ISRIC World Soil Information

Recovery of samples lost from the

ISRIC – World Soil Reference Collection

Rebuilding the strategic collection as leader in world soil information to support global development

Project Document

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SUMMARY

ISRIC - World Soil Information has the mandate to create and increase the awareness and understanding of the role of soils in major global issues. As an international institution we inform a wide audience about the multiple roles of soils in our daily lives. This allows informed decisions to be taken by policymakers, the private sector and civil society organisations[1].

In June 2005, 1391 reference samples from 227 soil profiles of the ISRIC World Soil Reference Collection were mistakenly lost during clearance of a Wageningen University building in which part of the reference collection was stored. Loss of a sample means that the entire soil profile is considered to be lost from the reference collection as no reference material is available for further research — this therefore has compromised the ability of ISRIC – World Soil Information to fulfil its mandate.

Consensus has been reached, by the parties concerned, about the necessity to restore the integrity of the ISRIC soil reference collection. “The only way to compensate for this loss of samples is to collect new samples all over the world, and to analyze, preserve and classify them”[2]. A recovery program will be designed such as to support the strategic plan of ISRIC, aligned with ongoing global projects to develop a world soil map, and to harvest international cooperation.

The recovery program will involve clustered collection of new soil profile information — profiles, site and soil description, soil analytical and physical analysis, also spectral analyses, and necessary supporting information (e.g. high resolution photographs and soil survey reports) — based on purposive sampling, assuming that the original locations of the reference soils of the affected regions cannot be traced. A standard protocol will be developed for use in the recovery program.

Six regions are mostly affected: North and West Europe (Finland, France, Germany, Great Britain, Ireland, Netherlands, Norway and Sweden); the Mediterranean (Greece, Italy, Romania, Spain and Turkey); East and Southern Africa (Kenya, Mozambique, Namibia and South Africa); South and East Asia (India, Indonesia, Malaysia, Sri Lanka and Thailand); Australia; West Atlantic (USA, Jamaica, Brazil

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[1] http://www.isric.org/UK/About+Soils/Question+and+Answer+Services/

[2] Letter Dijkhuizen (Wageningen UR) to Ministers Plasterk and Verburg, 06 March 2008, 08/2009/mh)

and Uruguay). Specifics about the soil types involved, by country, are detailed in Annex 1 in accordance with international FAO classification standards.

The work will be implemented in close collaboration with selected partner institutes worldwide, with regional soil-related mandates, to optimize efficiency of time and resources. The proposed project partners include researchers and field pedologists in Africa, Asia and South America; the project comprises both science-oriented and capacity building sub-components. The full field and laboratory program, which includes the development of a soil information system for storing the data and web-services for distribution of the newly collated data, will require three and a half years from team mobilization.

The recovery program consists of 7 work packages (WP):
WP0: Project Management and ISRIC strategy
WP1: Nomination and selection of sites
WP2: Field sampling strategies
WP3: Cataloguing, sample and monolith preparation
WP4: Analytical strategy
WP5: Soil Information System and web-services
WP6: Educational materials for World Soil Museum

An independent, expert-assessment of the most cost-effective way to restore the integrity of the collection recommended a selective re-sampling and analysis by standard methods, at a cost of some 2 million Euros.

Through this integrated approach, ISRIC-World Soil Information will strengthen its international network, web-based services, educational program, and make a contribution to the analyses of global development issues, necessary for decision making by the private sector, NGO's and policy. It therefore fits ISRIC strategy to develop a centralized and user-focused database containing only validated and authorized data with a known and register accuracy and quality, and to make this geo-referenced information easily accesible to endusers.

Upon project completion, a suite of tools/databases, with full instructions on how to use them, will be available from a single web site hosted by ISRIC – World Soil Information, the ICSU World Data Centre for Soils since 1989. All data collected, including imagery, will be made available freely accessible to the international scientific community, and other specialist user groups, upon completion of the project. The newly collected reference data, and data derived from them, may be used, for example, in support of studies on reducing soil degradation, world food supply, mitigation of greenhouse gas emissions from soils at national and global scale, thereby creating opportunities for new internationally funded projects. They will also be used to strengthen ISRIC's educational program through new thematic displays in the World Soil Museum.

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1 INTRODUCTION

1.1 Background

In June 2005, 1391 reference samples from 227 soil profiles of the ISRIC World Soil Reference Collection were mistakenly lost during clearance of a Wageningen University building in which part of the reference collection was stored. Loss of a sample means that the entire soil profile is considered to be lost from the reference collection as no reference material is available for further research — this therefore has compromised the ability of ISRIC – World Soil Information to fulfil its mandate. An independent, expert-assessment[3] of the most cost-effective way to restore the integrity of the collection recommended a selective re-sampling and analysis by standard methods, at a cost of a little over 2 million Euros.

In 1964, the foundation of an International Museum of Soil Standards[4], hosted and financed by the Netherlands, was approved by the General Assembly of UNESCO. During the first meeting of the UNESCO International Advisory Panel, it was affirmed that: "a representative collection of soils as will be shown on the Soil Map (of the World)[5] would have a great impact and a stimulating effect on all those who are concerned with the study of the soil with the aim to assist mankind, through greater knowledge, in reaching a better standard of living, specifically in the developing countries"[6]. The second meeting of the International Advisory Panel, in 1972, reiterated that "Future activities of the International Soil Museum[7] should concentrate on the collection of additional soil monoliths so as to obtain a collection of representative soils on a global scale. Monoliths should also be collected to illustrate and study landscape sequences, influence of human activities, soil degradation features, etc." Subsequently, the Ministry of Foreign Affairs of the Netherlands (Directorate General of International Cooperation) provided funds for the housing of staff, laboratory, collections and International Soil Museum in tailor made premises in Wageningen (1977).

Since its beginning, the Institute has maintained consistent standards of collection, description and analysis, thereby bringing together a unique collection of soil materials: some 1 000 soil monoliths from more than 85 countries; over 5 000 soil samples with full physical, chemical and mineralogical analysis, some 3 500 thin sections, photographic documentation, and supporting soil maps and reports. Out of the total soil profile (monolith) collection held by ISRIC – World Soil Information, some 75 per cent are *reference soils.*

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[3] "Proposal for recovery of samples lost from the World Soil Reference Collection" (2008)
[4] Currently, ISRIC – World Soil Information
[5] FAO-Unesco Soil Map of the World at scale 1:5 000 000.
[6] Report on the first meeting of the Advisory Panel of the International Museum of Soil Standards, a joint project of UNESCO and The Netherlands, 1967
[7] For administrative purposes, the Netherlands Government brought the Museum under the International Training Centre for Aerial Survey and Earth Sciences as a branch located at the Soils Department of the University of Utrecht (letter of the Minister for Education and Sciences of 13 February 1967, ref. DGW 153.780).

The Institute also safeguards other collections and data sets important to the documentation of world soil resources, including the *Glinka Memorial Collection* of soil monoliths from the former USSR collected on the occasion of the first Congress of Soil Science in Washington in 1925, the *Schmidt Lorenz Collection* of thin sections mainly from Africa, and the *Jongerius/Stiboka Collection* of thin sections of soils from the Netherlands.

The worldwide significance of the reference collection was emphasised by the fourth International Advisory Panel meeting on 13-18 January 1983, which recommended the change of name of the Institute to the *International Soil Reference and Information Centre (ISRIC) - a centre for the collection and study of soil reference materials.* In 1989, the Institute was accredited by ICSU as the *World Data Centre for Soils;* it will be incorporated into the new ICSU[8] World Data System (WDS) in 2010[9].

ISRIC became a Foundation in 1995. Subsequently, in 2002, ISRIC transferred its cooperative agreement from the International Institute for Aerospace Survey and Earth Sciences (ITC), Enschede, to Wageningen University. In 2003, the Institute was registered as ISRIC - World Soil Information.

ISRIC - World Soil Information has the mandate to create and increase the awareness and understanding of the role of soils in major global issues[10]. This key role — as initially endorsed by UNESCO and the Netherlands Government — has recently been re-stated in letters of support from the Division of Early Warning (DEWA) at UNEP and the Land and Water Division (NRL) at FAO[11]. As an international institution, with a global mandate, we inform a wide audience about the multiple roles of soils in our daily lives. This allows informed decisions to be taken by policymakers, the private sector and civil society organisations.

1.2 Uses of the soil reference collection

International use of the reference collection during the last decade includes the use of sub-samples from the entire reference collection to calibrate spectral analytical equipment and to create a reference IR-spectral library for rapid, non-destructive and low-cost analysis various soil attributes such as particle-size distribution, organic carbon and nutrients (ICRAF, Kenya); selected samples have been used by researchers at Wageningen University for soil carbon related studies; for the development of detergents by Unilever (UK); for assessment of marine influences on shore soils by the Netherlands Institute for Research of the Sea (NIOZ); and for pre- and post-Chernobyl soil conditions in the Middle East by ICARDA (Syria).

Materials from the reference collection also have been important in developing and testing new criteria for soil classification, notably for the World Reference Base for

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[8] International Council for Sciences (http://www.icsu.org/index.php

[9] http://www.ngdc.noaa.gov/wdc/

[10] http://www.isric.org/isric/webdocs/docs/ISRIC_brochure2009.pdf

[11] See p. 25 & 27, http://www.isric.org/UK/About+Soils/Question+and+Answer+Services/

Soil Resources[12]. They have also been used for the establishment of national soil reference collections (NASREC); NASREC activities were sponsored by the Netherlands Directorate General for International Cooperation (DGIS), with additional support from UNESCO, the Life Sciences and Technologies Development Programme (STD2) of the European Community and the Royal Academy of Sciences (KNAW).

In addition to the above, soil morphological and analytical data from the ISRIC World Reference Collection have been used to populate a number of soil databases at national and global scale, in support of studies on reducing soil degradation, world food supply, mitigation of greenhouse gas emissions from soils; examples of such studies may be found on the ISRIC website[13] and the above mentioned ISRIC brochure.

A selection of soil reference monoliths is on display in the ISRIC – World Soil Museum[14], illustrating the wide range of soils in the world with their different properties and land-use and management requirements. The collection has a scientific and educational value and also helps to show the use and aesthetics of soils to a more general public. Visitors to the Museum include: primary school children; secondary and high school students; university students in the natural resources sciences, including agriculture, biology, ecology, environment, forestry, geography and soil science; researchers and managers from national and international organizations; specialized study groups; and, the general public.

1.3 Reference soil profiles and samples

Requirements for soil profiles to be part of the ISRIC World Reference Collection are:

- Complete site and morphological description, including accurate location;
- A good soil monolith with adequate accompanying sample material to permit additional research — in some instances, where monoliths for similar soil units are already on display in the World Soil Museum, these may be replaced by high resolution, digital imagery as a cost-effective solution
- Analytical data (*from a certified, reference laboratory*) enabling correct characterization and evaluation;
- Characteristic for one of the soil units of the FAO-UNESCO *Soil Map of the World*, or its successor the digital *Harmonized World Soil Database*[15], and important for the country/region. Conversely, they may be illustrative of a specific theme such as catenas or chronosequences, cultural-historical (*Terra Preta do Indio* from Brazil; set from Italy illustrating the effects of deforestation in the Mediterranean since Roman times), biological activity (termitaria), land use and land management aspects (effects of manual and mechanical forest clearing), or soil formation on specific parent materials.

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[12] http://www.fao.org/ag/agl/agll/wrb/doc/wrb2006final.pdf
[13] http://www.isric.org
[14] http://www.isric.org/UK/About+Soils/World+Soil+Museum/
[15] http://www.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/

Soil samples are collected to characterise the various layers, or horizons, in a soil. Consistent guidelines for soil description[16] and sampling underlie the reference collection; soil analytical analyses are carried out according to defined reference methods[17], in accordance with Good Laboratory Practice[18].

As standard, the reference samples are analyzed for particle-size distribution, reaction (pH in water and KCl), electrical conductivity, organic carbon and nitrogen, available Phosphorus, exchangeable bases and cation-exchange capacity; for selected samples clay mineralogy by X-ray diffraction. Depending on *specific* soil properties, additional analyses are: for calcareous samples, carbonates; for gypsiferous samples, gypsum; for acid samples (pH-water less than 5) exchangeable acidity and aluminium; for volcanic samples, oxalate-extractable silica, iron and aluminium, phosphate-retention and bulk density; for tropical soils, citrate-dithionite-extractable iron; for Podzols, pyrophosphate-extractable iron and carbon; for saline soils, readily soluble salts; for acid sulphate soils, sulphur; for shrink-swell soils, the coefficient of linear extensibility. Similarly, depending on soil acidity (pH) different types of soil analytical procedure will be needed for the determination of available P (e.g., P-Bray versus P-Olsen).

In all cases, the new set of samples will have to be analyzed for the relevant soil attributes. On average, the soil profiles affected are characterized by six samples (two to thirteen samples per profile). Calculations of recovery costs and soil analysis are based on the average of six; detailed cost estimates are presented in "Proposal for recovery of samples lost from the World Soil Reference Collection" (2008).

Ideally, water retention characteristics and bulk density should be determined for all new reference soil samples (cores) as such data are under-represented in the reference collection (in view of cost of measurement) yet essential for a wide range of modelling applications (e.g. soil carbon stocks and changes; crop production; soil water retention). Available phosphorus will be measured on all samples seen its importance for soil fertility and ultimately food security[19].

1.4 Inventory of samples lost and recovery scenarios

Following the inventory of 1391 reference samples, from 227 soil profiles that were lost in June 2005 – their relevance to the World Soil Reference Collection has been described elsewhere[20].

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[16] ftp://ftp.fao.org/agl/agll/docs/guidel_soil_descr.pdf

[17] Van Reeuwijk, LP 2002. *Procedures for soil analysis (6th ed.)*. Technical Paper 9, ISRIC, Wageningen (http://www.isric.org/Isric/Webdocs/Docs/ISRIC_TechPap09_2002.pdf)

[18] van Reeuwijk LP 1998. *Guidelines for quality management in soil and plant laboratories*, FAO, Rome (http://www.fao.org/docrep/W7295E/W7295E00.htm)

[19] Smit AL, Bindraban PS, Schröder SJJ, Conijn JG and van der Meer HG, 2009. Phosphorus in agriculture: Global resources, trends and developments. Report to the Steering Comittee Technology Assessment of the Ministry of Agriculture, Nature and Food Quality, The Netherlands. Report 282, Plant Research International in collaboration with the Nutrient Flow Task Group (NFTG), http://edepot.wur.nl/12571

[20] "Proposal for recovery of samples lost from the World Soil Reference Collection" (2008)

Six regions are mostly affected:

- North and West Europe: Finland, France, Germany, Great Britain, Ireland, Netherlands, Norway and Sweden
- The Mediterranean: Greece, Italy, Romania, Spain and Turkey
- East and Southern Africa: Kenya, Mozambique, Namibia and South Africa
- South and East Asia: India, Indonesia, Malaysia, Sri Lanka and Thailand
- Australia
- West Atlantic: USA, Jamaica, Brazil and Uruguay.

Details by individual country, in terms of number of reference profiles and samples affected, are given in Annex 1. Conversely, in terms of major soil groups, the following are most significantly affected: Acrisols (17), Cambisols (31), Ferralsols (16), Luvisols (38) and Podzols (18). Also significantly affected are: Arenosols (7), Calcisols (8), Chernozems (6), Gleysols (8), Nitisols (8), Phaeozems (9), Regosols (10), Solonetz (7) and Vertisols (12). Albeluvisols (3), Alisols (3), Andosols (3), Anthrosols (1), Fluvisols (5), Gypsisols (2), Histosols (1), Kastanozems (1), Leptosols (1), Lixisols (4), Planosols (5), Plinthosols (1), Solonchaks (1) and Umbrisols (1) are the least affected.

1.5 Options for data recovery

To restore the integrity of the collection, four recovery scenarios, based on purposive sampling, have been proposed by an independent expert: a) one-for-one resampling; b) one-for-one new collection; c) clustered collection assuming the original locations can be traced with re-sampling according to the regions most affected and recovering representatives of the soils lost from other regions within the re-sampled region; and d) clustered collection assuming that the original locations of the reference soils of the affected regions cannot be traced.

Clustered collection (d) is considered most appropriate by the independent experts. This option assumes that the original locations of the soils of the affected regions generally cannot be traced. Therefore, all soils need new collection of samples, taken from a reference profile characterized using a monolith and/or high-resolution digital imagery, and accompanying documentation. This would provide the flexibility to collect new reference soil profile materials, for the soil units defined earlier, ideally within the geographic setting of ongoing international, collaborative projects as discussed in Section 1.6.

1.6 Implementation

Consensus has now been reached, by the parties concerned, about the necessity to restore the integrity of the ISRIC soil reference collection. “The only way to compensate for this loss of samples is to collect new samples all over the world, and to analyze, preserve and classify them”[21]. Costs for restoring the whole

[21] Letter Dijkhuizen (Wageningen UR) to Ministers Plasterk and Verburg, 06 March 2008, 08/2009/mh).

collection have been estimated at some 2 million Euros by an independent expert. Key elements in the discussions with the Wageningen UR Board of Directors are that "the reference collection must be restored;" further the recovery program must support ongoing international, collaborative research projects as well as the development of ISRIC's new web-infrastructure. Inherently, upon completion and publication, all primary data will be made freely accessible to the global scientific community as well as other user groups through ISRIC's new web services and the ICSU World Data Centre System. Newly collected monoliths will be used also for thematic displays in the ISRIC – World Soil Museum, focussing on key global issues as outlined in ISRIC's Strategic Plan for 2009-2012[22].

The scope for sampling typical soil topo-sequences (catenas) for major climate - soil type - land use zones also deserves special attention in the context of the recovery program. The collection of full reference profiles, with monoliths rather than only digital imagery, will concentrate on representative profiles depicting such catenas resp. effects of man-induced features. As stated in the founding advice of our Centre[23], "monoliths should also be collected to illustrate and study landscape sequences, influence of human activities, soil degradation features, etc." Strategic alliances for helping with site selection and the fieldwork will be established with internationally recognized institutes, for instance the International Center for Tropical Agriculture (CIAT) for South America and the World Agro Forestry Centre (ICRAF) for Africa.

All new samples collated during the recovery program will be analysed according to consistent laboratory methods[24,25] to ensure the integrity of the ISRIC soil reference collection that is the inter-comparability of the analytical data obtained. By their nature, however, these conventional analytical methods are generally time consuming and thus relatively expensive. However, they are essential for calibration and further development of less costly, new spectral analysis tools[26]. Within the recovery program, new reference sample materials will also be analysed by infra-red spectroscopic analysis at specialist Institutes (e.g. CSIRO, Australia, or ICRAF, Kenya) to strengthen the World Spectral Reference Library.

All new reference materials will be handled and stored at the ISRIC premises in Wageningen, in accordance with prevailing phyto-sanitary regulations, for archiving purposes and future use by international research groups.

Rather than collecting a full monolith for all new reference profiles, ISRIC will assess whether some physical monoliths may be replaced by high resolution, digital imagery — these can be used in support of ISRIC's web-based Museum services. This would also support ISRIC's goal for improved internet access to a comprehensive range of reference soil information, including supporting imagery.

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[22] Strategic Plan ISRIC – World Soil Information (2009-2012)

[23] Report on the first meeting of the Advisory Panel of the International Museum of Soil Standards, a joint project of UNESCO and The Netherlands, 1967

[24] van Reeuwijk LP 2002. *Procedures for soil analysis (6th ed.)*. Technical Paper 9, ISRIC, Wageningen (http://www.isric.org/Isric/Webdocs/Docs/ISRIC_TechPap09_2002.pdf)

[25] USDA-NRCS 2004. *Soil Survey Laboratory Manual* Soil Survey Investigations Report 42 (ver. 4.0), USDA-National Resources Conservation Service, Washington (Available at: ftp://ftp-fc.sc.egov.usda.gov/NSSC/Lab_Methods_Manual/SSIR42_2004_view.pdf; Accessed: 5 December 2009)

[26] http://www.worldagroforestrycentre.org/sensingsoil/libraryapproach.html

From an operational point of view, in particular in so far as the selection of sampling sites for reference profiles with accompanying soil monoliths is concerned, the most rational solution would be to "complement the ISRIC reference collection in parallel with other international, collaborative projects" that depend on good, soil reference soil information.

The activities in this project will be closely linked to ISRIC current and foreseen projects and will support the implementation of ISRIC strategy in developing a geo-referenced internet-based database system. Components of these operation issues have been integrated in the various work programs.

1) e-SOTER

The e-SOTER project[27], funded by the 7th Framework Program of the EC and coordinated by ISRIC, is the European contribution to a Global Soil Observing System. It will deliver a web-based *regional pilot platform* with data, methodology, and applications, using remote sensing to validate, augment and extend existing data.

The Group on Earth Observations - GEO plans a global Earth Observation System and, within this framework, the *e-SOTER* project addresses the felt need for a global soil and terrain database. Together with the Joint Research Centre (JRC), the project has taken the initiative to formulate a Global Soil Data task within the 2009-2011 GEO work plan[28], recently also endorsed by the *GlobalSoilMap.net* consortium.

Interpretations of the *e-SOTER* database, at scale 1:1 million will address threats defined in the EU Soil Thematic Strategy[29], such as soil erosion, decline in soil organic carbon, and compaction; results will be compared with current assessments for the relevant case study areas.

Once the e-SOTER methodology is operational, worldwide coverage in SOTER can be pursued. SOTER follows a soil-landscape based approach. However, for large sections of the world the amount and quality of existing (legacy) soil data is so restricted that new reference observations will be needed. This is particularly the case for Africa, Asia and Latin America – the new ISRIC soil reference data recovery program will provide part of the necessary data.

2) GlobalSoilMap.net

There is a need for accurate, up-to-date and spatially referenced soil information. This need has been expressed by the modelling community, land users, and policy and decision makers. This need coincides with a enormous leap in technologies that allow for accurately collecting and predicting soil properties at a fine resolution.

The GlobalSoilMap.net[30] consortium aims to make a new digital soil map of the world using state-of-the-art and emerging technologies for soil mapping and

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[27] http://www.esoter.net
[28] http://www.earthobservations.org/geoss_imp.shtml
[29] http://ec.europa.eu/environment/soil/index_en.htm
[30] http://www.globalsoilmap.net/

predicting soil properties at fine resolution. This new, pixel-based global map of soil properties will be supplemented by interpretation and functionality options that aim to assist better decisions in a range of global issues like food production and hunger eradication, climate change, and environmental degradation.

This international project receives funding from the Bill & Melinda Gates foundation and the Alliance for a Green Revolution in Africa (AGRA) to map most parts in Sub-Sahara Africa, and make all Sub-Saharan Africa data available. From this grant, funds are also available for coordinating global efforts and for the establishment of a global consortium.

Besides using new soil sampling and analysis techniques, the GlobalSoilMap.net consortium will draw heavily on available soil profile data, as co-variates[31]. New reference profiles for Africa and other parts of the world, collected during the ISRIC data recovery program, are also important to support this effort.

3) Carbon Benefits Project

This Global Environmental Facility (GEF) co-funded project (2009-2011) is executed by UNEP and lead by Colorado State University and the World Wide Fund for Nature[32]. The project will provide scientifically rigorous, cost-effective tools to establish the *net* carbon benefits of sustainable land management interventions in terms of protected or enhanced carbon stocks and reduced greenhouse-gas emissions. The CBP-system will be applicable at various levels of scale, from national level to the project level, made available freely as a web-accessible system. The modelling, measurement and monitoring tools will be available to project managers from a single web site together with instructions on how to use them. Users will be guided as to which tools are suitable based on the characteristics of the project, availability of existing data, and resource levels. The system will be available for use by Sustainable Land Management (SLM) projects in GEF5 and other *post-Kyoto* projects.

Within the CBP consortium, ISRIC is part of the so-called Modelling and Projection component. It will use new data collated by the recovery program "to establish the amount of soil organic carbon that can be stored in each of the world's major biomes (i.e. equilibrium content under the natural vegetation)". This will provide revised default values, with defined uncertainty, applicable at national scale and broader, for data poor regions according to IPCC[33] Tier I type inventory assessments. The global framework will also provide reference data on changes in soil organic carbon stocks – for defined climate and soil types - subsequent to defined changes in land use and management, again with defined uncertainty.

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[31] Sanchez-Maranon M, Soriano M, Delgado G and Delgado R 2002. Soil Quality in Mediterranean Mountain Environments: Effects of Land Use Change. *Soil Sci Soc Am J* 66, 948-958

[32] http://www.isric.org/isric/webdocs/Docs/CBP-Flyer_final.pdf

[33] IPCC 2006. *IPCC Guidelines for National Greenhouse Gas Inventories Volume 4: Agriculture, Forestry and other Land Use*. IPCC National Greenhouse Gas Inventories Programme, Hayama (JP) http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.htm

4) Green Water Credits

Green Water Credits are payments for farmers' water management activities that are, now, unrecognized and unrewarded. Benefits to poor rural people drive this initiative which, at the same time, safeguards water resources for everyone[34].

Management of the whole freshwater resource, including demands and uses even before the water reaches streams and groundwater, opens a wider stage for negotiation, trade-offs between competing claims, and action to optimize water flows.

Water productivity can be significantly increased, the hazards of flood and drought mitigated, and rural livelihoods secured by two fundamental improvements in soil management: increasing infiltration of rainfall into the soil, thereby cutting storm runoff, and shifting unproductive evaporation to productive water use. Additional soil reference data, in particular soil water retention properties, may support these activities.

Seen its integrated nature and scope, as outlined in the work package descriptions in Chapter 2, the sample recovery program will create opportunities for new internationally funded projects.

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[34] http://www.isric.org/UK/About+ISRIC/Projects/Current+Projects/Green+Water+Credits.htm

2 WORK PACKAGES

The full field and laboratory program will require three and a half years from team mobilization; it is built up of 7 work packages (WP).

2.1 WP0: Project management and ISRIC strategy

Overall project coordination and management, including reporting, will be carried out by the International Project Coordinator at ISRIC – World Soil Information (see Annex 2).

The project will be implemented with support from selected partner institutes worldwide, with regional soil-related mandates, to optimize efficiency of time and of labour and financial resources. The proposed partners include researchers and field pedologists in Africa, Australia, Asia, Europe, and North and South America; the project comprises both science-oriented (see WP2.6) and a capacity building sub-component (see WP2.3). This international collaboration will further strengthen ISRIC's global network and role in providing world soil reference materials.

In so far as scientifically justified within the framework of the recovery program (see Section 1.3 and WP2.3), new reference sites will be located in pilot areas of on-going international projects such as the GlobalSoilMap.net, World Soil and Terrain Database (e-SOTER), Carbon Benefits Project, and Green Water Credits Project (see Section 1.6). Options for clustering into regional sampling programs will be assessed, provided standard protocols for the ISRIC soil reference collection are maintained. Such regional programs can be managed more easily from within the region, rather than from Wageningen, with input from local scientists who have a much better knowledge of soil and terrain conditions in the region.

The project will be managed such as to ensure close linkages with the global and strategic projects of ISRIC and to support ISRIC's strategy in developing an easily accessible geo-referenced database on world soil information as outlined in WP5.

2.2 WP1: Nomination and selection of sites

The objective of WP2 is the nomination and selection of representative sites where new reference soils will be described and sampled. The following activities are planned:

- The Harmonized World Soil Database (HWSD)[35] will be used for the determination of the broad distribution of major soil types, by region and country
- Locations of reference soil profiles with missing samples (for details see Annex 1) will be plotted on this map

[35] http://www.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/ (ver. 1.1, 2009)

- When the soil taxonomic name (classification) of a reference soil corresponds with the legend units of the HWSD, a potentially suitable area for locating a new sampling site has been identified
- More detailed site-selection criteria will include the feasibility of implementation using established and new networks. It will be assessed whether the selected reference soil type can be sampled and described in the proposed area, depending on logistics, climatic conditions[36], etc., or whether a similar soil profile may better be obtained from another region/country considered in the global resampling program
- In all cases, definitive site selection will be based on more detailed field assessments, and analysis of remotely sensed imagery, in close collaboration with local soil experts (see WP2.3).

2.3 WP2: Field sampling strategies

Without bias, select location of new reference site profile in study areas identified under WP1:

- Map and characterize measurement plot sites according to project protocol
- For each site, describe and sample reference soil profile; also high resolution images of profile and surrounding site and landscape in accordance with standard protocol.
- For selected sites, taking of soil monoliths in accordance with standard protocol (see WP3)
- Randomized directional and distance sampling around reference profile (auger sampling to 50 cm); aggregate 4 samples from defined depths at each collection point.
- Accurate labelling of all sample bags; documentation; handling and despatch to regional collection centre.

Selection of sites for monolith preparation will be determined in conjunction with WP7, which will develop educational materials for the ISRIC – World Soil Museum focussing on impacts of human-activities on soil properties and soil quality/health. Relevant monoliths will be taken for future display in the Museum; regional distribution and themes can first be determined during the actual field programme; ideally, such ‘disturbed’ monoliths should be accompanied by ‘undisturbed’ versions of the given reference soil type, taken in close proximity.

Definition of procedures for shipment to regional storage facility for further handling. Ultimately, all soil materials will be dispatched to the central storage facilities at ISRIC – World Soil Information for further archiving, handling and subsequent dispatch to the reference laboratory.

WP3 includes developing and providing of a tailor made training related to field sampling, including the taking of monoliths, of defined reference soil profiles for the ISRIC reference collection. CIAT, Colombia, has already expressed its interest in building a joint training module on soils sampling procedures.

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[36] Inherently, field work is strongly dependent on meteorological, infrastructural and other conditions in the study regions; this may create some unavoidable delays in execution of the overall project.

2.4 WP3: Cataloguing, sample and monolith preparation

WP3 includes registration, pre-treatment and storage of all newly collated soil samples in a central depository; also preparation of soil monoliths in compliance with safety protocols.

Physical storage of all sample materials at ISRIC – World Soil Information. This is a *prerequisite* for maintaining the integrity of the soil reference collection.

Safety protocols
The ISRIC workshop conforms to the legal safety protocols applicable in the Netherlands (*cf.* Plant Protection Service, Ministry of Agriculture, Nature and Food Quality[37]).

Soil samples
Soil reference materials held in the sample bags (2-3 kg each) will be air-dried, sub-sampled and ground, and then stored in labelled sample bags.

Data entry and cataloguing of all new reference materials (i.e. soil monoliths and sample materials for each horizon) in a database, for reference purposes.

Subsamples to be sent to selected reference laboratory for soil analyses (wet chemistry resp. IR methods), see WP5. Each batch of samples will include internal references and standardized procedures for checking actual lab-performance at the time of measurement.

Results will be stored and handled in a central database (see WP5). This involves setting up a Soil Laboratory Information System; procedures in accordance with Good Laboratory Practice[38].

Monoliths
Monoliths will be prepared in the ISRIC workshop according to standard protocol[39]; inherently, procedures will vary according to soil type (e.g. as a function of their mineralogy). Also standardized photography of all finalized soil monoliths at high resolution, for linkage to the soil information system.

WP5 also provides for the development and testing of new, environmentally friendly, methodologies for impregnating soil profiles such as use of water-based lacquers or irradiation techniques.

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[37] http://www.minlnv.nl/portal/page?_pageid=142,2268041&_dad=portal&_schema=PORTAL&p_file_id=14023

[38] van Reeuwijk LP 1998. *Guidelines for quality management in soil and plant laboratories*, FAO, Rome (http://www.fao.org/docrep/W7295E/W7295E00.htm)

[39] Van Baren JHV and Bomer W 1979. Procedures for the collection and preservation of soil profiles. Techical Paper 1, International Soil Museum (ISM), Wageningen (http://www.isric.org/isric/webdocs/Docs/ISRIC_tp1.pdf)

2.5 WP4: Analytical strategy

All soil analyses to be carried out in a certified laboratory at a pre-defined centre, using consistent reference methods for wet chemistry resp. spectral analyses.

Performance of this laboratory will be screened in Proficiency Testing Schemes (e.g. Wepal[40]) to assess overall comparability of methods to the standard described above; also peer review.

For all soil samples collected under WP1:

- Comprehensive analysis of samples from reference profiles by established standard methods, including organic, carbonates, clay activity, water regime, nutrient supplying capacity, production constraints for soil pit using standard protocol (see Section 1.3 and Annex 1 for details); also Infrared Spectral (IR) analysis.
- For the greater number of randomized samples - IR spectroscopy for selected soil attributes; calibration based on analytical obtained data for the central pit. Will also serve to expand the World Soil Spectral Library.

Cross checking of analytical results to assess possible inconsistencies; data storage in central database (See WP5).

Subsamples from the reference collection will be made available for research to third parties request conforming to ICSU - World Data Centre Guidelines[41] for data exchange. ISRIC staff should be involved as co-authors in publications that use the reference materials; in all cases, results must be made available resp. communicated to ISRIC to permit monitoring of soil reference data usage.

2.6 WP5: Soil information system and web-services implementing part of the globally oriented ISRIC strategy

In line with ISRIC's mandate, the soil reference data and information generated through this project will be incorporated in the ISRIC Soil Information System (ISIS) that holds data of the existing soil reference collection. ISIS related holdings will be made publicly available through the ISRIC World Soil Information portal, and will form an integral part of the new ISRIC harmonized geo-referenced, internet-based soil database.

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[40] Wageningen Evaluating programs for Analytical Laboratories (http://www.wepal.nl/)

[41] http://www.ngdc.noaa.gov/wdc/guide/wdcguide.pdf

A soil's portal is under development, in line with ISRIC's strategy regarding its collections and in line with current projects with a web-infrastructural component like *e-SOTER* and *GlobalSoilMap.net.* Tailor made web-services will also be developed during the duration of the recovery program; see WP6.

The underlying data model, based on state-of-the-art XML-procedures, will accommodate all soil information, both of primary and derived nature; it will allow for exchange with other (inter)national soil datasets on other holdings. To this purpose, interoperability is key.

Interoperable soil information standards, including exchange formats and shared dictionaries, are currently in various stages of development. Both *e-SOTER* and *GlobalSoilMap.net* are developing open-source OGC compliant standards, based on GeoSciML (Observations and Measurements), for exchanging, respectively, soil-landscape and inferred soil property map data. Functional interoperability between these soil standards is yet to be achieved for which research is needed.

The following tasks are planned:

1. Development of ISRIC-ML (meta language) following established (international) standards
2. Implementation of the ISRIC portal and web-services

2.7 WP6: Educational materials for World Soil Museum

ISRIC hosts the World Soil Museum which illustrates the wide range of soils in the world with their different properties and land-use and management requirements. The unique collection is visited by a wide range of visitors annually. It provides an important component of ISRIC's tailor-made educational programmes on topics like: soils of the tropics, soil survey and classification, soil degradation and soil conservation, and soil fertility management.

During the sample recovery program, collection of reference profiles with accompanying soil monoliths will concentrate on selected (representative) profiles depicting both adverse as positive effects of selected man-induced actions on soil properties; also catenary sequences (see Section 1.6). Whenever possible, "disturbed" monoliths will be accompanied by a monolith representing "undisturbed" conditions for the same reference soil type in the given area. Special displays will be prepared for these monoliths to illustrate specific effects of main global soil issues, such as water erosion or pollution, to the wider public.

WP6 also entails developing new educational materials in the form of thematic displays for the World Soil Museum and course materials. It also includes development of on-line materials for distribution through the new ISRIC web-services (see WP 5).

3 REPORTING

Administrative and financial reports to be produced are detailed in the table 1.

Table 1. Administrative and financial reports

Report	Content	Timing	Responsibility
Progress report Describe the completion of planned activities and progress in relation to the project plan Document any constraints and potential consequences for project performance Provide information and data for annual progress reports	Person reporting and date Activity name and accomplishments within each work package this half-year Targets for the next half-year Comment on performance on progress toward project goals, and possible problems/constraints Report on any unanticipated results and opportunities, and on any checks to project progress	Half-yearly months	Project Coordinator
Financial reports Details project expenses and disbursements	Disbursements and expenses in categories and format as set out by the agreed budgets and sub-contracts together with supporting documents	Half-yearly	
Financial audits Annual audit by Wageningen UR or other approved External Auditors	Audit of accounts for project management and expenditures	Annual	External Auditors

4 BUDGET AND LIQUIDITY

Overall project costs are estimated at 2.01 million euro, as outlined in Tables 2 and 3, on a *pro rata* basis from “Proposal for recovery of samples lost from the World Soil Reference Collection” (2008). ISRIC staff costs are calculated on the basis of the *Wageningen UR Basistarief*. In-country staff costs take account of relative salary and per diem in-country. Travel is calculated on the basis of the lowest available air fare and in-country vehicle hire.

An overview of the costs per Work Package detailed for an annual distribution is provided in table 2. A time schedule is attached (table 3), because the activities will be implemented following a regional approach.

The liquidity flow for this project to recover the lost samples has been elaborated in Table 4, with the contributions of various parties incorporated. The contribution by third parties, till a maximum of 50% of the overall budget, as guaranteed by Wageningen UR, will be generated through concerted actions of the current actors. ISRIC will make its own contribution through strategic alliances with international partner institutions. The conditions and contributions have been elaborated in various letters from the involved parties, including:

- Letter Dijkhuizen (Wageningen UR) to Ministers Plasterk and Verburg, 06 March 2008, 08/2009/mh).
- Letter Hoogeveen (Min LNV) to Mr. Dijkhuizen (Wageningen UR), 21 November 2008, DK2008/2473
- Letter signed by Dr I.J.J.H. Breukink (Wageningen UR) and Dr. P.S. Bindraban (ISRIC) to Ms Dr. J.A. Hoekstra, 10 November 2009 (09/17230/mh).

Table 2. Costs per Work Package and distribution over years

Soil samples recovery project
WP financial details

Personnel hours	tariff / hour	year 1 hours	year 1 costs	year 2 hours	year 2 costs	year 3 hours	year 3 costs	year 4 (half) hours	year 4 (half) costs	total costs	total hours
WP 0											
Project manager	100	750	75,000	900	90,000	900	90,000	750	75,000	**330,000**	3,300
WP 1											
Researcher	90	150	13,500	200	18,000	100	9,000	50	4,500	**45,000**	500
WP 2											
Researcher	90	250	22,500	300	27,000	300	27,000	200	18,000	**94,500**	1,050
WP 3											
Technician	57	350	19,950	1400	79,800	1400	79,800	1,000	57,000	**236,550**	4,150
WP 4											
Researcher	90	150	13,500	200	18,000	200	18,000	153	13,770	**63,270**	703
WP 5											
Researcher	72	200	14,400	400	28,800	400	28,800	230	16,560	**88,560**	1,230
WP 6											
Researcher	90	0	0	250	22,500	300	27,000	250	22,500	**72,000**	800
	Sub total		**158,850**		**284,100**		**279,600**			**929,880**	11733

Other costs

Third parties	85,714	85,714	85,714	42,857	**300,000**
Material/equipment	14,286	14,286	14,286	7,143	**50,000**
Travel + per diem	22,857	22,857	22,857	11,429	**80,000**
Air fare + local transport	22,857	22,857	22,857	11,429	**80,000**
Freight	11,429	11,429	11,429	5,714	**40,000**
Lab analysis	142,857	142,857	142,857	71,429	**500,000**
Material education	8,571	8,571	8,571	4,286	**30,000**
Sub total	**308,571**	**308,571**	**308,571**	**154,286**	**1,080,000**
Sub total personnel + other costs	**467,421**	**592,671**	**588,171**	**154,286**	**2,009,880**
		Grand total			**2,009,880**

All costs per WP	year 1	year 2	year 3	year 4 (half)	total	% of total
WP 0						
Personnel	75,000	90,000	90,000	75,000	**330,000**	17
WP 1						
Personnel	13,500	18,000	9,000	4,500	**45,000**	2
WP 2						
Personnel	22,500	27,000	27,000	18,000	94,500	
Travel + per diem	22,857	22,857	22,857	11,429	80,000	
Air fare + local transport	22,857	22,857	22,857	11,429	80,000	
Freight	11,429	11,429	11,429	5,714	40,000	
Third parties	85,714	85,714	85,714	42,857	300,000	
Equipment	5,714	5,714	5,714	2,857	20,000	
					614,500	31
WP 3						
Personnel	19,950	79,800	79,800	57,000	236,550	
Material	8,571	8,571	8,571	4,286	30,000	
					266,550	13
WP 4						
Personnel	13,500	18,000	18,000	13,770	63,270	
Lab analysis	142,857	142,857	142,857	71,429	500,000	
					563,270	28
WP 5						
Personnel	14,400	28,800	28,800	16,560	**88,560**	5
WP 6						
Personnel	0	22,500	27,000	22,500	**72,000**	
Material education	8,571	8,571	8,571	4,286	30,000	
					75,000	4
		Grand total			**2,009,880**	100

Table 3. Time schedule specifying the regional approach

Work Package	2010		2011				2012				2013			
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
WP0														
WP1														
WP2 Latin America														
WP2 Africa														
WP2 Asia														
WP2 Europe														
WP2 N America														
WP2 Australia/Oceania														
WP3														
WP4														
WP5														
WP6														

Table 4. Liquidity prognoses

Period	2010		2011				2012				2013				Total
-	Q III	Q IV	Q I	Q II	Q III	Q IV	Q I	Q II	Q III	Q IV	Q I	Q II	Q III	Q IV	
Income															
* LNV	330,000														330,000
** RvB matching			330,000												330,000
Third Parties contribution					100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	100,000	1,000,000
ISRIC contribution							43,750	43,750	43,750	43,750	43,750	43,750	43,750	43,750	350,000
	330,000	0	330,000	0	100,000	100,000	143,750	143,750	143,750	143,750	143,750	143,750	143,750	143,750	2,010,000
Cost	143,564	143,564	143,564	143,564	143,564	143,564	143,564	143,564	143,564	143,564	143,564	143,564	143,564	143,564	2,009,900
Balance per quarter	186,436	-143,564	186,436	-143,564	-43,564	-43,564	186	186	186	186	186	186	186	186	101
Balance/cumulative	186,436	42,872	229,307	85,743	42,179	-1,386	-1,200	-1,014	-828	-643	-457	-271	-85	101	101

* LNV = Dutch Ministry of Agriculture, Nature and Food Quality
** RvB = Raad van Bestuur Wageningen UR

ANNEX 1 – CHARACTERISTICS OF WORLD REFERENCE COLLECTION SOILS AFFECTED BY LOSS OF SAMPLES[42]

Standard analysis: Sample pre-treatment (including measurement of fraction > 2 mm), particle-size distribution, pH water and KCl, organic C and N, exchangeable cations, exchangeable acidity and Al, cation exchange capacity
Relevance: Judgement of the significance of the soil profile as a representative of global, regional and national sol cover in terms of geographic extent of the taxonomic group: minor (+), moderate (++) or large significance (+++), globally[43] (G), regionally[44] (R) or nationally (N) - see footnote. Spatial extent, however, is not the only reason for holding samples; other key reasons are: essential component in soil-landscape relationships, soil-land use relationships.

Country	No	Soil type	No of samples	Additional analyses	Relevance		
					G	R	N
Australia	3	GYPSISOL (Calcic, Endosalic, Luvic)	8	gypsum; soluble salts	+	++	+++
	4	VERTISOL (Chromic, Grumic, Hyposodic)	7	COLE	++	+++	+++
	8	PHAEOZEM (Luvic)	6		++	++	++
	18	LIXISOL (Chromic)	4		++	++	++
	19	ACRISOL (Ferric, Humic)	8		+++	+++	++
	22	ACRISOL (Ferric, Profondic)	8		+++	+++	+++
	23	SOLONETZ (Calcic, Endogleyic, Magnesic)	6	carbonate	+	++	+++
	24	NITISOL (Humic, Eutric)	8	C-D and oxalate Fe	++	++	++
	29	PLINTHOSOL (Stagnic, Albic, Abruptic, Ferric)	12	C-D and oxalate Fe	+	+	++
	30	LUVISOL (Rhodic, Hypocalcic, Cutanic)	7	carbonate	+++	++	+++
	31	PLANOSOL (Sodic, Gleyic, Albic, Epidystric)	11		+	++	+++
	33	UMBRISOL (Humic)	6		+	+	++
Brazil	3	FERRALSOL (Geric)	6	gibbsite; water-dispersible clay	+++	+++	+++
	4	FERRALSOL (Rhodic)	6	water-dispersible clay	+++	+++	+++
	5	FERRALSOL (Geric)	5	gibbsite; water-dispersible clay	+++	+++	+++
	11	FERRALSOL (Xanthic)	9	water-dispersible clay	+++	+++	+++
Brazil	17	SOLONETZ (Haplic)	5		+	++	++
Canada	13	LUVISOL (Profondic, Albic, Cutanic, Hyperdystric)	9		+++	+++	+++
	18	LUVISOL (Fragic, Stagnic, Chromic, Cutanic)	9		+++	+++	+++
China	1	LUVISOL (Cutanic, Chromic)	6		+++	+++	+++

[42] Source: "Proposal for recovery of samples lost from thje World Soil Refervcnec Collection" by Dent et al. (2008, final printed copy)
[43] Minor extent refers to a total area of less than 2M km^2 on the *Soil Map of the World* (FAO-UNESCO, 1974); large extent refers to a total area of more than 6M km^2, whereas moderate extent refers to the intermediate range.
[44] Minor extent refers to a total area of less than 10% on the regional sheet of the *Soil Map of the World* (FAO-UNESCO, 1974); large extent refers to a total area of more than 25%, whereas moderate extent refers to the intermediate range. This also applies to the extent indication at national level.

Country	No	Soil type	No of samples	Additional analyses	Relevance		
					G	R	N
	2	CAMBISOL (Calcaric, Stagnic)	5	carbonate	+++	+++	+++
Colombia	2	CAMBISOL (Ferralic)	6		+++	++	++
	3	ACRISOL (Plinthic)	5	C-D and oxalate Fe	+++	+++	+++
	6	ALISOL (Haplic)	7		+	++	++
	10	ARENOSOL (Haplic)	5		+++	+	+
	12	ANDOSOL (Vitric)	5	oxalate Al, Fe, Si; P-retention; bulk density	+	++	+++
	15	ACRISOL (Ferric)	5		+++	+++	+++
	16	CAMBISOL (Ferralic)	8		+++	++	++
	17	FLUVISOL (Eutric)	11		++	++	++
	18	REGOSOL (Dystric)	9		++	++	++
Finland	1	GLEYSOL (Sodic)	5		+++	++	+++
	4	PODZOL (Haplic)	5		++	+++	+++
France	3	CAMBISOL (Dystric)	6		+++	++	+++
	4	VERTISOL (Pellic)	5	COLE	++	++	++
	6	LUVISOL (Cutanic)	5		+++	+++	+++
	7	ALBELUVISOL (Haplic)	8		++	++	++
	8	LUVISOL (Calcic)	8	carbonate	+++	++	+++
	9	PLANOSOL (Dystric)	9		+	++	++
	10	PODZOL (Haplic)	7		++	+++	++
	11	ALBELUVISOL (Gleyic)	7		++	++	++
Germany	2	LUVISOL (Dystric, Gleyic)	5		+++	+++	+++
	3	LUVISOL (Gleyic)	7		+++	+++	+++
	4	PODZOL (Gleyic)	7		++	++	+++
	6	GLEYSOL (Eutric)	3		+++	++	++
	7	CAMBISOL (Dystric)	6		+++	++	+++
	9	CAMBISOL (Gleyic)	7		+++	+++	+++
	11	CAMBISOL (Dystric)	7		+++	++	+++
	13	CHERNOZEM (Haplic)	8	carbonate	++	++	++
	14	CHERNOZEM (Luvic)	6	carbonate	++	++	+++
	15	PHAEOZEM (Luvic)	7		++	++	++
Germany	16	LUVISOL (Haplic)	6		+++	+++	+++
	17	CHERNOZEM (Haplic)	6	carbonate	++	++	+++
Ghana	2	REGOSOL (Endosodic)	8		++	+	+
	3	FERRALSOL (Haplic)	10	water-dispersible clay	+++	+++	+++
	4	ACRISOL (Ferric, Profondic, Hyperdystric, Chromic)	12		+++	+++	+++
Greece	8	CAMBISOL (Eutric)	6		+++	++	++
	13	LUVISOL (Chromic)	7		+++	+++	+++
Greenland	2	HISTOSOL (Dystric, Fibric)	3		++	+++	+++
India	5	CAMBISOL (Dystric)	4		+++	++	+++
	6	LUVISOL (Chromic, Profondic)	5		+++	++	++
	7	LUVISOL (Chromic, Profondic)	4		+++	++	++
	8	VERTISOL (Calcic)	4	carbonate; COLE	++	+++	+++
	10	VERTISOL (Calcic, Pellic)	6	carbonate; COLE	++	+++	+++
	11	CALCISOL (Hyposodic)	3	carbonate	+++	+++	+++
Indonesia	12	ACRISOL (Haplic)	8		+++	+++	+++
	15	FERRALSOL (Xanthic)	7	water-dispersible clay	+++	++	++
Ireland	1	PODZOL (Haplic)	6		++	+++	+++
	6	LUVISOL (Cutanic, Albic, Dystric)	6		+++	++	++
	7	LUVISOL (Cutanic, Albic, Epidystric)	5		+++	++	++
	9	PODZOL (Placic)	5		++	+++	+++
	10	PHAEOZEM (Siltic)	3		++	++	+
	11	LUVISOL (Albic, Gleyic,	5		+++	++	++

Country	No	Soil type	No of samples	Additional analyses	Relevance G	R	N
		Epidystric)					
	12	GLEYSOL (Dystric, Saprihistic)	4		+ + +	+ +	+ + +
Italy	1	CAMBISOL (Dystric)	6		+ + +	+ +	+ + +
	2	LUVISOL (Dystric, Rhodic)	5		+ + +	+ + +	+ + +
	3	ALISOL ((Profondic, Rhodic)	5		+	+	+ +
	7	PHAEOZEM (Haplic)	5		+ +	+ +	+ + +
	9	LUVISOL (Chromic)	6		+ + +	+ + +	+ + +
	10	CAMBISOL (Chromic, Fluvic)	8		+ + +	+ +	+ + +
	12	CAMBISOL (Chromic, Fluvic)	7		+ + +	+ +	+ + +
	13	VERTISOL (Eutric, Endostagnic)	9		+ +	+	+
	14	NITISOL (Dystric, Rhodic)	9	C-D and oxalate Fe	+ +	+ + +	+ + +
	17	CALCISOL (Endovertic)	8	carbonate; COLE	+ + +	+ +	+ + +
Jamaica	1	ACRISOL (Humic)	8		+ + +	+ +	+ + +
Jamaica	2	NITISOL (Eutric)	6	C-D and oxalate Fe	+ +	+ + +	+ + +
	3	FERRALSOL (Posic)	6	gibbsite; water-dispersible clay	+ + +	+	+ + +
Kenya	4	REGOSOL (Eutric)	9		+ +	+ +	+ +
	5	CAMBISOL (Dystric)	7		+ + +	+ +	+ +
	6	FERRALSOL (Rhodic)	7	water-dispersible clay	+ + +	+ + +	+ +
	7	CAMBISOL (Ferralic)	7		+ + +	+ +	+ +
	8	ACRISOL (Profondic, Rhodic)	6		+ + +	+ + +	+ +
	9	FERRALSOL (Rhodic)	7	water-dispersible clay	+ + +	+ + +	+ +
	10	SOLONETZ (Haplic)	6		+	+	+ +
	11	FERRALSOL (Rhodic)	6	water-dispersible clay	+ + +	+ + +	+ +
	12	ACRISOL (Haplic)	6		+ + +	+ + +	+ +
	13	SOLONETZ (Stagnic)	6		+	+	+ +
	14	PHAEOZEM (Luvic, Calcaric)	4	carbonate	+ +	+	+
	15	NITISOL (Rhodic)	8	C-D and oxalate Fe	+ +	+ +	+ + +
	21	SOLONCHAK (Sodic)	4	soluble salts	+ +	+ +	+
	22	SOLONETZ (Haplic)	5		+	+	+ +
	23	LUVISOL (Haplic)	6		+ + +	+ +	+ +
	24	REGOSOL (Eutric)	9		+ +	+ +	+ +
	25	PLANOSOL (Eutric)	5		+	+ +	+ +
	26	NITISOL (Humic)	5	C-D and oxalate Fe	+ +	+ +	+ + +
	27	CAMBISOL (Eutric)	5		+ + +	+ +	+ +
	30	LIXISOL (Haplic)	4		+ +	+ +	+ +
	31	LUVISOL (Haplic)	4		+ + +	+ +	+ +
	32	VERTISOL (Calcic)	4	carbonate; COLE	+ +	+ +	+ +
	37	ANDOSOL (Mollic)	3	oxalate Al, Fe, Si; P-retention; bulk density	+	+	+ +
Malaysia	51	PODZOL (Humic)	6		+ +	+	+
	53	PODZOL (Humic)	7		+ +	+	+
	54	FLUVISOL (Dystric)	5		+ +	+ +	+ +
	55	FLUVISOL (Eutric)	5		+ +	+ +	+ +
	57	FERRALSOL (Xanthic)	6	water-dispersible clay	+ + +	+ + +	+ + +
Mozambique	2	FERRALSOL (Hyperdystric, Acric, Rhodic)	9	water-dispersible clay	+ + +	+ + +	+ + +
	3	NITISOL (Ferralic, Rhodic, Orthidystric)	9	C-D and oxalate Fe	+ +	+ +	+ +
	5	PHAEOZEM (Luvic, Calcaric, Chromic)	6	carbonate	+ +	+	+

Country	No	Soil type	No of samples	Additional analyses	Relevance G	Relevance R	Relevance N
	8	SOLONETZ (Magnesic, Stagnic, Albic)	6		+	+	++
Namibia	1	ARENOSOL (Aridic, Rubic, Eutric)	6		+++	+++	+++
	2	LUVISOL (Chromic, Hyperochric)	6		+++	++	+
	3	ARENOSOL (Hypoluvic, Aridic, Rubic, Eutric)	9		+++	+++	+++
	5	LUVISOL (Profondic, Rhodic)	8		+++	++	+
	6	CAMBISOL (Fluvic, Calcaric)	6	carbonate	+++	++	++
	7	PHAEOZEM (Pachic)	4		++	++	+
Netherlands	2	PODZOL (Entic)	6		++	++	+++
	5	LUVISOL (Siltic, Cutanic)	6		+++	+++	+++
	6	FLUVISOL (Gleyic, Eutric)	7		++	++	+++
	7	CAMBISOL (Fluvic, Gleyic, Eutric)	6		+++	+++	++
	16	PODZOL (Anthric)	9		++	++	+++
	18	PLANOSOL (Gleyic, Luvic, Albic, Alumic)	6		+	+	+
Nigeria	1	LIXISOL (Haplic)	7		++	+++	+++
	4	LIXISOL (Haplic)	7		++	+++	+++
	8	ACRISOL (Plinthic)	5	C-D and oxalate Fe	+++	+++	+++
	11	LUVISOL (Gleyic)	6		+++	++	+
	12	ACRISOL (Plinthic)	5	C-D and oxalate Fe	+++	+++	+++
	13	ACRISOL (Plinthic)	4	C-D and oxalate Fe	+++	+++	+++
	14	LUVISOL (Gleyic)	6		+++	++	+
Norway	1	REGOSOL (Calcaric)	5	carbonate	++	++	++
	2	PODZOL (Haplic)	7		++	+++	+++
	3	CAMBISOL (Fluvic, Dystric)	7		+++	+++	++
Oman	1	REGOSOL (Aridic)	4		++	+++	+++
	2	CALCISOL (ArIdic)	5	carbonate	+++	+++	+++
	3	GYPSISOL (Calcic, Aridic)	5	gypsum; carbonate; soluble salts	+	++	+++
	4	LUVISOL (Aridic)	6		+++	++	+
Romania	1	CAMBISOL (Dystric)	8		+++	+++	+++
	2	CHERNOZEM (Calcic, Vermic)	10	carbonate	++	++	+++
	4	CHERNOZEM (Luvic)	11	carbonate	++	++	+++
	5	CHERNOZEM (Haplic)	10	carbonate	++	++	+++
	6	LUVISOL (Chromic)	10		+++	+++	+++
	7	ALBELUVISOL (Gleyic)	10		++	++	++
	9	KASTANOZEM (Haplic)	10	carbonate	++	++	+++
	10	CAMBISOL (Eutric)	5		+++	+++	+++
	11	PODZOL (Leptic)	5		++	+++	++
Samoa	4	ANDOSOL (Vitric, Mollic)	6	oxalate Al, Fe, Si; P-retention; bulk density	+	++	+++
	5	LUVISOL (Fragic)	6		+++	++	+
South Africa	1	PHAEOZEM (Luvic, Pachic)	6		++	+	+
	2	FERRALSOL (Humic)	8	water-dispersible clay	+++	+++	++
	3	CAMBISOL (Humic)	4		+++	++	++
	5	ACRISOL (Umbric, Humic, Chromic)	6		+++	+++	+++
	6	ARENOSOL (Dystric)	5		+++	+++	+++
	9	VERTISOL (Chromic)	6	COLE	++	+++	+++
	10	LUVISOL (Haplic)	6		+++	++	++
	11	SOLONETZ (Haplic)	7		+	++	++
	14	ARENOSOL (Albic, Dystric)	5		+++	+++	+++

Country	No	Soil type	No of samples	Additional analyses	Relevance G	R	N
	15	ALISOL (Umbric)	6		+	+	+
	19	CAMBISOL (Dystric)	6		+++	++	++
	21	NITISOL (Umbric, Humic)	9	C-D and oxalate Fe	++	++	++
Spain	2	LUVISOL (Stagnic, Chromic)	6		+++	+++	+++
	3	VERTISOL (Calcic, Stagnic)	7	COLE; carbonate	++	++	+++
	4	LUVISOL (Vertic)	10	COLE	+++	+++	+++
	5	CALCISOL (Petric)	5	carbonate	+++	++	+++
	6	LEPTOSOL (Calcaric)	4	carbonate	+++	+++	+++
	7	ARENOSOL (Haplic)	4		+++	++	++
	8	LUVISOL (Chromic)	7		+++	+++	+++
	9	CAMBISOL (Chromic)	6		+++	+++	+++
	10	ACRISOL (Plinthic)	8	C-D and oxalate Fe	+++	++	++
	11	CALCISOL (Petric)	3	carbonate	+++	++	+++
	12	VERTISOL (Mollic)	6	COLE	++	++	+++
	13	CALCISOL (Petric)	5	carbonate	+++	++	+++
	14	CAMBISOL (Vertic, Calcaric)	3	COLE; carbonate	+++	+++	+++
	18	VERTISOL (Chromic)	8	COLE	++	++	+++
Sri Lanka	1	ANTHROSOL (Anthraquic)	6	C-D Fe	+	++	+++
	2	LUVISOL (Chromic)	6		+++	++	++
	3	GLEYSOL (Dystric)	6		+++	++	+++
	4	ACRISOL (Humic, Sombric)	6		+++	++	++
Sweden	1	CAMBISOL (Calcaric)	5	carbonate	+++	+++	++
	2	PODZOL (Haplic)	7		++	+++	+++
Sweden	3	LUVISOL (Gleyic)	5		+++	++	++
	4	REGOSOL (Calcaric)	4	carbonate	++	++	+++
	5	PODZOL (Entic)	13		++	+++	+++
	6	REGOSOL (Arenic, Dystric)	6		++	++	++
	7	PHAEOZEM (Hypercalcaric)	7	carbonate	++	++	+
	8	CAMBISOL (Dystric)	5		+++	+++	++
	9	PODZOL (Haplic)	8		++	+++	+++
	10	PODZOL (Humic)	7		++	+++	+++
	11	GLEYSOL (Eutric, Endocalcaric)	6	carbonate	+++	+++	+++
	13	REGOSOL (Arenic, Endocalcaric)	6	carbonate	++	++	++
	14	REGOSOL (Dystric)	7		++	++	+++
	16	PODZOL (Haplic)	5		++	+++	+++
Thailand	1	FLUVISOL (Thionic)	4	sulphur	++	+++	+++
	2	VERTISOL (Calcic)	3	COLE; carbonate	++	++	++
	3	GLEYSOL (Eutric)	2		+++	+++	+++
	4	GLEYSOL (Eutric)	3		+++	+++	+++
	5	LUVISOL (Haplic)	3		+++	+	+
	7	LUVISOL (Chromic)	4		+++	+	+
	8	CAMBISOL (Dystric)	5		+++	++	++
	9	CAMBISOL (Ferralic)	4		+++	++	++
	10	FERRALSOL (Plinthic)	3	water-dispersible clay; C-D and oxalate Fe	+++	++	++
	11	CAMBISOL (Ferralic)	3		+++	++	++
	12	ACRISOL (Haplic)	4		+++	+++	+++
	13	CAMBISOL (Dystric)	4		+++	++	++
Turkey	3	CALCISOL (Haplic)	5	carbonate	+++	+++	+++
	10	CALCISOL (Luvic)	4	carbonate	+++	+++	+++
	13	LUVISOL (Chromic)	4		+++	+++	+++
	14	VERTISOL (Eutric)	3	COLE	++	++	+++
UK	1	CAMBISOL (Endogleyic, Calcaric)	4	carbonate	+++	+++	+++
	2	LUVISOL (Stagnic, Cutanic)	5		+++	+++	++
	3	LUVISOL (Gleyic, Stagnic, Albic, Cutanic)	5		+++	+++	++

Country	No	Soil type	No of samples	Additional analyses	Relevance G	R	N
	6	PODZOL (Histic, Stagnic, Placic)	6		++	+++	+++
	7	GLEYSOL (Saprihistic, Hyperdystric)	4		+++	+++	+++
	8	PODZOL (Haplic)	5		++	+++	+++
UK	9	ARENOSOL (Dystric)	4		+++	+	+
USA	3	NITISOL (Eutric)	5	C-D and oxalate Fe	++	++	++
	4	ACRISOL (Albic, Abruptic, Ferric)	6		+++	+++	+++
	8	FERRALSOL (Rhodic)	5	water-dispersible clay	+++	+	+
	9	FERRALSOL (Rhodic)	7	water-dispersible clay	+++	+	+
Uruguay	1	PLANOSOL (Eutric)	7		+	++	++
Total no. of profiles	227	Total no. of samples	1394				

Also, the following special collections were affected:
Indonesia: UNESCO Man & Biosphere reserves (20 samples)
Belgium/Netherlands: Podzols (10+ samples; ISRIC Monograph 1)

ANNEX 2 – STAFF REQUIREMENTS AND EXPERTISE

The full field and laboratory program will require three and a half years from team mobilization. All new reference materials will be handled and stored at the premises of ISRIC – World Soil Information, Wageningen.

New ISRIC staff requirements foreseen are, at least:

- *International Project Coordinator*: Soil scientist or physical geographer with proven field-experience (at least 10-15 yr) in soil survey, sampling and description of soils across the range of world climate-soil-land use zones; taking of soil monoliths, also familiar with procedures for soil monolith preparation; special interest for soil classification (FAO systems, 1974, 1990 and 2006), also experienced with FAO Guidelines for Soil Description; good understanding of soil-landscape relationships; good understanding of soil analytical methods en new IR analyses; ability to screen new data sets for inconsistencies; database management skills; proven track record in international project management and reporting procedures.

- *Workshop technicians:* Soil monolith and sample preparation, sample storage, labelling and on-line cataloguing. Preparation of subsamples for third parties. Ensuring phytosanitary procedures. Affinity with land or soil related activities.

Also, through our international partners:

- Field teams, including experienced soil surveyors and field staff, to be provided by the proposed partner organizations. Also, regional coordinator(s).

Current staff suport: most of the activities will be integrated in current and foreseen activities of ISRIC in implementing its strategy asa world leader in providing geo-referenced internet-based soil information. Close linkages will be maintained with staff members of Wageningen UR and international partners.