2018–2019 ANNUAL REPORT

ISRIC

World Soil Information

Contents

Foreword

Rik van den Bosch, Director

In our digital world, data is more valuable than ever. We need to answer questions such as: where is land quality getting better or worse? Where are soils storing or releasing the most carbon? To do that, scientists and policymakers need data they can trust. At ISRIC - World Soil Information, this is our passion—working behind the scenes to continually improve the quality of soil data, at a global and national level, so that people can make important decisions about how to manage land.

As celebrated as environmental data may be, the job of stewarding soil information is often overlooked. We future-proof IT infrastructure. We redesign soil database workflows. We store one of the world's largest soil reference collection in our basement. This is not glamourous work, but it is valuable and we take pride in it. In 2018, we received our re-accreditation as the World Data Centre for Soils with the Core Trust Seal. In 2019, we simultaneously released an update to WoSIS, our global point data repository, and SoilGrids™, our set of global soil property maps. Though in the world of soil data there are few Champaign-popping moments, in this report we take a time to celebrate a few milestones.

Importantly, we want to acknowledge our many partners including national soil institutes, international soil collaborators, environmental scientists, land-focused NGOs, sustainability-oriented agriculture businesses and policymakers tackling big challenges like sustainable agriculture intensification and land quality protection. In the past two years, we worked with people from all of these sectors. And of course we want to mention the 7,000 people who toured the World Soil Museum in 2018-2019 including visitors like Iraqi dignitaries, Chinese scholars, and German university students.

International collaboration is at the heart of ISRIC - World Soil Information's mission to provision quality-assessed soil information. In 2018 and 2019, we increased our contribution to the United Nations' Global Soil Partnership where we are guiding development of a Global Soil Information System (GLOSIS). A key activity to our strategy in this area is helping others to produce soil data products for themselves. In 2018 we re-tuned our digital soil mapping curriculum, part of our annual Spring School, towards the needs of emerging national soil institutes and have seen attendance increase. We are also working on the ground with national partners to assist with the development of national soil information systems, which should be the bedrock of GLOSIS.

Looking ahead, we are excited to invest more time in capacity building with our peers who are also generating and stewarding soil data around the world. As the field of digital soil mapping pushes into higher resolution, national soil institutes are best positioned to assess the accuracy and best use for high resolution products.

All of our past and future work rests on the tremendous teamwork between our specialists, supporting staff, guest researchers, PhD students, volunteers, and the board. Our ability to collaborate is our most valuable asset. I am proud and thankful to our team for their dedication and perseverance. I am also thankful to our funding partners who support our ongoing efforts to ensure the world has the best soil information possible at their fingertips. Good soil information is built on good relationships.

Rik van den Bosch, Director

ISRIC – World Soil Information
in a nutshell

Mission

As the custodian of global soil information we produce, gather, compile and serve quality-assessed soil information together with our partners at global, national and regional levels. We stimulate the use of this information to address global challenges through capacity building, awareness raising and direct cooperation with users and clients.

Vision

A world where reliable and freely-available relevant soil information is properly used to address global environmental and social challenges.

ISRIC - World Soil Information is a science-based organisation, meaning that the approaches and methods we use to build our products are based on sound science. We participate in scientific research in the field of soil measurement, soil mapping, pedometrics and soil information standards, aiming to generate knowledge which we use to innovate our methods. We maintain a deep understanding of soil assessment, soil analysis and soil data handling.

ISRIC - World Soil Information is an independent foundation by Dutch law. We are based on the campus of Wageningen University and Research (WUR). We have a service level agreement with the university, formalising operational support. Our presence on the WUR campus provides ample opportunities to set up strategic cooperation projects with WUR research groups.

ISRIC - World Soil Information funds a special professorship on 'Pedometrics and Digital Soil Mapping' at Wageningen University and Research, to stimulate further research in this field.

2018–2019 Major Achievements

We provision quality-assessed global soil information.

ISRIC - World Soil Information is a service provider to the international science communities, policy communities and the private sector. We provide support to tackle issues like increasing food production, sustainably managing land and water resources, mitigating climate change, monitoring environmental quality, enacting social justice, planning future land use, and protecting biodiversity.

We do this by providing quality-assessed soil data through the World Soil Information Service (WoSIS) and generating interpreted soil information through the SoilGrids™ framework. SoilGrids™ maps global soil properties using state-of-the-art digital mapping techniques.

Serving standardised soil profile data

The global soil science community rescued and compiled more than 800,000 soil profile descriptions into databases during recent decades. However, only a fraction are readily accessible in a consistent format for the greater benefit of the international community. In 2019, we fine-tuned our procedures for preserving, quality-assessing, standardising, and subsequently making available consistent, quality-assessed soil profile data managed in the World Soil Information Service (WoSIS). WoSIS is available to download through the ISRIC - World Soil Information soil data hub. The last snapshot (September 2019) comprises some 196,000 geo-referenced profiles originating from 173 countries, representing more than 832,000 soil layers (or horizons) and over 5.8 million records.

In coming years, we aim to fill gaps in geography. In order to do that, we depend on our existing and prospective partners to share a wider selection of soil profile data. A particularly important contributor of new data for the northern boreal region will be the International Soil Carbon Network (ISCN), with which we have a memorandum of understanding. New digital data sets are welcome and will be acknowledged on our website.

A recent development was that spectral libraries (i.e. spectral data with associated wet chemistry data) can now be incorporated in WoSIS and served. A next critical step, will be to derive soil property estimates from newly acquired sets of exclusively spectral data, using the available spectral libraries, so that these may be considered in the regular WoSIS standardisation workflow and subsequently SoilGrids™ modelling work. We will undertake this work in collaboration with the Global Soil Laboratory Network's (GLOSOLAN) Spectroscopy Working Group where the Charles E. Kellogg Soil Survey Laboratory in the United States and World Agroforestry (ICRAF) in Kenya are important partners. This is a working group of the Global Soil Partnership.

Location of soil profiles represented in the WoSIS 2019 snapshot

Updated procedures for generating global soil property maps

In 2019, we updated the procedures to generate soil property maps for the world (SoilGrids™) to better serve our user community. Major improvements included: (a) direct coupling with quality-assessed and standardized soil profile (point) data provided by World Soil Information Service (WoSIS), (b) an improved selection of covariate layers using Recursive Feature Elimination, (c) quantification of uncertainties in property predictions, using prediction intervals, through implementation of Quantile Regression Forests, (d) 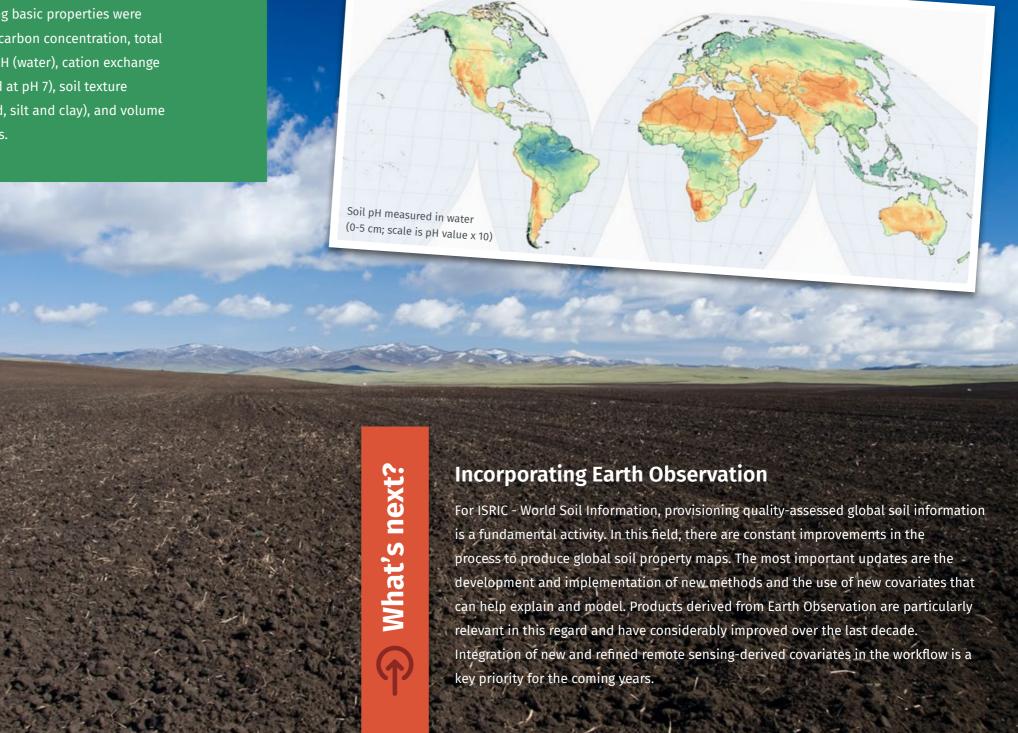adoption of an improved and more balanced cross-validation procedure, (e) use of the Homolosine equal-area projection, the only projection that minimises angular and distance distortions simultaneously, and (f) use of compositional data techniques for modelling of soil texture components.
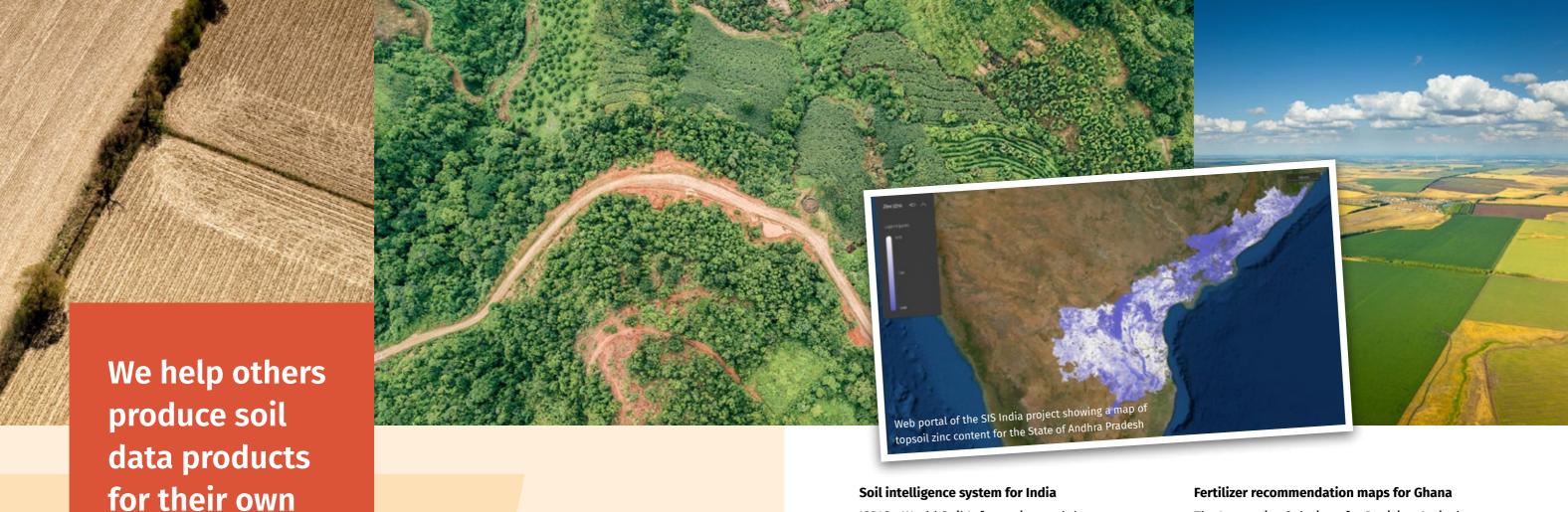
Based on available soil profiles, derived from WoSIS, the following basic properties were predicted: organic carbon concentration, total nitrogen content, pH (water), cation exchange capacity (measured at pH 7), soil texture (proportion of sand, silt and clay), and volume of coarse fragments.

Predictions were made for six depth intervals following the internationally adopted GlobalSoilMap specifications (0 - 5, 5 -15, 15 - 30, 30 - 60, 60 - 100, and 100 - 200 centimeters) at a resolution of 250 meters. A large range of approximately 400 environmental covariates was compiled and edited for the 2019 release. Out of this, a set of covariates was selected for predicting each soil property using de-correlation and recursive feature elimination. This is seen as a substantial refinement to the approach applied in earlier SoilGrids™ versions. Another major innovation was the use of the Quantiles Regression Forest algorithm, which allows for quantification of the uncertainty in the predictions.

A pre-release of the new SoilGrids™ was circulated on World Soil Day 2019 to get feedback from the international community. A first application of the new SoilGrids™ layers was to map global soil organic carbon stocks (0-30 cm) in support of the EU project Coordination of International Research Cooperation on Soil Carbon Sequestration (CIRCASA). At the time of this report's release, the new SoilGrids™ portal is live at soilgrids.isric.org.

Soil pH measured in water
(0-5 cm; scale is pH value x 10)

What's next?

Incorporating Earth Observation

For ISRIC - World Soil Information, provisioning quality-assessed global soil information is a fundamental activity. In this field, there are constant improvements in the process to produce global soil property maps. The most important updates are the development and implementation of new methods and the use of new covariates that can help explain and model. Products derived from Earth Observation are particularly relevant in this regard and have considerably improved over the last decade. Integration of new and refined remote sensing-derived covariates in the workflow is a key priority for the coming years.

Web portal of the SIS India project showing a map of topsoil zinc content for the State of Andhra Pradesh

We help others produce soil data products for their own geographies.

Developing soil information systems with partners

Making quality-assessed soil data and information available through our spatial data infrastructure and soil data hub is at the core of ISRIC - World Soil Information's mission. People use this information to protect environmental quality, make better data-driven decisions for their business, and carry out further research and analysis that informs government policies. Building on the expertise gained through projects like WoSIS, SoilGrids™ and GLOSIS, we support our partners, collaborators and clients in building their soil information systems (SIS). In 2018 and 2019, we were involved in projects aimed at bringing disparate soil data under a common standard, building national-scale soil information systems, and developing new, state-of-the-art standards for web-based exchange of soil data.

Soil intelligence system for India

ISRIC - World Soil Information and the International Maize and Wheat Improvement Center (CIMMYT), with support from the Bill and Melinda Gates Foundation, are building a soil intelligence system to make the wealth of soil data collected under the Indian Soil Health Card available in a standardised format. With soil health data widely available, people gain a tool to make informed agricultural decisions.

Regional focus began with the states of Bihar and Andhra Pradesh. We built components for the system including a relational database to store the Soil Health Card data, a data catalogue service, a web portal, and a prototype interactive dashboard to serve the quality-assessed data.
We also implemented digital soil mapping workflows to process Soil Health Card soil nutrient data into soil maps and quantify prediction uncertainty. The next step is to use these digital soil maps to design more efficient sampling schemes for soil data collection which we will undertake in collaboration with the statistical department of Wageningen University and Research.

Fertilizer recommendation maps for Ghana

The Innovative Solutions for Decision Agriculture Ltd. (iSDA), a spin-off of the Africa Soil Information Service (AfSIS) initiative, contracted ISRIC - World Soil Information to bring disparate soil data holdings for Ghana under a common standard in a new database system. The developed system, holding over 17,000 soil records from about 6,500 locations, was subsequently used to map the soil nutrient status for the country. These maps were ultimately fed into a soil fertility model to generate region-specific fertiliser (N, P, K) recommendations for maize. iSDA acquired the method used to produce these recommendations with the intention to apply them into future projects.
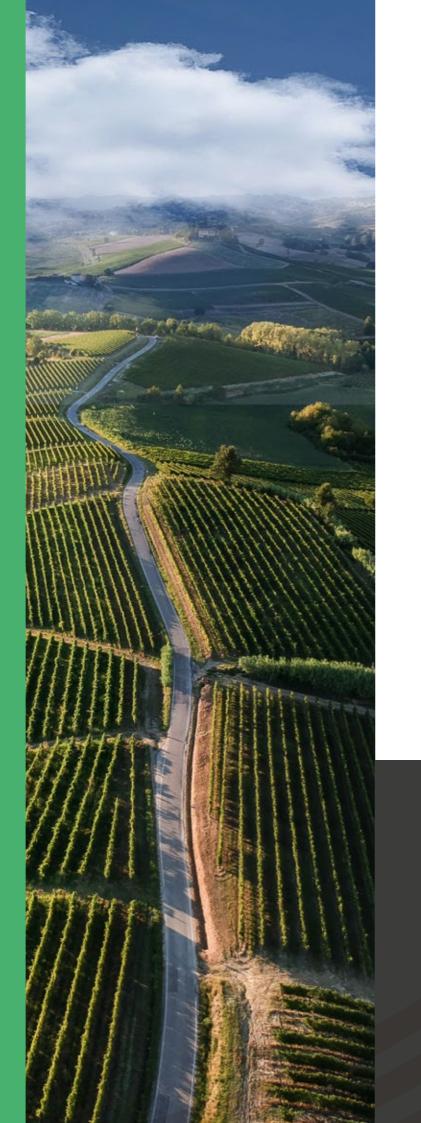
Global Soil Information System (GLOSIS)

In our role of Soil Data Facility, the technical backbone for the Global Soil Partnership's soil information and data pillar (Pillar 4), ISRIC - World Soil Information supports development of the Global Soil Information System (GLOSIS). This system aims to help countries organise and serve their soil data. It also brings together soil data from data providers world-wide in a federated way. This means that data providers will host and maintain their own soil data while also making it globally accessible via a web service to the GLOSIS network. These web services will be registered by the GLOSIS soil discovery portal, which provides easy access to all data assets made available by the data providers.

Bringing together soil information from across the globe into a single point of access via web services requires that all data providers 'speak the same language', i.e. all data providers must use the same standards for soil data exchange. In 2019, ISRIC - World Soil Information started developing a service for this based on state-of-the-art standards for spatial data exchange published by the Open Geospatial Consortium (OGC). We developed a proof-of-concept of the data exchange service and the GLOSIS soil discovery portal in close collaboration with partners from Wageningen Environmental Research, Manaaki Whenua-Landcare Research (New Zealand), Commonwealth Scientific and Industrial Research Organisation (CSIRO, Australia), Food and Agricultural Organization of the United Nations (FAO) and the European Environmental Agency (EEA). Results were presented at the annual meeting of the International Network of Soil Information Institutions (INSII) of the GSP in Rome.

Growing our Spring School alumni network

Since 2013, we organise yearly Spring Schools as part of our regular capacity building programme.

In 2018 and 2019, ISRIC - World Soil Information's Spring School was attended by 122 participants (around 60 each year) from 38 different countries. These one-week courses address two main topics, each with their own target groups. The first, 'Hands-on Digital Soil Mapping' focusses on methods and software for the management, analysis and mapping of soil types and soil properties within the R environment for statistical computing. The course includes lectures and computer exercises. The main topics covered are geostatistics, machine learning for soil mapping, soil functional mapping, proximal soil sensing, quantification of uncertainty, and sampling for mapping and soil map validation.

In contrast, the second course on 'World Soils and their Assessment' is more oriented towards pedologists. It provides an introduction to the diversity of soils of the world, main soil forming factors, classification according to the World Reference Base for Soil Resources (WRB), and soil management. The course draws heavily on the monoliths of the World Soil Museum and related soil reference collection.

The scope of the courses is regularly updated, partly in response to feedback provided by Spring School alumni. In particular, they appreciated guest lectures by staff from the Catholic University of Leuven and Wageningen University and Research, notably speakers from Biometrics and the 'Soil Biology and Biological Soil Quality' and 'Soil Geography and Landscape' chair groups.

The ISRIC - World Soil Information Spring School is organised under the C.T. de Wit Graduate School for Production Ecology and Resource Conservation of Wageningen University and Research. The Spring School and other courses we provide contribute to the implementation of the capacity building activities of Pillar 4 of the Global Soil Partnership.

Tired yet happy participants upon completion of Digital Soil Mapping course

What's next?

Building a community of practice.

As illustrated by the success of the Global Soil Partnership (GSP), interorganisational and intergovernmental collaboration is increasingly important. Within GSP Pillar 4, ISRIC - World Soil Information is entrusted with the establishment of a Global Soil Information System and development of local and regional soil information nodes through a bottom-up process. Communities of practice provide a new model for connecting people in the spirit of learning, knowledge sharing, and collaboration. In tandem with the GSP secretariat we invite people engaged in collecting and managing soil data as well as building soil data applications to be part of a community of practice which is under development. If interested, contact Emily Toner at emily.toner@isric.org.

We contribute resources for sustainable land management.

At ISRIC - World Soil Information, it is important that the products we make are actionable for policymakers, planning agencies, and land users. We, along with our partners and many of the people who use our soil data products, are committed to help achieve the United Nations' Sustainable Development Goals as well as enable climate-smart activites concerning soil. Therefore, we produce targeted products and services to address these needs.

Predicted soil organic carbon stock change for Argentina between 2001 and 2015, UNCCD Tier 1 approach on left and space-time machine learning model on right.

Mapping and modelling of soil organic carbon stocks

Transfer of knowledge about carbon sequestration in agricultural soils

Agricultural soils underpin food security. They also have potential to sequester carbon and contribute to climate change mitigation. Increasing attention on this area of opportunity has resulted in various initiatives to sequester organic carbon in agricultural lands. There is ongoing dialogue about the potential for sequestration, as well as the actual achievable levels, and a need for sharing knowledge and experiences on how to make this happen. In 2017, the EU-Horizon 2020 Coordination of International Research Cooperation on Soil Carbon Sequestration (CIRCASA) project, coordinated by the French National Institute for Agricultural Research (INRAE), was launched to address this knowledge gap. ISRIC - World Soil Information is a partner in the project. The overall objective of CIRCASA is to strengthen synergies among researchers and promote the transfer of knowledge on carbon sequestration in agricultural soils.

Soil carbon stocks

Management strategies that increase organic carbon sequestration in the soil, or at least limit its loss, are a key tool for mitigating climate change. Aligned with our expertise on digital soil mapping, soil carbon sequestration, and soil modelling, we helped set the vision and research agenda for soil organic carbon in 2019. An important element of this vision is to provide more accurate estimates of soil organic carbon stock change over space and time, towards which ISRIC - World Soil Information has been working in collaboration with The Nature Conservancy (TNC).

In 2019, we also contributed to thinking around a global framework for monitoring, reporting and verification of soil organic carbon change with a 2019 collaborative research paper in the journal Global Change Biology in order to support national and international initiatives seeking to change the way soils are managed.

Space-time modelling of soil organic carbon changes

Spatially explicit estimates of change in soil organic carbon (SOC) stocks are necessary to support national and international policies aimed at achieving land degradation neutrality (LDN) and climate mitigation through better land management. ISRIC - World Soil Information was a lead partner in a project funded by The Nature Conservancy that addressed the development, implementation and application of a data-driven, statistical space-time soil organic carbon stock mapping method. Argentina was the pilot area. We used machine-learning algorithms to predict soil organic carbon stock at 0-30 cm depth at 250 m resolution between 1982 and 2017, on an annual basis; the soil organic carbon stock change over time was mainly derived from time series of vegetation index maps. A comparison was made with results obtained using the UNCCD-modified IPCC Tier 1 approach, which uses default data. The project showed that machine learning methods can be used for space-time soil organic carbon mapping and may yield valuable information to land managers and policy makers, provided that soil organic carbon observation density in space and time is sufficiently large.

Using soil information to support soil fertility management

Developing crop-specific and site-specific fertilisers

In order to develop crop-specific and site-specific fertilisers and provide them to small-scale farmers, OCP Group's subsidiary for Africa, OCP-Africa, initiated a long-term collaborative agreement with us. Together with Wageningen University and Research and the Nutrient Management Institute, we are developing crop, soil and climate-specific, multi-nutrient fertiliser recommendations for major crops in Senegal and Mali using geospatial data combined with crop growth modeling.

Based on newly collected soil data, we produced locally precise and accurate soil maps for the target areas, which served as input to generate fertiliser recommendations which are specific to a particular site and crop. These were subsequently generalised into area-specific fertiliser

formulations, containing N, P, K, S, Zn, Cu and B. Based on this information, OCP-Africa developed six compound fertiliser products.

These new products were tested on 360 on-farm trials distributed over the project area of 22 million hectares in Mali and 10 million hectares in Senegal. The new formulation was tested relative to the default recommendations (di-ammonium phosphate and urea) and a control. Preliminary results from Mali show an increase of approximately 70% in grain yield relative to the response to the default fertiliser recommendation. As a sequel to this proof-of-concept, OCP-Africa required a second pilot project for annual rainfed crops in Ghana. Next step for this work is the development of a web-based platform that allows the user to develop crop and area-specific fertiliser formula recommendations for a selected set of crops for user-defined geographies across sub-Saharan Africa.

Using soil information to support European crop yield forecasting

ISRIC - World Soil Information produced SoilGrids™-derived pan-Europe maps, including Turkey, Maghreb and West Russia, of soil hydraulic properties and the soil rootable depth, as input for the Monitoring of Agricultural Resources (MARS) Crop Yield Forecasting System. This forecasting system is a longstanding project

of the Wageningen Environmental Research and the European Commission's Joint Research Centre. The crop yield forecasting system is a key tool for the European Commission to implement the EU's Common Agricultural Policy, which requires information on crop production of the current growing season. This updated soil data is under evaluation for informing the basis of future forecasting.

Testing new compound fertilizers in the Senegal delta.

PARTNERS : AfricaRice, ICRAF, Institut National de Pédologie du Sénégal; Office du Niger (Mali); Société d'Exploitation et d'Aménagement des terres du Delta et des vallées du fleuve Sénégal (Senegal).

Soil fertility is limiting agricultural productivity in large sections of sub-Saharan Africa (image: Chantal Hendriks).

What's next?

New tools for monitoring sustainable land management.

Our overall strategy focuses on the use of soil information products to support decision making in sustainable land management. We respond to demands from governments, donors and land managers for more data-driven decision-making tools. To this end our soil information products will be combined with other types of high-resolution environmental information and developed in collaboration with the World Overview of Conservation Approaches and Technologies (WOCAT).

We educate about the global diversity of soil.

World Soil Museum

The World Soil Museum provides the basis for our activities and programmes on education, research, collection, and documentation. The museum especially aims to inform, educate, and entertain visitors about the nature and diversity of soils in the world along with their importance and provision of ecosystem services.

In 2018-2019, around 7000 guests visited the museum. The main visitors are students of universities from Germany, Belgium and the Netherlands. Most of these study soil science. However, the number of students of ecology, biology, forestry, land and water management, and other environmental sciences is increasing, reflecting the growing recognition of the environmental and societal importance of soils. Notable visitors included Rem Koolhaas and his team from Office for Metropolitan Architecture, top officials from the Iraqi government including their first lady HE Dr Sarbagh Salih and ministers of water resources and agriculture as well as a delegation from South University of Science and Technology of China. Other visitors included primary and secondary schools, general-interest groups, and the general public.

A new story line and set up were introduced for the exhibition and educational programme to better explain the role of soils in the context of history, society and the environment. Increased involvement of dedicated and knowledgeable museum guides, under the volunteer programme, has allowed us to better serve our visitors tuned their level of interest and background.

Collections and Library

The exhibition draws heavily on ISRIC - World Soil Information's reference collection of soil monoliths, soil samples and thin sections, with supporting soil analytical data and slides. The whole collection consists of 1144 soil monoliths from around 75 countries; they were judiciously chosen to represent a wide range of geographic areas and environments, soil types, soil processes and human impact on soil conditions. For most reference profiles, sampling material is available on request for research purposes. Examples of research for which soil reference material has been requested are: correlation of analytical methods by Wageningen University and Research as well as forensic soil research by North Carolina State University.
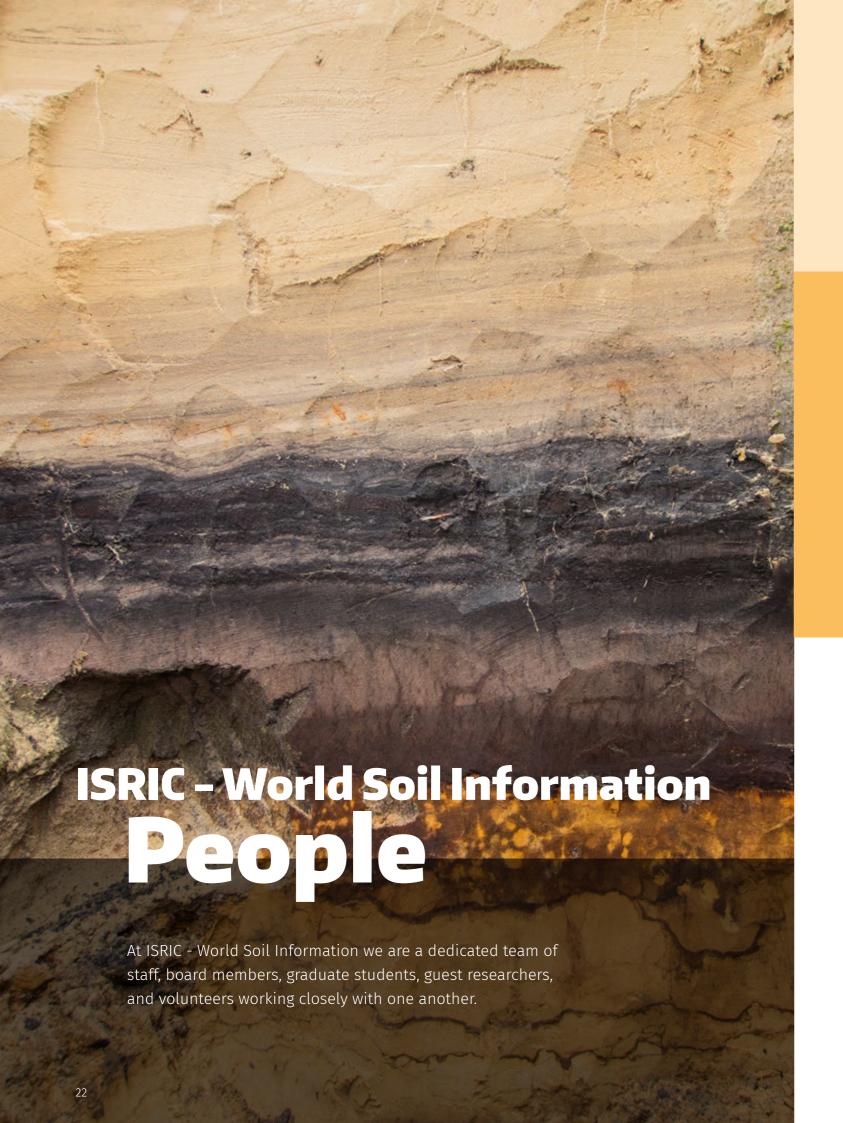
To make the reference collection widely accessible, we maintain a virtual World Soil Museum. In addition to this, the on-line ISRIC - World Soil Information library provides a repository for historic reports and 9100 maps on soil resources, many of which have been digitized (about 70% of maps and 30% of reports). We have a service level agreement (SLA) with Wageningen University and Research Library for the maintenance of our library holdings, and registration of newly scanned materials. We maintain a workshop for preparing newly collected monoliths and for repairing monoliths showing signs of decay. The preparation method for soil monoliths was adapted and developed to a more environmentally friendly procedure using wood glue (PVA) instead of nitrocellulose lacquer. Also, a method was developed to prepare organic soils that involves freeze drying in combination with the use of PVA.

In 2019 we started scanning our collection of thin sections (micromorphological collections) with a view to make these accessible on-line. A prototype for a device was designed and tested that allows distance inspection of thin sections on request. The concept is that users can inspect requested thin sections with an electron microscope from their computer anywhere in the world using an internet connection. We aim to offer that service in the future.

In 2019, Royal Eijkelkamp soil and water research became sponsor of the World Soil Museum to support the museum collections and activities.

ISRIC – World Soil Information
People

At ISRIC - World Soil Information we are a dedicated team of staff, board members, graduate students, guest researchers, and volunteers working closely with one another.

Board

The managing Board of ISRIC - World Soil Information is responsible for legal, financial and staff issues. The Board meets four times a year to discuss the strategy and program activities of the institute.

Currently, the Board consists of:

Prof. Dr. P.C. de Ruiter
Professor Emeritus, Wageningen University and Research and University of Amsterdam, The Netherlands (Chair)

M. Roos MSc
Operations Director Environmental Sciences Group, Wageningen University and Research, The Netherlands

Prof. Dr. Ir. A. Veldkamp
ITC, University of Twente, Enschede, The Netherlands

Prof. Dr. R.N.J. Comans
Soil Chemistry and Chemical Soil Quality, Wageningen University and Research, The Netherlands (Chair)

Dr. ir. J.E.M. Baartman
Ass. Professor, Soil Physics and Land Management, Wageningen University and Research, The Netherlands

Staff

At the end of 2019, the ISRIC - World Soil Information team consisted of 21 people (16.2 full time equivalent). Two new colleagues strengthened the team with expertise in digital soil mapping, geoinformatics, and spatial data infrastructure, while our valued sustainable land management expert went on full-retirement. For a list of current staff, please visit www.isric.org/about/people

Support on financial, legal, and HR affairs is provided by Wageningen University and Research.

Guest researchers and volunteers

Our guest researcher programme is aimed at strengthening international collaboration and stimulating exchange of knowledge and information. The past two years, we hosted five guests researchers that mainly worked on digital soil mapping, soil nutrient uptake modelling, and data quality. Six volunteers helped as guides in the World Soil Museum, while another volunteer helped with the library collection and digitization activities.

PhD candidates, MSc students and internships

In 2018-2019, ISRIC - World Soil Information supervised seven PhD candidates and six MSc students, with theses focusing on pedometrics, digital soil mapping, quantification of uncertainties in soil databases and statistical modelling of crop yield variation. We hosted two grantees (PhD-candidates) from the Climate Food and Farming Network (CLIFF) and the Global Research Alliance (GRA) programme.

Awards and scientific recognitions

Gerard Heuvelink was listed in the Web-of-Science list of 'Highly Cited Researchers'; he also became a Deputy Editor of the European Journal of Soil Science in 2019. In the same year, Niels Batjes became a Fellow of the British Society of Soil Science.

Our partners

ISRIC - World Soil Information collaborates with a range of public, private and international bodies. Our partnerships are based on a clear recognition of the value that is added through working jointly with partners and sharing strengths to achieve specific outcomes. Our partners include universities, advanced research institutions, national agricultural research organizations, private sector organizations, and government and non-government agencies in the fields of soil science, sustainable land management, environmental quality protection, conservation and climate change.

FUNDING ORGANISATIONS

Bill and Melinda Gates Foundation, United States

European Union Horizon 2020

Global Research Alliance on Agricultural Greenhouse Gases

Ministry of Agriculture, Nature and Food Quality, The Netherlands

Ministry of Foreign Affairs, The Netherlands

OCP-Africa, Morocco

Royal Eijkelkamp, The Netherlands

The Nature Conservancy, United States

PARTNERSHIP

"4per1000" Initiative, France

Coordination of International Research Cooperation on Soil Carbon Sequestration (CIRCASA)

Global Soil Laboratory Network (GLOSOLAN)

Global Soil Partnership (GSP)

World Overview of Conservation Approaches and Technologies (WOCAT), Switzerland

Aarhus University (AU), Denmark

AfricaRice, Côte d'Ivoire

Agencia Estatal Consejo Superior de Investigaciones Científicas (IRNAS-CSIC), Spain

Agrarian School of Coimbra (ESAC), Portugal

AgReasearch, New Zealand

Agricultural Research Centre for Development (CIRAD), France

Agricultural Research Council (ARC), South Africa

Agricultural University Athens (AUA), Greece

Agrifood and Biosciences Institute (AFBI), United Kingdom

BothEnds, The Netherlands

Brazilian Agricultural Research Corporation (EMBRAPA), Brazil

Bureau National des Sols (BUNASOL), Burkina Faso

Charles E. Kellogg Soil Survey Laboratory, United States

Chinese Academy of Agricultural Sciences (CAAS), China

Climate Food and Farming Network (CLIFF), The Netherlands

Colorado State University System (CSU System), United States

Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia

Consiglio Per La Ricerca in Agricoltura E L'Analisi Dell'Economia Agraria, Italy

Consulai, Consultoria Agroindustrial, Portugal

CorePage, The Netherlands

Cranfield University, United Kingdom

Debreceni Egyetem, Hungary

Department of Agriculture, Food and the Marine, Ireland

Dienst Landbouwkundig Onderzoek, The Netherlands

Ecologic Institute, Germany

Estonian University of Life Sciences, Institute of Agricultural and Environmental Sciences (IAES), Estonia

European Commission, Joint Research Centre (JRC)

European Environmental Agency (EEA), Denmark

Evenor Tech, Spain

Foundation for Sustainable Development of the Mediterranean (MEDES), Italy

French National Institute for Agricultural Research (INRAE), France

Gaec de la Branchette (GB), France

German Aerospace Center (DLR), Germany

Horta SRL, Italy

Innovative Solutions for Decision Agriculture Ltd. (iSDA)

Institut d'Économie Rurale du Mali

Institut de recherche pour le développement (IRD), France

Institut Sénégalais de Recherches Agricoles, Senegal

Institute for European Environmental Policy (IEEP), UK and Belgium

Institute of Agricultural Resources and Regional Planning of Chinese Academy of Agricultural Sciences (IARRP), China

Institute of Agrophysics of the Polish Academy of Sciences (IA), Poland

Institute of Soil and Water Conservation of Chinese Academy of Sciences (ISWC), China

Institute of Soil Science of the Chinese Academy of Sciences (ISS), China

Institutul National de Cercetare-Dezvoltare Pentru Pedologie, Agrochimie si Protectia Mediului, Romania

Instytut Uprawy Nawozenia I Gleboznawstwa, Panstwowy Instytut Badawczy, Poland

International Center for Tropical Agriculture (CIAT), Colombia

International Centre for Agricultural Research in the Dry Areas (ICARDA), Lebanon

International Fertiliser Development Centre (IFDC), United States

International Institute for Applied Systems Analysis (IIASA), Austria

International Institute of Tropical Agriculture (IITA), Nigeria

International Maize and Wheat Improvement Center (CIMMYT), India

International Soil Carbon Network (ISCN)

IP Pragmatics, United Kingdom

Kongskilde Intustries, Denmark

Laboratoire des RadioIsotopes, Madagascar

Langraedsla Rikisins, Iceland

Lesprojekt Sluzby SRO, Czechia

M.V. Lomonosov Moscow State University (MSU), Russian Federation

Manaaki Whenua-Landcare Research, New Zealand

Max Planck Society for the Advancement of Science (MPG), Germany

Ministry For Primary Industries (MPI), New Zealand

National Research and Development Institute for Soil Science, Agrochemistry and Environmental Protection (ICPA), Romania

National University of Ireland, Maynooth, Ireland

Norwegian Institute for Agricultural and Environmental Research (BIOFORSK), Norway

Nutrient Management Institute, the Netherlands

Office du Niger, Mali

Origen Enterprises, Ireland

Research Institute for Knowledge Systems, The Netherlands

Research Institute of Organic Agriculture (FIBL), Switzerland

RSK ADAS, United Kingdom

Slovenska Technicka Univerzita V Bratislave, Slovakia

Société d'Exploitation et d'Aménagement des terres du Delta et des vallées du fleuve Sénégal, Senegal

Soil and Fertilizer Institute of the Sichuan Academy of Agricultural Sciences (SFI), China

Soil Resource Information and Mapping Directorate of the Ministry of Agriculture, Ethiopia

Soil Research Institute of Ministry of Agriculture, Ghana

Stichting Dienst Landbouwkundig Onderzoek (DLO), The Netherlands

Sveriges Lantbruksuniversitet, Sweden

Technical University of Crete, Greece

Technical University of Madrid (UPM), Spain

The Agriculture and Horitculture Development Board, United Kingdom

The Cyprus Institute, Cyprus

The Secretary of State for Environment, Food and Rural Affairs, United Kingdom

Tystoftefonden, Denmark

Umwelt Tbundesamt GMBH, Austria

United Nations Convention to Combat Desertification, Germany

United Nations Food and Agriculture Organization (FAO)

Universidad Politecnica de Madrid, Spain

Universidade de Aveiro, Portugal

Universita Degli Studi Di Padova, Italy

Universita Deglia Studi Della Tuscia, Italy

Universita di Bologna, Italy

Universität Bern (UNIBE), Switzerland

Universitat de Valencia, Spain

University College Dublin (UCD), Ireland

University of Aberdeen, United Kingdom

University of Évora (UE), Portugal

University of Gloucestershire, United Kingdom

University of Leeds, United Kingdom

University of Ljubljana (UL), Slovenia

University of Miguel Hernández (UMH), Spain

University of Pannonia (UP), Hungary

US Department of Agriculture-Natural Resources Conservation Service-National Soil Survey Center, United States

Wageningen Economic Research, The Netherlands

Wageningen University & Research, The Netherlands

World Agroforestry (ICRAF), Kenya

Publications

In 2018-2019, ISRIC – World Soil Information generated a total of 87 publications including 54 contributions to journal articles, 11 abstracts to conference proceedings, nine technical reports, and four book chapters. Arguably, the three most noteworthy peer-reviewed papers for the period are: 'How to measure, report and verify soil carbon change to realise the potential of soil carbon sequestration for atmospheric greenhouse gas removal', prepared by Smith et al. in the framework of the EU-CIRCASA project; 'Including spatial correlation in structural equation modelling of soil properties' by Angelini et al. in the framework of a PhD thesis at ISRIC/WUR; and, 'Soil Quality - a critical review' prepared by Bunneman et al. in the framework of the EU-iSQAPER project.

HUMID TROPICS   DESERT

List of abbreviations

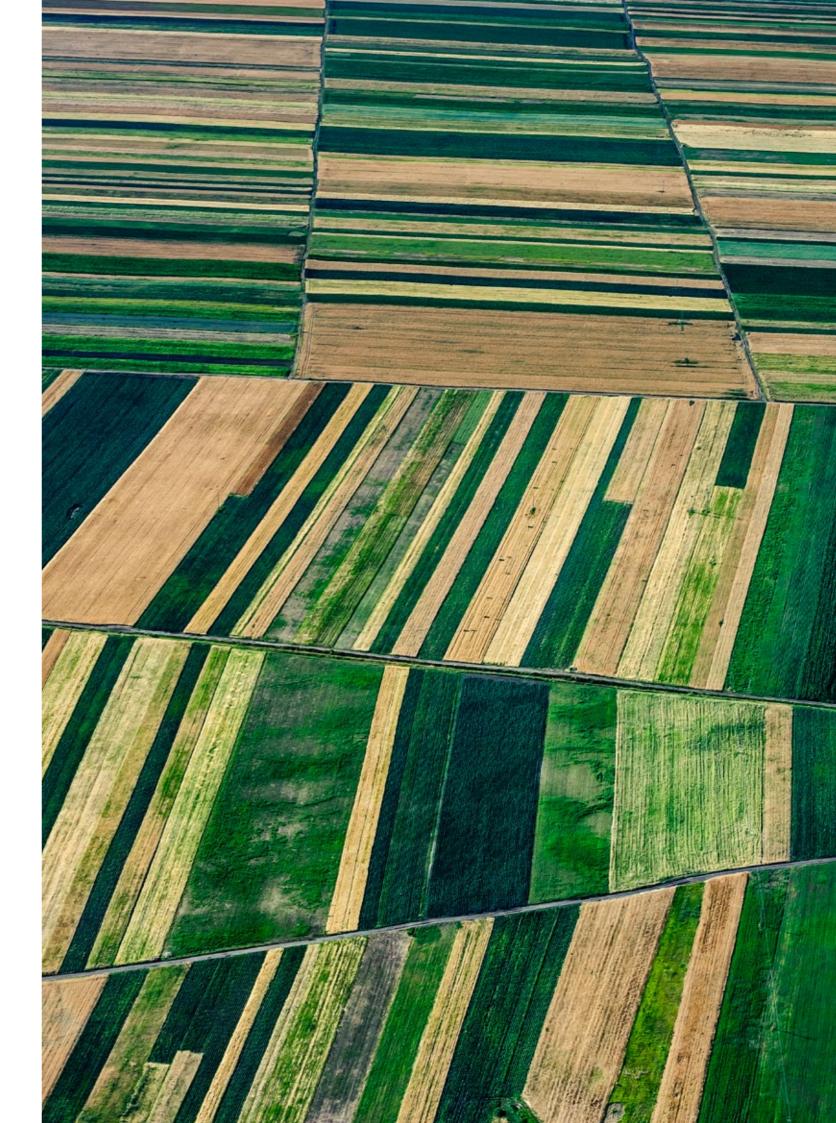|	
AfSIS	Africa Soil Information Service
CIMMYT	International Maize and Wheat Improvement Center
CIRCASA	Coordination of International Research Cooperation on soil Carbon Sequestration in Agriculture (EU project)
CLIFF-GRA	Climate Food and Farming Network (CLIFF) and the Global Research Alliance (GRA) programme
EU	European Union
FAO	Food and Agricultural Organization of the United Nations, Italy
GLOSIS	Global Soil Information System
GLOSOLAN	Global Soil Laboratory Network
GSP	Global Soil Partnership
ICRAF	World Agroforestry, Kenya
INRAE	Institut National de recherche pour l'agriculture, l'alimentation et l'environnement
ISCN	International Soil Carbon Network
iSDA	Innovative Solutions for Decision Agriculture Ltd., England
iSQAPER	Internactive Soil Quality Assessment in Europe and China for Agricultural Productivity and Environmental Resilience (EU project)
MRV-SOC	Monitoring, reporting and verification of soil organic carbon
SDF	Soil Data Facility
SHC	Soil Health Card
SIS	Soil Information Systems
SLA	Service Level Agreement
SoilGrids™	System for global digital soil mapping, ISRIC - World Soil Information programme
TNC	The Nature Conservancy
UNCCD	United Nations Convention to Combat Desertification
WOSIS	World Soil Information Service, ISRIC - World Soil Information programme
WRB	World Reference Base for Soil Resources