ABSTRACTS

1. Expert Consultation (SPUSH) on Advances and Monitoring for Managing Salt- affected Habitats

- **Introduction to the SPUSH Network and the Expert Consultation**
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Soil salinization has been identified as a major process of land degradation. Because the cost of measurements was prohibitive, the nature of the problem is dynamic, the lack of data (and also inconsistencies between data provided by various sources) that are required to classify a soil as salt-affected, there is incomplete information on the extent, distribution and degree of salinity development for all countries affected. According to various estimates, the range of salt-affected soils differs considerably in many countries due to: the lack of systematic surveys of salt-affected soils in many countries, the area affected by salinity continuously undergoing changes due to factors such as secondary salinization/sodication associated with irrigation, impedance of drainage, deforestation, intrusion of seawater, natural causes, etc. and differences between countries in approaches, criteria, classification and diagnosis of salt-affected soils. However all agree that the problem is extensive and growing, with an approximate globally estimation of about 77 M ha of land as salt-affected by human-induced salinization. According to different estimates, the world loses about 1.6 M ha of arable land to salinization every year.

The causes and origin of salinity/sodicity development varied in different regions and countries which should be identified, monitored and assessed very carefully so that they, and not the symptoms, should be managed and controlled. Many attempts tried to map salt-affected soils, however, figures and available maps are questionable and need to be updated because: they are based on data and maps collected more than 30 years ago, the problem is a dynamic process, estimation of salt-affected soil in different countries varies considerably as mentioned, differences between countries in the diagnosis, classification and criterion they use to identify salt-affected soil and saline soils can overlapped with sodic soils and also acid sulphate soils, mangrove soils etc., which are not included in the mentioned figures and maps.

Therefore, practical methodologies for monitoring and mapping of salt-affected soils is a requisite for inventorying the extent and magnitude of salt-affected soils; for assessing the causes and sources of the problem including the effectiveness and appropriateness of irrigation and drainage practices and for the management of salt-affected soils. However, monitoring and assessing of salt-affected soils is complicated by its spatially variable and dynamic nature caused by the effects and interactions of edaphic factors, human-induced processes and climate factors. Depending on the scope, intended use and scales, the methods can be selected and data collected on an agriculture field (micro) scale or on a basin-wide, national or even regional (macro) scales. Methods may include from soil sampling and simple laboratory analyses, measurements of EC In the field, EM sensors, four electrode sensing systems to GIS, Remote sensing and Decision support systems. However, data collected should be representative including, proper site selection, representative samples or measurements and their optimum numbers and locations. Based on information and data collected from soil survey, monitoring and remote sensing, practical computer models can be developed for salinity assessment and prediction.

Because of the above and to avoid the fragmentation of technical research and development efforts in different countries and to stimulate coordination of work between different international and national organizations for salt-affected soils, a cooperative project was signed in 1994 to establish a Network on Sustainable Productive Use of Salt-affected Habitats (SPUSH). The activities in the 30 member countries included, FAO collaborative projects, national programmes, and FAO-TCP Projects in the member countries; organization of International Workshop (Network Meeting) every two years; Newsletters; Network Web Site and Publications. While the activities of the Network stopped in 2001, publications derived from its work have been under preparation including a series of cases studies from member countries which have been documented. Based on the evaluation carried out by FAO on the SPUSH Network, and responding to requests by various network members, FAO has recognised the need to reactivate and expand the Network in cooperation with the International Center for Biosaline Agriculture (ICBA)

This paper is an attempt to provide brief, updated information on the magnitude and the causes of salinity problems and mapping attempts of salt-affected soils. Also to discuss the SPUSH Network, establishment, activities, case studies, reactivation and its expansion and introduction to the available technologies to monitor and assessment of salinity development for management of salt-affected soils in a sustainable manner.

Session 1: Assessment and monitoring of salt-affected soils (At field, landscape and irrigation district levels)

- Assessing and Monitoring the Risk of Salinization in a Sicilian vinyard by the Geonics EM-38

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In many arid and semi-arid countries, as well as in Sicily, the increasing scarcity of good quality waters coupled with intensive use of soil under semi-arid to arid climatic conditions, results in irrigation with saline waters, leading to secondary salinization.

Salinization is closely associated with the process of desertification, defined as "land degradation in arid, semi-arid and dry sub-humid areas resulting from climatic variations and human activities", with the term "land" including soil, water resources, crops and natural vegetation (UNEP, 1991). Salinity may have negative direct effects on crop-yield by reducing the ability of plant roots to adsorb water; the reduced availability of water to the plant is due to soluble ions and molecules causing an osmotic pressure effect. Threshold relationships between the soil electrical conductivity (EC) and crop yield have been empirically determined for several crops and can be used to evaluate the influence of saline irrigation water on agricultural production.

Salinity of an irrigation water is defined as the total sum of dissolved inorganic ions and molecules. Soil salinity can be measured in the soil by determining the electrical conductivity (EC) of the soil solution. The EC measured in the saturated extract (ECe) is used as an expression of salinity. The USSL (1954) developed the saturation extract technique, a way to estimate soil salinity that uses a reference water content. However, methods suitable for a rapid assessment of soil salinity are necessary for survey of large areas susceptible to degradation and for prevention of desertification.

Application of an electromagnetic induction sensor (EM-38) makes possible, after calibration, rapid surveys of large areas for selection of the places with the greatest hazard of salinization, places where detailed investigation is necessary to develop countermeasures and strategies suitable to control desertification. Application of this technique provides a measurement of the EC of the “bulk soil”, ECa. Since ECa is influenced not only by the chemical and physical properties of the soil solution, but also by those of the solid phase (soil texture, mineralogical composition of the soil), a preliminary calibration is necessary in order to convert the field measured ECa into the saturated electrical conductivity, ECe.

The objective of this paper was to show results of using the Geonics EM-38 probe (Geonics Limited, Mississauga, Ontario, Can.) for monitoring salinization in Sicilian areas where irrigation with saline water is increasingly practised, and a risk of salinization and desertification is envisaged. Maps showing the spatial and temporal variability of salinity determined by two different irrigation treatments were analysed, and the effect of using two irrigation waters of different salinity were discussed.

A number of international and national projects have been developed since 1998 in Sicily with the objective of developing integrated approaches for sustainable management of irrigation. This investigation is part of the “Evolution of cropping systems as affected by climate change” (CLIMESCO) project (2007-2009), and was carried out in the frame of a bilateral agreement for scientific cooperation between University of Palermo and Arizona State University.

- Use of Aboveground Electromagnetic Induction Meter for Assessing Salinity Changes in Natural Landscapes and Agricultural Fields.

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Keywords: *electromagnetic induction, soil salinity, salts zonation*

Salinity can be considered as a quick-changing-in-time soil property, influenced by lateral water movement through landscape and vertical water fluxes in soils, due to infiltration and evapotranspiration. An irrigation event or the rainfall associated to an intense storm can change the amount and distribution of salts in a soil profile. For large areas, soil conditions can differ from one site to another, imposing local differences in the management practices.

The nature of soil salinity/alkalinity is best studied through soil sampling and analysis of the saturated paste extracts and other soil properties. Within a framework of modern land management, some decisions are more rationally based if some soil geostatistical information is available. Anyway, the collection of numerous field samples and subsequent analysis in the laboratory is a costly activity for assessing/monitoring soil salinity. On the other hand, the decision about the necessary number of samples for giving a uniform area coverture, providing statistical information, as well as the decision about the samples localisation, poses a difficult question that should be answered after a previous salinity screening of the field. The ratio of desired number of samples to associated cost of sampling can be optimised though an adequate sampling design.

Electromagnetic induction (EM) is a useful technique for quick measurement being non-invasive, non-disturbing and can provide raw information about soil components (salts concentration, soil moisture and texture). The EM signal response can be related to apparent soil electrical conductivity (ECa) at particular depths, through statistical calibration. In a conceptual model, the EM signal response can be described as a complex function of soil solution conductivity, soil moisture, temperature and amount and type of clay, among other factors, each soil depth contributing unevenly to total signal response.

Two examples presented show the way of deriving soil salinity information from aboveground electromagnetic induction measurements. First example is a multitemporal monitoring of salinity in a small agricultural field with uniform texture and topography, with sodium chloride-type salinity, using a regular-grid surveying scheme. Two sensor geometries are used and based on the signal treatment, quasi three-dimensional multitemporal maps of bulk soil salinity can be drawn and trends of soil salinity recognised.

The second example is an automated longitudinal survey along a landscape, designed for discovering differences in salinity type, soil texture and total moisture content. Soil sampling sites are selected from the profiling and statistical treatment of response signal.

- Primary Soil Salinity, Sodicity and Alkalinity Status of Different Water Management Areas in South Africa

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INTRODUCTION: The objective is to describe and quantify the primary salinity, sodicity and alkalinity status of soils in terms of the 19 water management areas of South African by using data from more than 26 520 soil samples. South Africa's salt-affected soils, derived from complex geological formations and soil forming processes, comprise almost 32% of the country's surface area.

METHODOLOGY: The data were derived from soil survey reports for irrigation and environmental planning and the South African Land Type Survey of the ARC-Institute for Soil

Climate and Water. The minimum requirements for inclusion in the data set were: (a) the profiles should have comprehensive chemical and physical analyses, and the preference was given to data sets where soil analyses followed the methods of the Non-Affiliated Soil Analyses Working Group (1990) and where the analyses were done in the ARC-ISCW laboratory; (b) accurate profile location information should be available; (c) only primarily data could be used – no human-induced salinization or sodification (d) soil profile description should have been done according to Soil Classification: A Binomial System for South Africa (1977) or Soil Classification: a Taxonomic System for S.A.(1991). Although data verification was done on most samples previously, much effort was devoted to data cleaning. From the original in excess of 40 000 data points, only 26 520 data points were used due to the stringent cleaning protocol.

After a countrywide process of public consultation, 19 water management areas covering the entire country were established. The boundaries of the water management areas lie mostly along the divides between surface water catchments and do not coincide with the administrative boundaries that define the areas of jurisdiction of provincial and local government authorities. The water quality data that were used in the assessment of fitness for use of South Africa's surface water resources for domestic and irrigated agricultural use were collected as part of the National Chemical Monitoring Programme. This programme has been in operation since the early 1970's and samples are regularly collected at approximately 1 600 monitoring stations at a frequency that varies from weekly to monthly sampling. The data collected is stored on the Department of Water Affairs and Forestry's database and information management system, namely the Water Management System. For this study a suitable water quality sample site was considered to be one with an adequate level of sampling (not too infrequent or sparse) over the study period.

RESULTS: The problems of primary soil salinity, soil sodicity and soil alkalinity are most widespread in the arid and semi-arid water management areas of South Africa, but salt-affected soils also occur extensively in sub-humid and humid water management areas, particularly in the coastal areas where the ingress of sea water through estuaries and rivers and through groundwater causes problems. In South Africa, where the rainfall is approximately five to ten times less than the potential evaporation, salts derived from rock weathering, bio-cycling, and atmospheric deposition may accumulate to relatively high levels in the soil.

Currently the secondary salinity and sodicity of South African waters and soils are on the increase due to mining, urban, industrial and agricultural developments and the re-use of water resources. Irrigated agriculture is not only at the receiving end of water quality deterioration, it is itself a major contributor to the observed water quality deterioration in many rivers. The use of such water poses a future threat for soils in areas of South Africa where leaching is limited.

CONCLUSION: In South Africa, many water bodies are naturally high in dissolved salts, especially where rivers flow over marine sediments. Irrigation farmers are often accused of causing much of the salinization, sodification and alkalization of water in South Africa, because they are the biggest users of water, while leaching of primarily mineral salt from the surrounding geology after rainfall and pollution from industrial and mining activities are incorrectly not considered as also being important. Soil salinity seems to be largely under control in South Africa at present, but this situation can change dramatically as a result of industrial, municipal and mining effluents used on agricultural land. Primary soil sodicity and alkalinity are a bigger problem than primary salinity in South Africa.

Session 2 : Assessment and monitoring of salt-affected soils at national and regional levels.

- Advances in Assessment of Salt Affected Soils for Mapping and Monitoring in India and Management Strategies

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The Salt Affected Soils (SAS) in India with variable distribution patterns occur mostly in belts or patches that makes them difficult to map and monitor. First mapping of SAS in India began in 1902 when Leather delineated several *Usar* (alkali) patches enriched with sodium carbonates in the fields of Etah district in Uttar Pradesh. After independence in 1947 several workers across the country conducted traditional soil surveys including field traversing, profile studies, analysis of soils and water samples to produce reports and maps on SAS falling under various projects and irrigation schemes. Such surveys produced fragmented and localized statistics. They differed in methodology and criterion; hence the information produced could not be extrapolated to other areas. Based upon standard surveys using aerial photo interpretation the Committee on Natural Resources of Planning Commission in 1966 estimated 6 million ha SAS and depicted its distribution in a map. The map showed occurrence of SAS in compact areas of the Indo-Gangetic Plain and in scattered blocks in other parts. The Central Soil Salinity Research Institute (CSSRI) after its establishment in 1969 at Karnal made countrywide assessment of the problem and made first estimation about the nature and extent of SAS. By focusing on soil characteristics and reclaimability two main classes of SAS namely alkali and saline were recognized. Abrol and Bhumbla upgraded the estimate to 7 million hectares in 1971 and Bhumbla in 1975 depicted on map six categories of SAS viz; alkali soils, saline soils, potentially saline soils, coastal saline soils, deltaic saline soils and acid sulphate soils. In 1980 Murthy compiled and synthesized benchmark profiles of SAS from all over India and classified them into associations of great group. The mapping legend consisted of 12 associations. Absence of systematic surveys and a reconnaissance map showing the distribution and extent of SAS, prompted the individuals to report on their extent. The computed figures expectedly ranged from 3.3 to 26.1 million hectares. The wide variations in the statistics reflect upon the degree of concern and perception authors had for the problem.

The recent mapping methodology includes visual (manual) and digital (computer) interpretation of satellite data supported by field and laboratory investigations. The first systematic mapping of salt affected soils of the entire country was made in 1996 by the National Remote Sensing Agency (NRSA) Hyderabad in association with other National and State level organizations including the CSSRI and National Bureau of Soil Survey and Land Use Planning (NBSS&LUP of ICAR). A total of 125 false colour composite prints of the LANDSAT TM satellite images were used in mapping salt affected soils at 1:250,000 scale.

The methodology consisted of, development of nation-wide mapping legend, interpretation of satellite data, ground truth collection, analysis of soil samples, post field interpretation and reconciliation and area estimation. In order to accommodate salt affected soils occurring in different parts of the country, a common legend was evolved after extensive discussions with the collaborating partners engaged in either conventional soil survey and or those working with remote sensing techniques. 125 map sheets showed 6.73 m ha salt affected area in the country. However, it did not differentiate between saline and sodic soils, the two major classes for which distinct sets of reclamation techniques are evolved under Indian conditions. An exercise by abstracting information from the mapping legend, kind of soils, clay minerals, climatic conditions and physiographic setting of various regions was made at CSSRI, Karnal to reckon the figure of 6.73 m ha salt affected area under two major classes viz; Saline and Sodic. Moderate and highly saline soils were easily identified due to the presence of white salts on the surface. Combination of red and infra red bands helped in separating saline and sodic soils. Integration of thermal band interpretation with false colour composite helped in resolving the problem of spectral similarity between saline soils and sand dunes. The mapping legend prefixed with letter F represents medium and deep black soils, the letters s, n and sn denote saline, sodic and saline-sodic respectively. As per discussion on the threshold value of Exchangeable Sodium Percent (ESP) for sodic soils in black soils region the entire mapping units prefixed with letter F (black soils) were classified as sodic. Thus most of the salt affected soils occurring in Penninsula India were sodic in nature. Further, all the mapping units denoting saline-sodic conditions in physiographic regions A, B, E and H were classed under sodic. The mapping units of salt affected soils falling in physiographic regions C, D and G were classed under saline. In Uttar Pradesh, salt affected soils occurring in Agra and Mathura districts were classed as saline while the others under sodic. The CSSRI in the recent past has prepared digital maps depicting salt affected areas in 15 states of the country. The statewise distribution and extent of saline and sodic soils as reconciled with other national agencies is given in Table 1. Use of GPS in surveys of SAS had improved the quality of comparable studies like improvement in soil properties in the post reclamation phase, precise detection of hot spots of salinity emergence, expansion, identification and establishment of benchmark sites of SAS. Further, the CSSRI has developed sustainable and cost effective technologies for the reclamation and management of salt affected soils. A brief account of these technologies and their impact in terms of productivity gains, socio-economic dimensions and environment is also discussed in this paper.

Table 1. Extent and distribution of salt-affected soils in India

States	**Saline**	**Sodic**	**Total**
Andhra Pradesh	77598	196609	274207
Andaman & Nicobar Islands	77000	0	77000
Bihar	47301	105852	153153
Gujarat	1680570	541430	2222000
Haryana	49157	183399	232556
Karnataka	1893	148136	150029
Kerala	20000	0	20000
Madhya Pradesh	0	139720	139720

Maharashtra	184089	422670	606759
Orissa	147138	0	147138
Punjab	0	151717	151717
Rajasthan	195571	179371	374942
Tamil Nadu	13231	354784	368015
Uttar Pradesh	21989	1346971	1368960
West Bengal	441272	0	441272
Total	2956809	3770659	6727468

Say 6.73 mha

- Salt-affected Soils in Thailand: Assessment and Monitoring of Salinization

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Thailand is a country where agriculture has long been important for its socio-economic growth since 1238. About 21 million hectares. land area is currently under crop, 13 million ha. Are forests and the remaining areas 17 million ha compose of urban area, public area, sanitation, swamp land, railroads, highways, real estate and others. In terms of agricultural production, land has been used to cope with the rapidly increasing food demand, which increased along with the population growth. This led to diverse use of the land for many purposes, eventually resulting in degradation of land, particularly anthropogenic soil salinisation of arable land.

Salinity is the oldest and one of the most important environmental problems of mankind. It is a form of degraded land that has become a major causative factor for low agricultural productivity in the Northeastern region, the Central Plain and along the coastal belt of the country.

Salt-affected soils cover approximately 3.5 million hectares. These soils are classified broadly into two groups, i.e., 1) inland saline soils, and 2) coastal saline soils. These two broad categories of saline soils cover approximately 3.0 and 0.58 million hectares, respectively. These naturally occurring saline soils normally expand to cover wider areas with time. Aside from that, the anthropogenic soil salinisation also became an important part of the rapid increase in soil salinisation. The problem of salinisation is the presence of excessive salts on the top layer of the soil, resulting deterioration of its chemical and physical properties.

The assessment and monitoring of salinisation for managing salt-affected land in Thailand has been greatly facilitated with various methods. The goal of its process is to assess the influence of salinity, preventing distribution of salinity on arable land and to manage the improvement and sustainable utilization of land resources. The criteria in defining salt-affected areas are based on electrical conductivity (EC) value of 2 dS/m while water has an EC value of 0.75 dS/m. The methods were developed to complement the soil salinity classification system, to evaluate and predict the existing salt-affected areas and develop appropriate soil management guidelines. The conventional methods was used and conducted in 1963 to assess and monitor soil salinity, this methods is applied with integrated technologies have been assessed in terms of measurement of Electrical

Conductivity and laboratory analysis of soil and water samples including determination of vegetation and plant growth.

Since 1989 the advanced technologies for assessment and monitoring of soil salinity has been used to provide spatial coverage and faster than conventional methods. Image analysis of remote sensing data (Landsat) using visual and digital method is carried out and verify by ground truth data and laboratory investigations. False color composite bands 5, 3, 1 (blue, green and red) image showed promising data for visual interpretation. Ground based surveys, uses electromagnetic induction (EM 34 and 38) surveys were conducted to measure bulk soil conductivity to a depth of approximately 7, 15 and 30 meters, while EM 38 measures conductivity over a depth of approximately 1.5 meters. And peizometer installation on the salt-affected area was also used to observe and monitor water quality, depth of water table and flow.

The Land Development Department has been implementing the assessment and monitoring of salinisation in the above-mentioned methods in different areas for several decades. The prototype of soil survey and monitoring, remote sensing and some computer model was applied to generate maps of salt-affected areas to obtain manuals and reports on appropriate prevention of soil salinisation and improvement of technologies and approaches, database of soil resources and salinity management guidelines, including assessment and prediction of soil salinisation and distribution. The highlight outputs of its product has been used to conduct and disseminate to the stakeholders in the salt-affected areas, e.g. maps of salt-affected areas in the Northeastern region and the Central Plain provinces, map of reforestation areas for soil salinity control, report on the impact of tsunami in the West Coast areas, impact of shrimp farming on arable land and monitoring on reforestation to prevent soil salinisation, etc.

- An Overview of Salinity Problem in Iran: Assessment and Monitoring Technology

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Agriculture plays a vital role in the national economy of Iran. It accounts for twenty seven percent of GNP and twenty three percent of labour force of the country. Scarcity of water is the major constraint for agricultural development in the country and based on projection for 2025, Iran will be in a physical water scarcity situation. Considering the growing demand for water from other sectors and the fact that 93 percent of renewable water resources is already allocated to agricultural sector, allocation of more water to the sector is not foreseeable in the future. Under these circumstances, increasing water productivity in agriculture holds the greatest potential for improving food security and preventing environmental degradation.

The exact extent of salt-affected soils of Iran is not known. Based on a recent estimate 34 Mha or nearly 20 percent of the surface area of the country is salt-affected. This includes 25.5 Mha of slightly to moderately and 8.5 Mha of severely salt-affected soils. Salt-affected soils are mainly distributed in the central plateau, southern coastal plain, Khuzestan plain and intermountain valleys. The salinization of land and water resources has been the consequence of both naturally occurring phenomena and anthropogenic activities.

Secondary salinization has been the main cause for spread of salinity and as a result waterlogged area has increased from 160000 ha in 1977 to 0.7 Mha today only in areas under the command of new dams.

In spite of the extent of soil salinity in the country, there are few studies which have been carried out to assess and monitor soil salinity. A number of these studies have been concerned with evaluation of soil salinity in irrigated fields as a means of evaluating the appropriateness of on-going management practices. In these studies soil salinity has been assessed in terms of laboratory measurement of electrical conductivity. The results from one such study in the south-west of the country shows that wheat fields irrigated with saline water of electrical conductivity ranging from 8-12 dS m^{-1} produced a relatively good yield of 4-6.5 ton ha^{-1}. Monitoring of root zone salinity throughout the growing season for three years showed that mean root salinity in almost all the fields were nearly equal to the electrical conductivity of irrigation water, suggesting a high leaching fraction as a result of poor on-farm water management.

The use of advanced technology for assessment and monitoring of soil salinity based on bulk soil electrical conductivity is still at its early stages. Although the instrumentations such as EM38, four electrode probe and time-domain-reflectometry (TDR) are now available, but their actual field use have been very limited. On the other hand, remotely sensed data, especially satellite images, have been used for monitoring soil salinity in different parts of the country. In this case, some ordinary techniques such as visual interpretation and classification (both supervised and unsupervised) have been used to generate auxiliary data for field observations for mapping salinity and other soil and ground surface properties. For example, an attempt was made in Qahavand plain in Hamedan province. In this study, Landsat images of 1989 and 2000 (TM and ETM) were acquired and classified using unsupervised and supervised classification techniques, respectively. Based on this, temporal changes in soil salinity were monitored in the 11 years period. Accordingly, the results showed that aerial extent of slight and moderately to severely salt-affected soils increased by 41.0 and 48.0 percent, respectively.

- Advances in Assessment and Monotoring of Soil Salanization for Management of Salt-affected Habitats in Egypt

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The agricultural development in Egypt is facing human induced degradation mainly due to salinity and waterlogging. These are including seepage from irrigation canals , inadequate drainage system , poor irrigation practices, using slightly saline (drainage or mixed water) for irrigation without proper management and agronomic practices. The presence of excess salts in the soil therefore, affects directly or indirectly the plant growth. This effect could be extreme that even survival of normal field crops become impossible and we are confronted with completely barren soils which need not only to be reclaimed but also secured against new salt invasion from below or above. As a result, assessing soil salinity has become one of the most frequently used measurements to characterize field variability for application to sustainable agriculture.

The value of spatial measurements of soil EC to sustainable agriculture is widely acknowledged, but soil EC is still often misunderstood and misinterpreted. The following areas are discussed with particular emphasis on spatial EC measurements: a brief on soil degradation, soil salinity (worldwide) , and extent and causes of salt affected soils in Egypt. The paper, also, present an overview of most advances technology used for assessing and monitoring of soil salinity such as remote sensing (RS), geographic information system (GIS), mobile instrumental systems, and computer assisted expert systems. These advances technology can contribute to the planning and implementation of actual measures to compact salinization. Selecting the method of detection depending upon several factors such as the scale accuracy required, cost of project and available funds and area to be surveyed. The future of sustainable agriculture rests on the reliability, reproducibility, and understanding of these technologies.

Monitoring, predicting and quantifying soil salinity, sodicity and alkalinity in Hungary at different scales. Past experiences, current achievements and an outlook with special regard to European Union initiatives

- Recent Evolution of Soil Salinization in China and its Driving Processes

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Salt affected soils spread extensively in China, covering wide area from tropical to temperate zones, from the coast to the inland and from the semi-arid to desert regions. Currently the total area of salt affected soil is about 36 million hectares, which occupies 4.88 % of usable land in whole country. About nine million hectares of arable land is salt affected, accounting for 6.62 % of total land in the country.

The salt affected soils mainly distribute in the Northwest China, the North China, the Northeast China and coastal regions. Area of the soil in six provinces of western part of China accounts for 69 % of whole country. Current hot spots of soil salinization evolution almost involve all distribution areas of the salt affected soils, including Northeast China, Northwest China, the Inner Mongolia and the coastal region. In the Songnen Plain and the Great Band region of the Yellow River, salinization trend towards more severe at two aspects: expansion in area and enhancement in extent. Area of salt affected soils reaches 3.5 million hectares currently in the Songnen plain. Annual rising rate of salinization is as high as 1~1.4 % and about 45 % of salt affected land in the area has been degraded into abandoned severe saline land. Due to irrigation maladjustment, area of salinization increased 1%~3% annually in last three decades in the Great Band region of the Inner Mongolia. Secondary salinization also occurred in the West Corridor of Gansu Province by similar reason. Irrigation with brackish water has been an important cause of salinization evolution in north part of China. According to a monitoring data from Guyuan region of Ninxia Province, soil salt content increased to 2.3 $g.kg^{-1}$ after 5 years of brackish water irrigation and up to 8.3 $g.kg^{-1}$ after 14 years. Shallow ground in most River irrigation districts of Ninxia, Inner Mongolia and Xinjiang Provinces has been observed and salinization occurred as the result. Salt-water regime is changed under drip irrigation practices in some region of Xinjiang, which causes sat accumulation consequently. Generally, 35 % of irrigation land in Gansu, Xinjiang and Ninxia, and 50 % irrigation land in inner Mongolia is current facing the hazard and threat of salinization. As another hot spot, salt-water movement is unbalance in coastal regions such as the Yellow River delta, and salinization is also developing in such area.

Driving factors of evolution of salinization in China mainly consist of irrationalities in water resource management and land management, and of climate change. Irrational water use is the dominant cause of soil salinization evolution in irrigation districts, which are mainly represented as great seepage of irrigation canal and low efficiency of the irrigation water, as unnecessary high irrigate norm, poor drainage system and blockage of drainage ditches, and as raise of ground water table by construction of plain reservoir. Micro irrigation practice such as drip irrigation in arid region has potential dangers on change of salt-water regime and therefore may cause salt accumulation. Local salinization has already been found in some areas with such irrigation practice and such phenomena trend to an expansion.

Irrational land management in semi-arid and arid regions is also a driving factor in salinization accelerating, including cutting down the area for salt disposal basin by overexploitation of waste land in irrigation districts, worsening of soil physical and chemical properties owing to poor fertility management, and increasing of surface evaporation and weakening of drainage due to destroy of plantation by over-grazing, deforestation and irrational land exploitation. Salt affected area is generally located in the region influenced by climate change in China.

Climate change is considered as another significant driving factor on salinization evolution. Currently climate in North China and Northeast China has been turning to a trend of warm-and-dry process. Such climatic change has promoted the evolution of modern salinization process in the region. Climate change can also cause the sea level raise. Salt leaching of soil in coastal region including the Yellow River and Changjiang River deltas is therefore subject to a disadvantage owing to blockage of salt outflow and seawater intrusion. Consequently, Desalinization in the region is staved and even local salinization expansion is observed.

- Assessment and Management of Salt-affected Soils of Sudan

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Sudan, the largest country in Africa, it has an area of approximately 2.5 million square kilometers. Its climate is diverse ranging from the tropical humid in the south to the desert in the north. This paper highlights the changes in climatic conditions, the properties of salt-affected soils in relation to salinity and sodicity. The distribution and area covered in every region is shown. The system adopted in Sudan for the assessment of a soil as being salt-affected is derived from the USDA system with amendments to fit the Sudan conditions based primarily on the results of research trials. The research activity in reclamation of salt-affected soils is also covered and some of the results of the trials were shown.

The studies on climatic changes showed that there is a considerable decrease in the annual rainfall, it reaches 19% in the arid climatic zone and 1% in the semi-arid climatic zone comparing the meteorological normals of 1941-1970 and 1971-1999(Adam, 2002). This, combined with human misuse of natural resources, water scarcity and removal of vegetation cover, necessarily implies a deterioration in the soil properties.

The increase in population and the limited extent of good agricultural lands in Khartoum area and along the river banks in the northern regions, lead to expansion into the marginal lands of the higher terraces of the Nile where soils are affected by varying degrees of salinity and /or sodicity.

In many areas of the world, presence of salts including sodium, in the arid and semi-arid zones, is a widespread phenomenon and Sudan is no exception. The salinity or sodicity may result as a consequence of physical weathering, under low rainfall conditions coupled with low humidity and high temperatures by evaporation or by capillarity. All these conditions exist or have existed in Sudan.

Reclamation of salt-affected soils has been very limited till the 70s of the last century, and is only confined to some experiments in the Gezira, Soba and Hudeiba research stations. In the 1970s Sudan witnessed some environmental, political, scientific and demographic changes that accelerated the need for reclamation of salt-affected soils due to:

- The decrease in good agricultural lands due to desertification, sand encroachment and river bank erosion that lead to the thinking for expansion in new lands to cover food gap and support the export.
- The adoption of local governments system, and so the different states look for developing and exploiting their resources and hence the northern states as wheat producing areas expanded their areas into the high terrace salt-affected soils.
- The foundation of Land and Water Research Centre, with its main duties being to classify, evaluate and reclaim the salt-affected soils.

The salt-affected soils in Sudan fall under three soils orders, Verticals, Aridisols and Entisols (USDA, 1999). They extend along vast areas from latitude 14^{o} N to latitude 22^{o}N including White Nile, North Gezira, Khartoum state along the river Nile crossing River Nile and Northern states.

The land suitability classification system adopted in Sudan by Land and Water Research Centre (Kevie and Eltom, 2004) is derived from FAO system but some amendments were made to fit the Sudan conditions and hence ESP values of up to 35 in the topsoil and 50 in the subsoil were incorporated as acceptable limits for the potential rating of the soil as marginally suitable land in Gezira soil and these values were generalized over other soils in Sudan

Very good efforts in the reclamation sector were carried by researchers from Agricultural Research stations in Gezira, Hudeiba and Soba and the farm of University of Khartoum. Land and Water Research Centre and other consultants on mapping of soils reported that about 268,636 ha were found to be affected by salinity and /or sodicity.

From research results on reclamation of salt-affected soils in Sudan it was concluded that gypsum is a good amendment for leaching soils from the topsoil, while organic amendments like farm yard manure, chicken manure, dry sewage increased crops yield. The strategy for research should focus on a well defined soil series, for easiness of transferring that technology to other similar soils. Encouraging breeding programs for salt and heat tolerance is of paramount importance. Promotion of extension programs to transfer the technological packages to the farmers. Finally, the Land and Water Research Centre, of the Agricultural Research Corporation, is a carrying a very important program to have soil database of all soils in Sudan with special reference to salt-affected soils and now we have an up-to-date geo-referenced soil information database with digital maps.

Session 3: Modelling for Salinity/Sodicity Development

- Overview on Salinity Modelling Approaches at Different Spatial-temporal Scales.

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Keywords: Soil salinity, salinity modelling

Salinity is a natural property of many natural environments, arising from the geomorphic and geochemical processes creating landforms and coastal areas. During the recent decades, the environmental role of natural salt-affected ecosystems has been recognised and conservation and restoration of such habitats has become a priority policy worldwide. On the contrary salinisation is a progressive soil and water degradation process human-droved, and an increasing environmental concern that affects the most productive agro-ecosystems under irrigated agriculture in arid and semiarid regions.

Modelling is a valuable mathematical tool for study, dealing with simplified representations of the reality, revealing complex interrelations of properties of the system under study, and capable of building-up scenarios for investigating what-if questions. Modellisation of the functioning of natural saline environments, as well as of agricultural environments subject to salinisation, has been addressed in several manners, from deterministic soil-plant-water-atmosphere approaches to Systems Dynamics development including social, economical, or cultural factors, among others.

Each modelling effort try to give answer to a particular question formulated, hence the input information required for running the models ranges in complexity as does the data acquisition efforts. Some models are used quite only by researchers whereas others are affordable by farmers. Many models are dynamic in conception while others reflect a steady-state condition. The scale of application, geometry of the system, biological, chemical and physical processes represented, as well as the capability of representing an evolving system, make the main differences among models.

Some aspects important under normal agricultural practices are not well reproduced by some codes nowadays. Management practices, geometry of irrigation and evaporation, sinks of solutes (plant uptake) and interaction of fertilizers with soil components are incorporated in an uneven way in the available codes, and should be further developed.

Although is a desideratum that the models become more and more deterministic and mechanistic, this require a very intensive effort in research and computing. There are uncertainties associated to the values of the input parameters, to the computation procedure or to the inaccurate description of the system. The parameters estimation, analysis of sensitivity and validation procedures are refinements applicable to most models.

This paper gives an overview of different modelling approaches, compares the most used models based on their implementation, advantages and limitations, and discuss the possibilities of nested approaches and the advantage of clearly establishing an exit strategy into the management plans.

- SMSS: a Soil-Plant Model Describing the Impact of Irrigation on Salinity of Soil and Runoff Water

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In arid and semi-arid regions, water is the main limiting factor of the agricultural production. In fact, both the quantity and the quality of irrigation water affect fundamentally the soil quality and crop production.

The presence of salts in irrigating water and the evaporation potential in the irrigated areas lead usually to the salinity and alkalinity of soils and particularly in arid and semi-arid zones. The monitoring of both soil and water qualities in irrigated areas is necessary to measure the sustainability of the production system. Thus, modeling movements of salts in irrigated soils is a mean to predict their evolution.

For this purpose two models (**SMSS2** and **SMSS3**) were developed in order to predict the impact of irrigation on soil and water qualities. The first model (SMSS2), based on that of Laudelout model (1994), is used to analyze the movements of salts in saturated conditions with perfect drainage. It's a simple model allowing essentially the prediction of salinity / sodicity of soil after a long period of irrigation. It's controlled by two types of parameters: the exchange selectivity coefficients and the volume and quality of irrigation water.

The second model (SMSS3), developed is improved from LEACHM (Hutson et al., 1992) and UNSATCHEM (.Šimůnek et al., 1993c) models, is used to simulate water and solutes transport in partially saturated in soil profiles. It allows the follow-up during a short period of time of the soil salinity and sodicity which are controlled by different parameters such as: (i) simulation period, (ii) the conditions at the boundaries, (iii) the physicals characteristics of soil, (iv) the chemicals characteristics of soil (exchange selectivity and ionic activities products), (v) the crop, (vi) the temporal distribution of applied chemicals, tillage, rain and irrigation water and (vii) weekly distribution of the cultural coefficients and the potential evapotranspiration.

The validation of the **SMSS2** model on the data of the low valley of the Euphrates in Syria showed that the simulated data agreed with those measured in the field. The mean differences
found between the simulated and the measured data in the field vary between 0.5 and 1 dS/m.

The validity of **SMSS3** model, applied to Doukkala region in Morocco, allowed to predict with acceptable precision the evolution of soil salinity and the sodicity in the studied area. The obtained mean differences between the measured data in the field and those simulated vary between –0.25 and 0.13 dS/m. A sensitivity study of this model allowed to show that the use of Ionic Activity Products (IAP) of soluble minerals is preferable to theirs solubility products. For example, the use of IAP of calcite permitted to gain in precision, of the electrical conductivity, which is estimated to 18% in comparison with the obtained result using it's solubility product.

Key words : salinity, alkalinity, irrigation, modeling, Euphrate, Syria, Doukkala, Morocco.

Session 3 : Mapping and Interpretation of Spatial Data

- Emerging Challenges addressing the Characterization Mapping of Salt-induced Land Degradation

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Salt-induced soil degradation is an inherent and natural feature of the arid and semi-arid regions. Over the last few decades, it has increased steadily in several major irrigation schemes throughout the world. This has triggered imbalances between the goods and services supplied by the natural resources (land and water) and the demands of societies. Since soil degradation occurs both 'on-site' and 'off-site', it affects the livelihoods within and outside the farming communities. Therefore, salt-affected soils are usually considered as a major environmental and agricultural productivity constraint. However, these soils are a valuable resource that cannot be neglected, especially in areas where significant investments have already been made in irrigation infrastructure. From the perspective of managing salt-affected soils for economically feasible productivity enhancement, it is imperative to characterize different types of salt-affected soils for suitable technical interventions. Several efforts have already been done in the past to characterize salt-affected soils through different approaches. Owing to the complexity of different processes leading to the development of salt-affected soils and the use of a variety of assessment criteria, there is no single system that fits well with the characterization and classification of these soils.

Understanding the processes that lead to natural (primary) or anthropogenic (secondary) soil salinization is an important step towards the characterization of salt-affected soils. From an agroecological perspective a distinction needs to be made between primary and secondary salinization. Primary salinization refers to the build-up of salts as a result of lithological inheritance or topographical position, and is a natural process within arid zones. Secondary salinization is not linked to natural factors, but involves anthropogenic activities related to the use of both freshwater and saline water for irrigation without the provision of an artificial drainage system or the presence of a natural drainage outlet; groundwater depletion, which may lead to tapping saline groundwater; and/or seawater intrusion.

The current status of salinity assessment in the dry areas is not satisfactory. There is a lack of good information on the actual location, extent and severity of the salinity problems in most countries. This has severe implications on the ability of the respective governments to formulate appropriate policies and target investment towards salinity control or reclamation projects. Although soil salinity is easy to detect, most soil maps, particularly at small scales, show primary salinity because of its association with geological or geomorphological features, which are easy to map at these scales. The mapping of secondary salinization is more complicated because of high spatial and temporal variability. Therefore, reliable figures are however hard to obtain. Secondary salinity is spotty both in horizontal and vertical distribution and can affect any soil type, which makes it difficult to obtain representative sampling points from which to extrapolate its true extent. Secondary salinity responds more rapidly to management practices than primary salinity, and is therefore more difficult to capture in classical soil surveys, which provide one-time shots of a highly dynamic picture.

Mapping salinity is expensive and in order to achieve a rapid and effective assessment of its extent and severity, a multi-scale strategy is essential. The key principle is to build up an understanding of the spatial variability at different scales using indicators appropriate for each scale. These indicators can include spectral signatures from different remote sensing platforms, secondary data such as existing thematic maps, direct field measurements using appropriate sampling schemes and interpolation methods, and participatory assessments with farmers along transects. Used in a practical and complementary manner, these approaches will help to zoom rapidly into the salinity hotspots at different resolutions and be far less costly than the classical field surveys, even where assisted by geostatistical tools.

Given the highly dynamic nature of salinity, assessments of extent and intensity need to be undertaken at regular intervals for trend monitoring, and require an institutional setting to be effective. The most effective way might be by adapting the mission and mandates of the national institutions with the capacity of undertaking soil surveys and land resource studies to the new information requirements of development projects and environmental monitoring agencies. The United Nations Convention to Combat Desertification (UNCCD) could be a useful framework for capacity building in long-term salinity monitoring.

- Monitoring, Predicting and Quantifying, Soil Salinity, Sodicity and Alkalinity in Hungary at Different Scales. Past Experience, Current Achievements and Outlook with Special Regard to European Union initiatives.

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Approximately 13 percent of Hungary is considered to be salt-affected and with this large extent it is unique in Europe. There are large areas of naturally saline and sodic soils, but also secondary salinization is known to occur.

Due to the geological and hydrological conditions, the country demonstrates the most characteristic features of natural continental (not marine) salinization, sodication and alkalinization. Since the most important direct source of soil salinization is the shallow groundwater level below the lowland surface, there is a chance of irrigation-related salinization in two dominant situations: when the abundant use of river waters causes waterlogging and rise of saline groundwater (salinization from below); and when typically saline tubewell-waters are used for irrigation (salinization from above).

The spatial assessment of salt-affected areas began with the systematic mapping of salt-affected areas. There is a series of ten maps describing different aspects (salt-affected soil types, vegetation types, salt-efflorescences) of the salinity-status nation-wide from 1897 onward, with the latest survey finished last year.

Besides the national scale of 1:500 000, soil salinity is also mapped at the scale of 1:100,000 on the „AGROTOPO" map sheets and 1:25,000 in the „Kreybig"-practical soil information (spatial vector data for maps and database for profiles and borings) systems. In spite of the two systems being digitally available, the information collected at the scale of 1:10,000 is available only for 2/3 of the country and is not digitized.
Very early maps at field scale, later at regional scale showed numerical salinity/sodicity values. At present field scale numerical maps are analysed in order to optimize salinity mapping in space and time.

Systematic monitoring of soil salinization in irrigated areas dates back to 1989 in the irrigation district of Tiszafüred in the county „Jász-Nagykun-Szolnok". Soon after it the nationwide Soil Information and Monitoring System was initiated from 1991. In this system out of 1236 soil profiles, 67 profiles were classified as „salt-affected" are sampled and analysed yearly for the indicators of salinity and alkalinity.

When the large-scale irrigation projects were planned in the second half of the last century, prediction of soil salinization was based on the concept of „critical depth of saline groundwater". As an alternative a numerical rule-based algorithm was developed for the prediction of the risk of soil salinization in irrigated fields. Numerical process-based modeling with LEACHM and UNSATCHEM simulation programs was tested for Hungarian areas with limited success so far.

Based on environmental correlation, there is a long history of predicting the occurrences of salt-affected areas. A unique physical modeling system, „compensation" lysimeters are used for testing the effect of saline groundwater with different depths and drainage management in a dominantly sodic area.

The reclamation, including drainage and afforestation of salt-affected soils has lost its peak in the country due to a decrease in financial profitability. On the other hand, the recent years showed a clear picture how efficient are the different reclamation techniques and how afforestation changes the salt distribution of soils and underlying strata.

Hungarian soil scientists play a leading role in the development of good practice for the management of salt-affected areas in Europe. Based on the initiatives of „Soil Framework Directive" of the European Community, salinization is considered as a serious „soil threat" to agriculture. There is a well-developed concept of salinization and a set of „common criteria" for delineating areas threatened by salinization, are agreed upon. A running EU-financed research project („ENVASSO") focuses on the assessment methodologies for quantifying the soil threats, and another one „RAMSOIL" catalogs and evaluates the available risk assessment methodologies of each EU member country. To facilitate the spatial assessment of soil salinity/sodicity/alkalinity according to the EU-wide legal framework, the EU provides grants for promising research proposals to establish sensor-based digital field soil mapping methodologies. Such projects are based on the rich history of salinity sensing with field devices, such as the German Geophilus for multiple depth assessment of salinity.

- Salinization and Sodification on Irrigated Soils in Eastern Kenya

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The Hola irrigation scheme covers 1,700 hectares of land of which 872 hectares are under irrigation. The scheme is in agro-climatic zone VI where the ratio of rainfall to evaporation is 15% - 25%. This zone covers 12.4 million hectares of land in the country of which 2.3 million hectares have soils that are slightly saline, 1.4 million hectares are moderately saline and 1.9 million hectares are severely saline. The major land uses in the research zone are semi-nomadism and nomadism. The soils in the study area are classified as Mollic and Haplic Solonetz, sodic or salic phase; Gleyic, Vertic and Calcaric Cambisols, sodic or salic-sodic phase are developed on marine sediments of Pleistocene to Recent age and old alluvial deposits. Irrigation in the area started more than fifty years ago but increased salinization and sodification of the soils has led to the abandonment of irrigated farming in many fields since the mid 1980s. The objective of this study was to assess irrigation induced changes in soil characteristics in the period 1987 – 2002 with a view to giving recommendations on possible management remedial measures in addition to assessing the possible impacts on the soil characteristics by the introduced shrub *Prosopis juliflora* in the study area.

Though the quality of irrigation water had been assessed to be satisfactory, sodicity and salinity of the soils have been increasing while porosity has been decreasing in the topsoils during the fifteen years of monitoring. Mean EC value initially increased from 1.4 dSm^{-1} to 2.1 dSm^{-1} in the first nine years and has decreased to 1.1dSm^{-1} during the last six years; an indication of increased leaching after the introduction of the shrub *Prosopis juliflora* which improved soil physical characteristics and thus enhanced flushing of the dissolved salts. Mean ESP values have more than doubled from 10% to 24% while porosity has reduced from 53% to 48%. Increase in EC and ESP indicate that processes of salinization and sodification have been taking place possibly due to inefficient use of irrigation water. A decrease in porosity indicates deteriorating soil physical characteristics.

- Nature and Distribution of Salts in the Upper Ruvu-Wami Plains, Morogoro Tanzania: Implications to Land Management

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Tanzania has about 7159750 ha of potential irrigated agricultural land, which is located in 9 major river basins. The acreage under irrigated agriculture almost doubled to reach 3% of the total potential irrigated land over the past 10 years. While the government of Tanzania has ambitious plans to rapidly expand the area under irrigation as one of the strategies to address Millennium Development Goals, there is evidence of decline in crop yield in farms that have been under irrigation for some time. The decline is associated with salinization process which is attributed to poor land management. Salinization is considered one of the key factors accounting for low returns in small-scale irrigation schemes in Tanzania. This study was conducted within upper part of the Wami-Ruvu River basin in Tanzania in order characterize and map salt affected soils for the purpose of developing an appropriate land management strategy suitable for small-scale irrigated and rainfed rice production.

A 250 ha piece of farmland located along the Ngerengere River and representative of the upper part of the Wami-Ruvu basin was chosen for the study. It is located between latitude 6^o 49'00''S and 6^o 49'00''S and between longitude 37^o 35''E and 37^o 35' 10''E. Soil auger observations were conducted at 50 m grid points to the depth of 100 cm in order to characterize the distribution of soils in the area. Soil samples from representative soil profiles were analysed for selected chemical, physical and mineralogical characteristics. The soils were classified according to FAO (1988). Rock, soil and surface and ground water samples were collected and analysed in the laboratory for the content of bases so as to determine the source of salinity in the soils. Supplementary 10 m-grid soil observations were carried at a depth of 0 – 50 cm in a 2 ha area. The area had patches that showed clear features of salt accumulation at the soil surface coupled with pockets in which the paddy rice crop performed poorly or the soil surface was bare. Soil samples from these points were analysed in the laboratory for pH and electrical conductivity. Salinity and alkalinity classes were developed using established criteria. The performance of paddy rice crop was evaluated at the vegetative stage prior to flowering on the basis of crop vigour.

The studied soils fell into four salt affected categories and taxonomic mapping units: saline soil (Gleyic Solonchack), saline-normal soil intergrade (Chromic Luvisol), sodic soil (Gleyic Luvisol) and saline-sodic soil (Sodic Solonchack). Both the Gleyic Solonchack and Gleyic Luvisol contained swelling type of clays. Basic gneiss, amphibolite and hornblendite were among the dominant rocks in the study area. All of them were rich in bases, hence can be considered to be an important source of salinity in the soils upon weathering. The electrical conductivity of the water in the Ngerengere River remained low throughout the year while the content of sodium increased from 0.3 – 0.4 mg/l during the rainy season to reach a maximum of 29.9 mg/l at the end of the dry season. Most of the ground water samples contained high levels of electrical conductivity and like the surface waters; the chlorides, carbonates and bicarbonates of sodium dominated them. They are taken to be the direct source of salinity and possibly alkalinity in the studied soils. Drastic spatial variations in EC and pH occurred over short distance in the saline-sodic soil. They had a pattern similar to that of the performance of paddy rice during the late vegetative growth stage. The mean EC in the root zone were 0.5, 4.0 and 20.2 in the patches with healthy, wilted and withered crop or bare ground surface while the corresponding mean pH values were 7.0, 8.1 and 8.9 respectively. These differences were statistically significant. On the basis of the linkage between the performance of the paddy rice crop and the corresponding pH and electrical conductivity values, the studied soils can be put into three broad salinity-alkalinity: very slightly acid to moderately alkaline and none saline to slightly saline soils; moderately alkaline to very strongly alkaline and moderately saline to strongly alkaline soils. These could serve as the basis for land management in the area. It is recommended that knowledge of the salt patch distribution, their characteristics and the chemistry of both ground and surface waters over the entire growing season should be sought prior to any attempt to solve the problem of salinity and alkalinity in the study area. In view of the inconveniences that small-scale farmers are likely to face while linking with specialized laboratories to have soil and water samples analysed for electrical conductivity and pH, efforts should be made to facilitate field-based characterisation and interpretation.

- Salt affected soils in Romania

by **M. Dumitru, C. Simota, Daniela Raducu, Elisabeta Dumitru, Irina Calciu, N. Florea**
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Paper presents information related to: (A) the assessment of salt affected soil based on specific indicators and on (B) diagnostic criteria for their classification; (C) a distribution of salt-affected soils in Romania including (D) a map of salt affected soils and vulnerable or susceptible soils to salinization;(E) a simple example in pilot area; (F) the research concerning reclamation and management practices applied in Romania for salt-affected soils.

The assessment of the quality of salt affected soils has done along the years using classical indicators showing soil salinity. Soil sodicity is characterized by TSC (Total Salt Content in $mg.10^{-2}g$ soil), ESP (Exchangeable Sodium Percentage in percentage of CEC), SAR (Sodium Adsorption Ratio in $mg.me.l^{-1}$), and pH (in soil water 1:2.5). Saline Soils are characterized by EC (Electrical Conductivity in $mmhos.cm^{-1}$ or dSm^{-1}). From the taxonomical point of view the salt affected soil are assessing by the main specific diagnostic horizons: Salic Horizon (sa), Hyposalic Horizon (sc), Natric Horizon (na), Solonetzic Horizon (Btna), Hyponatric horizon (ac), Sulphuric Horizon. According to the all criteria the main soils types affected by salt content occurring in Romania are solonchaks, solonetz and salinez soils, a special category is that of non/salinized soils but with high risk or potential for salinity under certain conditions and water management. Soil surface area affected by salt cont in Romania is showing in one table. According to the data presented in the table, Soil surface areas affected by salt content in different zones of the country are in total, respectively, in Romanian Plain $200.6.10^3$ ha, Western Plain 175.10^3 ha, in Moldavia 114.10^3ha, in Transilvania $20.4.10^3$ ha, in Dobrogea 104.10^3 ha, being in total 614.10^3 ha. In addition, at this total area we have to add surface area with risk or potential salinity, which is in total 1221.10^3 ha. The Map of Salt Affected Soils and Susceptible Soils to be Affected by Salt in Romania is showing: the distribution of the very strongly affected soils by salts, weakly to strongly affected soils by salts, susceptible soils to be affected by salts, unaffected and unsusceptible soil to be affected by salts, and also classes and sub-classes affected land units, and Regions or zones with dominant salinization type, and other details: relief units, ground water depth, ground water salinity.

The research concerning the reclamation and management practices applied in Romania for salt affected soils has had a long tradition in Romania. During the years, different Research

Institutions have been involve in techniques of application and management of reclaimed land affected by salinization, such as: National Research and Development Institute for Soil Science, Agricultural Chemistry and Environment (ICPA)-Bucharest, Research and Development Station for Improvement of Salt Affected Soils - Braila, etc.., testing traditional agricultural management related to the type and the degree of soil salinization. According to the National Soil Quality Monitoring System, since 1977 such soil represented a special issue. Related to this program, rice cropping was one of the most profitable farming systems, therefore, since 1980, the rice-cultivated area increased two times in the eastern part of the country, in the region Maxineni-Corbu, from 20.10^3 ha to 49.10^3 ha, but after 1990, such area decreased dramatically.

Other good solutions for controlling soil salinization, tested in the experimental fields, refer to: type of drainage systems, land levelling and modelling, leaching, gypsum amendment, chiselling, soil improvement fertilisation, tolerant crops, crop rotation, etc., getting positive results in crop yield and soil quality status. Also, is presented a simple example of study concerning the salt-affected soil in a pilot area located in western part of Romania.

2. Meeting on 'Status and Progress of Biosaline Agriculture'

Session 7: Sustainable Biosaline Agricultural Systems

- Biosaline Agriculture: Prospects and Potential Within Global and Regional Context

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During the last few decades, net agricultural production has suffered a significant drop, though productivity per unit area has increased. Among the many reasons, salinity and associated factors, like waterlogging and/or drought have contributed significantly. The increase in saline areas have been directly attributed to both water and soil salinity problems. Increase in ground water pumping has resulted in the intrusion of sea water, both in coastal and inland areas. Furthermore fresh water aquifers have been exhausted and hence overlying saline water layers mixes with fresh water, resulting in the increase of salinity in the ground water. The most common reasons for increase in salt affected lands is due to the mis-management of irrigated areas. Inadequate or absence of drainage system and high rate of irrigation water application has resulted in the movement of salts in the soil profile, especially in the dry areas, where these salts are brought to surface as a result of high evapo-transpiration rates.

A number of approaches have been evaluated and implemented for combating the salinity problems, based on specific types of site-, regional- and global-problems. These include, soil reclamation; water management; and plant based approaches. The first approach of soil reclamation in large areas not only requires high financial investment, but also continuous maintenance to make it technically feasible. The other two approaches are management strategies using appropriate irrigation and drainage systems; and selection of appropriate agriculture production systems, suitable for specific edaphic and climatic conditions. These approaches when applied in an integrated form constitute the backbone of 'Biosaline Agriculture'.

Plant based approaches to use salt affected lands economically and environmentally safe is based on the salinity ranges of soil, water (and groundwater) and other associated factors. The selected production system(s) not only help in halting further deterioration of the marginal lands, but also have direct commercial uses as food, forages/fodder, livestock industry, medicinal uses, wood, etc., through the primary products In addition, use of these marginal resources also provide many secondary and indirect products, including bio-fuel and bio-energy, carbon sequestration, phyto-remediation, etc.

Strategies for plant based solutions to the use of salt affected areas include production of new genotypic material through conventional breeding or biotechnological methods (for glycophytes) or selection and adaptation of existing salt tolerant germplasms (both glycophytes and halophytes). Both strategies are equally important and feasible based on the nature of the salinity conditions.

This paper will mainly cover on the latter approach of identifying, evaluating, screening and optimizing productivities of existing salt tolerant germplams. Different management strategies to increase productivities will also be discussed. Case studies will be presented from different regions of the world (especially from third world countries) to use marginal and saline resources into different types of agricultural production systems. The paper will also describe the economical and environmental benefits of the case studies.

- Greywater Use for Irrigation of Home Gardens in Peri-urban Areas of Jordan.

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Marginal water includes saline water, wastewater, and runoff water. These water sources differ in location with regards to the application site, quality, quantity, and stability of supply. Marginal water is usually deficient in one or more qualities that make it fit for open irrigation or other beneficial uses.

In a water scarce region like the Middle East, it is not a surprise that marginal water is considered to be an important water resource. Reclaimed wastewater is used mainly in agriculture and its proportion in comparison to ground and surface water will be on the rise as the volume of municipal water flow increases and the respective collection and treatment systems expanded and enhanced.

Projects implemented in Jordan show that implementation of greywater reuse systems could lead to an increased efficiency in the use of water, as well as decrease in water demand by 15% and water bill by 27% on average. This opens an opportunity that should not be missed for improving the life quality of urban poor people as well as rural households.

Greywater reuse for urban agriculture is especially relevant given that by 2015, it is expected that 85% of Jordan's population will be living in urban areas.

The Inter-Islamic Network on Water Resources Development and Management, Amman, Jordan (INWRDAM) since year 2000 implemented more than 1200 greywater use installation in different parts of Jordan. The experience is that the potential of greywater use at household level is not fully utilized and that there are no social or religious barriers against greywater use for irrigation of home garden crops under restricted irrigation practices.

This paper will address technical and socio-economic issues of greywater use at household level in peri urban areas of Jordan and how greywater use is gaining increasing popularity in nearby countries such as in Lebanon, Yemen, the West Bank and Gaza and other countries in the region. The paper will address issues related to greywater treatment options and quality possible to achieve by low cost treatment methods, types of crops to grow, environmental impacts of greywater on soil and plants, benefit-cost analysis of reuse, acceptance by the local community and recommended reuse guidelines that are possible to apply to regulate greywater reuse. The paper will also discuss and recommend policy options for increased use of greywater as un tapped marginal water resource.

- Saline Agriculture: Pakistan's Experience

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Pakistan having land area of 800,000 square kilometers is highly dependent on irrigated agriculture to feed its over 155 million people, while irrigation has been one of the most important causes of salinization in the cultivated areas. Out of approximately 6.3 million hectares of salt affected area, about one half is situated within the canal commands, thus having serious social and economic consequences for Pakistan. These salt affected soils vary not only in terms of physical and chemical characteristics, depth of water table, availability of water for leaching of salts as well as crop cultivation and drainage characteristics, but also their distribution pattern in highly variable. Therefore, the options to reclaim these lands have a wide range and so is the case for their profitable agricultural uses. Various types of salt affected lands in Pakistan have been defined.based on the assessment of the salinity studies done. Discrepancies are also observed in figures defined from different sources, mainly due to the methods of assessment, that would be discussed in the paper

A summary of the wealth of knowledge accumulated through detailed experimentation involving screening programs for salt tolerance of crop species, studies in laboratory and small and large scale agronomic studies in field have been described in this paper. Some indicators of economic returns of Saline Agriculture have also been discussed. The history of Saline Agriculture in Pakistan and the success story of the studies carried out in different parts of the country are included in the paper.

- Extent of Salt affected Land in Central Asia: Biosaline Agriculture and Utilization of Salt - affected Resources

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The economy of Central Asian countries (Uzbekistan, Kazakhstan, Turkmenistan, Tajikistan and Kyrgyzstan) is based primarily on agriculture and agricultural processing, with cotton and wheat being the major export crops. This dependence of the economy on agrarian based activities is unlikely to change in the foreseeable future as the most of mentioned countries embarks on a staged process of market liberalization. With the collapse of the former Soviet States and their independence, economies in several of these countries have contracted with associated socio-economic, environmental and food security issues attaining greater prominence. Large expansion of the irrigated area in the Aral Sea Basin has extracted a substantial toll on land and water resources in the Basin. Elevated water tables associated with poor irrigation management and non-functional drainage infrastructure, due to the lack of financial resources have resulted in significant salinization of crop lands that invariably results in abandonment of land due to declining wheat and cotton yields. The predominant reasons for development of these crops are poor irrigation water management and inadequate drainage, rising groundwater tables and associated mobilization of primary salts within the soil profile. Approximately 600,000 ha of irrigated cropland in Central Asia have become derelict over the last decade due to water logging and salinization. It is estimated that approximately 20,000 hectares of irrigated land of Mirzachuli steppe (marginal transboundry areas of Uzbekistan, northern Tajikistan and south part of Kazakhstan) is lost to salinity and invariably abandoned every year. The proportion of irrigated land that is salinized to some extent has risen from 48% in 1990 to approximately 64% in 2003. In some downstream provinces of Uzbekistan (Navoiy, Bukhara, Surkhandarya, Khorezm and Karakalpakstan), Turkmenistan (Dashauz) and Shileisk massive at delta of Syrdarya from Kazakh side, 86-96 % of irrigated lands are salinized. Saline areas are generally found in poorer areas of the region with per capita incomes 30% lower than average national indicators and unemployment levels 40% higher. Soil salinity and waterlogging are a heavy burden for resource poor farmers who are located in arid/hyper-arid land-degraded zones. This phenomena has had a major impact on the livelihoods of rural communities who are dependent on land and water resources for goods and services. The conventional approach to rehabilitating these salinized areas requires major technical expertise and investments that are beyond the means of the national budgets as well as farmers' investment capacity in these emerging/transition economies.

Additionally, degradation of desert natural pastures, throughout the whole Central Asian states has reached an alarming degree, requiring prompt actions to the fragile ecosystems. The average annual rainfall here varies from 80-120 mm. Soils are sandy loam to loamy in texture, with poor vegetation cover that is highly saline and with a low fertility level. *Artemisia*-ephemeral and psammophytic rangelands available for grazing of animals were replaced by halophytic plant communities with less palatable fodder plants. Besides, this *Artemisia* pastures tends to disappear under excessive and permanent grazing and also because currently it heavily uprooted for fuelwood. The anthropogenic transformation of vegetation of pastures is evidently along well or watering place, saline lakes, near settlements, sheep fold, along roads.

In addition, poor natural drainage system of marginal cropping irrigated lands and sandy desert has also caused an increase in the salt contents of surface soils and groundwater, which has induced secondary salinization. These have resulted in the migration of local (mostly Kazakh and Uzbeks) population to neighbouring cities and/or countries. The consequence of pasture degradation has resulted in a big decline on the livestock system and livelihoods of the communities in the region.

Nowadays a unique source for development of agropastoral livestock-feed system in the remote desert/semidesert zones of all central Asian countries is the reclamation of saline pastures that occupy more than 3.2 m.ha, and are predominantly established to halophytes that have the ability to grow adequately under prevailing edaphic conditions and play a valuable role as feed for livestock and for medicinal purposed. Until recently, no serious research efforts have been made on the cultivation of wild halophytes; therefore, they have had no market value so far.

The role of plants in the remediation of saline and sodic soils is an emerging low cost approach in the reclamation of abandoned irrigated lands. In this respect, the creation of highly productive fodder systems through the establishment of palatable halophytes has been shown to remediate saline / sodic soils as well as provide an income to resource poor farmers. These genetic resources play a very important role for the (i) rehabilitation of degraded lands, (ii) controlling high water tables, (iii) utilization of non-conventional water resources, (iv) landscaping, etc. Innovative program and experimental fields on domestication and utilization of *Glychyrryza glabra, Hippophae ramnoides, Elaeagnus angustifolia, Artemisia diffusa* and *Alhagi pseudoalhagi* with suitable modern agro-technologies were initiated in 2006 in the Central Kyzylkum Desert. Incorporation of these plants into a biosaline farming system represents the only source of income for many poor rural families, who live far away from markets. These plants due to their ability to be propagated by both reproductive (by seeds) and vegetative (numerous suckers) means are the target fodder species for rehabilitation of degraded pastures; sand-fixing; water-table and soil erosion control; haymaking and silage; better stock feeds (feed blocks) for animals in the late-autumn winter; bee-keeping and honey production; using volatile oil of *Artemisia* for traditional medicine; as well as delicacies and for medicinal purposes fruits of *Hippophae* and *Elaeagnus* as they are rich in sugar, falconoids, various vitamins; for using as food by local people for jam and vine production; paint extraction. Glychyrric acid extracted from *Glychyrryza glabra* roots is used as a flavoring in food, tobacco, alcohol, candies and cosmetics industries.

Options for improving the livelihoods of the rural population in the some Central Asian region by using artesian thermal and underground water is evident. The artesian waters could be used for development of arid fodder production systems, in addition for recreation, vegetable production, and other purposes through management practices. The establishment of high productive fodder systems will ensure the safety of natural habitat and increase the income levels of the poor farmer's. However, since the whole issue is using the saline artesian water for long-term sustainable production, care needs to be taken on management and environmental issues as well.

Transfer of new technology or methodology of ICBA (International Centre for Biosaline Agriculture) in planting of both perennial and annual valuable halophytes (based on around the world dataset from similar sites and conditions) is an alternative approach that is already being tested in some Central Asian region. Preliminary results are very encouraging to demonstrate the potential of salt tolerant plants and halophytes, for food, feed, fueldwood, bioenergy and other products. These species are alternative to the traditional cotton growing systems, the yield of which has been significant reduced due to increase in salt affected areas. Many farmers who had abandoned their cotton farms have returned back into production system and gaining economic returns. Sorghum, pearl millet among conventional forages and *Atriplex* spp. and *Acacia ampliceps*, among the non-conventional forages have gained quite an interest on farmer's fields in the region. Such integrated research is both novel and timely for bringing these countries into the modern World.

- Extent and Utilization of Salt-affected Lands: Biosaline Agriculture and Marginal Resources in Tajikistan

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The agricultural sector is important in the national economy due to its contribution to the GDP, employment, and exports. Considering that three quarters of the population live in rural areas, the agriculture sector will play a crucial role in poverty alleviation. While arable land is scarce, experience in recent years, based on the ongoing restructuring of the large state-owned, cooperative farms, has shown that the transition to private farms can substantially raise yields.

Food security is a big issue for Tajikistan. It is a landlocked country, and the Government has emphasized that self-sufficiency in wheat production is a national priority, flour being the single staple food. Agricultural land in Tajikistan, especially arable land, is a very scarce resource. Total agricultural land is 4.57 m.ha , of which arable land totals 0.7 m.ha, or 0.11 ha per capita, including pasture lands. The major problem is the access of peasants to land and its fair distribution. Efficient use of, and fair access to, land and water resources is one of the sector's priorities in fighting poverty. A key issue for agricultural development in irrigated zones of Tajikistan is the pumping and maintenance costs of ground water and irrigation facilities. Large expenditures are required every year to keep them in working condition. With the transition of the country to a market system, a fee on water consumption was introduced, starting in 1996. However, farmers are able to cover only a small part of the maintenance costs. The main concern stil remains is the state of pumping stations covering almost 300,000 ha, or 40% of irrigated land. A rural population of about 2 million resides and earns a living in this area.

Low efficiency of water consumption in agriculture is another big problem. Lack of inputs and technical recourses and destruction of their distribution systems, destruction of irrigation system infrastructures and other resulted in soil degradation by salinization and waterlogging. This has resulted in decreasing productivity of crops that reaches up to 50-60%, poor crop quality, higher energy for pumping water. As a result, nowadays Tajikistan has more than 116000 hectares of saline and 30 000 hectares of waterlogged land. The irrigation and drainage water in valleys have raised the groundwater level (1-2 m to soil surface) in the lower lying lands and territories. Many of the cotton producing areas of the country are now suffering from marked salinity.

Development of irrigation in the republic had been accompanied by increase of water use. For 80 years, it was 5.5 km^3/year now 11.2 with water consumption above 20 000 m^3/ha/year. As a result, result 30 000 hectares of irrigated lands have resulted in secondary salinization and water logging.

Biosaline agriculture provides a big opportunity to use these marginal resources in wastelands and turn these into production systems. Use of physical, chemical and biological management practices could help in pushing the salts down in the soil profile. As a result of plant succession using different salt tolerant plant species, economical returns can be achieved and thus alleviating poverty of poor farmers.

- Necessity of Biosaline agriculture and irrigation management for sustainable agriculture

by Ali A. Aljalod,
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- Salinity Problem in the Sultanate of Oman: Past, Present and Future Perspectives

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The Sultanate of Oman is located in the semi dry area with an average annual rainfall of less than 100 mm. During the last three decades, salinity problem has increased dramatically. The main reason, beside the less rainfall, was the over pumping of fresh water. The government of Oman, Ministry of Agriculture and Fisheries (Ministry of Agriculture, presently) has taken serious note of this issue. Through a field survey, it was found that at least 50% of ground water at the agricultural coastal of Batinah region was saline. One of the immediate actions taken was the legislation for digging any new wells. Detailed surveys were conducted to study soil and water salinity problems. In addition, attempts were also initiated to use the saline water. Programs were established and still being conducted to select salt tolerant crops that can use the saline water and give economic returns to the poor farmer's. Several experiments were conducted on field crops, forest trees, shrubs and vegetables. The Ministry has collaborations with international institutes, like the International Center for Biosaline Agriculture (ICBA) and Food and Agriculture Organization (FAO). In addition, agencies like the University of Sultan Qaboos and Ministry of Regional Municipalities and Water Resource are also active partners

The International Center of Biosaline Agriculture (ICBA) in 2004, initiated a program called *'Development of salt- tolerant cultivars and varieties under saline conditions'*. Under this program, different lines/varieties of pearl millet, sorghum, barley, and canola (*Brassica* spp.)

were studied with moderate and highly saline irrigation water. Also shrubs species (*Atriplex lentiformis, Atriplex halimus* and *Atriplex nummularia)* and tree species *(Acacia ampliceps)* were tested using high salinity water. In addition, demonstration plots of grass species (*Leptochloa fusca*, *Paspalum vaginatum, Distichlis spicata, Sporobolus virginicus*). The most salt tolerant lines of the above mentioned plant varieties were selected and are being tested select the suitable germplasm for distribution to the farmers.

Recently the Ministry also got involved in a program with the University of Sultan Qaboos. This program has the following objectives; (i) monitoring and preparation of salinity maps, (ii) identification of management practices to tackle soil and water salinity, (iii) salt-tolerant fodders/grasses and sowing techniques, (iv) fish culture with saline water, and (v) socio benefit analysis.

In order to identify the quantity and quality of the brackish water in whole of the Sultanate, the Ministry of Municipalities, Water Resources, and Environment conducted a field survey using remote sensing tools. Areas of aquifers were identified and maps were prepared. An area of about 107.8 km^2 of brackish ground water was found in the inland areas of Oman. Options are being looked suggested for using the brackish water including direct use, economic model projects, preference of using large-scale farming, small aquaculture farms, and reverse osmosis desalinization for potable water.

The salinity problem in the Sultanate could be tackled through (i) applying the legislation of minimizing ground water pumping; (ii) developing of new salt tolerant plants through screening and breeding techniques; (ii) developing plant management and irrigation techniques to suite the saline agriculture system. The paper will describe all the above mentioned strategies that are being carried out in the Sultanate.

- Water Shortage in Western US and Saline Recycled Water Use for Urbn Irrigation

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Submitted abstracts but did not participate in the Consultation

- Characterization of the Current State of Salinity in the Irrigated Perimeter of MINA (Algeria)

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This project is regarded as a stage of the process engaged by the National Institute of the Soils, Irrigation and Drainage (INSID - Algeria), for the creation of the national observatory for the follow-up of the irrigated perimeters, and the degradation of the arable lands

phenomena in Algeria, and in particular, the salinity, which affects meadows of a million (1.000.000) hectares, especially in the western area of Algeria.
And sight the falls of outputs, in the majority of the irrigated perimeters in ours country, the institute engaged a chart for the realization of a study of characterization of the current state of salinity in irrigated perimeter of MINA.

The perimeter irrigated of MINA, which is equipped with a significant agricultural hydro infrastructure, constitutes one of the significant assets of the socio-economic development of the area. However, irrational and increased use of the subsoil water resources, and surface, coupled to the intensified agriculture conduits to the deterioration of the quality of the grounds and water. For few years, the searchers tried to record the type, the extent, the gravity and the speed of evolution of the salinity of the grounds. But the diversity of methodologies produced divergent estimates.

The teledetection and the geographical information systems (SIG) have become tools of choice for the identification of the physical problems and in particular the characterization and the follow-up of salinity of the irrigated perimeters. The purpose of the recourse to these new techniques, is to facilitate the access and the data transfer and to carry out more efficient analyses, in a faster way and especially in way repeated in time and this when wish.
The methodology which was followed for the realization of this project consists of the use of new tools and methods which are:

- The GPS and geographical information systems (SIG) for géoréférencement of the numerical and space data;
- The statistics and the géostatistics one for the relationship between the values of electromagnetic conductivity and the results descended from the analyses of the corresponding samples of soil and the electric conductivity of the saturated soil extract.

The numeric and spatial treatment by the specific software permitted the establishment of a numeric data bank, to the perimeter as well as the spatial visualisation of:

- The distribution of the soil occupation
- the distribution of the salinity classes ;
- The distribution of the classes of crops tolerance to salinity;
- The distribution of the soil occupation step to the classes of tolerance of the cultures to salinity.

These results allowed us to delimit by classes, the surfaces affected by saltines what will make possible to the persons in charge, to take the necessary decisions by the use of the suitable management methods in order to target the actions by agriculturist.

- The Diagnostic Categories and the Qualifiers of the World Reference Base for Soil Resources (WRB) as Information Sources for Identifying Delineating Areas of Salinization

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Salinization if one of the eight degradation processes that European Commission defined as the main threats to vital soil functions in the official Communication of 'Towards a Thematic Strategy for Soil protection'. In Hungary 10% of the total land area is influenced by salinization (including Solonchaks, Solonetz, intergrading soil types and secondary saline and sodic soils). The salt-affected areas are generally overlapping with the least developed rural areas of the country. Research on and classification of saline soils has long traditions in Hungary (Sigmond, 1927; Varallyay, 1967; Szabolcs, 1974).

The development of the soil framework directive and other recent European and global initiatives resulted in an increasing demand for harmonized digital soil information on soil properties especially those that limit normal soil functions. Hungarian soil scientists are deeply involved in the above mentioned areas of research and policy related activities (Tóth et.al ., 1991, 2002, 2006, Michéli et. al. 2005, 2006).

The paper will demonstrate how the World Reference Base for Soil Resources (WRB) can serve as an information sources for identifying delineating areas of salinization.
The World Reference Base for Soil Resources (WRB) was endorsed and adopted as the system for soil correlation and international communication of the International Union of Soil Sciences (IUSS) in 1998. After eight years of intensive worldwide testing and data collection, the 2nd edition of the WRB was published. One of the major changes in the new („WRB 2006") edition is the significantly increased number of the diagnostic categories and qualifiers. This increase received some critique, however in our digital data demanding world it is important to store interpreted, quantitative data in global and regional soil databases.
The diagnostic categories and qualifiers of the WRB 2006 carry the following information on salinization and sodification and related properties:

- salt content (categories based on electric conductivity and pH),
- depth of salt accumulation,
- chemistry (composition) of salts,
- influence and depth of surface or ground water
- texture and texture differences in the profile

It will discussed how a database that stores the WRB diagnostic categories and the qualifiers may serve as information source for identifying and even delineating soil units with certain properties and/or are threatened by the salinization processes.

Key words: Salinization, World Reference Base for Soil Resources (WRB), harmonized soil databases, risk area delineation.

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-Using Satellite Imagery and Electromagnetic Induction to Assis Salinity, Drainage Problems and Crop Yield in the Rio Fuerte Irrigation District.

by **Dr. PULIDO-Madrigal Leonardo[1] and GONZALEZ-Meraz Jorge[1]**

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Soil salinity and drainage deficient areas surveying, as well as yield estimation, in the Rio Fuerte Irrigation District, northwest Mexico, were carried out by applying satellite imagery, a portable electromagnetic-type sensor, and a GPS unit Soil and plant samples were obtained in selected salt-affected fields grown with wheat (*Triticum aestivium*), cotton (*Gossipium hirsutum*), sorghum (*Sorghum bicolor*) and maize (*Zea mays*), which were considered as the reference crops, since all together covered most of the cropped area of the irrigation district. Spectral values (TM2, TM3 and TM4 bands) were extracted from Landsat TM images. The images were obtained during the flowering stage of each crop. Salinity and spectral data were analyzed, and multiple regression models were obtained to estimate the salinity status of the cropped areas, together with its correspondent crop yield. Salinity and yield maps for each crop were digitized and classified on the Landsat image using the regression models. The non-referenced area of the district (fields planted with any other crops, non cropped, fallowed, or abandoned) was mapped *in-situ* using an EM-38 electromagnetic sensor, along with a GPS unit to locate the geographic coordinates of each of the sites. Both Landsat- and EM38-based salinity maps were joined, and a final map covering all the Irrigation District area was obtained. The total mapped area was 319,976 ha, and it was estimated a salt-affected area of 138,345 ha (43%, EC > 4 $dS{\cdot}m^{-1}$). Poorly drained areas were also obtained based on water table monitoring for the most critical period of the year. This information was also added to the salinity map previously obtained, so salt-affected areas with shallow water table were determined for reclamation and planning purposes. Yield maps were also combined with the salinity map to analyze the effect of the various existing salinity levels on crop yield. An economical analysis was performed, and concluded this method is highly cost and time effective, compared to the traditional one (extensive soil sampling and laboratory analysis).

- **Key words**: satellite imagery, salinity, drainage, yield, regression model, electromagnetic sensor.

- Mots clés : Sols – Dégradation – Alcalinisation – Salinisation – Irrigation – Fleuve Niger – Nappes – Piézomètres.

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La dégradation des sols par alcalinisation et ou salinisation est un handicap majeur pour la productivité des sols irrigués dans les zones arides et semi – arides en général, au Niger et au Mali en particulier. Le phénomène de cette dégradation est très peu élucidé. L'étude que nous avons réalisé tente de comprendre le phénomène à travers les quelques résultats obtenus après un suivi piézométrique des nappes sous riz à Sébéry au Niger et à Niono au Mali. Le suivi a concerné la mesure dans le temps et l'espace du niveau statique (NS) des nappes sur les deux sites. Une évolution similaire à été observée entre les piézomètres de chaque site.

La conductivité électrique a évolué dans le temps tant à Niono qu'à Sébéry pendant que le pH a très peu varié. Le changement du pH étant un processus très lent en conditions naturelles dans le sol, surtout pour un intervalle aussi court que la durée de stage, nous n'avons pas observé des variations interprétables.

Un des paramètres le plus important dans le domaine de la dégradation a également été suivi même si partiellement : le bilan ionique des eaux des nappes. Ce paramètre pour la période du suivi indique que la nappe à Sébéry a un faciès sulfaté magnésien calcique alors que celle de Niono a un faciès carbonaté sodique. Ce constat nous a permis de conclure que la salinité à Sébéry n'a pas pour origine les eaux du fleuve du Niger à faciès carbonaté sodique. Cependant, l'alcalinité à Niono a pour origine les eaux d'irrigation issues du même fleuve.
Les sols étudiés sont hydromorphes à caractères vertiques et/ou hydromorphes à pseudogley d'ensemble. Ils sont argileux à limono-argilo- sableux. Le bilan ionique des extraits au 1 : 10 d'échantillons de ses sols indique les mêmes tendances en ce qui concerne les types d'anions et de cations en terme de quantité que les nappes.

- Advances in Assessment and Monitoring of Salinization for Managing Salt-affected Habitats in Peru.

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The salt-affected soils are originated ***at the Coastal Plain Geomorphic Region***, located between de Pacific Ocean and the western side of the Andes Western Cordillera; that forms an extensive mostly seaward sloping area.. having an elevation 0 to 2500 m sea level.
The region is subdivided into four main sections and due to differences in the genesis, geology, clay mineralogy, texture and topography, determines the nature, content and saline or sodic conditions.

a. The Coastal Alluvial Plains, are formed by fifty two rivers coming from the western side of the Andes are forming an equal number of alluvial valleys. They vary in width from a few meters in the mountainous landscape and to some kilometres when entering the Coastal Plain. The soil moisture regime is mostly aridic, but aquic in lowlands or close to the Ocean; the soil temperature regime is isohyperthermic in the north and isothermic in the south; the natural vegetation is represented by several desert species, but all kind of tropical field crops are presently cultivated under irrigation; secondary or human induced salinization increases due to water logging and a salic subsurphase diagnostic horizon has been formed.

In the alluvial valleys of Lambayeque, due to the very intensive land use with a mono cultivated crop such rice, small islands of salt-affected ecosystems of closely natural status have been left out of cultivation, and they are the less productive lands. About 40 percent of these irrigated lands are considered to be affected by soluble salts. Sodicity rarely has been observed due to the type, class and amount of clay dominant in the soil.

Electrical conductivity proved to be an almost equivalent substitute for soil salinity.
Salt affected soils can be mapped by use of remotely sensed images because either of the presence of natural vegetation, or the stunted growth of crops, or the specific coloration of the soil surface. Remotely sensed images only are applied to estimate the pattern of heterogeneity.
The soil reclamation is made by intermittent water flooding, following the equation:

$$\frac{C}{Co} \times \frac{dl}{ds} = K$$

Where C = Maximize permissible salinity
Co = Initial EeC
ds = Effective depth to be recuperated in cm.
dl = Height of water
K= Leaching efficiency according to organic soil K= 0.45
Clay loam = 0.3
Sandy loam = 0.1

b. The Coastal Plain Terraces, are sets of narrow marine terraces distributed around the littoral and they are separated by scarps at their landward edge. They form steps of variable width extending sea ward from this scarp and are covered by a mantle of terrace sediments consisting mainly of a mixture of gravel, sand silt and gypsic, petrogysic, petrocalcic or salic sub diagnostic horizons are identified. The three first has not been used with agricultural purposes. Reclamation of soils with salic sub horizons has been leached with water.

c. The Tablazos, are extensive uplifted quaternary plains of marine origin, which are lithological dominated by carbonated rocks: limestone, calcareous shells, calcareous sandstones, conglomerates, marl and lutites. The tablazos are mainly localized in the centre and de NW of the arid Peruvian coast. Barren land dominates in the landscape and the soils are generally psaments, Orthents, or orthids. No saline, no alkaline problems.

d. Pampas, They are broad nearly level plains or gently undulating regions, considered to be of marine origin. This applies to the lowest Pampas and those located close to the Pacific Ocean, which are still dominated by their marine character.

The inland Pampas however , with elevation between 1200 and 1700 m above sea level are covered by drift sediments mixed with volcanic materials. Characteristics of the Pampas are old lacustrine basins. Many of these playas have well developed salt crusts formed in unconsolidated sediments and the arid soils are of high content of salts easily reclaimed by leaching.

- Salt-affected Habitats in the Syrian Arab Republic

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The Syrian Arab Republic is located in the Eastern part of the Mediterranean region and covers a total area of 18,518,000 ha. The total population is 18,356,000. The climate is mostly semi-arid and is generally dominated by the moderate Mediterranean climate, which is characterized by four seasons. Interactions between rainfall, temperature, and evaporation from the soil surface serve to distinguish five settlement zones. Evaporation from the soil surface in settlements zones 2 to 5 exceed rainfall which require using irrigation water to fulfill crop water requirement especially summer grown crops.

The contribution of annual average annual rainfall is about 46.76 billion m^3 of which about 36.43 billion m^3 evaporates annually (i.e. about 78% of rainfall). The average annual surface and ground incoming water is estimated to be about 16.559 billion m^3. Most of this water is of good quality and is used for municipal, industrial, tourism, and agricultural purposes. Agriculture consumes about 85% of the total renewable water resources. A part of irrigation water, especially in the Euphrates Basin, produces annually about 1.3 billion m^3 of saline drainage water. The domination of slightly soluble rocks in large areas especially in the North eastern part and Euphrates basin produce saline ground water too. Using such water in irrigation increase soil salinity and hence reduce soil productivity.

Soil salinization in the Euphrates Basin started in the early 1960s with the introduction of cotton. Since then farmers grow cotton as the main summer crop with wheat and barley as winter cereals and lentil and chickpea as winter legumes, in addition to sugar beet and potato. Excess irrigation water use raised water table in large areas of Euphrates basin and other areas in the north eastern part of the country in the absence of appropriate drainage system which aggravated the salinity of soils. New approaches for planning and management are needed for non-conventional water resources such as saline drainage and groundwater if escalating conflicts are to be avoided and environmental degradation is to be halted and reversed. Clearly, there is an urgent need for sustainable use of saline water resources and saline soils to meet the present and future needs of farming systems in Syria.

A better monitoring of soil salinity and ground and surface water quality by personnel of Ministry of Agriculture and Agrarian Reform in addition to Ministry of Irrigation are required. Moreover, good practices to rehabilitate and reclaimed salt-affected soils and increase the productivity of salt-affected habitats are needed to prevent secondary salinization and possible sodication.

- La Politique Tunisienne en Matiere de Gestion de Suive et D'Evaluation de la Qualite des Sols (Salinisation des Sols)

by **Hedi Hamrouni**
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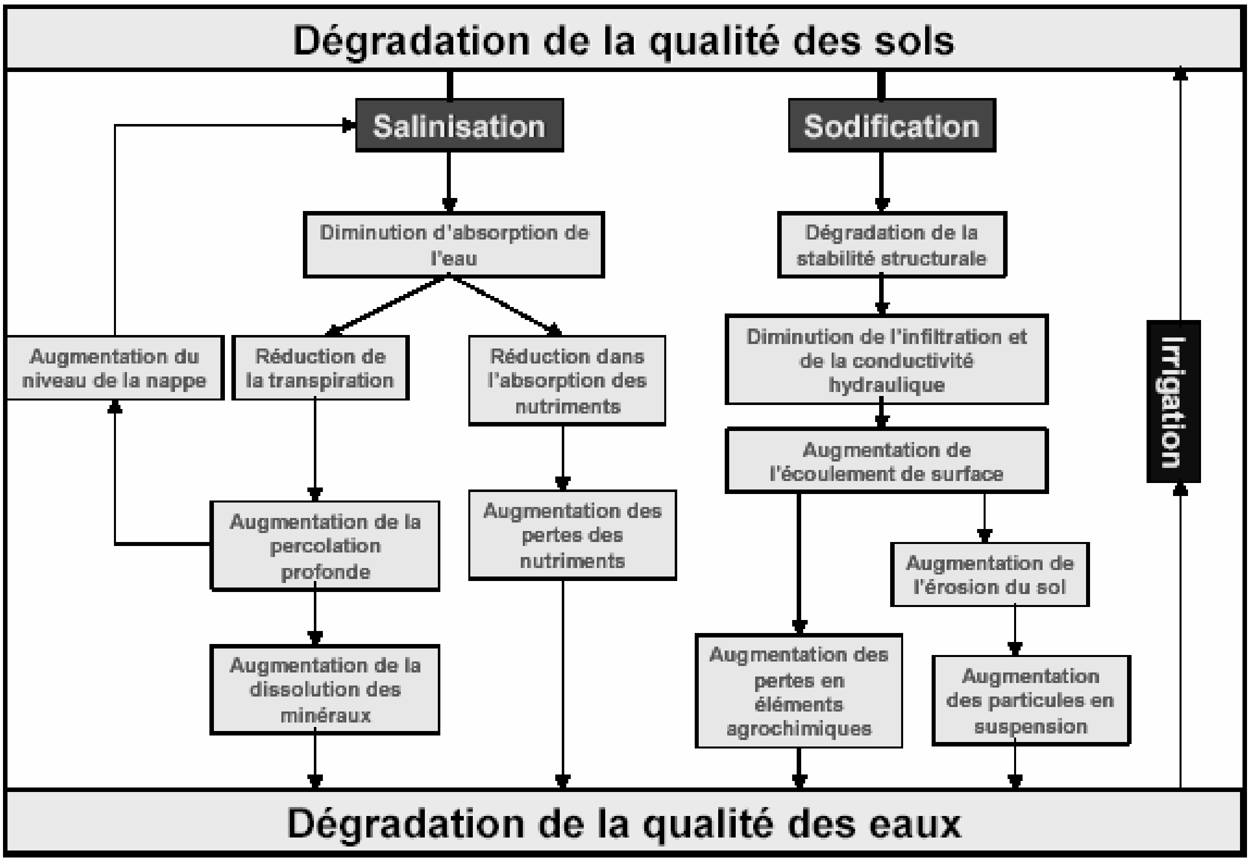
Dans un pays aride comme la Tunisie, l'irrigation des terres est nécessaire pour assurer une production agricole permettant de répondre aux besoins croissants et diversifiés de la population. Des efforts d'investissement importants ont été déployés par les pouvoirs publics pour mobiliser l'eau et pour aménager les sols irrigables. Ainsi, la superficie irriguée est estimée à environ 402000 ha, répartie en périmètres dits publics aménagés par l'état (199000 ha) et en périmètres privés pris en charge directement par les agriculteurs (203000 ha). 70 % des superficies irriguées sont équipées en matériel pour l'économie d'eau

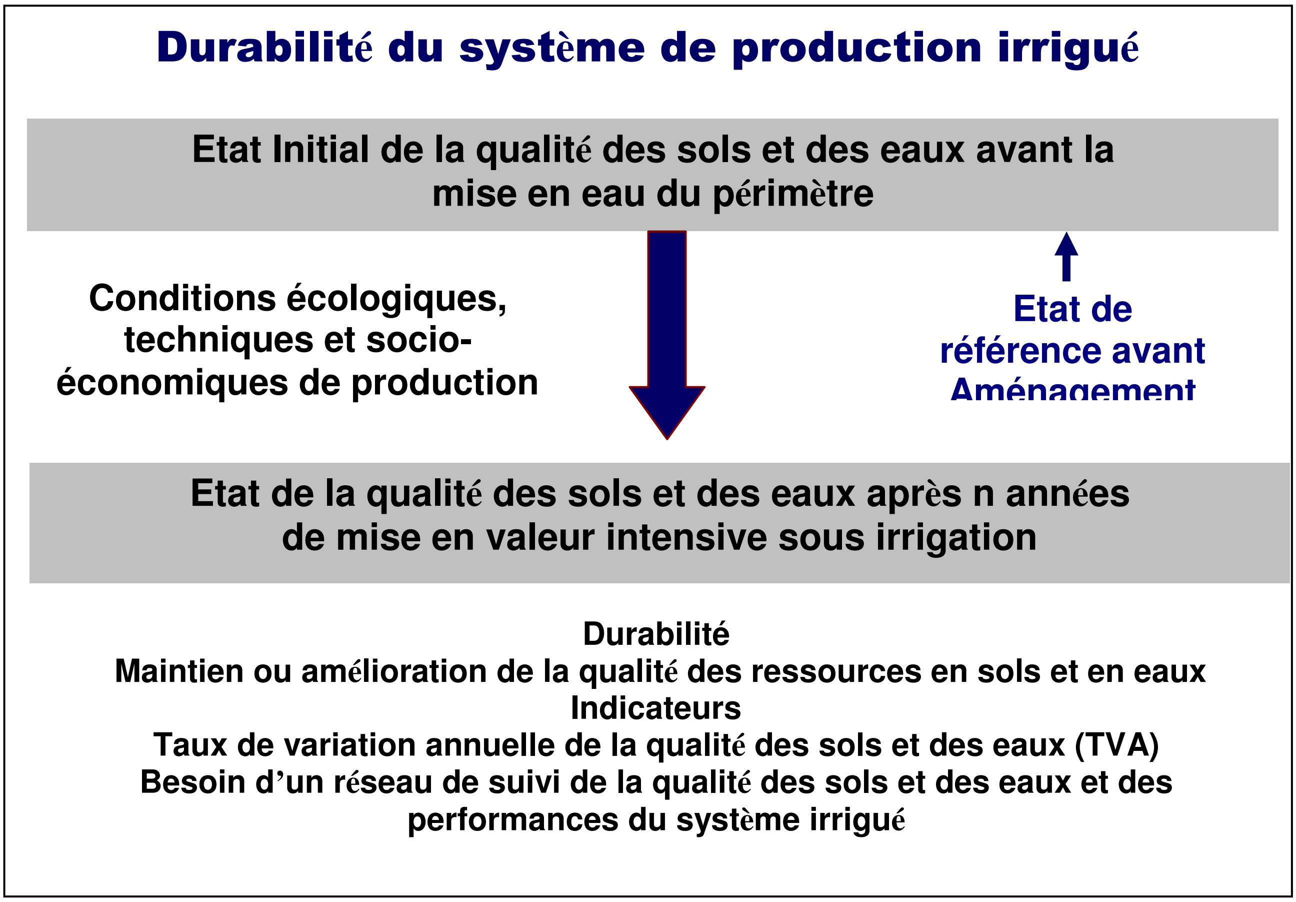
Cependant, l'irrigation conduit souvent à l'accumulation des sels dans les sols suite à l'apport de quantités importantes de sels solubles en plus l'intensification des cultures pourrait engendrer une baisse de fertilité des sols si aucune mesure d'amendement et de restitution de la fertilité des sols n'est prise en considération dans le système culturale. En effet la salinisation secondaire est d'autant plus rapide et importante que l'eau d'irrigation est chargée en sels, que l'évapotranspiration est forte, que les sols sont lourds (texture argileuse) et que la nappe phréatique est proche de la surface, soit à cause d'un mauvais drainage, soit à cause d'une remontée induite par la sur-irrigation. En effet, la maîtrise de la trilogie irrigation-salinité-drainage est la clé de la durabilité des systèmes de production agricoles sous irrigation (cf. schéma ci-dessous).



En Tunisie, la salinisation des sols irrigués est un processus actif et relativement bien connu. Des manifestations d'accumulation des sels ont été observées un peu partout dans les périmètres irrigués. L'impact de la salinisation se traduit par une dégradation de la qualité des sols, une difficulté d'absorption d'eau par les cultures et par **conséquent une diminution de la productivité des terres irriguées. Ainsi, la valorisation du m^3 d'eau utilisé se trouve réduite.**

Le problème de la salinisation des terres en Tunisie est tellement important que les pouvoirs publics ont décidé de lancer deux études dans le cadre de la composante *Promotion des ressources et de protection de l'environnement* du projet PISEAU en vue d'élaborer une stratégie et un plan d'action permettant d'atténuer processus de dégradation des sols. En plus le projet LADA (FAO) où la Tunisie est partenaire permettra aussi de renforcer la stratégie Nationale de Gestion de Suivi e d'Evaluation de la dégradation des Terres aussi bien en système irrigué et pluviale.

L'objectif à moyen et à long terme est d'assurer la durabilité du système de production agricole intensive sous irrigation et de faire passer la contribution du système irrigué dans la production agricole total de 35% actuellement à 50% à l'horizon 2009 laquelle est tributaire du maintien ou de l'amélioration de la qualité des ressources en eau et en sol. Le suivi et l'évaluation de la qualité des sols et des eaux sous irrigation permet de mesurer cette durabilité par l'intermédiaire d'indicateurs pertinents (cf schéma ci-dessous). En plus de maintenir la productivité des terres sous système de culture pluviale (Suivi et évaluation de l'érosion hydrique et éolienne, amélioration de la fertilité des sols, protection de la qualité des eaux ..)



- Preliminary Information on Salt-Affected Soils in the Ukraine

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In the Ukraine, on soil maps, in land and reclamative cadastres it is separately taken into account salt-affected, sodic-salted and alkaline (including solonetz) soils. Salted and alkaline soils distinguish on natural and anthropogenous (secondary) origin. Various hydromorphic soils, including secondarily underflooded soils are also by object of the account and the researches.

All listed soils are revealed and are reflected on different scale maps as a result of inspection 1957-1961. The next years the results of initial inspection updated, and approximately with 70^{th} of last century monitoring properties of irrigated and adjacent with them of unirrigated soils were organized. The program of monitoring covers a wide set of parameters. The obtained materials are generalized in the several books, the maps, the estimations of an actual condition of territory are made, and there are attempts of forecasting of development of secondary processes.

The area of the **salt-affected soils** in Ukraine (mainly in Steppe) 1,92 mln ha. Besides among irrigated soils is about 200 thous. ha of secondarily salt-affected soils. The majority of them tilled, excepting strongly salted soils and solonchaks. In group salt-affected soils are incorporated soils with the increased contents of solubilized salts in water. The salts structure is determined by a method of soil water extract (relation soil: water 1:5) by definition of the following ions in mg-ekv/100 g of soil and in %: CO_3, HCO_3, Cl, SO_4, Na, K, Ca, Mg. As a result of summation of the contents of ions in % the total sum of salts and sum of toxic salts are determined. All ions Na, Mg, Cl, CO_3 and also connected with Na and Mg SO_4- and HCO_3-ions concern to toxic salts. A salinization degree determines under the contents total and/or of toxic salts with the account of salinization kinds. Methods of definition of the ions content in water are standard.

The soil classifications on a degree of salinization are developed. Depending on the content of salts allocate not salted, poorly, meadow and strongly salted. The soil classifications are developed depending on depth of salt horizon. The soil classifications on a degree of salinization are included in structure of the state departmental normative documents and in project of the national standard of Ukraine.

The method of specific electrical conductivity (Standard 26423-85) is applied also to definition of a salinization degree, but this approach in Ukraine has not found wide application.

The data on the areas of salt-affected soils are placed in land and reclamative cadastres. On the basis of the areas data and the degree of soils salinization are planned measures under the prevention or warning and struggle with soil salinization - construction of a drainage, washing salted soils, selection of salt-stable cultures, soil chemical reclamation. The State Committee of Ukraine for Land Resources has developed and has ratified the Order of Soil Conservation, on the basis of which salted soils with the contents of toxic salts more than 0,4 % is subject to transformation from land of agricultural appointment in other categories of lands.

The area of **alkaline soils**, that is, soils, in which structure of absorbed complex the certain part is occupied by ions of Na and K, giving soils adverse physical properties, makes 2,25 mln ha (mainly in Steppe), approximately 2/3 of them tilled, and about 0,8 mln ha - irrigated. Owing to large popularity of solonetzic topic these soils in the Ukraine very well investigated. The theories of an origin and evolution these soils are developed, their basic properties and modes, and also ways of improvement are known.

For an establishment of alkalinization degree, including processes of secondary alkalinization, the complex of criteria is used: the sum absorbed Na and K, relation of the sum absorbed Na and K to the sum of all cations, relation of Na-ions activity to a root square of ions Ca activity, and also parameter pNa - 0,5pCa. In irrigated conditions alkalinization depends on quality of irrigated waters, initial properties of soils, which determine their stability to alkalinization (first of all contents of $CaCO_3$ and activity of Ca-ions) and of depth and mineralization of ground waters. As the conducting reason of development of secondary alkalinization processes is the application for irrigation of limited suitable and unsuitable waters, the basic method of struggle with this dangerous phenomenon is the discontinuance of irrigation by waters 3 classes and greatest possible restriction of irrigation by waters 2 classes. Justifies itself also use of complex agroreclamative measures of struggle with alkalinization - chemical reclamation (first of all gypsuming), selection of alkaline-stable cultures, phytoreclamation, entering of organic fertilizers in high dozes. Perspective measures of improvement of alkalined soils have shown itself depth tillage on 60 cm (if parent materials have favorable agrophysical properties, and the horizon of accumulation $CACO_3$ or $CASO_4$ is not deeper 50 cm. In experiences with application of depth tillage, which are conducted in Ukraine from the end 40 years the uniqueness of this measure on duration afteraction - about 50 years is proved.

Soils with active processes **alkalinization and of soda formation**. If as a result of secondary alkalinization pH of soils achieves 7,5 and above, in root layer the soda can be formed. This process develops or under action of mineralized ground waters rise, or as a result of sulfatreduction processes or other reasons. At the contents in soil $HC0_3$ in quantity 0,6 -1,0 mg-ekv/100 g soil processes become dangerous, is higher 1,0 mg-ekv/100 g of soil - very dangerous. In Ukraine the areas are geographically outlined, where there is a danger of soda formation. The greatest danger (there, where in soil profile there is a normal soda) is present on the area more than 60 thous. ha. It first of all rice sowing districts in the Kherson area and in Crimea. The basic methods of struggle are entering of acid amendments, physiologically and chemically acid fertilizers, discontinuance of irrigation by waters potentially capable to alkaline soil.

The total area of soils, where as a result of natural or of secondary processes, the level of ground waters is on depth less than 2 m or its rise is observed (**underflooded soils**) makes 6,9 mln ha. On the data of the State Committee of Ukraine on Waters Facilities, in a southern and southeast part of the country, in underflooded condition there are 223 villages, including only in Crimea about 100 villages. Among the reasons of activization of this process last years the cyclic global changes of a climate are established, but, probably, in the greater measure it is result of numerous infringements of anthropogenous activity. The basic diagnostic attribute of underflooding is presence of gleyzation, increase of concentration and strengthening of migration of amorphous of iron, decrease of oxidation-reduction potential, deterioration of physical properties. Among measures of overcoming of underflooding are offered and are tested: the discontinuance of irrigation of soils with depth of ground waters less than 1,5 m, repair of drainage systems, increase of water-protected zones and others.

The soil classifications on a degree them salinization, alkalinization, sodicity and underflooding use state services at realization of ecologic-reclamative monitoring (State Committee of Ukraine on Water Facilities), ecological monitoring (State Management on Ecology), soil, soil-reclamative, soil-geochemical, agrochemical passportization of land for agricultural appointment.

In the report it is supposed to demonstrate last results of generalization of the information about problem in soils of the Ukraine connected mainly with salinization, alkalinization, and rise of ground waters (underflooding) as the appropriate databases, maps and normative estimations, and also scientific and practical experience of reduction of adverse influence of the listed phenomena on soil productive and ecological functions.

-Combining Assessment Tools and Models for Salinity Management

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There are increasing demands for limited fresh water for municipal and industrial use. In arid areas water use is already in excess of sustainable quantities, thus irrigation as currently practiced with use of high quality waters cannot continue. Coupled with decreased fresh water supplies is the fact of increasing salinization of arid and semi-arid land soils. In order to maintain agricultural productivity we need new assessment and management tools as well as improved management practices for both soil and water management. Most regions have abundant quantities of low quality saline, drainage and sewage waters, most of which could be used for irrigation. This will require new strategies for water management as well as alternative crops or varieties. In many areas the overall water requirements can be met by a combination of rain, fresh water and saline water. In some instances periodic reclamation of the soil or continuous application of amendments will be necessary to control salinity sodicity and toxic element concentrations.

All these trends indicate an increased need to assess salinity status and evaluate management options. Remote sensing technology can be used to provide rapid, inexpensive and detailed salinity maps. In addition to the direct benefit of salinity assessment, the data in these maps can be used as input to management models, such as SWS. These models can be used as tools to analyze the performance of various management practices including blending and sequential use of fresh and saline water. Existing salt tolerance criteria, developed to avoid potential problems, are generally overly cautious if proper management is practiced. Mediterranean climatic conditions result in winter leaching of surface soils, allowing for low salinity conditions during early growth stages, which are generally the most salt sensitive. Models are essential for evaluating salinity response under such dynamic conditions. Examples are given from a large scale field reclamation study using gypsum as an amendment, a field study with cyclic use of fresh and drainage water and use of model simulations for management recommendations for irrigation with high B waters.

- An Overview of Salinity Problem in Uzbekistan: Assessment and Monitoring Technology

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Agriculture is the key economic sector in Uzbekistan, making up about 28% of gross national product (GNP), accounting for 38% of employment, and about 40% of export income. Water scarcity and deterioration of irrigation and drainage infrastructures is a major constraint for agricultural development and satisfaction needs of 26 million populations. Irrigated agriculture already consumes more than 95% of the total intake and demand for water will grow in response to the need to ensure food security and human beings. Thus, with the expected growth of human activity and water demand, the development of irrigation should be based on the retention of soil moisture and the saving of the available water resources. This can be achieved through the adaptation of highly efficient technology, know-how and techniques for improving food security and ecosystem services. However, considerable part of the agricultural lands is affected by a number of destructive phenomena and degradation processes due to inappropriate land use and water mismanagement.

Total area of salt-affected soils in Uzbekistan is 8.4 million ha. It is estimated that more than 2.300 Mha or 53% of the cropland have suffered from serious secondary salinization of which more than 1.080 Mha is classified as moderate and high degree of salinity. Annually 20 000 hectares is abandoned owing to high salinization and water logging. In some cases the problem is more complicated where large areas of salt-affected soils are in gypsiferous soils (total gypsiferous soils are 0.377 Mha). The most dangerous habitats are concentrated in the Syrdarya (mainly in the Hunger steppe and central Ferghana) and Amudarya River basins (mainly in main stream in Kashkadarya, Bukhara and Navoiy provinces and downstream in Karakalpakstan and Khorezm provinces). As a result of salinity and waterlogging development, the production capacity has fallen and farmers' incomes have decreased. Annual losses of agricultural productivity are estimated to be approximately $31 million USD, and economic losses due to land abandonment, because of high salinity, are estimated about $12 million USD.

Several studies and demonstration projects under the support of international institutions have been addressed to introduce and demonstrate integrated low-cost, low-risk management techniques in the salt-affected, waterlogging and other problem soils. In order to assess impact and benefits of the demonstrated techniques the soil/water/crop yield monitoring programmes have been provided. The portable field equipment (Waterproof") and stationary equipment (InoLab, Spektroquant) for measurement of electro conductivity, pH and sum of soluble salts were used. The analytical system AAS NovAA300 is applied for definition of heavy metals (micro elements) in different solid and liquid objects. However, this advanced equipment is very limited and not available for monitoring and control of soil salinity at provincial and farm levels.

Up to the present day the monitoring and control of soil salinity is implemented according to the standards and procedures, accepted in the former Soviet Union. This approach and techniques based on old methods of treatment and point measures is a main constraint of assessment and data interpretation and analysis. With support of EC-Tacis the information systems (WARMIS, WUFMAS, and ISEAM) already have been adapted, and GIS and remote sensing technologies introduced. In the framework of the Bukhara case study the suitable LANDSAT TM image and conceptual model (IWACO) have been tested for assessment and supervised classifications. Based on image interpretations the observation and mapping of salt-affected soils and their rehabilitation measures were defined.

In other pilot study investigating the salinization process, a coupled ground water and surface water model, HYDRO-GW (Mott MacDonald et. al. 1997, 1999), has been developed with the facilitates to model the processes in the root zone and in the unsaturated and saturated subsurface system. The model is applied to the Kashkadarya Region to assess the impact of various changes in land and water management practices on reducing salinity levels. Simplified equations have been presented which have potential application for assessing the salinization process and can be used as precursors to detailed assessment using a coupled surface and ground water model. However, the GIS/RS techniques and decision support systems are not countrywide introduced due to lack management tools and experiences and economic problems.

- **The Use of Environmental Factors for Assessment of Spatial Distribution of Soil Salinity**

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It is a well accepted fact that land use and management practices in arid regions are hampered by soil salinity. Over the last few decades, the area in the Amu Darya river delta in Uzbekistan has experienced soil salinization due to intensive farming. Timely interventions such as leaching have become ever prominent with growing deterioration of the environmental conditions caused by the over exploitation of the Amu Darya and the desiccation of the Aral Sea. Salinity appraisal in the region, however, still relies upon traditional soil surveys with subsequent laboratory analyses.

The development of new statistical methods now allows the use of data sets generated or sampled on different spatial scales. The use of interpolation techniques to predict values at unsampled locations adds more opportunities to combine factors which were previously hard to incorporate. The main objective of the work was to characterize the spatial distribution of soil salinity and to estimate the spatial distribution of soil salinity on a larger scale based on readily or cheaply obtainable environmental parameters.

Soil salinity was measured by conductivity device (CM-138) on a regular grid covering an area of approximately 3 km by 4 km. Six nested samplings within selected grids were conducted to account for small-scale variation. The farm-scale (~15 km2) results were used to upscale soil salinity to a district area (~400 km2). Apart from widely used terrain indices and those acquired from remote sensing, distance to drains and long-term groundwater observation data were used to account for local parameters possibly influencing soil salinity. Standard statistical procedures were applied for data description, correlation between variables, analysis of variance, and regression. Characterization of the spatial distribution of soil salinity and interpolation of point data were carried out using geostatistics. Soil salinity estimation based on environmental attributes was carried out using a neural network model, as this offers enhanced generalization compared to other models. Analyses were integrated into a GIS for visualization and presentation of the results.

Topsoil (30 cm) salinity was highly variable even at short distances (40 m) compared to average soil salinity at 0.75 m and 1.5 m depth measured by the CM-138. Overall distribution of soil salinity was influenced by soil texture and topography, while at the local scale terrain attributes such as curvature, plan and profile curvatures, and solar radiation were the most influential factors. Groundwater table depth and salinity had marked correlations with soil salinity; however, the direction of the influence could not be explained. The inclusion of these controlling variables in modeling is fundamental, and efforts must be directed towards obtaining reliable and accurate databases in order to derive them.

With an environmental correlation model that was built for the farm scale, soil salinity was estimated using environmental parameters in a neural network approach and shows a high correlation coefficient between estimated and measured soil salinity of 0.83. The accuracy of the prediction of soil salinity was satisfactory taking into account that the measurement scales of soil salinity and environmental data derived from

- Soil Salinity Monitoring and Assessment in Irrigated Arab Agriculture.

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In the Arab world, irrigated agriculture contributes about 70% of the total crop production commodities. The irrigated agriculture in the Arab world is about 10.7 million-hectars.The irrigations systems used for irrigating such land is flood sprinklers and localized. About 87.6% for the irrigated areas is irrigated with different flood irrigations practices, 11% with sprinkler and1.4 percentage localized. The efficiencies of irrigations` systems used are not more than 50%. These low efficiencies of irrigation systems lead to increase in soil salinity and water logging of the irrigated land. In addition due to the shortage of good quality water several Arab countries has huge reservoirs of low` quality water (3-11dS/m) underground or Agricltural drainage water as well as sewage drainage water. Use of such water became visible if it is properly managed. The use of low quality water must be used with extensive planning and proper infra structure of drainage networks.

Good Agriculture practices will minimize salinity build up in the soil profile. These agricultural practices are good irrigation scheduling, addition of organic manures, deep plowing, and no tillage practices. Addition of soil inorganic and organic amendment has been used to prevent soil alkalization. Low quality water has been used by ACSAD in different Arab sates for irrigating winter crops such as barely, wheat, potato (etc) as supplementary irrigation this irrigation practice proved the income of poor framers without degrading their fields by salinity. This finding was determined by salinity monitoring for seven years in more than 80 farmer's fields and in ACSAD experimental stations more than fourteen years. The salts in these fields are leached out as far as 3.5 meters below soil surface in sandy and sandy loam soils. By measuring salts in the soil profile, salts moved down to drainage systems in clay, Clay loam and silt clay.

ACSAD used different mythology for monitoring and assessments of soil salinity these methods include Field methods such as EM38 and salinity sensors and traditional methods by collocating soil samples and determine their soil salinities. Each method of the above has some hand caps and some of them gave wrong interpretations and correlation with yield increase or decrease if not carried out by expertise .But we found the one which correlated with yield increase or decrease is the soil Solutions collected by ceramic cups.

Salt Balance in irrigated agricultural Mediterranean coastal shows most of salts, which accumulated in summer crops, leached out by rainy season in winter if the conditions of soil profile are adequate for leaching.

-On-Demand Delivery Schedule as a Toll for Reducing Groundwater Salinity

by Nicola Lamaddalena Ines Oueslati

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A study was conducted on a large-scale irrigated area located in Southern Italy to analyze the likely cumulative salt effects on aquifer due to operation techniques of the irrigation system. The area is characterized by quite high levels of groundwater salinity, likely due to intensive exploitation of the aquifer during peak water demand periods and to consequent seawater intrusion. Increase in salinity levels are noted during the first part of the irrigation season up to time of peak crop irrigation requirements. The present study aimed at assessing the impacts of different irrigation delivery schedules to groundwater quality. Two delivery schedules were simulated using a soil-water balance approach under different combinations of crop-soil-climate. The first simulation concerns the delivery schedule currently implemented by the local water management organization. The second scenario simulates the on-demand delivery schedule aiming at maximizing the crop yields. Winter and summer salinity maps were also developed through the interpolation of groundwater samples collected during pumping periods, by using a commercial GIS software. These maps clearly show a strong relation among the effects of delivery schedule, aquifer exploitation and salinity increase.

Key words: irrigation delivery schedules, groundwater pumping, aquifer salinity