database structure was designed and input software developed in the form of a dBase programme in 1994. This enabled the SOTER methodology to be used as an operational tool in land resources inventories and assessments. An area covering parts of Argentina, Brazil and Uruguay was the first zone where the methodology was applied (LASOTER).

An updated version of the Procedures Manual, including some additional attributes on salts in the soil solution, was published in 1995 and in addition to the English and Spanish versions, a French edition was also produced. The input software was further developed and became available as an executable file. This made the need of database management system software obsolete at least for data entry and editing purposes.

Apart from the input side, applications of the SOTER database were further developed. A complete overhaul and reprogramming of the existing SOTER water erosion assessment programme (SWEAP) was completed and published in 1995.

A land evaluation model using SOTER data was implemented in the Automated Land Evaluation Model (ALES) for some of the land utilization types in three countries with a SOTER database. One of the major factors determining the suitability is the available moisture in the soil. For this factor a simple water balance model (WATSAT) has been developed and incorporated in the evaluation programme.

A preliminary version of a salinity status programme (SOSA) has become operational during 1996. It can assess the salinity of the soil profiles in the SOTER database and the impact of the salt status on productivity on crops. It has been distributed to a selected group of users for testing.

SOTER data have also been used to fill the soil parameters in an input file for an existing crop simulation model.

2 Compilation of databases

CONTINENTAL DATABASES

SOTERLAC

The ongoing activities in the compilation of a 1:5 M SOTER database of Latin America and the Caribbean, replacing the Soil Map of the World (FAO-Unesco, 1974-1981) received a new boost in 1995 with additional funding from FAO, UNEP and the International Potato Institute (CIP). In the beginning of 1995 the SOTER database of Mexico, Cuba, Venezuela, South Brazil, Uruguay and Argentina were completed. Correlation between Argentina, Uruguay and Brazil was also finished.

In the course of 1995 contacts were established with soil institutes in the remaining countries for the compilation of SOTER databases of their countries. Resulting maps were digitized (where necessary) by ISRIC and joined into the continental database. First outputs were distributed to the participating institutes for comments. At the end of 1996 the database was completed for the entire area. A final correlation trip to selected countries is planned for the beginning of 1997.

A total of 1350 SOTER units have been defined for the whole area with more than 1700 described and analyzed profile pits.

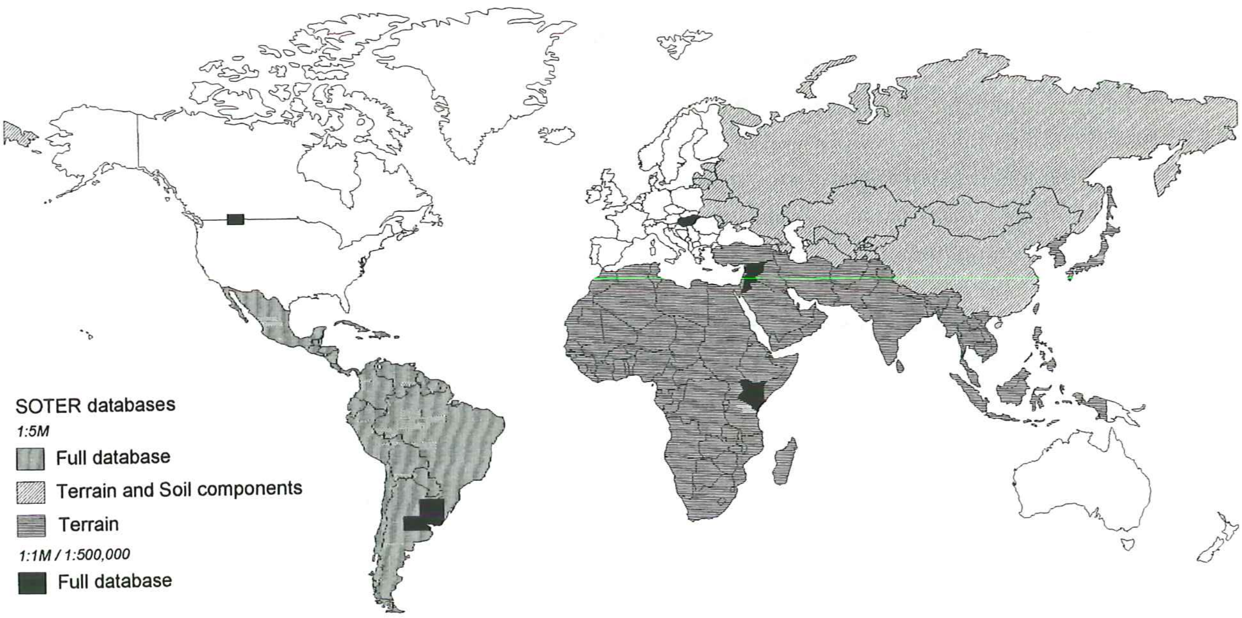


Figure 2. Status of SOTER databases

Other areas

A by-product of a degradation study in SE-Asia is a 1:5 M physiographic database of that area according to the SOTER criteria. FAO, in cooperation with other partners and in consultation with ISRIC, has initiated efforts to compile building blocks of other continental SOTER databases. Parts of these 1:5 M databases are now complete for the former USSR, China, Mongolia.

NATIONAL DATABASES

HUNSOTER

Already started in 1994, the SOTER database at scale 1:500,000 of Hungary was completed by RISSAC in Budapest with technical support from ISRIC. In 1995, the final modifications were added and a 3-day workshop was held in June in Budapest. The applicability of the database was demonstrated by RISSAC and ISRIC to participants from soil institutes of the Czech Republic, Bulgaria, Croatia, Poland, Romania, Slovakia and Slovenia.

KENSOTER

The completion of the SOTER database of Kenya at scale 1:1 M in the course of 1994 was the starting point for a demonstration of the results and the possibilities for SOTER activities in Eastern and Southern Africa. For that purpose a 4-day workshop was organized in Nairobi at the premises of the Kenya Soil Survey in March 1995 with participants from soil institutes in Botswana, Ethiopia, Lesotho, Madagascar, Malawi, Mozambique, South Africa, Sudan, Swaziland, Tanzania, Zambia and Zimbabwe. The proceedings of the workshop were published as SOTER report 9.

During the entire reporting period corrections and additions to the first version of the database continued. Also various thematic maps were extracted from the database. The products were used in several poster displays in workshops and conferences where they were used as public relations materials for ISRIC.

MESOTER

Training and technical support was given to the soil scientists of ACSAD, the Syrian Soil Directorate and the Jordanian National Soil Map and Land Use project in the compilation of a 1:500,000 SOTER database for both countries. A first version became available in the course of 1996. The assistance consisted of (3) training workshops in the setting up and use of the database. Also a field correlation trip was made in both countries by a joint team from both institutes and ISRIC.

ETHIOPIA

A short training was given to international (DHV) and national staff of the Tekeze River Basin Development Master Plan project where the staff wished to apply the SOTER methodology for mapping and interpretation of soil and terrain data at a scale of 1:250,000 for an area of 60,000 km^2 in the north of the country. Local terrain conditions necessitated modifications to the SOTER structure as well as changes in the existing applications, mainly land evaluation.

In the framework of the United Nations Environment Programme (UNEP) sponsored project for the 'Compilation of soil and terrain database in the Republic of Kenya (KENSOTER) for national and local agricultural planning purposes' (Project No. FP/CD/6101-92-02(3025)), the Kenya Soil Survey (KSS) and the International Soil Reference and Information Centre (ISRIC) had organized an international workshop at the premises of KSS from 14 - 17 March 1995 for displaying the results of the project and for raising interest for SOTER activities at sister institutes in the region.

The workshop was attended by representatives of soils institutes of 11 southern and eastern African countries, by local (potential) users of the KENSOTER database and some donors. The latter two groups only took part in the first session of the workshop.

The programme of the workshop covered three major subjects:

- an explanation of the SOTER methodology and the implementation in Kenya with a demonstration,
- national reports of all participating countries on the status of soil surveys and GIS,
- discussions on possible SOTER activities in the participating countries.

Demonstrations of SOTER in Kenya were, apart from database input, queries for thematic single value maps, mainly focused on a land evaluation and a soil erosion hazard application. Both have already been published separately (Mantel, 1994; Van den Berg, 1992).

The national reports on the status of soil survey and GIS in the participating countries gave a state-of-the-art overview on soil mapping in Southern and Easter Africa. The outcome of the discussions have been put down as recommendations of which the major ones were:

1. The scale-independent SOTER methodology is a useful tool for making data on soil and terrain resources quickly accessible to resource managers, policy makers and the scientific community at large for various types of interpretations. In all participating countries data are available for the creation of a 1:1 M soil and terrain database. In some countries data collection has advanced towards a larger resolution and consequently these countries aim at a larger scale.
2. One of the advantages of the SOTER methodology is the provision of applications/ interpretation methods that can be used with minor adaptations in most countries. Another is standardization with the possibility for data exchange between neighbouring countries.
3. Several participating countries have already invested largely in the creation of soil profile databases (point observations), e.g. FAO-ISRIC Soil DataBase and local varieties, while part of the soil maps is in digital form. However, a linkage between the two systems has not yet been established. If the countries will implement SOTER an easy transfer of profile data into SOTER is absolutely necessary.

3.1.4 Assessment of Human-induced Soil Degradation in South and Southeast Asia (ASSOD)

Early 1995 ISRIC embarked on a project called Assessment of Human-induced Soil Degradation in South and Southeast Asia (ASSOD). This project was initiated by the FAO Asian Network on Problem Soils and was financed by UNEP. It is a sequel to the Global Assessment of Human-induced Soil Degradation (ISRIC/UNEP, 1990) and uses a revised GLASOD methodology in which more emphasis is placed on the impact of degradation on productivity (in relation to level of management) and on the rate of degradation in order to enable the identification of trends. The physiographic units of the base map were identified using the SOTER methodology at a scale of 1:5M. The assessment hence yielded considerably more detail than GLASOD (average scale 1:10M).

National institutions in 16 countries in the region provided the source data, based on expert estimates and following guidelines prepared by ISRIC. The data were compiled and analyzed at ISRIC where the database was linked to a GIS, enabling a flexible preparation of outputs to be made, adjusted to specific user groups or uses. Rather than producing one map as an endproduct (like the GLASOD map), various thematic outputs in different formats can be prepared.

ASSOD is a entirely qualitative assessment, based on expert judgment. As such it reflects the current knowledge on the status of degradation in the region, and also reveals differences in perception of degradation between countries (see Map 4).

The project was terminated later than planned, early 1997, as a result of difficulties in the collection and analysis of data from so many different sources. A report with statistical data and two maps is available from ISRIC, while the database is available on request. A database viewer will be developed in the near future.

3.1.5 World Overview of Conservation Approaches and Technologies (WOCAT)

The WOCAT project is another activity in which ISRIC participates. It developed from the earlier GLASOD work. WOCAT was launched in 1992 by the World Association of Soil and Water Conservation (WASWC) and is coordinated by the Centre for Development and Environment of the University of Berne. WOCAT is organized as a consortium consisting of various national, regional or international institutions that contribute either financially and/or technically. Major donors are SDC, UNEP, FAO, GTZ, SIDA. ISRIC is a principal participant in this project, in particular with regard to the cartographic aspects.

While GLASOD was "breaking the bad news" in terms of severity of degradation, WOCAT is collecting examples of successful soil and water conservation (SWC) activities worldwide. The project has developed a methodological framework for the evaluation of SWC activities. Comprehensive questionnaires have been developed on all aspects of SWC approaches and technologies, and on the geographical distribution of these activities.

To facilitate the data collection, three regional workshops have been organized to date in Africa, whereas Thailand has taken the lead in Asia with the organization of a national workshop. Through the use of the WOCAT questionnaires, these workshops have generated a wealth of data that are being compiled and analyzed in Berne. However, national data will be handled in principle in the countries themselves. For 1997 finalization of the African continent is envisaged, while activities elsewhere will be expanded.

Outputs of WOCAT consist of books and reports on SWC technologies and approaches, maps of SWC activities, databases, a decision support system and world-wide accessible information in paper format or through the Internet.

Participants WOCAT workshop, Chieng-Mai, Thailand

3.1.6 Impact of food production on the environment

Throughout history, agriculturalists have attempted to reduce the influence of the natural environment in order to increase crop yields, but the impact of food production upon the environment was not seriously considered. In the second half of the present century, since the widespread use of artificial fertilizers and new cultivars became available, the agricultural industry has been extremely successful in meeting the food requirements of the developed countries, even reducing the area of cultivated land. Without access to chemical fertilizers and current agricultural technology, countries of the developing world have been less successful. World-wide, the point has now been reached when all the most suitable land has already been brought into cultivation. Fortunately, not all this land is cultivated to its full potential, because demographic forecasts predict a rise in population from the present 5.2 billion to over 8 billion in the next 25 years.

With such problems in mind, FAO called a World Food Summit which was held in Rome in November, 1996. In preparation for this conference 15 background documents were prepared and presented to the participating Ministers, governmental officials and their advisors. ISRIC was asked by FAO to assist Professor Louise Fresco, of the Wageningen Agricultural University, in the preparation of a document entitled *Food Production and Environmental Impact*. Compilation of this document necessitated exploring a point of view that is not normally taken when considering food production. It raised an interesting question of what impact the production of food has upon the natural environment, including the soils, the vegetation, the atmosphere, the hydrology, the land use and how all these aspects of food production interact with the social backgrounds of people in different parts of the world.

The document first considered the use of natural resources for food production, discussing the physical modification of the landscape, the use of natural plant and animal species, the effects upon biodiversity, the use of water resources, and soil resources. Of particular concern was the vulnerability of soils to degradation when subject to the demands of agriculture. A second chapter considered the land use and food production systems used within the major agro-ecological zones and the effect these have on biogeochemical cycles. Thirdly, the technical and ecological options available for the production of food are discussed with the impacts which would be made upon forestry, soil and water and the technical options which exist for overcoming or minimizing these impacts. As with the successful green revolution in South East Asia, so, a second green revolution is necessary for African countries. In order to provide an adequate diet for the present population as well as food for a rapidly increasing population, greater demands will inevitably be placed upon the environment, particularly in developing countries, yet at the same time it is essential that natural biodiversity is maintained and environmental degradation restricted. The problem cannot simply be solved by bringing more and more land into cultivation, because the remaining uncultivated land requires greater inputs and presents greater risks of crop failure than areas currently under cultivation. A laissez-faire policy is equally unacceptable as this will allow current levels of environmental degradation to continue and even increase.

Environmental impacts of food production have important implications for human well-being in all societies throughout the world. At the local level it is necessary to have a satisfactory system of land use planning, so that the most suitable soils are utilized for the role which suits them best. Closer monitoring of the impact of increased food production on the environment will be necessary, and governments must appreciate that the necessary training and capacity of advisory services must be increased to deal with and co-ordinate the sustainable use of the agricultural soils of the world. At an international level, no country should be allowed to act unilaterally on a unsustainable basis. Non-degrading patterns of food production and trade should be encouraged and rural poverty minimized so the present subsistence farmers can obtain sufficient reward to farm their land without destroying the ecological balance.

Whilst the capacity of the earth to provide sufficient nourishment for the human race is not in doubt, compilation of this document revealed the extremely wide range of ideas on the subject. It brought to light the many competing theories and practical possibilities for arresting the damage to the environment caused by the inevitable impact of increased demand for food and its processing. It opened out the whole area of interactions between soils, the food producers and the commercial, financial, social, legal and administrative sectors of society. Governments must develop incentives to encourage environmentally sound agriculture and food security, otherwise the scientific contributions and international policies will not have lasting positive effects. When all the theorising has been done, at the heart of the problem lies the sustainable use of the fundamental natural resource called soil.

The full report, as presented to FAO, will be made available in due course, as an ISRIC Technical Paper.

3.2. Assessment of Soil and Terrain Resources for Sustainable Development

3.2.1 Application of the WISE Database

The integrated WISE database, in combination with auxiliary sources on the main biophysical and socio-economic driving variables, can be used for a range of environmental studies at a resolution coarser than ½° by ½°. Such studies include assessments of crop production potentials, soil gaseous emission potentials, land degradation by water or pollution, and studies of global carbon pools. Depending on the topics under investigation and the spatial and temporal resolution required, the various primary soil data have to be clustered and analyzed in different ways. The resulting secondary files of derived soil data provide a uniform basis for production of thematic maps, using GIS, and an input for auxiliary modelling activities.

So far, WISE has been used for: (1) an analysis of soil pH properties by FAO-UNESCO (1974) soil unit; (2) computation of total carbon and nitrogen stocks in the soils of the world; (3) a study of the water holding capacity; (4) and, creation of a file of median soil properties by FAO-UNESCO soil unit which can be linked to the digital ½° by ½° soil map (see Maps 1a, 1b). These initial studies, provided a uniform basis for generating a number of ½° latitude by ½° longitude raster image files. The WISE-derived soil data sets have been combined with auxiliary databases on land cover and climate in an integrated, global assessment of land vulnerability to water erosion (see RIVM/GEO, 3.2.3).

An important development has been the adoption by the Global Soil Data Taskgroup of the International Geosphere-Biosphere Project's Data and Information System (IGBP-DIS) for a subset of the WISE profile database as a foundation for some of their modelling work. The full profile complement of WISE has been used in a collaborative activity of FAO, the International Institute for Applied Systems Analysis (IIASA) and ISRIC to generate uniform files of derived-soil-properties for use in regional and global Agro-Ecological Zoning studies. The derived attributes can be linked to both the vector and 5' by 5' version of the digital Soil Map of the World, using the soil unit and topsoil textural class as the logical link. The preliminary subset, complemented with information derived directly from the Soil Map of the World (e.g. drainage, depth), will be circulated amongst a group of experts in 1997 to fill the remaining gaps. Subsequent to this data completion and peer-review process, the "validated" digital file is intended to provide a uniform set of derived soil properties for modelling at a regional and global scale, using the full-composition, digital Soil Map of the World.

Users of WISE-derived data

ISRIC maintains the WISE database; mainly derived products are made available on request to third parties. These mainly included research scientists interested in (a) primary soil (profile) data for specific soil or environmental research purposes, and (b) scientists and modellers especially interested in obtaining uniform and well documented (secondary) sets of "derived soil properties" for their studies.

In order to meet the requirements of the first user-group, ISRIC prepared the "International Profile Data Set" [*alias*: GPDB, Global Pedon Data Base] comprising 1125 profile descriptions plus a compiled version of the WISE data handling system. This data set was created at the explicit request of the IGBP-DIS Global Soil Data Task (GSDT). So far over 40 copies of GPDB have been distributed (Table 2), and this largely via electronic mail. The second group of users is interested mainly in publications which arose from WISE, as well as in the derived digital set of derived soil properties on a 0.5 x 0.5 degree grid. The spatial set so far includes: soil pH, organic carbon pools, and available water capacity.

Request for WISE-based soil data have been received from scientists working at national and international organisations/institutes, including: IGBP, FAO, UNEP, IIASA, RIVM, Potsdam Institute for Climate Impact Research (PIK), Max Planck Institute for Meteorologie, several CGIAR centres, and universities. An overview of data users (known to ISRIC) by broad geographic region is shown in Table 2.

Table 2. Number and type of request for WISE-derived data, by broad geographical region

Region	Primary data	Secondary data
Africa	3%	5%
Asia	2%	2%
Australasia	3%	3%
Europe	59%	46%
North America	34%	39%
South & Central America	2%	5%

Note: In total 43 sets of primary data and 90 copies of secondary data have been distributed to users, largely at their request (status as of December 1996). No information is available on other users.

IGBP-DIS soil data set for pedotransfer function development

Some soil attributes, necessary for a wide range of environmental studies, are seldom collected on a routine basis, particularly water retention versus tension relationships, unsaturated hydraulic conductivity and bulk density, because they are cumbersome to measure and expensive. The solution then is to derive these relationships from the available measured soil data, using pedotransfer functions.

At the request of the Global Soil Data Task (GSDT) of the Data and Information System of the International Geosphere Biosphere Programme (IGBP-DIS), ISRIC prepared a uniform soil data set for pedotransfer function development. The necessary chemical and physical soil data have been derived from ISRIC's Soil Information System (ISIS) and the CD-ROM of the Natural Resources Conservation Service (USDA-NRCS). The Pedo Transfer Function data set is available on request to the international modeling community for the development of various pedotransfer functions.

3.2.2 Degradation Assessment in Kenya

ISRIC was invited to participate as an external advisor on soil degradation assessment and mapping in the project entitled "National Land Degradation Assessment and Mapping in Kenya", sponsored by UNEP and executed by a consortium of various ministries and institutions in Kenya. The SOTER database compiled by the Kenya Soil Survey during the period 1993-1994 was used in the SOTER Water Erosion Assessment Programme (SWEAP). The exercise proved to be successful as a major input in the project and as a means of proving the usefulness of the SOTER database. Moreover, the intense use of the database revealed errors and omissions in it that could not be detected in earlier screening procedures. Results of the water erosion assessment were printed as a wall poster (see Map 2).

3.2.3 RIVM/GEO Regional and National Studies

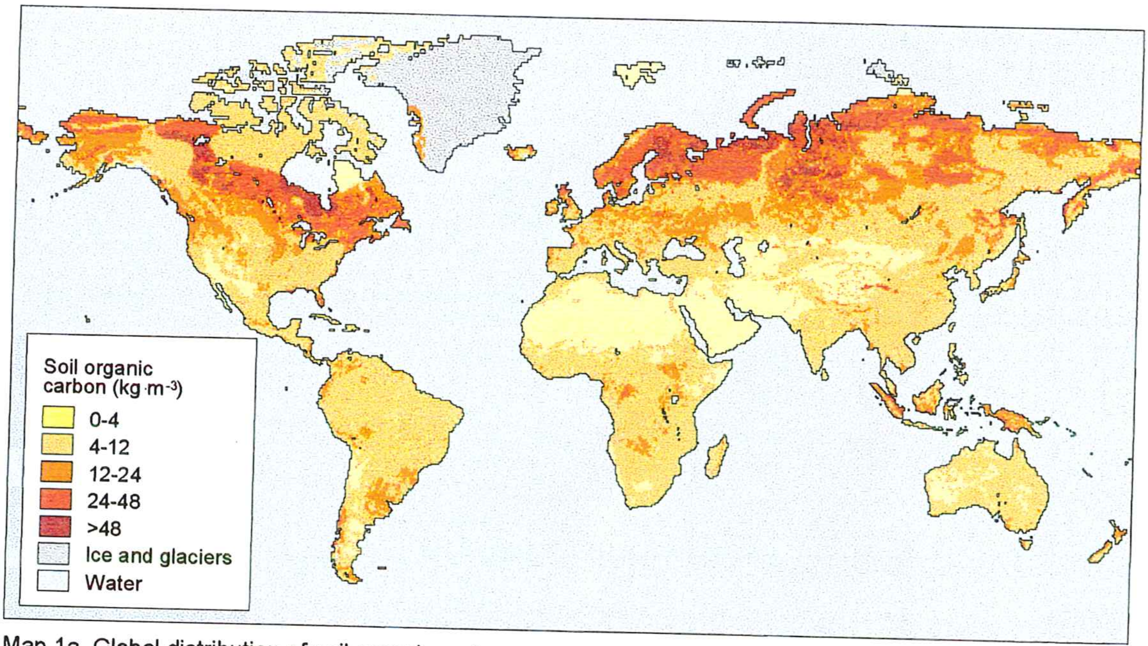
In the framework of UNEP's Pilot Global Environmental Outlook project, the Netherlands National Institute of Public Health and the Environment (RIVM) and the International Soil Reference and Information Centre (ISRIC) have been asked to perform a number of studies which would focus on impacts of land degradation on food productivity. The focus of ISRIC's activities would be on assessing the importance of scale and structure of environmental databases and model formulation on the possible level of detail of conclusions drawn with respect to the assessment/quantification of the impact of water erosion on food production. Although several models have been developed to assess effects of erosion on soil productivity, their widespread use is often limited by their considerable demand for data and they are seldom suited for large scale extrapolation. In addition, possible impacts of environmental degradation on future food production are seldom considered in regional and global studies of food productivity.

Three activities were undertaken by ISRIC in the context of GEO:

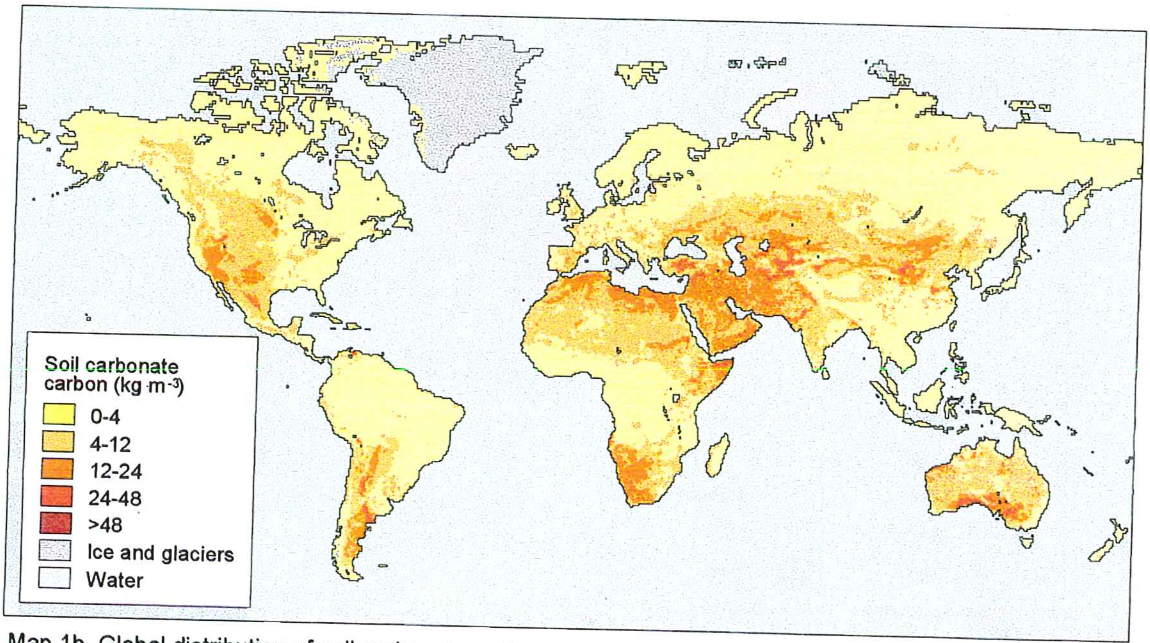
First, a simple methodology for assessing the risk of water erosion at the global level has been developed. It uses the ½° by ½° WISE soil database and auxiliary databases on climate and land cover. Model output for vulnerability was evaluated against observed data on severity of soil degradation by water as presented on the map of human-induced soil degradation (GLASOD), showing a fair geographic agreement between grid cells considered vulnerable to water erosion, under current conditions of land cover, and regions in which water erosion occurs currently.

In a second investigation, the above model has been adapted for use with input data from the 1:5 million scale Soil and Terrain Database (SOTER) for a pilot area covering parts of Argentina, Brazil and Uruguay. The desk study showed the potential of a 1:5 million scale SOTER database for identifying areas at risk from water erosion. However, there was little possibility to evaluate the outcome of the model against 'ground-truth' nor to quantify effects of food production on water erosion, and *vice versa*, for which more detailed follow-up studies are needed. Although qualitative models can serve to raise awareness on issues of soil degradation by water at the regional and global level by identifying regions at risk, they do not provide any information on the actual rate of erosion at field scale nor on the associated decrease in crop productivity and biodiversity for which more detailed studies are needed at the national level.

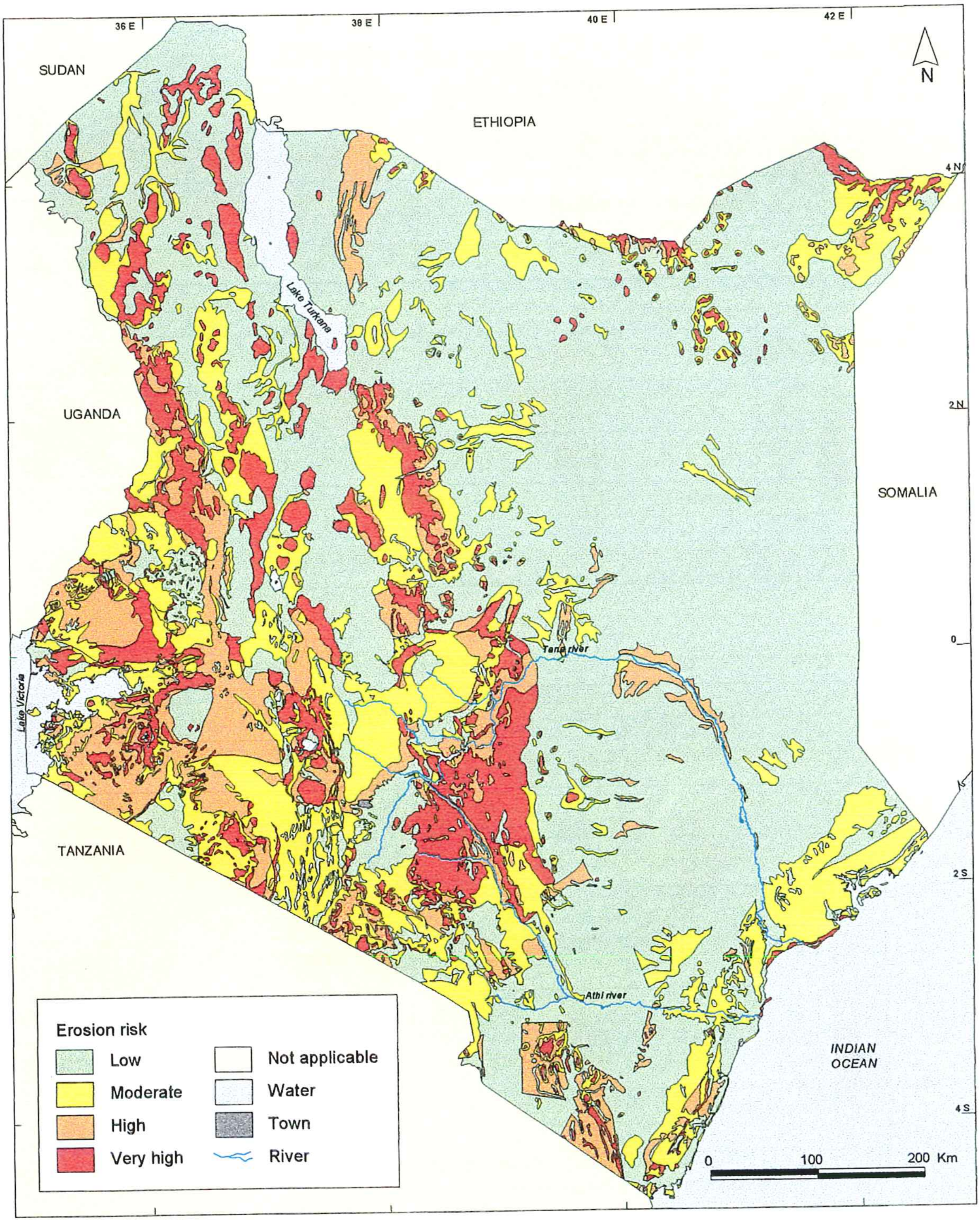
In the same framework a third study was undertaken that elaborated a mixed qualitative/quantitative methodology for assessment of the impact of erosion on productivity of a land use system, given the variability in natural conditions (e.g. soils, landform and climate). This approach was applied to three countries, situated in two regions; South America (Uruguay and part of Argentina) and East Africa (Kenya), with different types of land use and in highly varying agro-ecological conditions. A chain of models was used to study the impact of erosion on crop production. The studies were based on national 1:1 M scale Soil and Terrain (SOTER) databases. Soils and terrain attributes are linked to a Geographical Information System (GIS), permitting spatial analysis. The following steps were made: (1) suitability calculation for a major food crop using the approach defined by the Framework for Land Evaluation of FAO (1976) and implemented in the Automated Land Evaluation System (Rossiter, 1993), (2) erosion risk for this land use modelled with the SOTER Water Erosion Assessment Programme (SWEAP) (3) transformation of the erosion risk into a loss of topsoil during the scenario period (20 years), (4) potential productivity calculation with the WOFOST model before and after the erosion scenario. The national institutes, being the authors of the databases, were strongly involved in the programme in respect of erosion assessment and land suitability studies (see Maps 3a and 3b).



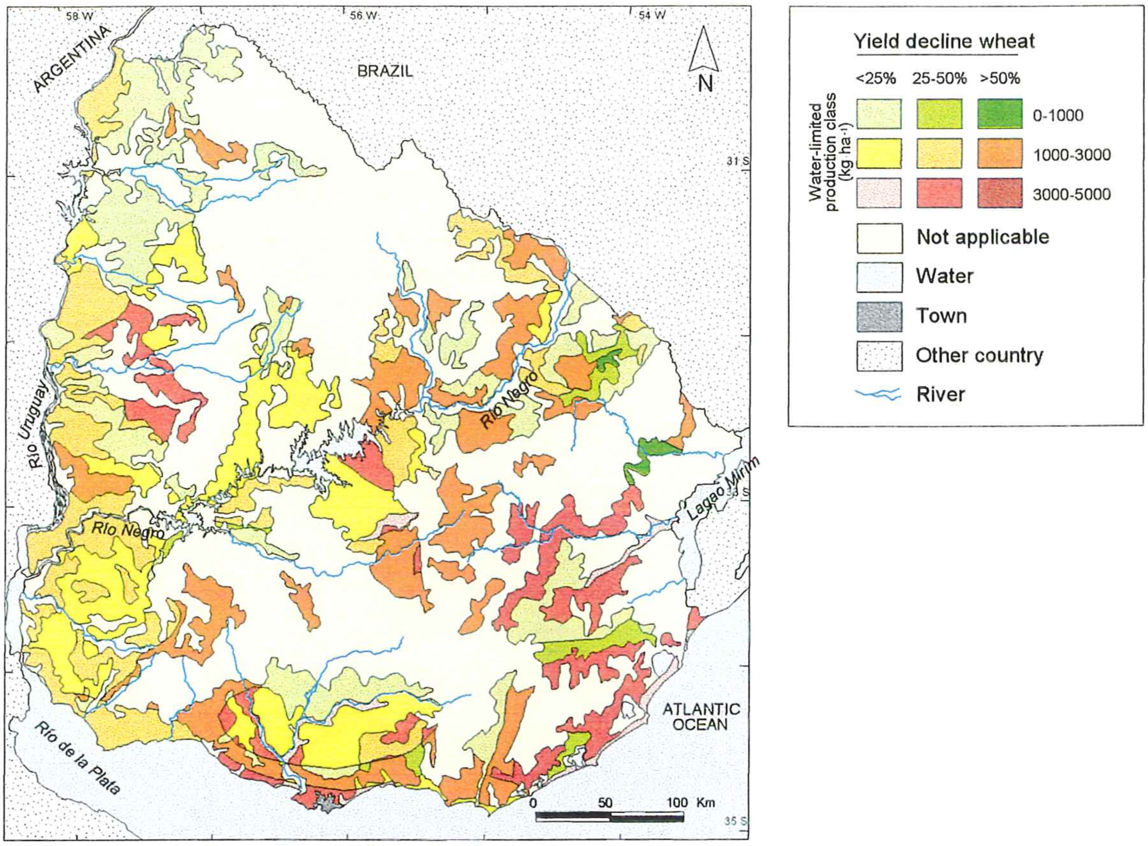
Map 1a. Global distribution of soil organic carbon



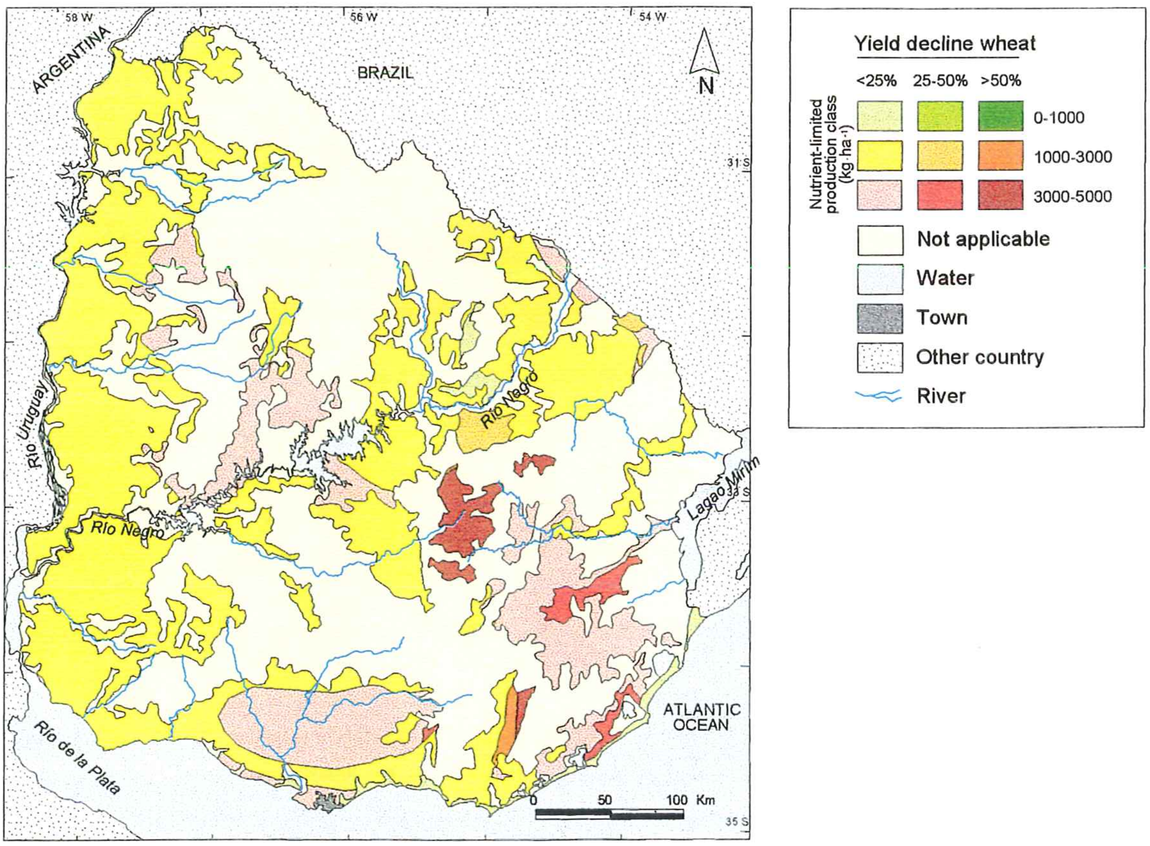
Map 1b. Global distribution of soil carbonate carbon



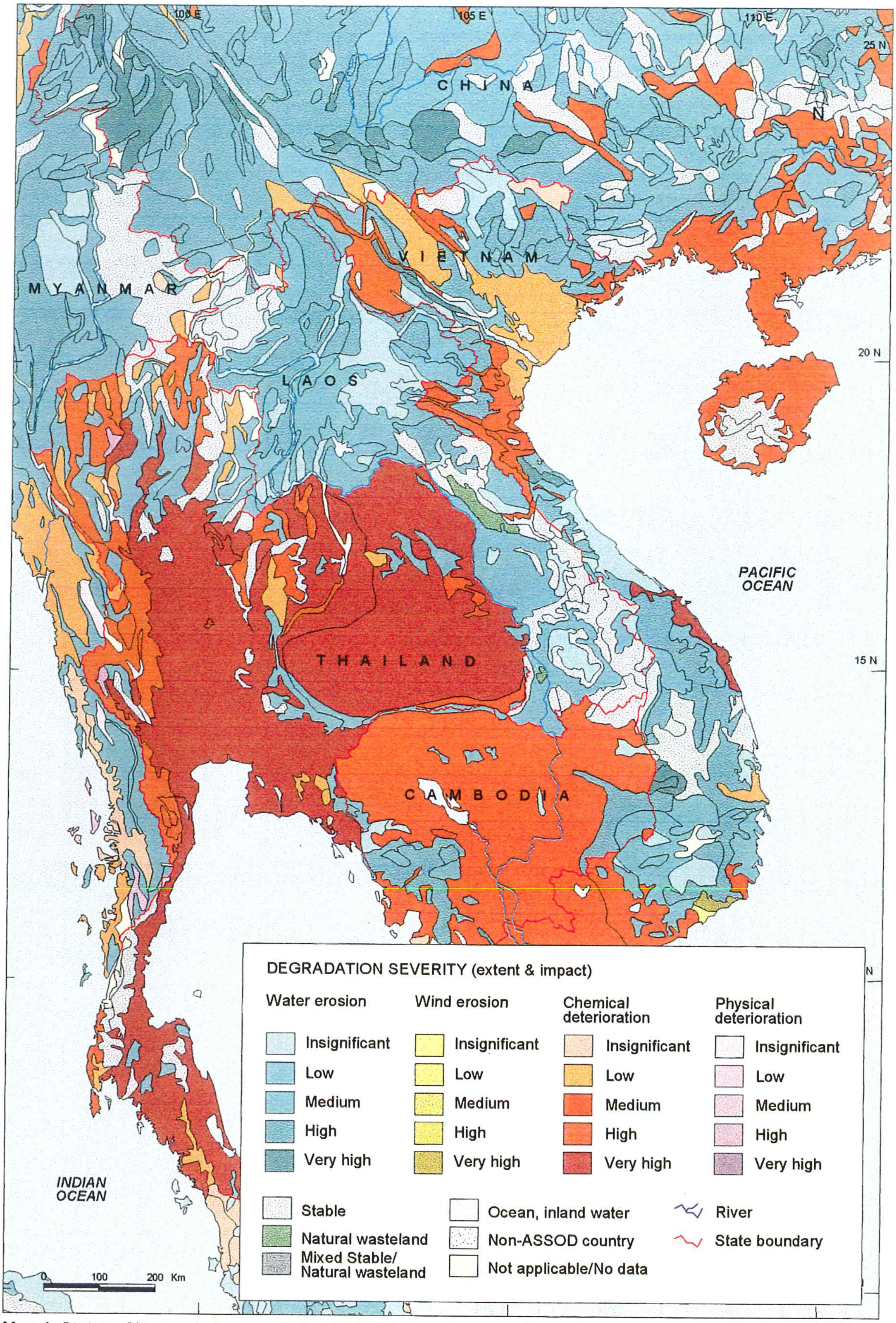
Map 2: Erosion risk under maize in Kenya



Map 3a: Water limited wheat yield decline in Uruguay
(after simulated 20 years of soil erosion)



Map 3b: Nutrient limited wheat yield decline in Uruguay
(after simulated 20 years of soil erosion)



Map 4: Status of human-induced soil degradation in south and southeast Asia: Dominant degradation type

3.2.4 ILEIA project

Background

"For more than a decade the Information Centre for Low External Input and Sustainable Agriculture (ILEIA) has played a key role in sharing information and stimulating interest in ecologically sound agriculture. ILEIA's documentation and information service, and publications as the ILEIA Newsletter and books like "Farming for the future", the latter published in various languages, are widely known. Many farmers are aware of the need for ecologically sound agriculture and it is generally recognized that farmers participation in identifying and trying out new options is the key to developing ecologically and economically sustainable ways of farming. Since 1994 ILEIA's original mandate of disseminating information has been expanded with a research task focusing on the potentiality of Low External Input (LEI) agriculture in various ecological zones, including areas with edaphic constraints (the so-called 'marginal' areas), because doubts exist in the minds of many as to the production potential and possibilities for wide scale adoption of LEI agriculture. Assessing such a complex subject can only be valid if it recognises the environmental and institutional reality. The assessment must therefore be embedded in the reality which the farmers, field workers and researchers experience. ILEIA has developed partnerships with organisations, which support sustainable agriculture in these three environments and which are trying to assess its potential and limitations" (from ILEIA's Strategy brochure of spring 1996).

Soil research component

Towards the end 1995, ILEIA and ISRIC signed a Cooperation Agreement to carry out a number of soil investigations in 6 pilot areas located in three agroecological zones of contrasting potential considering market access and institutional setting:

- the dryland savannas of northern Ghana (near Langbensi and Wiaga);
- high mountain valleys in the Andes of Peru (near San Marcos in Northern Peru, and Quilcas in Central Peru);
- Sub-humid low-land of the Philippines (in the broad alluvial plain of central Luzon).

The main issues to be addressed in this collaborative project are:

(1) Correlation of farmer's knowledge of soil and land suitability with (inter)nationally accepted systems of soil and land suitability classification, in order to identify main constraints and to propose possible solutions.
(2) Assess the geographical representativeness of the pilot areas for the agro-ecological zone and district in which they occur.
(3) Presentation of project results to farmers and NGO's in participatory meetings.
(4) Establish linkages for international collaboration on developing a sustainable basis for agro-technology transfer, in a participatory framework.

Main activities

ISRIC first formalized the working relationships with 3 regional institutes familiar with the pilot areas by signing subcontracts in early 1996 with i) the Institute of Soil Research, Kumasi, Ghana; ii) the Bureau of Soil and Water Management, Manila, Philippines; and iii) the Soil Department of the Universidad Nacional de la Molina, Lima, Peru.

Actual fieldwork in the 6 pilot areas was carried out by the subcontracted agencies, under overall coordination by ISRIC, and in consultation with the local NGO/farmer/ILEIA groups. ISRIC staff members participated in the field work during visits to the institutes and pilot sites concerned.

All participating institutes mapped soil boundaries as perceived by the farmers, using local soil names, and have documented the main limitations/potential of the land as experienced by these farmers in preliminary reports with supporting tabular data and maps. This information is being correlated with the information on soils/terrain and land use systems based on internationally accepted terminologies (e.g. Soil Taxonomy and FAO-Unesco) as well the nationally accepted systems.

ISRIC organized several meetings in Wageningen with other by ILEIA contracted partners to discuss the state of affairs of the research programme, notably the linkages between the various project activities in the three countries concerned.

Ongoing and future work

During the final period of the contract with ILEIA, reports for the various pilot areas will be finalized in close cooperation with the collaborating institutes. Results of these activities will be presented formally in a journal paper.

It was envisaged that the results of the pilot areas would be extrapolated for a larger area within each of the three main agro-ecological zones concerned. However, many parties considered critical up-scaling and spatial generalisation to the national level, as foreseen in the original ILEIA research plan to be difficult, so this aspect is being reconsidered following a change in the management of ILEIA, which took place in the second half of 1996.

3.2.5 Bio-diversity Project

Background

The EU-funded STD3 Biodiversity project with the title "An integrated study of land properties, their floristic indicators and appropriate farming systems in an acknowledged biodiversity centre in Amazonian Peru" started with a workplan formulation workshop in December 1994. The project combines geological and biological approaches to gain understanding of the ecological constraints of agricultural production in an area around the city of Iquitos, Peru. Its results will help find realistic alternatives to migratory farming currently practised in Amazonia by:

- determining the geological background for the existence of soils with different production potentials
- developing a model for the identification of edaphic differences utilizing ecological knowledge of indicator plant species along with remote sensing data
- promoting the development of appropriate farming systems for each soil type to allow continuous production of food plants and/or silvicultural products

The study is a combination of fundamental and applied research. The fundamental studies attempt to gain understanding of the variation in site edaphic conditions using aspects of geography, geology, pedology and biology. The applied studies try to develop appropriate farming systems for the dominant soil types.

Participants

Turku University, Turku, Finland: project coordination, remote sensing, floristic and geology studies.

Universidade Nacional de la Amazonia Peruano [UNAP], Iquitos, Peru for forestry-fallow, agro-forestry experiments and soil survey investigations.

Instituto Nacional de Recursos Naturales [INRENA], Lima, Peru: remote sensing, geology and deforestation studies.

Forschungsinstitut Senckenberg, Wilhelmshaven, Germany: clay mineralogy

ISRIC, Wageningen, Netherlands: soil characterization, classification and land evaluation aspects, and the analyses of soil samples.

Activities

A summary of ISRIC's main contributions:

- Participation in fieldwork and the 1st and 3rd Workshop at UNAP, Iquitos, Peru.
- Various logistic support.
- Participation in the 2nd Workshop at Turku University, Turku, Finland, in which a framework for the book presenting the final project results was discussed.
- Soil analyses by ISRIC laboratory: chemical, physical and mineralogical analyses of about 200 soil samples taken by the botanists, geologists and soil scientists.

Preliminary results

In addition to the clearly identifiable, very deep sands near the town of Iquitos (*Arenosols* and *Spodosols*), the dominant area of the studied soil sites consists of very acid clays, with a (very) low base content, a medium or high Cation Exchange Capacity (CEC), and a high, sometimes extremely high, exchangeable aluminium content (*Acrisols*, *Alisols* and *Ferralsols*). A minor portion of the soils sampled, mainly restricted to the deeper subsoil of sites near rivers, present a completely different picture with a neutral soil reaction, a high content of exchangeable bases, no exchangeable aluminium, and a very high CEC. The latter samples can directly be correlated to soils formed in the Pebas formation. The Pebas formation is a Tertiary lacustrine water deposit found extensively at depth in the Amazon region, which predominantly is characterized by smectite in its clay fraction.

Ongoing and future work

Together with UNAP's soil scientists, and in collaboration with specialists in vegetation and geology, to prepare a soil chapter for the book, which will include the following:

i) collect available soil documentation of the study area, which includes about 10 studies carried out by various institutions during the past 20 years,
ii) input the soil data extracted from this documentation, plus data of the soil reference profiles studied for this Bio-diversity project, into the ISIS database, and proceed with the subsequent statistical and GIS processing,
iii) drafting of the text of the soil chapter with sections on characterization, classification, land evaluation and soil formation.

3.2.6 Holistic Approach to Soil Science

Since 1991, ISRIC staff have been involved in discussions about the future of soil science arising from the concern that pedology was frequently marginalized by other scientists and by society at large. Following a meeting in Rennes, attended by the ISRIC Director-designate, a subsequent meeting was attended in 1993 by two members in Zimbabwe, and in 1995 at Bologna by one member of staff. From the Rennes meeting came the collective view that a broader approach to their subject should be made by soil scientists[1)]. Where appropriate, this fresh approach should incorporate as far as possible all persons involved with the soil, and use should be made of indigenous knowledge to link with a scientific approach. This concept became known as an holistic approach. The meeting in Zimbabwe explored the holistic framework within the context of the developing countries of southern Africa and proved to be a stimulating experience for participants both from Europe and Southern Africa[2)]. It was, however, still 'preaching to the converted', and it became clear to delegates that a further meeting was required which would incorporate the views of other specialists who were not soil scientists.

Therefore, at the meeting in Bologna the organising committee attempted to widen the scope of the discussions by bringing together people whose work impinged upon soils, but was not central to their interests[3)]. The participants explored the wider implications of adopting a holistic approach bearing in mind the successful application of the methodology in Tunisia and Vietnam where consultation and negotiations with the interested parties took place early in the development process. Socio-economic data were taken into consideration as well as the bio-physical character of the environment. Because it engages the majority of people involved in the soil in making land-use decisions, the holistic framework for soil science is a challenging method of working. However, the chances of ultimate success in projects involving the sustainable use of the soil are much greater if all the community, soil scientists, non-soil scientists and farmers alike, feel involved and committed.

[1] *New Challenges for Soil Research in Developing Countries: a holistic approach.* (eds G. Stoops and C. Cheverry) 1992. E.N.S.A., Rennes.

[2] *A Holistic Approach to Sustainable Soil Use in SADC Countries.* (eds E.M. Bridges, S.C. Muchena, G. Prasad and Williams, M.) 1994. Directorate General XII for Science Research and Development, EUR 15809 EN, Brussels.

[3] *Holistic Approach to Sustainable Development: interaction of soil science with different disciplines.* (eds L. Reale, M. Nori, and G. Ferrari). ASTER, Bologna.

Workshop on ILEIA, Quilcas, Peru, 1996

3.3 Strengthening the Capacities of Soil Institutions

3.3.1 National Soil Reference Collections and Databases (NASREC)

Background and progress

The main objective of the NASREC programme is to strengthen the capability of national soil and land resources institutions to disseminate information about the major soils of their country, with special reference to their potentials and constraints for different types of land use, to a wide range of users. In order to achieve this objective four main categories of activities were implemented: basic training courses; building of soil monolith expositions with supporting documentation; development and handling of soil profile databases; and after-training support services.

The NASREC programme, which started on an ad-hoc basis in Colombia in 1980, included a series of international courses with participants from about 40 countries attending. During its first phase, training and major supporting activities took place in 3 countries, while 3 other countries were provided with minor support. In the second phase, from 1990 to 1994, the NASREC activities were expanded with the establishment of 11 soil reference collections in African, Asian and Latin American countries. NASREC activities were carried out in the framework of a technical assistance programme with major financial support from the Netherlands Directorate General for International Cooperation (DGIS) and complementary support from UNESCO, the European Community — Life Sciences and Technologies for Development Programme (STD2) and the Royal Dutch Academy of Sciences (KNAW).

Workshop

Based on a recommendation made by an international review panel at the end of the second phase of the NASREC programme, an international workshop was organized at ISRIC from 6 to 17 November 1997. This workshop brought together existing and potential collaborators and other resource persons with the following objectives: i) to review past performance of NASREC; ii) to map out a collaborative strategy and network structure; iii) to develop elements for a project document for NASREC, phase 3; iv) to familiarize participants with new information technologies in soil science and application programmes to improve communication with users of natural resources information.

Sponsors

Sponsorship for the workshop was given by the Netherlands Directorate General for International Cooperation (DGIS), the International Service for National Agricultural Research

(ISNAR), the Centre Technique de Coopération Agricole et Rurale (CTA), The European Community (EC), and the Food and Agriculture Organization of the United Nations (FAO).

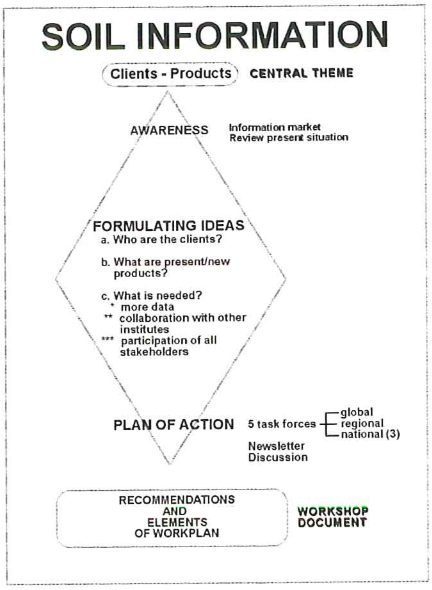
Programme

The first week of the workshop was centred around the theme of the workshop 'users and their demands for information'. The ultimate goal was to identify products of soil information which would satisfy the demands and the needs of the users. To achieve this, a framework was established during the workshop whereby an awareness was created of users needs and demands through an information "market", a lecture and discussions. The lecturer, Professor N. Röling of the Agricultural University, indicated three ways of interaction between soil scientists and their clients. These included: i) Transfer of Technology, ii) Consultancy, and iii) Facilitation. The text of this presentation is given in volume 3 of the Workshop Proceedings. At the information "market", participants presented their ideas and views on the products of soil information. This creation of awareness led to the formulation of a wide array of ideas from the participants on "who are our clients?; what are our present products?; what are potential new products?; and what is needed to satisfy the demand of the users of soil information?" (more data, data relevance and quality, collaboration with other institutions such as those dealing with water resources, climatic data and socio-economic studies, and active participation of all stakeholders?). These ideas formed the backbone of the work of 5 task forces, inventorizing and streamlining them on a global, regional and national scale, to arrive at a plan of action. This plan of action has finally helped to formulate the recommendations of the workshop and elements of a future workplan on NASREC activities.

The second week of the workshop was devoted to a series of lectures and practical PC exercises focusing on new information technologies and applications in soil science. The workshop concluded with a discussion of user-oriented information transfer. This discussion was introduced by brief oral presentations of the panel members: Dr. W.G. Sombroek (chair, former ISRIC director), R. Fall (Bureau of Soils of Senegal, representing the NASREC countries), Dr. C. Lightfoot, Prof. N. Röling and Prof. A. Zinck. Results of the forum discussion are included in the workshop conclusions.

Proceedings

The proceedings of the NASREC workshop consist of three volumes (see section 4). The first volume comprises information on the progress of NASRECs in the period 1980-1995 details on the programme, results of the discussions, conclusions and recommendations of the workshop. The second volume contains papers on applications of soil databases developed at ISRIC (ISIS, WISE and SOTER). Papers in the third volume relate to oral presentations made by invited resource persons for which written contributions were received. It further contains written contributions about NASREC activities throughout the world, listed by country. The country papers relate to NASREC experiences at different stages of implementation, ranging from the initial setting-up of a national soil reference collection to the later stages in which user-oriented database applications and publications are prepared. This was reflected in the difference in amount of detail contained in the various contributions. The proceedings also include a number of papers by representatives of organizations who were not part of the current NASREC network, yet implemented similar activities in their countries.



NASREC WORKSHOP NEWS

6-17 November, 1995
ISRIC, Wageningen

Country Reports and Soil Briefs

A series of Country reports and Soil Briefs prepared by NASREC programme participants and ISRIC staff was presented during the workshop. For more information on these documents see section 3.1.1. and the previous Biannual Report.

Plan-of-action

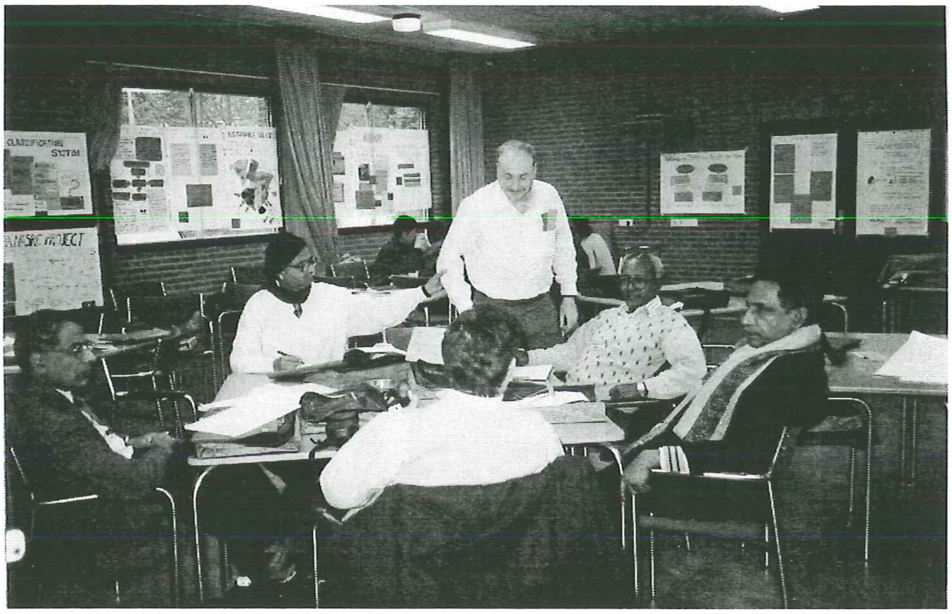
The workshop was considered to be a milestone because it was the first occasion in which 36 soil scientists, from 30 countries, could share their experiences about soil reference collection projects completed in the last 15 years. It provided a unique opportunity to identify, discuss and propose future actions at the national, regional and global level. The consensus of the workshop was that the scope of the NASREC programme should be broadened, in a possible third phase.

CONCLUSIONS

1. The apparent gap between users of land and producers of information on natural resources may be bridged by correlating indigenous knowledge with internationally and nationally accepted scientific know-how (*concept of ethno-pedology*), and by stimulating a "participatory development technology approach" as learning medium for land users and scientists alike.
2. Recommendations on sustained utilization of land should be based on high quality data in geo-referenced databases on land and water resources. Cooperation between natural resource data centres must be promoted to enhance optimal use of existing data and to avoid duplication. Collaboration between land resource, social and economic institutions is required to address adequately present complex sustainable agriculture and environmental issues.
3. Techniques and methodologies should be inventorized and/or developed to translate scientific knowledge about land degradation, rehabilitation and conservation into recommendations which are tailored to the different groups of users.
4. Strategically located land resource data centres with an established record can act as regional focal points for training and exchange of information in order to better focus on regional environmental aspects and needs and to strengthen South-South cooperation. Such focal points should link up with appropriate networks and maintain strong ties with ISRIC as the coordinating and backstopping centre.
5. ISRIC as ICSU's World Data Centre on Soils should: facilitate world-wide networking of present and future national and/or regional soil reference and database centres; identify and address focus areas on environmental issues; continue correlation, harmonization and standardization of soil and terrain data sets; develop database applications for land use planning and environmental research; and enhance public and global awareness of the nature and importance of soil as non-renewable natural resource.

RECOMMENDATIONS

1. Land resource institutions should initiate participatory approaches with the user of soil and terrain data to maintain and upgrade their role as a service centre for providing user-oriented information at different levels of aggregation.
2. Training opportunities should be provided for natural resource scientists in land resource information technologies, such as the establishment and use of soil reference collections, development of databases, application of geographic information systems to soil and terrain related issues, and use of soil laboratory management systems to improve data quality.
3. Strategically placed land resource centres should be mandated to serve as regional focal point for more efficient and cost-effective facilitation of data collection, of information dissemination and for training regional scientists. Where possible, such regional focal points are to establish links with appropriate present and future networks.
4. The role of ISRIC as a global coordinating and supporting centre, as a training centre on information technology, and as a research centre for the development of user-oriented application programmes for the optimal utilization of the land and water resources should be strengthened.



The NASREC workshop, ISRIC, November 1995.

3.3.2 SOTER Workshops

SOTER workshops that were part of regular projects were organized in Nairobi and Budapest. On various other occasions the SOTER methodology has been promoted in workshops:

- Arendal, Norway, May 1995: Workshop on UNEP and CGIAR cooperation on the use of GIS (organized by UNEP-GRID);
- Cairo, Egypt, April 1995: Workshop on land degradation studies in the Near East (organized by CEDARE);
- Athens, Greece, March 1996: Workshop on European Soil Database (organized by ESB);
- Palermo, Italy, September 1996: Workshop on land degradation pilot studies in the Near East (organized by CEDARE);
- Regional Land and Water Use Conference (Beirut, December 1996, organized by the Regional Office for the Near East of FAO);
- Monitoring Soils in the Environment with Remote Sensing and GIS (Ouagadougou, February 1995, organized by ISSS).

3.3.3 The Analytical Laboratory and GLP/SOILIMS Programme

The analytical laboratory

The report on the work of ISRIC's laboratory first deals with activities related to the monolith reference collection. Secondly, developments concerning the Good Laboratory Practice/SOILIMS and the Fayoum project are described.

The laboratory work during the report period was dominated by the NASREC workshop in November 1995. An ambitious goal was set to complete as large a number of Country Reports as possible to be presented at the workshop. After that, work on the collection was geared down in favour of analyses for the Turku University (Finland) Ecuador Biodiversity project, and in support of ITC students' research projects (M.Sc. and Ph.D.) at Enschede. The "Tropenbos" (Tropical Forest) foundation requested a sizable data verification exercise on Cameroon soils, and several small work orders by various external clients were completed.

It is felt that (project) managers and decision makers are increasingly aware of the need to fill databases with quality data (as opposed to 'rubbish in, rubbish out'). Verification of data by the laboratory of a reference institute is one way to check their reliability. Plans were initiated to form an alliance with other research laboratories in Wageningen to expand the range and capacity for this type of work.

Meanwhile, the Laboratory Manual (Technical Paper No. 9) was updated and the 5th edition was published, now carrying the FAO logo illustrating that the ISRIC laboratory is to a large extent using international "standard" methods. By the end of the report period some research topics were in progress, mainly related to method validation: the gypsum determination and the new ISO-normal CEC method using $BaCl_2$. Also, because the new ISO normal for particle-size analysis prescribes end-over-end shaking, a low-budget model for such a shaker was developed for possible local construction by smaller laboratories.

Cooperation with the consulting company IWACO in studying waste-incinerator bottom-ash (a volcanic ash-like material with environmental problems) was continued. With this company a paper was co-authored on the removal of fluoride from ground-water by using andic soil material, a possible method to fight fluorosis at village level in East Africa.

GLP/SOILIMS

The quality of data produced by a laboratory greatly depends on the quality assurance measures implemented. The principle of Good Laboratory Practice (GLP) is that all activities related to laboratory work are documented. Unambiguous work instructions for equipment and procedures have to made, maintenance and calibration of instruments is recorded. Personnel should be qualified and /or additionally trained, safety measures are taken and, finally, data produced should be checked by internal as well as external routines. As an assemblage these operating procedures and protocols constitute the Quality Manual of a laboratory which, together with the records, should be available for inspection by the management and auditors. Ultimately, in its perfect form, such a system is needed for official accreditation of a laboratory. However, this is a costly affair and generally only affordable by large commercial laboratories. Yet, the credibility of other laboratories such as soil and plant research laboratories, is greatly increased if to some extent rules of Good Laboratory Practice are implemented, particularly the quality control of data. The Guidelines for Good Laboratory Practice, compiled by ISRIC with co-sponsorship of FAO, can be used to help initiating or further improving the quality assurance system of soil and plant laboratories.

A major element of GLP, the accurate recording and management of data, can be greatly assisted by the computer. Commercial programs for Laboratory Information Management Systems (LIMS) are available but these are generally very expensive and often quite troublesome to customize and install. Therefore, many laboratories attempt to write such programs themselves. This is a difficult and time-consuming exercise which often leads to an unsatisfactory result. For soil, plant, and water laboratories that cannot afford an expensive commercial LIMS, ISRIC's SOILIMS can be a solution. By the end of 1996, after more than 5 years of development, Version 1.4 was released. Until then, some 100 demonstration versions of SOILIMS were distributed and over 25 fully-fledged systems were sold. Customers included members of SPALNA (the Soil and Plant Analytical Laboratory Network of Africa), national soil research institutes and several CGIAR institutes. Training activities in this field were continued. Individuals were instructed at the institute and, as in the previous years, ISRIC contributed to the Postgraduate Course on Soil and Plant Analysis and Data Handling (a joint project with the Wageningen Agricultural University and the International Agricultural Centre at Wageningen). Also, two training sessions were given to participants of SPALNA . One in English in Nigeria and one in French in Cameroon, both at the premises of IITA. It is expected that in cooperation with ORSTOM, both the Guidelines for GLP and SOILIMS will be translated into French. Portuguese versions of SOILIMS are already in operation.

3.3.4 Strengthening National Soil Laboratories

Central Laboratory at Fayoum, Egypt

ISRIC was commissioned by DGIS to assist in the planning, equipping and developing a new soil, plant, and water laboratory in the Fayoum region in Egypt, where salinity is a major problem. The future managers of the laboratory visited the Netherlands for a study tour, an Egyptian senior technician followed the Postgraduate Course on Soil and Plant Analysis mentioned above, and a senior ISRIC laboratory technician will visit the Fayoum twice to provide training and assistance. After a delay in the construction, the laboratory was close to completion by the end of 1996 and assistance at the location was foreseen for 1997.

Wageningen Soil, Plant and Water Analytical Services

By the beginning of 1997 agreement was reached between four laboratories in Wageningen to offer their joint expertise, experience and capacity to third parties interested in having analyses in the field of soil, crop, or water carried out by research laboratories. These four laboratories are those of the Dept. of Soil Science and Geology and the Dept. of Soil Science and Plant Nutrition, both of the Wageningen Agricultural University, the Winand Staring Centre for Integrated Land, Soil and Water Research (SC-DLO), and International Soil Reference and Information Centre (ISRIC).
Clients may primarily be companies, institutes or projects interested in a wide range of analyses or perhaps a few particular analyses. Also verification of analyses carried out elsewhere can be considered. The office of the alliance, the name of which still has to be established, will be housed at ISRIC.

A cheap and simple stand-alone LIMS developed by ISRIC for small to medium-sized soil, plant and water laboratories is SOILIMS. It is a user-friendly system which is easily installed and learned (the manual contains a Tutor) and can be used immediately after installation. Although the system has about 100 analyses in the standard configuration, it can be further customized (and re-customized later) by the supplier. A unique feature is that more than a dozen different cross-checks can automatically be performed in order to screen soil data for internal consistencies: when "anomalities" occur, the data concerned are flagged for closer inspection before they are released (not all anomalities are necessarily wrong in all cases). The very attractive feature is its price which is comparable to that of a bench-top pH meter. The main features are the following while the system's main menu is given below.

- Unambiguous registration by automatic assignment of unique work order and laboratory sample numbers.
- Possibility of priority assignments by deadline definition.
- Flexibility to alter work order requests and deadlines.
- Time-saving routine for sample label production.
- Protection of data against non-authorized users.
- Backlog reporting.
- Detailed information regarding the status of pending work orders.
- Production of work lists provides the manager with complete and accurate information for fast decision making.
- Allows for many control samples.
- Manual or automatic data input (direct ASCII file reading).
- Second-line control by automatic verification of control sample results in Control Charts.
- Unique attribute-attribute cross-checking capabilities (artificial intelligence).
- Increased efficiency by easy production of reports and invoices.
- Data export facilities to LOTUS 123 or text editors.
- Easy-to-use automatic archival procedures.
- Audit trail capabilities for specified samples, clients, work orders, or laboratory personnel.
- Stand-alone and single-user network version.
- Option for plant and water analysis included.

(Minimum required hardware: IBM PC (or compatible) 386 SX with 4Mb RAM)

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                         SOILIMS MAIN MENU

   Thursday, 23 May 1996                           10:32:43

 S A M P L E S                        PROCESSING TOOLS
   A. Registration                      D. Pending Jobs
   B. Ghange Registration Status        P. Print Options
   C. Data Input (automatic)            Q. Invoices
   M. Data Input (manual)               R. Report & Bill Status

 GLP PROCEDURES                       SYSTEM INFO
   E. Approve Data Input                I. Installation
   F. Audit Trial                       T. Present Storage Capacity
   S. Control Charts                    H. Check Data Interity
   U. Authorized Users                  V. Archival
                                        Y. LOG OUT

        [Enter Your Selection A - Y, or X to eXit - :]
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3.4 Enhancement of Accessibility of Soil and Terrain Information

3.4.1 ISRIC's Soil Monolith Collection

During the last two years considerable effort has been made to improve the presentation of ISRIC's world collection of soil monoliths. The soil profiles on exhibition, illustrating the Major Soil Groupings of the FAO Soil Map of the World, had been static for several years, and, with only minor changes, had served well the initial purpose for which the exhibition (and ISRIC) was created. Under the threat of flooding during the winter of 1993, the whole exhibition was dismantled and moved to safety on the upper floor of the ISRIC building. Although the flooding did not take place, it provided ISRIC with an opportunity to re-design the exhibition on a more user-friendly basis with less emphasis on soil classification.

The new layout of the exhibition hall is along soil ecological lines, reflecting the agro-ecological zones of FAO. Some 80 soil profiles, illustrative of the major soil groupings in the humid tropics, the seasonally dry tropics, the arid regions, the temperate regions and high elevation (mountainous) regions are now on display. Supporting information on the climate, vegetation, and land use is provided for each soil ecological zone and the significant features and classification of each monolith on display are given. Detailed analytical figures for each profile are available on request. Space is also provided for special topics which can reflect matters of international concern or the outcome of projects undertaken by ISRIC.

In support of the re-arranged exhibition a draft guide has been prepared providing the visitor to the exhibition with additional information about the soils on display. It is envisaged that this guide could be used by the leaders of groups to prepare for their visit, thus enabling their time at ISRIC to be more effectively used. The incentive of change has re-invigorated the work of preparation of monoliths, reducing the backlog of profiles already collected, and bringing new profiles, especially those derived from the NASREC programme, into the exhibition.

The re-arranged format of the exhibition hall enables the soils on display to be approached at a number of different intellectual levels: the exhibition can be appreciated at a general level for non-soil specialists, at a level suitable for visiting groups of undergraduates and there is also sufficient information available for the professional soil scientist. Comments received on the new layout for the exhibition hall have been favourable.

3.4.2 ISRIC's Documentation Facilities

Library, map collection, and slide collection

The aim of ISRIC is to make a systematic collection of books and reports, including 'grey' literature, soil maps, related thematic maps and data. This relates especially to the compilation of a World Soils and Terrain Digital Database (SOTER), as a follow-up of the FAO-Unesco Soil Map of the World. Book and map collections increasingly are consulted as a source of information for scientists, students and consultants in soil studies and in the preparation of missions to developing countries. Slides are not only used internally, but are increasingly requested for outside use in books and journals and for lecturing.

Books and Journals

The library policy is deliberately sharply focused, acquiring only books dealing with soil science, and the most significant soil science journals, since the nearby Staring Building houses the specialized 'soil and water' library in Wageningen. As an exception, attention is being giving to reference books and periodicals on environmental issues, particularly where soils are concerned. At present, the library contains about 10,000 books, it subscribes to about 40 journals and receives many bulletins, Newsletters, etc. free of charge. All books have been entered in a database, using Cardbox Plus program but the database cannot be consulted on-line.

Soil maps and Reports

ISRIC is building a world-wide collection of soil maps and reports, with an emphasis on the developing world. This is available for consultation by interested persons, and provides material for updating the FAO-Unesco Soil Map of the World and the compilation of a new Soils and Terrain Digital Database (SOTER) at a scale of 1:1 Million.

At present, ISRIC aims to have a comprehensive collection of small-scale maps at 1:200,000 or smaller of each country, and a reference system of soil surveys carried out at any scale, accompanied by maps showing the area covered. The maps are complemented by the accompanying reports and related thematic and derived maps. The collection consists of more than 5,000 maps and some 600 photo-negatives. About 2000 maps are entered in a database using Cardbox Plus.

REQUEST FOR MAPS AND REPORTS ON SOIL RESOURCES

Cartographic materials form an important part of ISRIC's documentation section. Geographic coverage of the collection is the whole world with emphasis on developing countries. The subject emphasis is on soils, but related geographic information on climate, ecology, vegetation, land use, land capability, geology, geomorphology, etc. is also important.

The acquisition policy is to obtain world coverage of maps at reconnaissance and smaller scale; examples of more detailed maps and index maps/lists of soil and related surveys carried out in a country. The selection criteria are relevance of the maps for soil science, agricultural development and environmental issues.

The major purpose of maintaining and enlarging the map collection at ISRIC is its use for updating the FAO-Unesco Soil Map of the World at scale 1:5 million and the compilation of the new World Soils and Terrain Digital Database (SOTER) at 1:1 million.

The map collection serves also as a source of basic information for scientists and students using ISRIC's facilities for guest research or training.

ISRIC is willing to reimburse you for the material and mailing charges.

Slides

The collection of nearly 20,000 slides includes soils, landscapes, vegetation, crops, forests, etc. from sites throughout the world. It is a much sought-after resource for teachers, publishing companies, etc. The slides are being listed in a database, using Cardbox Plus, a time-consuming activity which will last for several years. Other commitments have precluded further work on this aspect for some time. A selection of about 70 slides covering major soils and landscapes and some land uses is permanently available for sale.

REQUEST FOR INFORMATION ON VISUAL TRAINING TOOLS

During the last decade a large increase in the use of films, slides and videotapes and other training aids have been produced by universities, agricultural high schools, training institutes, etc. This also applies to soil science. Unfortunately, there is no central listing of the available material.

In cooperation with the Secretariat of the International Society of Soil Science (ISSS) a register of such visual aids is being made. It will, in due course, appear in the Bulletin of the ISSS.

We would be grateful if you could send us a listing of available films, slides or slide sets, and videotapes on soil science *sensu lato*.

Please supply information on:

- title and main contents
- level of audience,
- size and length of film,
- type of sound track,
- video system type,
- year of preparation,
- availability and price,
- ordering/contact address.

The cooperation of yourself or your colleague is much appreciated!

3.4.3 World Reference Base for Soil Resources

After the presentation of the Draft World Reference Base for Soil Resources (WRB) during the 15th Congress of the ISSS in 1994 at Acapulco, Mexico (ISSS-ISRIC-FAO, 1994), numerous comments have been received from all over the world. The WRB is an initiative of the International Society of Soil Science (ISSS), supported by FAO and ISRIC, to provide scientific depth and background to FAO's Revised legend of the Soil Map of the World (1988), incorporating the latest knowledge relating to the global soil resources and interrelationships.

The mandate of the ISSS Working Group RB, covering the WRB work, for the period 1994-1998 is to solicit comments on the draft publication, to test proposals during field visits, and to work out a first edition to be presented for adoption during the 16th World Congress of Soil Science in 1998 at Montpellier, France.

For this purpose meetings were held at Leuven (1995), Kiel (1995), Moscow (1996) and South Africa (1996). In 1997 two further meetings are scheduled, in Argentina and Vienna.

During the meeting in Leuven a WRB Steering Committee was set up with as main objective to streamline WRB meetings and to take final decisions (cf ISSS Bulletin no.88, 1995/2, p. 63). During the meeting in Kiel, hosted by Professor Blume, a number of Reference Soil Groups were discussed at length (Chernozems, Kastanozems, Phaeozems, Andosols, Cryosols and Cambisols). These were the soil groups that had received most of the comments, particularly concerning their definition. A field trip through Schleswig-Holstein was made to study Anthrosols/Anthric Regosols, and a sequence of Podzols.

The first meeting in 1996 was mainly to test proposals concerning the Podzols, Glossisols, Phaeozems and Chernozems, as well as to continue the discussion on Cryosols. The meeting was jointly held with the International Working Meeting on Soil Micromorphology in Moscow. Field trips were made from St. Petersburg to Moscow, in the vicinity of Moscow, and from Moscow to Kursk. During this meeting agreement was reached amongst the WRB participants from various countries (USA, Russia, Australia, Germany, Italy, South Africa, United Kingdom, Belgium and The Netherlands) on issues related to the name, characteristics and definition of Glossisols (renamed as Albeluvisols), the omission of the Stagnosols from the list of Reference Soil Groups, and on a better and clearer description and definition of Chernozems and Phaeozems.

The second meeting in 1996 was held in South Africa, at the invitation of colleagues at the University of Pretoria and the Institute for Soil Climate and Water. One of the criticisms to the Draft World Reference Base for Soil Resources has been that it takes too little account of the specific soil conditions in the southern hemisphere. At higher southern latitudes no large land masses occur and, consequently, different climatic conditions compared to the northern hemisphere prevail. South Africa is excellently situated to test the proposals as it has soils which have developed on very old geomorphic surfaces. The meeting yielded excellent discussions and for a number of participants, in particular those from Russia and China, were an eye-opener. It also resulted in a number of new elements being introduced into the WRB and the definition of a new Reference Soil Group, the Durisols was confirmed.

List of Reference Soil Groups used in WRB:

Histosols	Plinthosols	Albeluvisols
Anthosols	Ferralsols	Gleysols
Leptosols	Planosols	Nitisols
Cryosols	Solonetz	Acrisols
Vertisols	Arenosols	Luvisols
Fluvisols	Chernozems	Lixisols
Solonchaks	Kastanozems	Umbrisols
Alisols	Phaeozems	Cambisols
Andosols	Gypsisols	Regosols
Podzols	Calcisols	Durisols

These thirty Reference Soil Groups are defined in the World Reference Base. A list of adjectives with unique meanings has been developed which can be used to specify second, third and lower level units, as well as to create linkages between the World Reference Base for Soil Resources with national soil classification systems.

Participants of the South African WRB meeting, East London, September 1996.

Some participants of the joint International Working Meeting on Soil Micromorphology (X-IWMSM) and World Reference Base for Soil Resources (WRB) meeting, Russia, July 1996.

Field work, South African WRB meeting, September 1996.

3.4.4 Land Quality Indicators Metadata Information System

During 1996, ISRIC has participated in the Land Quality Indicator (LQI) initiative, developed by the World Bank, UNEP, FAO and the CGIAR. The intiative entailed the development of a metadatabase describing data sets relevant to land qualities. It is envisaged that such a metadatabase will be used by donor agencies, planners and decision-makers to provide an insight into the effects of land development activities. Technical assistance to the development of the LQI information system was provided by the Consortium for International Earth Science Information Network (CIESIN), based in Saginaw, Michigan, USA.

Initially, ISRIC was to collect and screen databases held by the relevant CG institutes, FAO, UNEP, WRI, USDA and ISRIC, and to prepare metadata entries for the LQI information system to be developed by CIESIN. This task was specified in the draft project document "Development of a global information system land-related resources".

Visits were made to the World Bank, the World Resources Institute, the International Food Policy Research Institute and USDA-NRCS in Washington, and CIESIN in Saginaw specifically to discuss ISRIC's contribution and to formulate a cooperation agreement, including finances, with the LQI partners. In view of the tremendous work load originally assigned to ISRIC, involving frequent travel to all the LQI partners, and in view of ongoing activities in the field of LQI metadata development by the various partners, it was decided that the CG centres (through GRID-Arendahl), FAO, UNEP and the WRI would develop the metadata themselves, and that ISRIC would concentrate on global datasets held by other institutions. An initial selection of which already had been during a meeting of the Integrated Environmental Assessment/Global Environmental Outlook (IEA/GEO) Core Data Working Group in January 1996.

ISRIC assisted CIESIN in updating their Parameter Indexing System to suit the LQI requirements, and screened CIESIN's Gateway on metadata suitable for the LQI information system. It also supported CIESIN in georeferencing some of the metadata.

In 1996, ISRIC developed a metadatabase about such global data sets as the "Global Historical Climatic Network (GHCN)" and the "Major World Ecosystem Complexes (Olson Vegetation)" (GNV1) of the Oak Ridge National Laboratory (ORNL), USA, the "Holdridge Life Zones" (GNV5) of the International Institute for Applied Systems Analyses (IIASA), the Tropical Forests Digital Map Database" of the World Conservation Monitoring Centre (WCMC), the "ISRIC Soil Information System (ISIS)", the "ISRIC-WISE International Soil Profile Data Set" (alias Global Pedon Data Base (GPDB) developed for IGBP-DIS) and the "ISRIC-WISE Spatial Data Set of Derived Soil Data", all of which are held at the International Soil Reference and Information Centre.

In the course of the year a strategic alliance was formed (the "Greater Wageningen Group"), including SC-DLO, AB-DLO, Soil Science and Geology, WAU, and RIVM. This group, coordinated by the Staring Centre, is to develop two land quality indicators, viz. yield gaps and nutrient balances. Work on these LQI's will start in 1997.

CIESIN and ISRIC

The Consortium for International Earth Science Information Network (CIESIN) was established in 1989 as a private, non-profit organization dedicated to furthering the interdisciplinary study of global environmental change. It is agency-neutral, specializing in the access and integration of physical, natural and socioeconomic information across agency missions and scientific disciplines.

CIESIN efforts are dedicated toward making the data collected by U.S. government agencies, the scientific community, non-government organizations and international governmental organizations available for widespread use in scientific research, public policy making, and education. The Consortium is developing the following resources and capabilities:

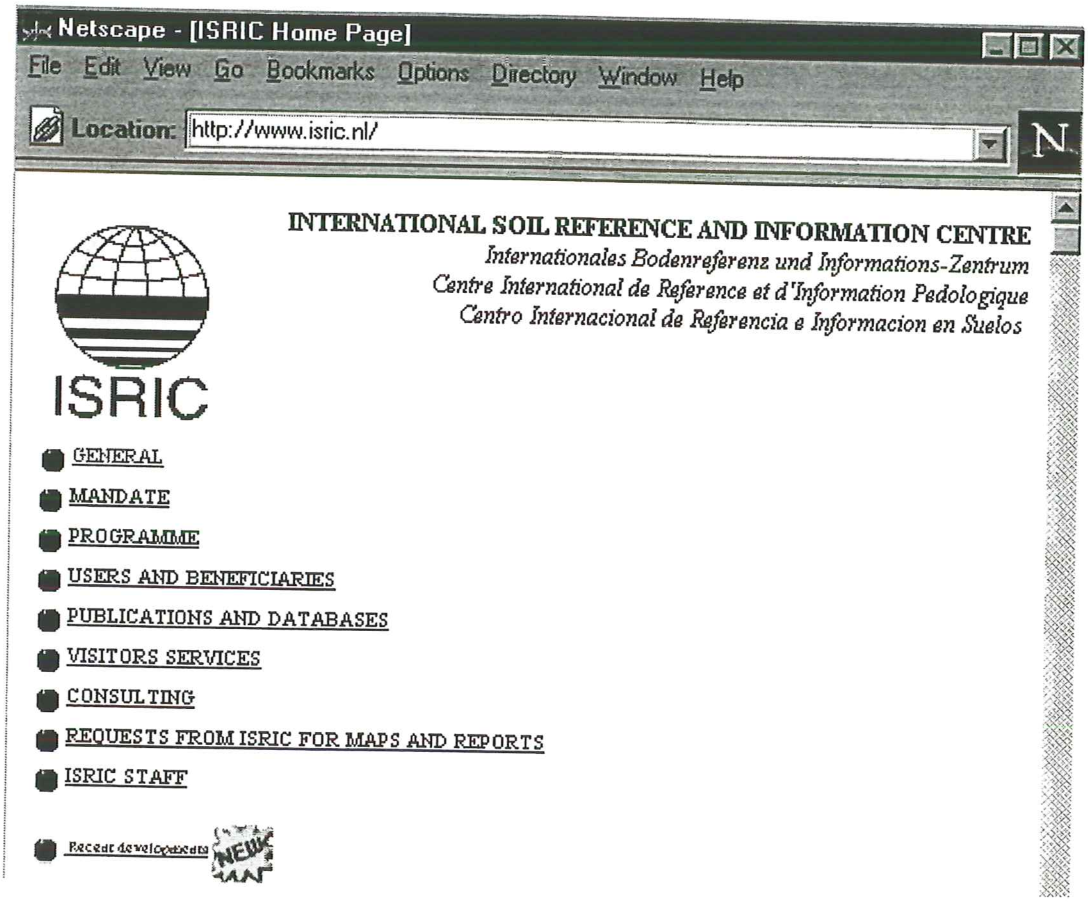
- Global-scale time series and baseline data and information on the human interactions in global environmental change;
- Advanced network computing tools for data access, research, and analysis across disciplines;
- A bridge between socioeconomic and natural science research communities and between research and policy communities; and
- Data and information identification, acquisition, management, integration, and distribution through a worldwide data cataloging network.

As a spin-off of the cooperation between ISRIC and CIESIN in the Land Quality Indicators Initiative, an agreement was signed between the two institutions on Collaborative Data Access and Dissemination Initiatives. ISRIC and CIESIN agreed to cooperate in such a manner that each may benefit from the other's resources and enhance their respective programmes.

ISRIC has become an active partner in CIESIN's Information Cooperative and will have access to data, information and services provided through this data-sharing network. CIESIN and ISRIC will also work together to enhance ongoing efforts to disseminate data and information for use in scientific research, public policy, and education: ISRIC through its expertise in agriculture and CIESIN through its expertise in information technology.

3.4.5 ISRIC's Home Page on Internet

Since mid-1996 ISRIC Home Page is active on Internet (http://www.isric.nl). A counting facility has not yet been added, but the ease in using the home-page and the attractive, up-to-date text resulted in some new contacts. It is hoped that Internet facilities in general will soon also increase in the developing countries, where many of our contacts are and most of our work is carried out.



4 STAFF PUBLICATIONS

Reports issued in the framework of Programme 1
(Assessment of soil and terrain resources)

Articles in Refereed Journals and Published Proceedings

Batjes, N.H., 1996. Total Carbon and Nitrogen in the Soils of the World. *European Journal of Soil Science* 47:151-163.

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Batjes, N.H., 1996. Global assessment of land vulnerability to water erosion on a ½° by ½° grid. *Land Degradation & Development* 7:353-365.

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5 TRAVEL AND MEETINGS

Within the four operational programmes detailed in Chapter 1, ISRIC staff has been called upon to play a leading role in many rapidly advancing fields of soil science. Requests are received from organizers of conferences and workshops around the world, but with only a small staff to call upon, it is inevitable and regrettable that ISRIC cannot respond to all invitations.

The preceding list of publications indicates the growing significance of databases in the handling of soil information and importance of the relationship of soils to other aspects of the environment. The data handling systems developed at ISRIC are meeting an increasingly wide demand from soil and environmental scientists. Staff members of ISRIC actively participated in meetings concerned with the adoption of SOTER on all continental landmasses, except for Australia and Antarctica, including conferences or workshops in Addis Ababa, Aleppo, Arendal, Athens, Beirut, Budapest, Chiangmai, Damascus, Iquitos, Lima, Nairobi, Ouagadougou, Rome and Washington.

Applications which have been developed as a result of the WISE global database have generated interest from international research bodies, many research institutes and conference organizers. The possibilities opened by the availability of a reliable, digitized soil database are still being actively explored. ISRIC has been represented at meetings in Arona, Hannover, Laxenburg and Orleans discussing the present and future use of soil parameters in assessing soil carbon contents, moisture holding capacities and cation exchange capacities, as well as the definition of agro-ecological zones.

Land degradation, soil loss and effective communication with those who work the land occupies the continuing concern of earth scientists who observe the gradual deterioration of the earth's most fundamental resource for food production. ISRIC staff participation in the ILIEA project has been involved in raising awareness of the problems of soil vulnerability and degradation at conferences in Adana, Amsterdam, Anapolis, Berne, Bilthoven, Cairo, Chiangmai, Rabat, Iquitos, London, Magoebaskloof, Manila, Nairobi, Nanjing, Ouagadougou, Rome and Palermo.

In cooperation with FAO and the International Society of Soil Science, ISRIC staff has been involved in the development of the World Reference Base for Soil Resources, participating in meetings at Leuven, Montpellier, Moscow and Pretoria. Development of the framework within which soil science exists has involved members of staff at meetings in Brussels and Bologna. ISRIC staff has also been involved with the process of determining research funding at the request of the European Commission in Brussels.

6 PERSONNEL

6.1 Board of Management (December 1996)

- Dr.Ir. A.W. de Jager (Chairman), on behalf of the Board of ITC, Enschede
- Prof.Dr. J. Bouma, Department of Soil Science and Geology, Wageningen Agricultural University (on behalf of the Scientific Advisory Council of ISRIC)
- Ir. W. van Vuure, European Commission, DG XII, Brussels (on behalf of the Ministry of Agriculture, Nature Management and Fisheries)
- Prof.Dr. M.J. Kropff, Department of Theoretical Production Ecology, Wageningen Agricultural University (on personal title)
- Dr. A.N. van der Zande, DLO Winand Staring Centre for Integrated Land, Soil and Water Research (SC-DLO), Wageningen (on behalf of the Agricultural Research Department of the Netherlands)
- Prof.Dr.Ir. M. Molenaar, Department of Geo-informatics, ITC, Enschede (on behalf of the Board of Wageningen Agricultural University)

Changes

In view of retirement in November 1995 as Director of the DLO Winand Staring Centre for Integrated Land, Soil and Water Research (SC-DLO) Ir. G.A. Oosterbaan has been replaced by his successor, Dr. A.N. van der Zande. Prof.Dr. L.O. Fresco resigned from her position as a member of the Board as of November 1995, and she has been replaced by Prof. M.J. Kropff. Both outgoing persons were associated with ISRIC for many years.

6.2 Scientific Advisory Council (December 1996)

- Prof.Dr. J. Bouma (Chairman), Dept. of Soil Science and Geology, Wageningen Agricultural University
- Dr. A.T. Ayoub, UNEP, Nairobi, Kenya
- Ir. G.W. van Barneveld, DHV Raadgevend Ingenieursbureau BV, Amersfoort
- Prof.Dr. W.E.H. Blum, International Society of Soil Science, Vienna, Austria
- Dr. R. Brinkman, FAO, Rome, Italy
- Prof.Dr. P.A. Burrough, University of Utrecht
- Dr.Ir. P.M. Driessen, Dept. of Soil Science and Geology, Wageningen Agricultural University
- Dr.Ir. G.W.W. Elbersen, International Institute for Aerospace Survey and Earth Sciences (ITC), Enschede
- Dr. F. Fournier, Unesco, Paris, France
- Prof.Dr.Ir. H. van Keulen, Research Institute for Agrobiology and Soil Fertility (AB-DLO), Wageningen

- Ir. M.J.H.P. Pinkers, International Institute for Land Reclamation and Improvement (ILRI), Wageningen
- Ir. B.J.A. van der Pouw, DLO Winand Staring Centre for Integrated Land, Soil and Water Research (SC-DLO), Wageningen
- Prof.Dr. J. Sevink, University of Amsterdam
- Prof.Dr.Ir. L. Stroosnijder, Dept. of Irrigation and Soil and Water Conservation, Wageningen Agricultural University
- Dr. C. Valverde, International Service for National Agricultural Research (ISNAR), the Hague
- Ir. M.M. Vierhout, Haskoning Koninklijk Ingenieurs- en Architectenbureau, Nijmegen

6.3 Staff of ISRIC (December 1996)

Directorate

L.R. Oldeman (Director)
J.H.V. van Baren (Deputy Director)
Y.G.L. Karpes-Liem (Secretary)

Research and Development Division

V.W.P. van Engelen (SOTER/GIS and application research)
J.A. Dijkshoorn (SOTER, Latin America)
S. Mantel (SOTER applications)
J.W. Resink (GIS programme analyst)
P. Tempel (software programmer)

J.H. Kauffman (pedon databases and application research)
N.H. Batjes (WISE, global change)
J.A.K. Boerma, guest researcher (Glinka Memorial Collection)
G.W.J. van Lynden (soil degradation, soil conservation)
O.C. Spaargaren (World Reference Base, ISIS)

L.P. van Reeuwijk (GLP/LIMS), soil and plant analytical laboratory)
J. Brunt (consultant, SOILIMS)
J.R.M. Huting (soil, plant and water laboratory analyst)
N. Manuchehri (soil, plant and water laboratory analyst)
A.J.M. van Oostrum (soil, plant and water laboratory analyst)
R.A. Smaal (soil, plant and water laboratory analyst)

Information and Documentation Division (*J.H.V. van Baren*)
M. Ahmad (soil monolith preparation)
W.C.W.A. Bomer (cartographic designer)
A.B. Bos (ISIS, communications, facility management)
E.M. Bridges, guest researcher
D. Creutzberg, guest researcher
J.C. Jonker-Verbiesen (librarian)
H.F. de Ridder-Helder (secretary, library assistant)

B.H. Thalen (cartography, data analyst)

Administration (***Directorate***)
K.J. Berendsen (computer hardware system)
J. Brussen (financial administration)
H. Soekhram (general support)

The following staff changes have taken place:

Incoming staff

Ir. J.A. Dijkshoorn	September 1995	(SOTER)
Ms. H.F. de Ridder-Helder	September 1995	(Information and Documentation)
Ms. B.S. Thalen	April 1996	(Information and Documentation)

Outgoing staff:

Dr. E.M. Bridges	February 1992 - May 1996	(guest researchear)
Ir. J. Brunt	January 1992 - January 1995	(SOILIMS)
Ms. M-B.B.J. Clabaut	November 1985 - September 1995	(secretary)
Ing. A.E. Hartemink	March 1995 - November 1995	(guest researcher)
Ir. E.E. van Loon	August 1994 - August 1995	(ISIS)
Mr. J.E.M. Rigtering	November 1994 - September 1995	(WOCAT)
Drs. A.F. Rotmans	November 1994 - November 1995	(SOTER)
Ir. M.H.C.W. Starren	November 1995 - February 1996	(World Food Studies)

IN MEMORIAM

It is with deep regret that we have to report that Mr. W. Bomer (senior) passed away on 14th February 1996. Until his retirement at the end of 1983, Mr. Bomer was associated with ISRIC (then the International Soil Museum) for a very long time, since 1st April 1966, as technician in monolith preparation. He will be remembered for his active participation in the development of ISRIC and especially through his many impregnated profiles in our exhibition hall.

APPENDIX Acronyms used in Bi-Annual Report 1995-1996

AB-DLO	Research Institute for Agrobiology and Soil Fertility, the Netherlands
ACSAD	The Arab Center for the Studies of Arid Zones and Dry Lands, Syria
ALES	Automated Land Evaluation System
ASSOD	Assessment of Human-induced Soil Degradation in South and Southeast Asia
CEDARE	Centre for Environment & Development for Arab Region and Europe, Egypt
CGIAR	Consultative Group on International Agricultural Research
CIESIN	Consortium for International Earth Science Information Network, U.S.A.
CIP	Centro Internacional de la Papa, Peru
CTA	Centre Technique de Coopération Agricole et Rurale, the Netherlands
DGIS	Directorate-General for International Cooperation, Ministry of Foreign Affairs, the Netherlands
DHV	DHV Consultants, the Netherlands
EC	European Community
ESB	European Soils Bureau
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GDE	Group for Development and Environment, Switzerland
GEO	Global Environmental Look, RIVM/UNEP project
GHCN	Global Historical Climatic Network
GIS	Geographic Information System
GLASOD	Global Assessment of Soil Degradation project, ISRIC
GLP	Good Laboratory Practice
GPDB	Global Pedon Data Base
GSDT	Global Soil Data Task
GTOS	Global Terrestrial Observing Systems
GTZ	Gesellschaft für Technische Zusammenarbeit, Germany
IBSRAM	International Board for Soil Research and Management, Thailand
ICIMOD	International Centre for Integrated Mountain Development, Nepal
ICSU	International Council of Scientific Unions
IFPRI	International Food Policy Research Institute, U.S.A.
IGBP	International Geosphere-Biosphere Programme
IGBP-DIS	International Geosphere-Biosphere Programme, Data & Information System
IGCP	International Geological Correlation Project
IIASA	International Institute for Applied Systems Analyses, Austria
IITA	International Institute of Tropical Agriculture, Nigeria
ILEIA	Information Centre for Low External Input and Sustainable Agriculture
ILRI	International Institute for Land Reclamation and Improvement, the Netherlands
INRENA	Instituto Nacional de Recursos Naturales, Peru
ISIS	ISRIC Soil Information System
ISNAR	International Service for National Agricultural Research, the Netherlands
ISS-AS	Institute of Soil Science, Academia Sinica, P.R. of China
ISSS	International Society of Soil Science
ITC	International Institute for Aerospace Survey and Earth Sciences, the Netherlands
IWACO	IWACO b.v., the Netherlands
KNAW	Royal Dutch Academy of Arts and Sciences
LEI	Low External Input
LIMS	Laboratory Information Management System
LQI	Land Quality Indicators
NASREC	National Soil Reference Collections, ISRIC
NGO	Non-Governmental Organization
NRCS	Natural Resources Conservation Service of the United States
ORNL	Oak Ridge National Laboratory, U.S.A.
ORSTOM	Institut français de recherche scientifique pour le développement en coopération, France
PIK	Potsdam Institute for Climate Impact Research, Germany
RISSAC	Research Institute for Soil Science and Agricultural Chemistry, Hungary
RIVM	National Institute of Public Health and Envrionmental Protection, the Netherlands
SC-DLO	The Winand Staring Centre for Integrated Land, Soil and Water Research, the Netherlands
SDC	Swiss Development Cooperation
SIDA	Swedish International Development Authority

SOILIMS	Soil Laboratory Information and Management System, ISRIC
SOSA	Salinity Status Programme
SOTER	World Soils and Terrain Digital Database, ISSS
SOTER-LA	SOTER project, Latin America
SOTERLAC	SOTER project, Latin America and the Caribbean
SOVEUR	Soil and Terrain Vulnerability Mapping Europe, ISRIC
SPALNA	Soil and Plant Analytical Laboratories Network of Africa
STD3	Science and Technology for Developing Countries
SWC	Soil and Water Conservation
SWEAP	SOTER Water Erosion Assessment Programme
SWNM	Soil and Water Nutrient Management
UNAP	Universidad Nacional de la Amazonia Peruviana, Peru
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USDA	United States Department of Agriculture
WASWC	World Association of Soil and Water Conservation
WATSAT	Water balance model
WAU	Wageningen Agricultural University, the Netherlands
WCMC	World Conservation Monitoring Centre
WISE	World Inventory of Soil Emission potentials
WOCAT	World Overview of Conservation Activities and Technologies, Switzerland
WOFOST	World Food Study model
WRB	World Reference Base for Soil Resources

INTERNATIONAL SOIL REFERENCE AND INFORMATION CENTRE

Internationaal Centrum voor Bodem-referentie en -informatie
Internationales Bodenreferenz und Informations-Zentrum
Centre International de Référence et d'Information Pédologique
Centro Internacional de Referencia e Información en Suelos

GENERAL AIM

The collection and dissemination of scientific knowledge about soils for the purpose of a better understanding of their formation, characterization, classification, distribution, and capability for sustained land use at local, national, and global scales.

SPECIFIC AIMS

* To serve as a centre for documentation about the soils of the world as a natural resource. To assemble soil monoliths, reports, maps and other information with emphasis on soils of the developing countries.
* To contribute to an increased understanding about soils enabling their sustained utilization in a changing global environment.
* To improve the accessibility of soil and terrain information for the widest possible range of users through applied research, improvement of research methods, and advice on the establishment of soil laboratories, soil reference collections and databases.
* To contribute to developments in soil classification, soil mapping and land evaluation and in the development of geographically referenced soils and terrain digital databases.

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