TOWARDS GLOBAL SOIL INFORMATION: ACTIVITIES WITHIN THE GEO TASK GLOBAL SOIL DATA

Workshop Report

20 - 23 March 2012
FAO Headquarters, Rome, Italy

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1 Forward

The present workshop report summaries the proceedings of the GSP workshop held at FAO headquarters in Rome from 20th March to 23rd March 2012. The objective of the workshop was to discuss in particular the various aspects of global soil information (Pillar 4 of the GSP) and the related information gathered by the e-SOTER project. The presentations and discussion were subdivided in four main sessions dealing with the following subjects:

- Status and needs of Global Soil Information
- Tools for polygon-based soil mapping (e-SOTER)
- Tools for Digital Soil Mapping
- The way-forward for Global Soil Information

2 Welcome and Opening Statement

The following welcome speech was given by Mr. Alexander Mueller, Assistant Director General, Natural Resources and Environment Department, FAO:

Ladies and gentleman, welcome to FAO. This is a second GSP meeting and we are very glad as participants of this workshop are soil scientists, or representatives of countries and CSO from all the regions in the world and whose commitment with this process should be recognized. As a background to this meeting, I want to point out that:

- In last September, FAO has launched the idea of a **Global Soil partnership** during a highly productive international meeting "Towards the Global Soil Partnership".
- GSP specifically aims to address the linkages between food security, soil health and ecosystem services to promote innovative and sustainable solutions of low carbon emission agriculture and taking advantages of agro-ecological processes and outcomes;
- GSP should create an enabling environment and specific expertise and fund raising capacity for sustainable improvements in soil and land management, allowing experience to be shared among farmers and scientists across countries and regions and to promote win-win solutions while addressing controversial issues such as payments for ecosystem services,
- GSP is focused and coordinated at the global and regional levels and also networks with national soil organisation to address the specific soil- and ecosystem-related problems of land users.

Progress of GSP up to date:

(1) Development of Terms of Reference

In this regard, a **Technical Working Group (TWG)** was established on 17 October 2011 to prepare the draft of Terms of Reference for the establishment of GSP. 76 worldwide voluntary members were invited to review the ToR. By the end of February 2012, a consolidated Zero version had been prepared.

Permanent Representations to FAO will review this Zero version ToRs submitted by the TWG.

(2) Actions in the field

While GSP is being formally established, problems in the field cannot be left out. FAO has started funding the establishment of institutional networks in different regions in order to set the basis for the Regional Soil Partnerships and start a process of developing soil information systems in which Capacity Development will be a top priority. This is done through Letters of Agreements with leading institutions

in the region (for example, in what is known as South-South cooperation) in Africa, Asia, and Latin America.

The present GSP workshop:

1. This workshop has the objective to review current status of soil information at global and regional level. At the end of the workshop we will have an improved knowledge of the current soil mapping initiatives and state-of-the art tools and methods for soil mapping and information dissemination.
2. Furthermore, we expect that all the participants will contribute to the preparation of a plan of action for GSP on **Enhancing the quantity and quality of soil data and information**.
3. FAO has been the leading institution for generating global, regional and national soil information. For example, the world soil map was produced by FAO in 1978, which is the only global soil dataset available and in use for various applications.
4. Capacity development in soil mapping has been always a priority for FAO and continues to be. FAO is currently supporting many regions and countries on the same.
5. Since technology and science have dramatically evolved, there is need to update and upgrade the global and regional soil information systems. Of course this can be done only if we join forces. Fortunately, GSP is providing the mechanism that could facilitate such a step.
6. Top-down approaches are not valid anymore and local talents should be empowered together with their institutions.
7. Soil information should be produced to answer the current demands and future challenges. This is not the only obligation for soil scientists. We also need to have a strong voice in the climate debate and in the RIO+20 process.
8. The only way to succeed on producing the new generation of soil information is through joining efforts and resources. GSP is ready to facilitate this process by involving national institutions, who are its key drivers.

Mr. Mueller then opened the workshop wishing success and concrete outputs that could contribute on the implementation of the Global Soil Partnership activities.

3 Session 1: Status and Needs of Global Soil Information

Keynote Addresses:

Dr. Parviz Koohafkan
Director Land and Water Division, FAO

Parviz Koohafkan (FAO) emphasized that soil activities in general and soil mapping in particular have gone through a deep cut-off in the last years influencing the production of information and its impact on the decision making. This has also happened in FAO, where soil-related activities have been dormant. However, soils are back on the agenda and an institutional framework to promote soil resources is needed. The Global Soil Partnership (GSP) is the perfect platform for fulfilling this need. It is aimed to be the platform to co-ordinate and advocate for soil resources through improved global coordination of intergovernmental mechanism and through enhanced and applied soil knowledge. Joining forces is the only way to overcome the current challenges. FAO has been historically a key organization promoting activities on soil information production and use (with some gaps). Its intergovernmental setting provides it with recognition in the countries, especially in the developing world. Soil information is fundamental, especially in addressing key needs of the countries and regions in all fields of application. Making good use of the current technologies, tools and methods will help to properly address the needs of soil information. "Enhancing the quantity and quality of soil data and information" is a key pillar of the GSP. Different partners were called to contribute their best in order to successfully implement the activities in this pillar of GSP.

Dr. Christian Witt
Senior Programme Officer Soil Health
Bill and Melinda Gates Foundation

Christian Witt (Bill and Melinda Gates Foundation) explained the objectives of the Foundation which focus on investments in agricultural development to reduce poverty, particularly in South Asia and Sub Saharan Africa. Improving the soil information particularly in Africa is one of the cross-cutting issues the foundation support. Attention is also paid to soil management, the yield gap and environmental monitoring to fill a need for real time information beneficial to farmers. In response to questions it was stated that the support of the Foundation focused geographically, although that only a limited number of countries would be supported, such as Kenya, for example. Some others would benefit from training and auto-finance to update their soil information (Ethiopia, Ghana). In response to another question it was admitted that land tenure issues were indeed very important in Africa but were not yet addressed in the project.

Thomas Strassburger (European Commission) gave an overview of how soil policy has been promoted in the EU. A Soil Framework Directive was prepared in 2006 but has not yet been adopted by all the member states. Soil policy in Europe aims at reducing erosion and increasing the organic matter content in soils within a reasonable time frame. This commitment will be made at the Rio+20 meeting later this year. However, a main concern remains how to measure and monitor these soil changes. Most of the EU member states, unlike Austria and Germany, have no record of densely measured historical soil (fertility) data. The achievements of the LUCAS (Land use Change Assessment Survey) that has analyzed more than 20 000 topsoil samples in recent years were highlighted. In response to

questions it was admitted that there remains a problem of accessibility of soil data (for IP and protection of privacy reasons) and that the use of pedo-transfer functions rather than directly measured data may lead to a propagation of errors.

Terry Roberts (IPNI) discussed the IPNI programme that aims at rationalizing fertilizer use. He illustrated some methods (e.g. the use of omission plots) that were very effective and quickly. He admitted that the acceptance of these methods by extension services was not ideal and often one has to rely on modelling, such as QUEFTS model, as an alternative (). However, there is a lack of reliable soil data to support application of these models because soil maps are neither at an appropriate scale nor fully focused on agronomic issues. A number of comments were made on this presentation: (i) the fact that soil and soil fertility are only part of the factors that explain yield (ii) the need for seed money to start a soil fertility monitoring programme (iii) the spatial variability in soil legacy data is often too high.

Pasquale Steduto (FAO) explained the principles and applications of the AQUACROP crop growth model developed in the land and water division. This model requires a number of soil parameters such as Permanent Wilting Point, Field Capacity, Soil moisture holding capacity, soil depth, saturated hydraulic conductivity and soil fertility levels. These parameters are often not available and have to be deduced from other data. In response to a question why this model was developed while FAO and IIASA had already developed the AEZ model with the same aims, it was said that the AQUACROP model had proven to be simpler and at the same time was robust and accurate. In response to another question it was admitted that the model could not yet simulate tree growth and production.

Achim Dobberman (IRRI) gave an overview of the needs of agronomists for soil data. He stated that the lack of adequate soil information is often the weakest link in providing agronomic questions. Users require recent soil information that allows monitoring and is available as raw data. The inaccessibility of soil data is unwarranted as there are multiple sources for soil information (not only those held in national soil institutes) and that the value of soil information does lie mainly in its interpretation. A treaty mechanism to allow sharing of soil data should be established under which a lot but not every bit of information would be free.

Victor Castillo (UNCCD) gave an overview of the objectives of the UNCCD and its implementation and organization. The ten year Strategy of the UNCCD asks for tracking the progress made in the achievements of the strategic objectives. In 2012 affected country Parties will report for the first time against impact indicators such as (1) Proportion of the population in affected areas living above the poverty line and (2) Land cover status. Reporting on impact indicators is part of the new performance review and assessment of implementation system (PRAIS).

Neil McKenzie (CSIRO) gave an overview of the state of progress of the various initiatives that are ongoing, notably the digital soil mapping project (globsoilmap.net) which aims at producing point based soil property information at very high resolution and the development of more sophisticated polygon based information as developed under e-SOTER. He referred to the presently available global soil information in the Harmonized World Soil Database (HWSD). He concluded that: (1) New technologies are our great opportunity for building a valuable global digital knowledge base and as well as our greatest risk (2) We need to help build a better institutional system for soil knowledge at home and internationally (c.f. weather, climate and geosciences) (3) A Good strategy is essential to design the soil knowledge base needed to meet the needs of 2020, 2030 and beyond, and (4) The institutional arrangements are our biggest challenge and the GSP with supporting investment is our best opportunity for a long time.

Martin Yemefack (African Soil Science Society) discussed the status and the needs of soil information in the African context. He referred to the Soil Atlas of Africa presently being prepared by JRC and the achievements of AFSIS until now. He questioned the operational set-up of the latter project because it

appeared only to benefit directly a single African country and a limited number of institutions. He made a plea for more capacity building in digital soil mapping across Africa. Finally, ASSS highly support all collaborative initiatives such as GSP and is ready to work with all for enlightening the relationship between soil and society, and to help create the conditions for Africa soils, in their diversity, to fulfil their various functions and play a full role in food production and environment conservation, which are indeed factors for peace and stability.

Rainer Baritz (BGR) discussed the soil information needed for carbon monitoring particularly in forest soils. He concluded that: (1) Topsoil properties are not sufficiently reflected in international soil classification; (2) The overall soil variability is extremely high in forest soils; (3) In managed forest ecosystems the O-layer and mineral soil processes should be decoupled; (4) The spatial assessment of Soil Organic Carbon (SOC) is dependent on the quality of the data base and its resolution; (5) For the prediction of SOC stocks coarse fragments (stones) are the main uncertain soil property; (6) C stock change assessment of GHG effects such as : Management effects, climate change, projections, sensitivity etc. can only be made on the basis of soil biophysical models; (7) The resolution of digitally available soil maps is poor and the specific soils under forest is often not known and that the data about the O-layer is missing (8) The density of plot measurements is actually not so poor (in Europe at least), but there are severe access and quality restrictions; and (9) The quality of spatially explicit data on land use and climate is still poor, which is seriously limiting modelling exercises.

<u>Other presentations on the status and needs for global and regional soil information:</u>

The objectives of the Global Soil Data Task (GEOSS) by Vincent van Engelen (ISRIC), who drew the attention to the facts that: (1) Data from local organizations are currently not provided in an OGC compliant interoperable way; (2) In certain continents (e.g. Africa) no capacity is available to provide these services to the international user community; (3) The system should allow the local organization either to host their data in a consistent way locally, or at a continental node; and (4) A common Data Exchange Protocol for soil data should be defined under the Open Archive Initiative, allowing for exchange across the globe.

Global Earth Observation System of Systems (GEOSS)-Global network for sharing soil data *Mr. Vincent van Engelen*

The status of soil information in Asia by Ganlin Zhang (ISSCAS) provided information on the implementation of the Asian Soil Partnership/network under the FAO-ISSCAS agreement. A regional report on the status of soil institutions and soil data/information will be prepared. In addition, a regional soil map making use of available national soil maps based on legacy data will also be produced).


Harmonized World Soil Database (HWSD): The only accessible Global Soil Information System – *Mr. Freddy Nachtergaele*

The status of soil information in Latin America was presented by Aracely Castro who stated that FAO through the GSP is funding initial activities in LAC regarding soil legacy data. This activity is being implemented by CIAT. Under the same project, EMBRAPA Solos will develop a Digital Soil Mapping toolbox to implement it in a capacity development process. Twenty Latin American countries are involved and they have a lot of expectations, specifically in regard to training.

The Harmonized World Soil Database by Freddy Nachtergaele (FAO/IIASA) drew the attention to the fact that this database is the only truly global one currently available which should urgently be enhanced by (1) An improved Geographical coverage, (2) Improved Quality of Soil Property predictions, and (3) Improved Harmonization in cooperation with e-SOTER and Globsoilmap.net.

Improving fertilization practices with the help of a Soil geo-database in China by Wei-Li Zhang (CAAS) treated the following topics: (1) Problems related with unreasonable fertilization; (2) The status of fertilization techniques; (3) The principle of the Harvest Genius its development and application; and (4) The remaining constraints and perspectives.

Plenary discussion

In the discussion that followed it was emphasized that:

There appears to be three great challenges and demands for soil information:

1. Soil status (soil properties, soil health) at a relatively detailed scale that are vital to the global modelling community, in particular those concerned with mitigating Climate Change and those concerned with Food Security status. The soil health and status is also of importance to International Organizations and Conventions that determine the state of land and water (FAO) or those concerned with desertification (UNCCD, UNEP, GEF and FAO).
2. Soil monitoring, requires ideally highly accurate global soil data at high resolution in real time and in three dimensions. Soil changes in time are of major importance to funding agencies and policy makers who need to justify investments and implemented policies in terms of a consequent positive change. It could also serve farmers, for instance, in precision farming and to rationalize fertilizer use.
3. It would appear that progress is being made on the soil state and that digital soil mapping will - in time- be able to provide the required information. Updating geographically and quality-wise the Harmonized World Soil Database seems to be a priority in the short term. The e-SOTER achievements are not lost as they will allow a sounder polygon approach at national scale.

As far as soil monitoring is concerned it is not obvious if the data to be provided by other global initiatives will be sufficient. Such data may be adequate in terms of resolution and to establish a base line, but they may not measure the right properties (land degradation for instance is often more driven by land use and management than by soil and terrain), nor can they be achieved any time soon. The results up to now do not come close to real time three dimensional measurements as demanded by some keynote speakers.

There remains a problem of soil data accessibility, data sharing and exchange

Although the data accessibility, sharing, and exchange are partly technical problems, the workshop appeared confident that at least the tools and the architecture of a soil data sharing centre (or centres) can be developed quickly. The problems of intellectual property rights and protection of privacy rights of soil data remain a challenge, but could perhaps be alleviated by provision being established by INSPIRE and GEOSS. Partly it is also a problem of missing data: a gap that could be filled relatively easily by industrial nations, but will require investment and capacity building in developing countries.

Capacity building and additional investments

The majority of participants agreed that the need for technical capacity building and additional investment was important.

4 Session 2: Tools for polygon based soil mapping (e-SOTER)

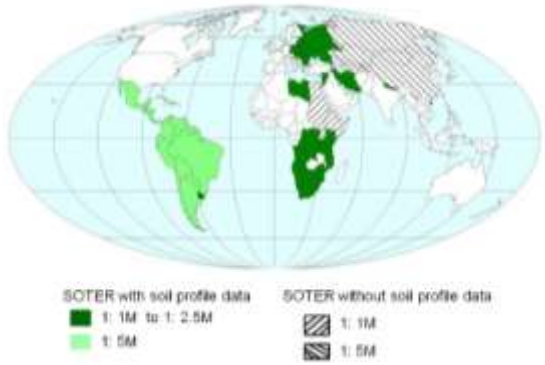
There were 13 presentations on e-SOTER project. They majorly dealt directly with the SOTER project. Another 5 presentations demonstrated the application of polygon-based mapping units. These were the following:

Drs. Vincent van Engelen
ISRIC

Progress, methods, and outputs of e-SOTER

e-SOTER as a contribution to a Global Soil Observing System: Vincent van Engelen (ISRIC) reported on the achievements of the project and emphasized that more research is still required notably in morphometric descriptions, soil parent material characterization, pattern recognition by remote sensing, standardization of procedures, quality assessments and uncertainty analysis.

Development of terrain and parent material platform at scale 1:1 million: This issue was reported upon by Endre Dobos (University of Miskolc) who concluded that a quantitative methodology to delineate SOTER terrain units using digital data sources like satellite imagery and digital terrain models in combination with legacy data has been developed. However, there should not be attempts to reproduce the ”traditional” datasets with the new tools, but rather to convert and save all the information from the legacy datasets using the new tools in a novel dataset design.



Global distribution of SOTER data
By Vincent van Engelen - ISRIC

Developing the soil component of e-SOTER was discussed by Erica Micheli (Szent Istvan University) who drew the attention to the fact that the unavailability, and limited access and quality of soil data remain a major limitation. Expert knowledge and better guidelines for soil observation need to be improved /harmonized while further developing distance methods and other numerical approaches which are promising.

Enhancing the Terrain component in the e-SOTER database was presented by Joanna Zawadska (Cranfield University) who tested two different approaches and concluded that both methods give different but not dissimilar results Bayesian Networks favour approaches based on homogenous objects while Cramer’s V statistic finds more value in approaches based on physical entities.

A new system of terrain classification was presented by Rudiger Kothe (Scilands GmBh) who concluded that terrain analysis and classification on the base of DTM can deliver a valuable contribution to create or enhance soil maps. Particularly in regions with poor data availability terrain analysis on the base of SRTM data in the form of geo-morphographic maps can help to create soil maps.

A new classification of soil parent material was discussed by Ulrich Schuler (BGR) who emphasized the advantage of a revised classification of parent material (FAO, 2006) for the derivation of soil properties. This could serve to develop a global parent material layer for SOTER. Advantages and disadvantages of gamma spectrometry were also discussed.

Integration of terrain, parent material and soil information in e-SOTER at 1:250 000 scale was presented by Michael Bock (BGR). The procedure consistently implements the site factors relief and parent material Pre-stratification of the landscape according to soil regions is required for larger mapping projects The validity to serve as a conceptual soil map is promising, but it needs further investigation by soil surveyors.

e-SOTER web services: status and way ahead to a Global Soil Information Service was discussed by Yusuf Yigini (European Commission). The web portal designed at the Joint Research Centre for disseminating the results of eSOTER was illustrated. It made also use of the metadata of GeoNetwork. It is expected that the portal will go live in April 2012.

<u>Applications and further testing of e-SOTER outputs</u>

Enhanced e-SOTER database for a study area in the UK was discussed by Joanna Zawadzka (Cranfield University). She concluded that both presented approaches added value to the SOTER database Inclusion of terrain component based on physical entities appropriate for 1:250 000 scale mapping while the Terrain component based on homogenous objects is appropriate for small scale maps (1:1 – 1:5 M). The accuracy of the database in terms of provision of soil information is affected by the accuracy of parent material data and soil observations.

Application of the e-SOTER approach in Morocco: opportunities and constraints was presented by Rachid Moussadek (INRA) who concluded that the e-SOTER approach remains good approach as a first step framework for a soil mapping program of the unstudied areas of Morocco. This approach is also a great opportunity to build local capacity and establish a Moroccan Soil Database to be used in studies for mitigating climate change and soil erosion, while enhancing soil fertility and land suitability.

Validation and uncertainty analysis was presented by Gerard Heuvelink (Alterra) who concluded that important error sources in the UK e-SOTER soil map are the over-representation of Histosols and Podzols and the absence of Leptosols as a dominant soil group. Important error sources in the G/CZ e-SOTER soil map are the under-representation of Chernozems and Podzols and the confusion between Hydromorphic soils, Cambisols and Luvisols. DEM uncertainty has the largest effect on slope class. Uncertainty about the prevailing landform attribute, quantified by the entropy, is generally small.

Applications of the e-SOTER database using some models to simulate soil threats was discussed by Simone Verzandvoort (Alterra) who stated that there was a large deviation of model outputs compared to expert responses Model outputs based on the e-SOTER database are not always better according to the experts than those based on legacy databases.

Standard and services for soil and terrain data exchange: SoTeRML were discussed by Steve Hallet (Cranfield University) who proposed that data should be available over the internet in a standard format (OGC WFS) while merging legacy and new data across domains.

Example of application of global soil data
Soil atlases - *Prof. Ciro Gardi*

Status of Soil Atlas of Africa was presented by Arwyn Jones and the **Latin American Soil Atlas** by Ciro Gardi (both from the European Commission). The Soil Atlas of Africa is intended to raise the awareness of the general public, policymakers and other scientists of the importance of soil in Africa. It would also serve as educational material to schools & universities and support EU policies and instruments for Development and Aid Assistance. The Soil Atlas of Latin America would also estimate the Soil Carbon Stock, in some test areas, using digital soil mapping approach and evaluate soil threats, thanks to a survey among LAC Soil Scientists

Soil Erosion in Chile, current and future was discussed by Aracely Castro (CIAT).The present approach gives detailed information by region, province and commune and uses also Satellite Technology. It provides institutional support for professionals in regions and gives general information about development programs and recovery of degraded soils. Special attention was drawn to the dramatic effects of forest fires in the country.

Revising arable land evaluation with new tools by Rokhaya Fall (FAO) drew the attention to land suitability in Senegal and developed a method to determine the extent of arable and suitable lands. It could be extended to other regions in the Sahel and it requires that additional studies are undertaken on water stress and nutrient deficiencies.

The use of geological information for soil mapping was presented by Raimonds Kasparinskis (University of Latvia). Determining the existing relationships between geology and soils facilitates the future mapping of the boreal soils on a regional scale of 1:50000. Taking geological contours as a basis, it is possible to single out soil group associations in soil mapping, although it is difficult to single out separate soil groups.

Discussion

The e-SOTER presentations were followed by a two hour debate chaired by Jon Hempel (NCSS) of which the highlights are summarized here.
Eddy De Pauw (ICARDA) kicked of the discussion by asking if the terrain analysis was a single track or if this could follow several tracks. Jon Hempel concluded that on the basis of the interventions it appears indeed that several tracks are possible depending on the availability and quality of the data (in particular geology).
The advantages and disadvantages of polygon based mapping versus pixel based mapping were discussed by Vincent van Engelen (ISRIC), Endre Dobos (), Rainer Baritz (BGR) and (ICARDA), in particular how to devise ways to distribute soil profile information within the polygon.
Another discussion launched by Luca Montanarella questioned the future of eSOTER as his expectations had been at the onset of the project that it would result in a full SOTER update of Europe at 1:1 M scale. Vincent van Engelen as team leader of eSotER pointed out that the project document did only specify the preparation of a tool to do so and to refine the methodology at 1:250 000 scale in specific windows and for future national applications. Both these objectives were achieved. Erica Michele (Szent Istvan University) stated that although the eSOTER update for Europe at 1:1 million scale was started, there were problems with soil profile information access from several countries. Given the present economic and financial crisis collecting new soil information is not a priority for countries in the EU. Luca Montanarella concluded that although a global SOTER remained a long term goal it would be better to concentrate on the 1:1 million scale update for Europe only, which could feed in the HWSD product.

The decision to continue the effort to produce a 1:1 million SOTER for Europe was later confirmed in a parallel meeting of executive committee of the European Soil Bureau Network.

5 Session 3: tools for point based soil mapping

Session 3 benefitted from nineteen presentations, mostly concerned with digital soil mapping tools**.** They are briefly summarized here and are available in full on CD-ROM.

Current advances

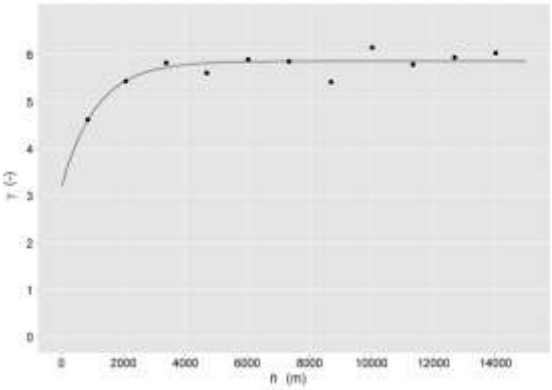
Africa Soil Profiles Database Johan Leenaars (ISRIC) stated that the goal of the project was to build a database with 2 to 3 soil profiles per 1000 km^2 for a total of 30-40 000 soil profiles for Sub Saharan Africa. At present the database contains 12 500 soil profiles with a high concentration in Nigeria and Malawi. Several applications of the database have been made. The database will become available after quality control through WoSIS at ISRIC. Legacy soil data are compiled very cost-effectively.

Rationalization and harmonization of soil legacy information was presented by Jacqueline Hannam (Cranfield university) who stated that rationalization and interpretation unlocks the potential of soil legacy data with Vector, point, class and property output. Spin-offs include a revised 'classification' systems, soil-scapes, pedo-transfer rules. The system provides training data platform for DSM, although there remain Issues with reconciling the initial aim of the legacy survey with the new application.

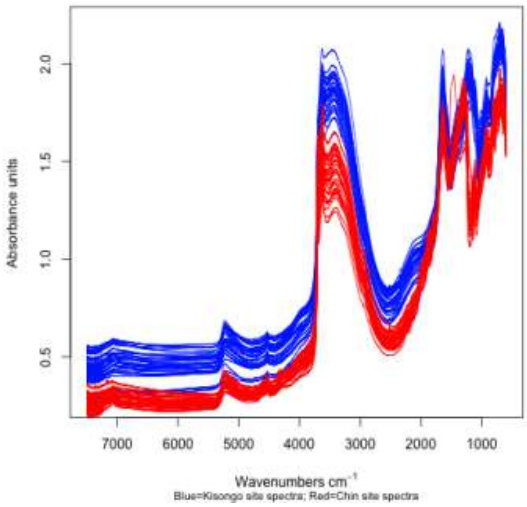
Electronic Soil Data storage: possible approaches with an emphasis on the Russian soil database. Pavel Krasilnikov (Eurasian Centre for Food Security) discussed the aims of improving the structure and design of the Russian soil database and also ways and means to (1) Filling the database with real soil data (2) plan for a future geographic extension of the database (3) Develop a data sharing format; data sharing with EuroDB (HWSD), which is a priority.

Processing and integrating soil map information from different regions into the China Geo-database at 1:50 000 scale by Wei-Li Zhang (CAAS). She concluded that soil information has an important role to play in agriculture (Fertilization, Water management Plough techniques etc.) The task of Soil scientists is to make valuable forecasting or services for end users by using historical and actual soil observation. The GSP should try to supply soil information to improve small farmers fertilizing practice in Asian & Africa.

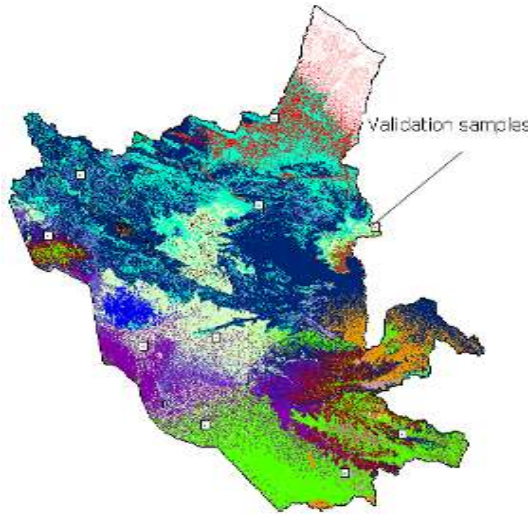
Some of the DSM methods



Modelling uncertainties – Dr. Gerard Heuvelink



Infrared spectroscopy – Dr. Ermias Betemariam



Mapping soil types – Dr. Christian Omuto

Digital Soil Mapping from legacy data and hyperspectral imagery in CapBon (Tunisia): first results and perspectives by Philippe Lagacherie (INRA) showed that the conversion of legacy data into DSM inputs is not a straightforward step. Pedometric techniques may help to overcome some problems. In some regions of the world, processing only legacy soil data and globally available soil covariates may produce uncertain estimations of soil properties but this however provides a strong rationale to planify new investments in soil data to fulfil user's requirements It is recommended that new covariates like hyperspectral imagery should be considered in the near future at least in the most difficult regions.

Overview and recent development of SoLIM an effort moving DSM in the modern area by A-Xing Zhu showed that coordinated but distributed efforts with capacity building should be the focus whereby each member country responsible for its own country under FAO coordination, Training of the new technology is also required.

From polygon based soil unit mapping to probabilistic maps of soil properties in the West Asia – North Africa region Eddy De Pauw (ICARDA). As far as the needs go for the WANA region it is necessary to improve the knowledge of soil distribution and while data are available for large parts of the region, access to this information will only be possible through a capacity building programme that includes specified deliverables and data sharing arrangement. A test case in Syria illustrated the use of several layers of information to provide specific answers in terms of soil properties about land suitability for de-stoning.

The global soil spectral library – a good tool for global soil mapping was presented by Raphael Viscarra-Rossel (CSIRO). A spectrometer allows the efficient and cheap measurements of a number of soil properties, among others organic matter, clay mineralogy and carbonates. The method can be applied remotely or on the go close to the ground. A spectral library has been established and has been used to predict soil properties and soil types, both in WRB and the USDA Soil Taxonomy. Spectroscopy is a promising tool to make advances in digital soil mapping quickly, particularly for poorer countries.

Towards a global soil Infrared Spectral Calibration database by Ermerias Betemariam (ICRAF) discussed the ICRAF Global spectral library and some of the challenges facing it, notably: (1) Soil spectral calibrations are limited by quality and consistency of the reference data (2) Large libraries are needed to cover the global range in soil conditions and (3) The need to include a number spectral instrument types (VNIR, NIR, MIR).

ISRIC Global Soil Information System Facilities was discussed by Hannes Reuter (ISRIC). GSIF is a framework for enhancing, collating, harmonizing, and use of soil and covariate data to: (1) store/rescue legacy data and (2) assist production of added value global soil information at various resolutions. It promotes collaborative cooperation which brings in the required soil knowledge from local participants and provides training at ISRIC. The Components include Soil Property Maps, OpenSoilProfile, Worldgrids.org , GSIF Packages, and a GSIF Manual.

Digital Soil mapping in Argentina: challenges to overcome by Marcos Angelini (INTA) discussed recently developed tools for digital soil mapping that have been combined to obtain soil maps point based, what has shown promising results. The maps not only offer information about the edaphic variables, but also an estimation of point value and error. When working on disaggregation polygons maps, the applied methodology allows the use of information about the different soil classes that form the cartographic units. In this manner one can obtain raster maps of soil types associated with the probability of their occurrence.

DSM for mapping soil classes in Somalia. Christian Omuto (University of Nairobi) illustrated with a digital soil mapping programme in northern Somalia that (1) Digital soil mapping can overcome a significant proportion of challenges in soil data generation (2) National institutions/individual

researchers/NGOs can provide useful links in soil database development and validation of methods and (3) There are important training needs for national researchers on new trends and tools.

Progress of the Globsoilmap.net for the North American node. Jon Hempel (USDA) showed a first test that can use SSURGO, STATSGO, SLC data to produce property maps (weighted averages) that meet GSM.net specifications. The method could be applied anywhere in the world with digitized soil maps and attributed polygons can produce soil property data. The system still needs work on uncertainty and one should research and develop deconstruction/disaggregation technology.

Digital Soil Assessment. Thomas Mayer (Cranfield University) stated that the Challenge was the Multi-functionality of soils and that the solutions lie in the pursuit of (1) Digital Soil Mapping (2) Individual soil functions and (3) Multi-functionality of soils. He suggested the need for more "pedo" in "pedometrics" and was convinced that any Digital Soil Mapping programme will fail if it is not supported by pedologists/surveyors.

The collaborative Soil App advances in augmented reality visualization by Barry Rawlins and others (British Geological Survey Keyworth) illustrated an iphone-application that was able to present the geological map of the surroundings in the UK. A similar application would be possible for soils because development cost are falling & the uptake increasing. It would make soil data available for the public and the experts alike.

IUSS Working Group on Soil Information Rainer Baritz (BGR) and Hannes Reuter (ISRIC) said the IUSS WG SIS provides a concept for data exchange and concluded which: (1) Is implemented within the IUSS community (2) Exchanges and combines the developments in soil information systems (as an open network) with the objective to facilitate max. data availability, gobally (3)Needs to be embedded into a global governance structure despite the idea of a distributed system (4) GS Soil goes through a large spectrum of soil (data) networking issues, introduces data providers into data infrastructures and web-GIS and (5) Provides guidance/best-practice (BP) recommendations.

Needs for harmonization of soil methods, measurements and guidelines by Allan Lilly and Helaino Black (James Hutton Institute) made a plea for: (1) Interoperability rather than harmonization (2) Legacy data owned and managed by data collectors (3) The reuse and revitalisation of legacy data. The way forward requires reference standards and standardized, reproducible laboratory methods.

Data specification and information structures for soils data by Stephen Hallet and Damiel Simms (Cranfield University). They stated that the challenge is to draw together the many excellent initiatives for soil data codification and exchange and the Global Soil Partnership is an excellent context in which to do so. This requires (1) the adoption of established techniques of Digital Soil Assessment and integration of output data in a new generation of applications tools and (2) application of practical, user-driven methods to transform Soil Data to Information to Knowledge

Towards a Universal Soil Classification System by Jon Hempel and Erica Micheli (both IUSS WG USC) illustrated a centroid approach with average values of the selected 37 properties of the available profiles. The complexity of the definitions and requirements of soil diagnostic horizons was noted. Significant progress has been made to bring closer together the WRB and USDA systems. A topsoil classification is required. Soil Scientists are invited to join the discussion at the following URL: http://soils.usda.gov/technical/classification/Univ_Soil_Classification_System

6 Session 4: The Way Forward for Global Soil Information

The discussion was organized around two presentations: one by Luca Montanarella (EU) on targeted global and regional soil information inputs, and one by Neil McKenzie (CSIRO) on a proposal for future

soil information activities under GSP by the Globsoilmap.net project. These two presentations were followed by a lively debate that focused on the steps needed to achieve an action plan for pillar 4 of the GSP.

Participants discussing the way-forward for GSP

Contributing to the discussions- Dr. Pavel Krasilnikov

Steering the discussion: *Ronald Vargas*

The presentation by Luca Montanarella drew the attention to the conditions required to achieve a significant improvement of global soil information based on lessons learned while preparing the digital European Soil Database. These conditions were:

1. Neutral leadership.
2. Intellectual property rights on data remain with the data producers.
3. The work is undertaken in a participatory manner (Networking).
4. National capacities to produce soil data are present.
5. Clear user needs are established.
6. There is a long term perspective and the activities are process oriented.

If the above conditions were fulfilled one could proceed as follows under the neutral leadership of FAO:

a. Prepare version 2.0 of HWSD at 1km resolution by including data from industrial nations.
b. Prepare version 0.1 of GSM.net at 100 meter resolution
c. Establish regional soil partnerships which includes legacy and new data.
d. Prepare version 1.0 of GSM.net
e. Distribute and maintain GSM.net products.

Neil McKenzie answered some more specific questions raised by the previous presentation, in particular those related to the use of splines that were required to model property distributions with depth. He also mentioned that the 100 m grid proposed is a geometric unit that allows to maintain the precision of information in nations with the most dense soil information, but that these geometric units will probably be filled with lesser accuracy in other nations or in areas of lesser interests (deserts, etc).The presentation also proposed that the governance of pillar 4 of the GSP would be organized along the regional

nodes that are now operational in the GSM.net project. Neil drew the attention to a number of specific issues that would need to be highlighted in the plan of operations:

- Provide a spatial infrastructure and IP and access rights.
- Supply a complementary set of spatial soil data products (HWSD, e-SOTER and GSM.net) – He also announced that the USA and Australia had agreed to contribute to HWSD and that also Canada would be approached.
- Design a Global Monitoring Network
- Rebuild the technical capacities in selected participating nations.
- Report on the Status and trends of global soil health.
- Governance of the GSP with clear responsibilities by leading soil institutes and the GSM.net project.

The debate that followed highlighted that in Europe IP for soil information is embedded in INSPIRE and is therefore strictly regulated. There are also concerns on privacy rights with geo-referenced information.

The use of the term "leading soil institutes" and the proposal to use the present nodes of the GSM.net to govern GSP pillar 4, was questioned by Pavel Krasilnikov. He noted that Russia did have leading soil institutes and was not presently part of GSM.net. Concerns were also raised about the association of India in the Asian node and the present organization of the African node. Ronald Vargas stated that FAO was not a member of GSM.net either and that regional nodes could in the future probably be supported by the FAO (sub) regional offices.

Rainer Baritz (BGR) proposed a way forward for the Data infrastructure organization in regional nodes and a linkage with products (HWSD, SOTER, DSM, Soil Profiles archive, Soil properties). Neil McKenzie also proposed the establishment of a working group to deal with the issues identified. The working group would produce a report that could be the roadmap and plan of action for pillar 4 of the GSP.

Ronald Vargas (FAO) stated that in a separate meeting the Regional Representatives to FAO had in principle agreed to adopt the Terms of Reference proposed for the GSP (provided they were summarized) and would endorse them in May during the session of the Commission for Agriculture (COAG). He also proposed to focus the discussion of this pillar about 4 main subjects:

- The organizational structure of the pillar.
- Capacity building in national soil institutes
- The data structure and legacy data.
- Joint plan of action defining short term activities and long term goals.

Wei-Li Zhang (CAAS) and Rokhaya Fall (FAO) both pointed out that more attention should be paid to the end user in particular the farmers, and the food security situation. This remark triggered a debate on the end users of the data. Luca Montanarella (EU) indicated that the main users of these data are climate change and food security modellers. David Wiberg (IIASA) stated that also large commercial firms have a great interest in the derived products. Christian Nolde (FAO) said that it smallholders were central to FAO's mandate and that these products should also serve them. It was concluded that both kind of end users would benefit directly or indirectly of enhanced soil information.

Prem Bindraban (ISRIC) stressed that ISRIC would continue to serve the international community as a world soil data centre and has a vital role to play in the organization of the data structure in this pillar, but it should be clear that this should be seen as a collective effort and not something owned only by ISRIC. David Wiberg (IIASA) stated that any questions on HWSD could presently be addressed to IIASA

and FAO. Freddy Nachtergaele (FAO) stressed that the HWSD is in the public domain and FAO and IIASA would prefer to maintain this arrangement.

The meeting then proceeded to define the issues to be discussed in the working paper. The scope of the paper would cover the following:

- Governance and Structural Organization
- The links between Global soil information and end-users
- Primary soil data and spatial data products including accuracy issues.
- Reporting on global soil health: soil capacity and functions.
- Technical monitoring
- Global monitoring network
- Archives, References and standards

The meeting elected a drafting committee for the working paper on the basis of a balanced regional representation as follows:

- Africa: Martin Yemefack
- Asia: Ganlin Zhang
- Europe: Rainer Baritz
- Latin America: Aracely Castro
- MENA: Rachid Moussadek
- North America Jon Hempel
- Oceania: Neil McKenzie
- Secretary: Ronald Vargas

The meeting also agreed on a time schedule for the production of this report (of less than 50 pages) bearing in mind the Rio+20 meeting:

1. First draft by 11/05/2012
2. Consultation by 01/06/2012
3. Revised draft including plan of action by 30//08/2012
4. Consultation by 1/12/2012
5. Submission to GSP and Panel of International Science Advisors 15/12/2012

Ronal Vargas (FAO) assured the meeting that plan of actions for the other pillars of GSP would also be prepared for instance the pillar of Soil Management would be discussed at a IAEA meeting in Vienna.

The meeting was closed by Ronald Vargas and Luca Montanarella who thanked all participants for their contributions throughout the proceedings and wished them a safe journey home.

7 Workshop conclusions

An agreement was reached on an international working group that would prepare a scoping paper and a plan of action for pillar 4 (Global Soil information) of the GSP by the end of 2012.

The meeting concluded that the e-SOTER project was successfully completed and that a wealth of information was gathered during the project, both in the selected study areas and for Europe overall. It was also decided that the eSOTER findings would be applied for the whole of Europe at 1:1 million scale, which would serve as input for a new version of the Harmonized World Soil Database.

Various scientists involved with Digital Soil Mapping illustrated new and exciting techniques that will accelerate the global and continental exercise now undertaken respectively by Globalsoilmap.net and AFSIS. The meeting heard several suggestions on platforms for data exchange, standardization of data and web based applications. It was suggested that a version 0.1 of the Globsoilmap.net is prepared soonest.

Various participants promised to contribute to the update of the Harmonized World Soil Database. In particular the industrial nations (Australia and the USA, possibly expanded with Canada, Mexico and Russia) committed themselves to tackle the incorporation of their legacy soil data in this database. Regions of the developing world indicated that they could also do so, provided this was accompanied by training and capacity building in general and digital soil mapping in particular.

A number of donors and agricultural scientists and decision makers gave a clear overview of the needs, challenges and expectations concerning global soil information. These can be subdivided in information that concerns the state of the soil resource (soil health) and the information that would allow tracking soil changes. Although there was general confidence that the former could be satisfied, there was more concern that the expectation for documenting soil change was unrealistic, at least at plot level.

There was some divergence as to the prime users of the global soil data generated. While everyone in the meeting agreed that they serve the global modelling community to make more accurate predictions on mitigating climate change and enhancing global food security, there was less agreement on the use that could be made by farmers of this information, although they would undoubtedly benefit indirectly from the information generated.

A major obstacle remains soil data access, legal provisions and exchange and sharing mechanism, protecting in the first place the data holders, may solve this problem in the long run.

8 Annexes

Workshop program

TIME	ACTIVITY	PRESENTER	CHAIR
Day 1: Tuesday 20th March	**Status and Needs of Global Soil Information (Philippines Room C277)**		
08:00 – 09:30	Registration		
09:30 – 09:40	Welcome and opening	Mr. Alexander Müller Assistant Director-General FAO Natural Resources Management and Environment Department	Chair: Ronald Vargas FAO
09:40 – 10:05	Keynote: Soil Data and Information, a key pillar of the Global Soil Partnership	Dr. Parviz Koohafkan, Director Land and Water Division, FAO	
10:05 – 10:30	Keynote: Why is soil information needed? Overview from a Donor Perspective	Dr. Christian Witt Senior Programme Officer Soil Health Bill and Melinda Gates Foundation	
10:30 – 11:00	**Coffee Break**		
11:00 – 11:25	Keynote: Soil information for policy making	Dr. Thomas Strassburger DG ENV European Commission	Chair: Vincent van Engelen ISRIC
11:25 – 11:50	Keynote: The value of global soil information to the International Plant Nutrition Institute	Dr. Terry Roberts International Plant Nutrition Institute (IPNI)	
11:50 – 12:15	Keynote: Soil information demand for crop growth simulation	Dr. Pasquale Steduto Deputy Director, Land and Water Division FAO	
12:15 – 12:40	Keynote: Soil data and information needs for Agronomists	Dr. Achim Dobermann International Rice Institute (IRRI)	
12:40 – 13:05	Keynote: Role of soil information for the implementation of the UNCCD	Dr. Victor Castillo UNCCD	
13:05 – 14:30	**Lunch Break**		
14:30 – 14:55	Keynote: Status of Global Soil Information	Dr. Neil McKenzie Chief CSIRO Land and Water	Chair: Ganlin Zhang ISSCAS
14:55 – 15:20	Keynote: Status and needs of soil information in Africa, where are we?	Dr. Martin Yemefack President Africa Soil Science Society	
15:20 – 15:45	Keynote: Soil information for forest soils and carbon monitoring	Dr. Rainer Baritz, BGR Germany	
15:45 – 16:00	**Coffee Break**		
16:00 – 16:30	GEOSS (Global Soil Data Task)	Mr. Vincent van Engelen (ISRIC)	Chair: Erika Micheli Szent Istvan University
16:30 – 16:50 **16:50 – 17:10**	Status of soil information in Asia Harmonized World Soil Database Version 1.2.	Prof. Ganlin Zhang ISSCAS, China Dr. Freddy Nachtergaele IIASA/FAO	

17:10 – 17:30	Improving fertilization practices with help of Soil geo-database in China	Prof. Wei-Li Zhang Chinese Academy of Agricultural Sciences	
17:30 – 18:30	Open plenary and recap of the day	Chair	
18:30 – 20:30	**Cocktail**		Aventino Room
Day 2: Wednesday 21st March	**Tools for Soil Mapping (polygon based) e-SOTER**		
08:30 – 08:50	e-SOTER: EU contribution to a Global Soil Observing System	Mr. Vincent van Engelen ISRIC	Chair: Prem Bindraban ISRIC
08:50 – 09:10	Development of a terrain and parent material platform at scale 1:1 million	Prof. Endre Dobos University of Miskolc	
09:10 – 09:30	Developing the soil component of e-SOTER	Prof. Erika Micheli Szent Istvan University	
09:30– 09:50	Enhancing the terrain component in the e-SOTER database	Ms. Joana Zawadzka Cranfield University	
09:50– 10:10	A new system of terrain classification	Mr. Rüdiger Köthe Scilands GmbH	
10:10– 10:30	A new classification of soil parent material	Dr. Ulrich Schuler BGR	
10:30 – 10:50	**Coffee Break**		
10:50 – 11:10	Integration of terrain, parent material and soil information in e-SOTER at scale 1:250.000	Mr. Michael Bock BGR/Scilands GmbH	Chair: Alan Lilly James Hutton Institute
11:10 – 11:30	Enhanced e-SOTER database for a study area in the UK	Ms. Joanna Zawadzka Cranfield University	
11:30 – 11:50	Application of e-SOTER approach in Morocco: opportunities and constraints	Dr. Rachid Moussadek INRA, Morocco	
11:50 – 12:10	Validation and uncertainty analysis	Dr. Gerard Heuvelink Alterra	
12:10 – 12:30	Applications of the e-SOTER database using some models to simulate soil threats	Dr. Simone Verzandvoort Alterra	
12:30 – 12:50	e-SOTER web services: status and way ahead to a Global Soil Information Service	Dr. Yusuf Yigini European Commission	
12:50 – 13:10	Standards and services for Soil and Terrain Data Exchange: SoTerML	Dr. Steve Hallett Cranfield University	

13:10 – 14:30	**Lunch**		
14:30 – 16:10	Open plenary about e-SOTER		Chair: Jon Hempel NRCS
16:10 – 16:30	**Coffee Break**		
16:30 – 16:50	Status of the Soil Atlas of Africa and Latin America.	Dr. Arwyn Jones/Prof. Ciro Gardi European Commission	Chair: Rokhaya Fall FAO Representative
16:50 – 17:10	Soil Erosion in Chile, current and future.	Dr. Eugenio Gonzalez CIREN Chile	
17:10 – 17:30	Towards the LAC Soil Information System	Dr. Aracely Castro CIAT	
17:30 – 17:50	Revising arable land evaluation with new tools.	Dr. Rokhaya Fall FAO Representative to Central African Republic	
17:50 – 18:10	The use of geological information for soil mapping.	Mr. Raimonds Kasparinskis University of Latvia	
Day 3: Thursday 22nd March	**Tools for Soil Mapping (point based and others)**		
08:30 – 08:50	Africa Soil Profiles Database	Dr. Johan Leenaars ISRIC	Chair: Jose Luis Rubio CSIC
08:50 – 09:10	Rationalization and harmonization of soil legacy information	Dr. Jacqueline Hannam Cranfield University	
09:10 – 09:30	Electronic Soil data storage: possible approaches with an emphasis on the Russian Soil Database	Dr. Pavel Krasilnikov Eurasian Centre for Food Security, Russia	
09:30– 09:50	Processing and integrating soil map information from different regions into China Geo-database at 1:50.000 scale	Prof. Wei-Li Zhang Chinese Academy of Agricultural Sciences	
09:50– 10:10	Digital soil mapping from legacy data and hyperspectral imagery in CapBon (Tunisia), first results and perspectives.	Dr. Philipe Lagacherie INRA France	
10:00 – 10:20	**Coffee Break**		
10:20 – 10:40	Overview and recent developments of SoLIM- an effort moving DSM into the digital era	Dr. A-Xing Zhu University of Wisconsin	Chair: Martin Yemefack ASS
10:40 – 11:00	From polygon-based soil unit	Dr. Eddy De-Pauw	

17:15 – 18:00	Plenary session-Recap	Chair	
Day 4: Friday 23rd March	**The way forward about global soil information (from ideas to action)**		
08:30 – 08:55	Towards targeted global and regional soil information: inputs for consideration	Dr. Luca Montanarella European Commission	Chair: Ronald Vargas FAO
08:55 – 09:20	Proposal for future soil information activities under GSP by the Globalsoilmap.net project	Dr. Neil McKenzie CSIRO	
09:20 – 10:30	Plenary discussion about needs and opportunities regarding soil information at global and regional level. GSP Pillar of action (strengthening of Soil Data and Information)	Chair and all	
10:30 – 10:50	**Coffee Break**		
10:50 – 13:00	Cont of plenary discussion.	Chair and all	
13:00 – 14:30	**Lunch**		
14:30 – 15:30	Preparation of a concerted Plan of Action for the Implementation of Pillar 4 of the GSP	Chair and all	Chair: Luca Montanarella European Commission
15:30 – 15:50	**Coffee Break**		
15:50 – 16:30	Agreement on the Way Forward	Chair and all	
16:30 – 16:40	Closure of the event	Dr. Parviz Koohafkan Director Land and Water Division, FAO	

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