Development of Soil Information System for the Turkish Republic of Northern Cyprus

A. O. Dinç

Cukurova University Faculty of Agriculture Department of Soil Science Adana, Turkey

In this study, detailed soil information based on Soil Mapping Units (SMU) that were identified during the soil survey were digitized using ArcGIS and Arc-View GIS software in order to create the Soil Information System (SIS) for the Turkish Republic of Northern Cyprus. A total of 7881 mapping units belonging to 109 soil series were compiled into the database. For each SMU geo-referenced physical, chemical and biological attributes in total 20 characteristics were entered. The selection of the criteria is based on the Soil Geographical Database for Eurasia and The Mediterranean. Spatial analysis was conducted in order to produce soil depth, slope, zinc sufficiency levels and soil salinity maps. However the capability of the database is much more where; specific information for any of the attributes could be extracted and a separate map could be processed for each individual characteristic. The spatial analysis of the data showed that 28.75 % of the soils are deeper than 120 cm where 20 % are shallower than 30 cm. Also nearly 60 % of the country soils are on slopes between 0 to 6 %. The results of the soil salinity analysis were 3.5 % of the country soils had salinity problems where 27 % had zinc deficiencies. Soil Information System (SIS), which could be used for sustainable development for the Turkish Republic of Northern Cyprus, is completed with this study. This study can assist and provide detailed soil information for agronomists as well as decision-makers from other disciplines for the improvement and sustainability of the country.

Keywords: Soil map, GIS, slope, salinity, Cyprus, Soil Information System.

Kuzey Kıbrıs Türk Cumhuriyeti İçin Toprak Bilgi Sisteminin Oluşturulması

Bu çalışmada, Kuzey Kıbrıs Türk Cumhuriyet'inde (KKTC) daha önce yapılmış olan detaylı toprak haritaları ve toprak etüd raporu sonucunda belirlenen haritamala birimleri ArcGIS ve Arc-View yazılımları kullanılarak Toprak Bilgi Sistemi oluşturulması amacıyla sayısallaştırılmış ve toplam 109 farklı toprak serisine ait coğrafi konumları belli olan 7881 haritalama biriminin fiziksel, kimyasal ve biolojik özellikleri veri tabanına girilmiştir. Bu özellikler, Avrasya ve Akdeniz Coğrafi Toprak Veritabanı kriterleri göz önünde bulundurularak seçilmiştir. Toplam 20 adet toprak özelliği veri tabanına girilmiş ve alansal analiz yöntemleri kullanılarak; derinlik, eğim, tuzluluk ve çinko noksanlık özellikleri seçilerek örnek haritalar oluşturulmuştur. Ancak KKTC Toprak Bilgi Sisteminin kapasitesi çok daha fazla olup şeçilen her bir özellik için farklı haritalar oluşturmak da mümkün olmaktadır. Alansal analiz sonucunda ülkenin tarım topraklarının % 28.75'in 120 cm'den derin ve % 20'sininde 30 cm'den sığ topraklardan oluştuğu saptanmıştır. Ayrıca toprakların % 60'ının % 0-6 eğim aralığında olduğu tespit edilmiştir. Bunun yanısıra ülke topraklarının % 3.5'ğunun farklı seviyelerde tuzlu olduğu saptanmış ve % 27'sinde ise cinko noksanlığı belirlenmiştir. Bu çalışma sonucunda oluşturulan KKTC Toprak Bilgi Sisteminin kullanılarak, tarımcılar, mühendisler ve planlamacılara farklı toprak özelliklerine ait haritaların sunulmasıyla, ülke düzeyinde gelişmeye ve sürdürülebilirliğe katkı sağlaması hedeflenmiştir.

Anahtar kelimeler: Toprak haritası, CBS, eğim, tuzluluk, Kıbrıs, Toprak Bilgi Sistemi

Introduction

Soil is one of the essential elements of the biosphere which necessitates a global policy for management, evaluation and conservation (Borlaug and Dowswell, 1994). To implement such a policy, it is necessary to have information harmonized both in space and time (Bouma and Bregt, 1989). Soil information is often used as part of spatial decision-making processes. Until recently it was available mainly as printed soil maps and text-based information. But soil maps are graphically constrained and thus cannot hold an infinite quantity of information. Also they have a static nature in which changes and upgrades are very difficult to implement. Relatively they have to present a simplified view of reality in order to adhere to readability constrains. Finally, most users agree with the fact that maps are usually correct but that they are often still difficult to interpret (Msanya et al. 1987).

Geographical Information Systems provides a powerful tool to present and analyze soil information (King et al. 1995). Entering and extracting of information once it is compiled into the GIS is become much easier, efficient and faster.

Request for information on land use and soil conservation require increasingly accurate information on soil properties and their geographical location. Soil maps have always been useful documents that met these requirements thus helping in decision-making processes. Information presented on soil maps and reports are now managed by computer teqniques using Geographical Information Systems (GIS) (Finke at al. 2003)

Development of the Soil Geographical Database for Eurasia and the Mediterranean is based on SMU and STU's. Using Arcinfo software 1:1000000 scale soil database is under development. The database contains a list of STU's characterizing distinct soil types that have been identified and described. The STU's are described by attributes (variables) specifying the nature and properties of soils (Lambert et al. 2003).

The aim of the study is to create a Soil Information System that will identify areas with management problems or limitations for crop production as well as land use because of soil characteristics. Readily available information on soils will assist the overall objective of the study. Geographical Information Systems will be used to achieve the goals of this project. The information produced will assist the planning and decision making processes which is a great importance for a developing country. Soil Geographical Database for Eurasia and the Mediterranean criteria will be considered for the development of the Soil Information System for Turkish Republic of Northern Cyprus (Lambert, et al. 2003).

Materials and Methods

Soil survey report and detailed soil maps 1:25000 scale of Turkish Republic of Northern Cyprus was used as the basis of soil information (Dinç et al. 2000). The total area is 334959 ha. Soil data such as topsoil texture, slope, soil depth, stoniness, salinity, land capability classes, potential land use classes, and irrigation suitability classes that are present in the detailed soil maps are entered for each SMU. Also data belonging to each soil series which are presented in the soil survey report (Dinç et al. 2000) such as; organic matter, zinc, manganese, iron, copper, potassium, phosphorous levels as well as pH, dominant texture of the profile, cation exchange capacity, % calcium, infiltration rates, bulk density and soil associations, which could affect the crop production and decision making are compiled in to the database.

ArcGIS and Arc-view GIS software was used to digitize and analyze information (ArcGIS, 2006; Arc-View, 2000).

This study consisted of five stages:

-digitizing of SMU

-entering attributes for each SMU

-selecting and entering soil series information for each SMU (Building Topology)

-conversion of polygons into raster format

-query and analysis

Detailed soil maps 1:25000 scaled were digitized as polygons and their attributes were

entered in to the database for each SMU. Each SMU is defined by a unique integer number (the SMU identifier) and each SMU are represented on the map by at least one polygon (Finke et al. 2003).

A total of 20 soil properties belonging to SMU's were entered into the database as numeric or alphanumeric information, depending on their format or representation in the soil survey report in order to create the attribute table. To make an user-friendly approach some soil properties are classified into groups prior to entry into the database to minimize the confusion. Especially micro and macronutrient, and soil salinity levels are classified in order to make the end user understand and interpret much easily. The reason for this approach was users from different background other than agronomy could understand and interpret the results/maps more efficiently. Therefore these soil properties are entered into the database as sufficiency or severity levels. The other soil characteristics were entered in the same format as they are represented or presented in the detailed soil maps and soil survey report.

Selected soil characteristics are analyzed using spatial analysis teqniques provided by the software (ArcGIS, 2006). The polygons that are digitized are converted to raster format in order to calculate the area coverage by each SMU's classes. The pixel/cell size are set to100m*100m.

Based on the systematic collection of quantitative and qualitative information the aim of spatial analyses are the careful and accurate description of events in geographical space and improving the ability to predict and control events occurring in geographical space (Haining, 1995). The spatial analysis of soil depth, slope, zinc and salinity levels based on the information available on the database are undertaken in order to produce the geographical distribution of these properties within the Turkish Republic of Northern Cyprus.

Results and Discussion

Limited number of maps are analyzed and presented for this study because of limited space. However it is possible to produce for any of the characteristics which are available in the database. Only selected soil properties are presented in this section. These are; soil depth, slope, salinity and zinc levels maps.

Soil depth distribution map is given in Figure 1. Soils which are deeper than d0 (represented as +120 at the mapping legend) have the highest coverage with 96,230 ha which represents 28.75 % of the country. The second highest coverage is by d4 (represented as 0-30 cm at the mapping legend) with 67070 ha which is 20 % of the total area. The other soil depth are 37768 with 11.3% for d1 (90-120cm), 35953 ha with 10.75% for d2 (60-90 cm), 44917 ha with 13.4 % for d3 (30-60 cm). Areas which are excluded from survey covered 53021 ha with 15.8% of the total area. As a result; nearly half of the soils in Turkish Republic of Northern Cyprus that was surveyed have deep or very shallow soils depths. This information is useful for the planning of irrigation projects for agronomist as well as planning of the infrastructure for the engineers where excavations could be difficult on shallow soils for example when under laying pipelines or cables in the ground.

Soil slope map distribution map is given in Figure 2. The highest coverage on soil slope is class3 73292 ha (represented as 2-6 % slope) representing 21.8 % of the country. The second highest coverage is class2 (represented as 1-2 % slope) 68837 ha with 20.5 % of the area. The other soil slope classes are distributed as: class1 (0-1 % slope) 51479 ha with 15.30 %; for class4 (6-12 % slope) 28984 ha with 8.65 %; for class5 (12-20 % slope) 26541 ha with 8 %; for class6 (20-50 % slope) 26305 ha with 8 % and class7 (50-90 %) 6693 ha with 2 %. Nearly 60 % of the soils are between 0-6 % slope range. This information could be used for irrigation planning as well as erosion risk assessment and for runoff control projects from soils.

Spatial analysis of the soil salinity map (Figure 3) showed that 81.2 % (271867 ha) of the countries soils have no salinity problems represented as class1. However 2.4 % (7075 ha) were severely saline concentrating in Meseria Plain as class4. Only 1 % (3054 ha) are slightly saline as class2 and soil that have moderate salinity is 0.05 % (135 ha) class3.

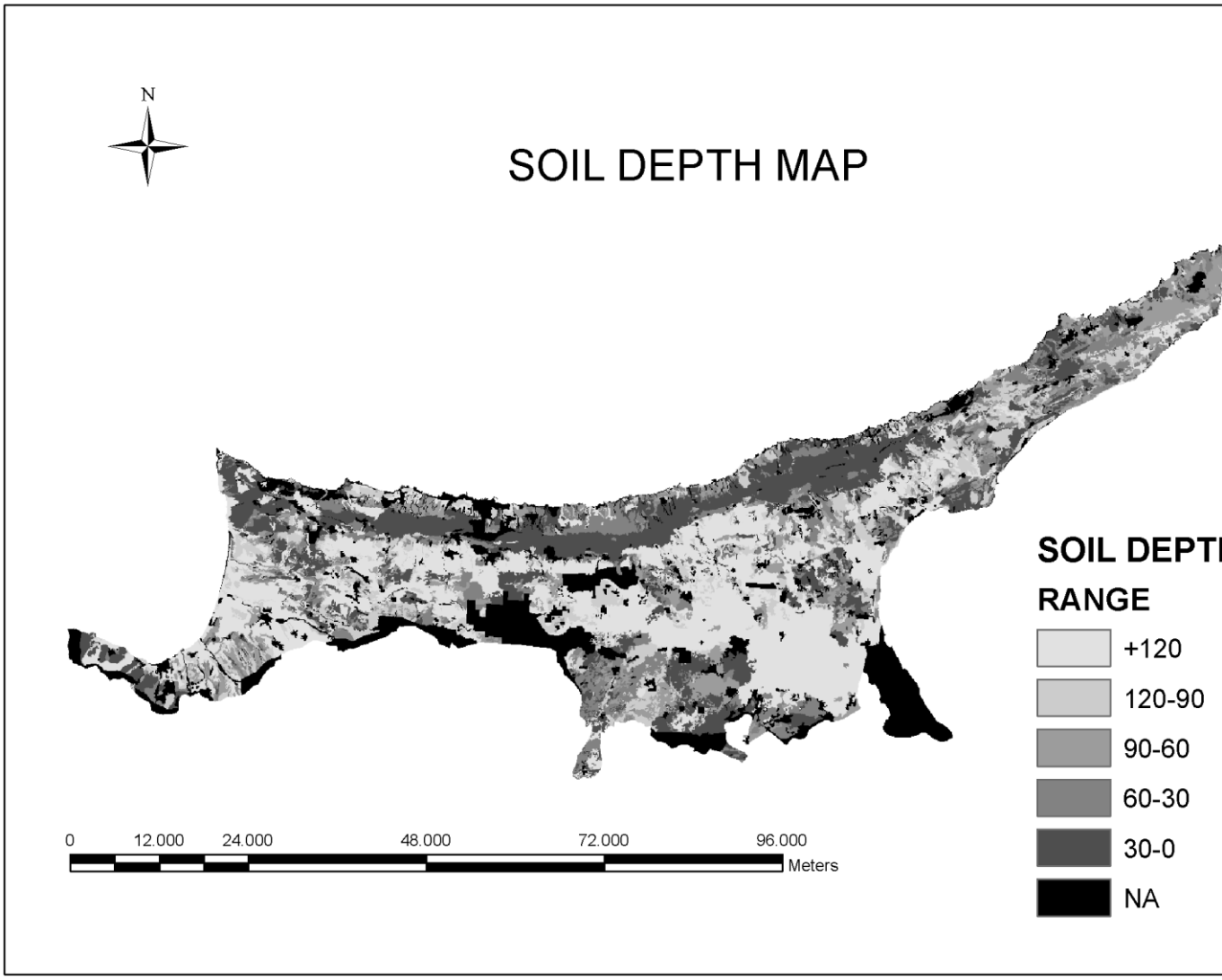

Figure 1. Soil depth map of the Turkish Republic of Northern Cyprus.

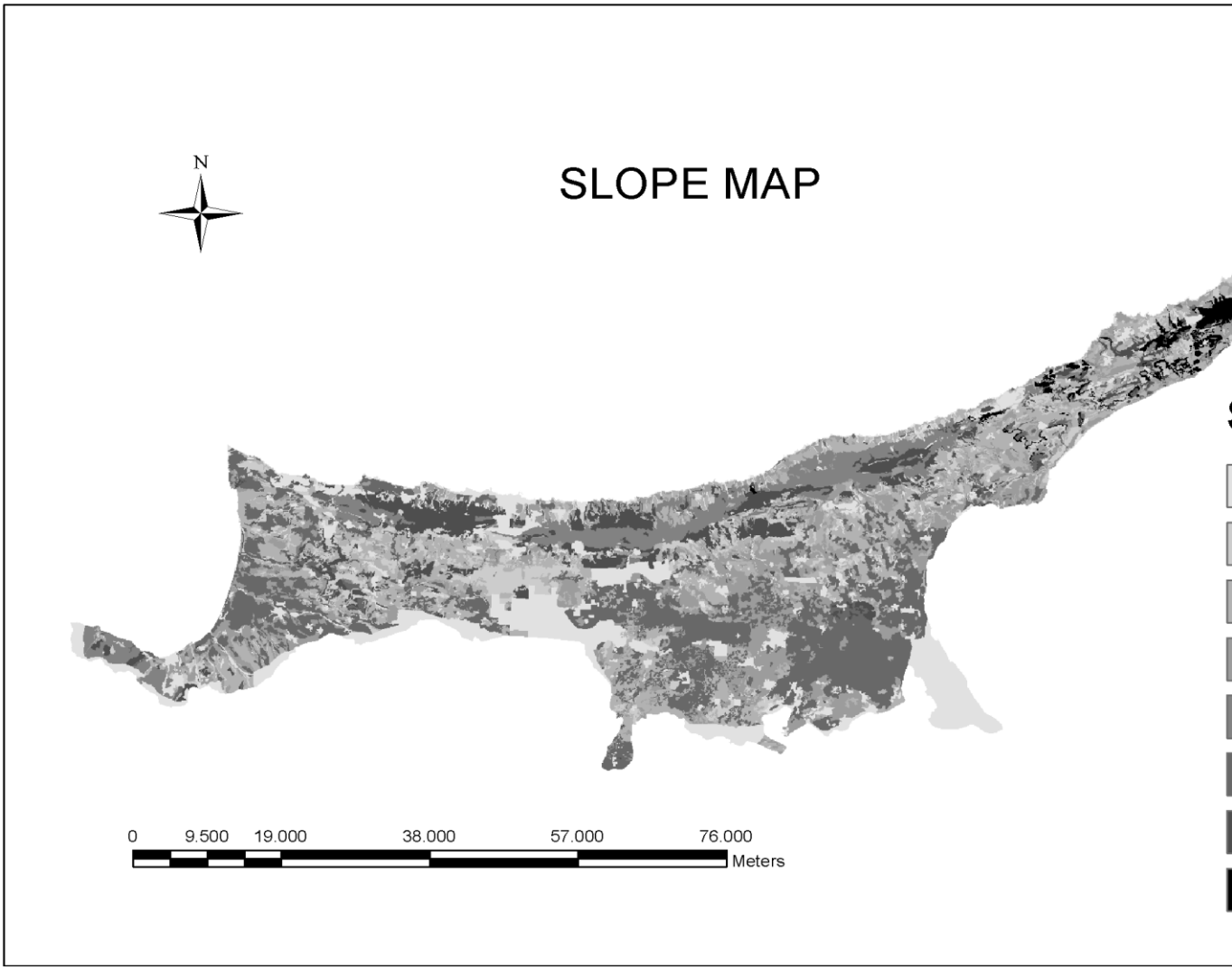

Figure 2. Slope map of the soils for the Turkish Republic of Northern Cyprus.

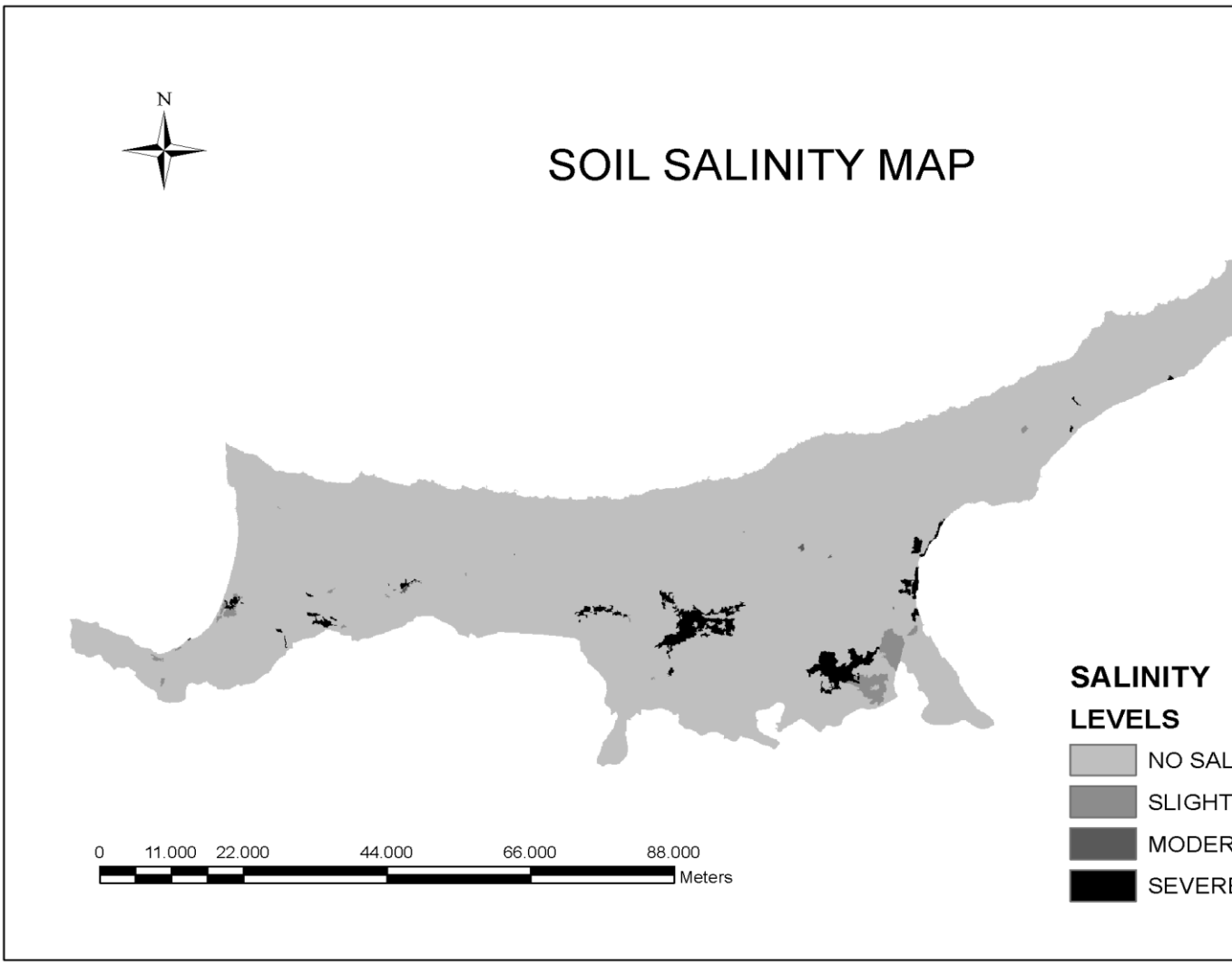

Figure 3. Salinity map of the soils for the Turkish Republic of Northern Cyprus.

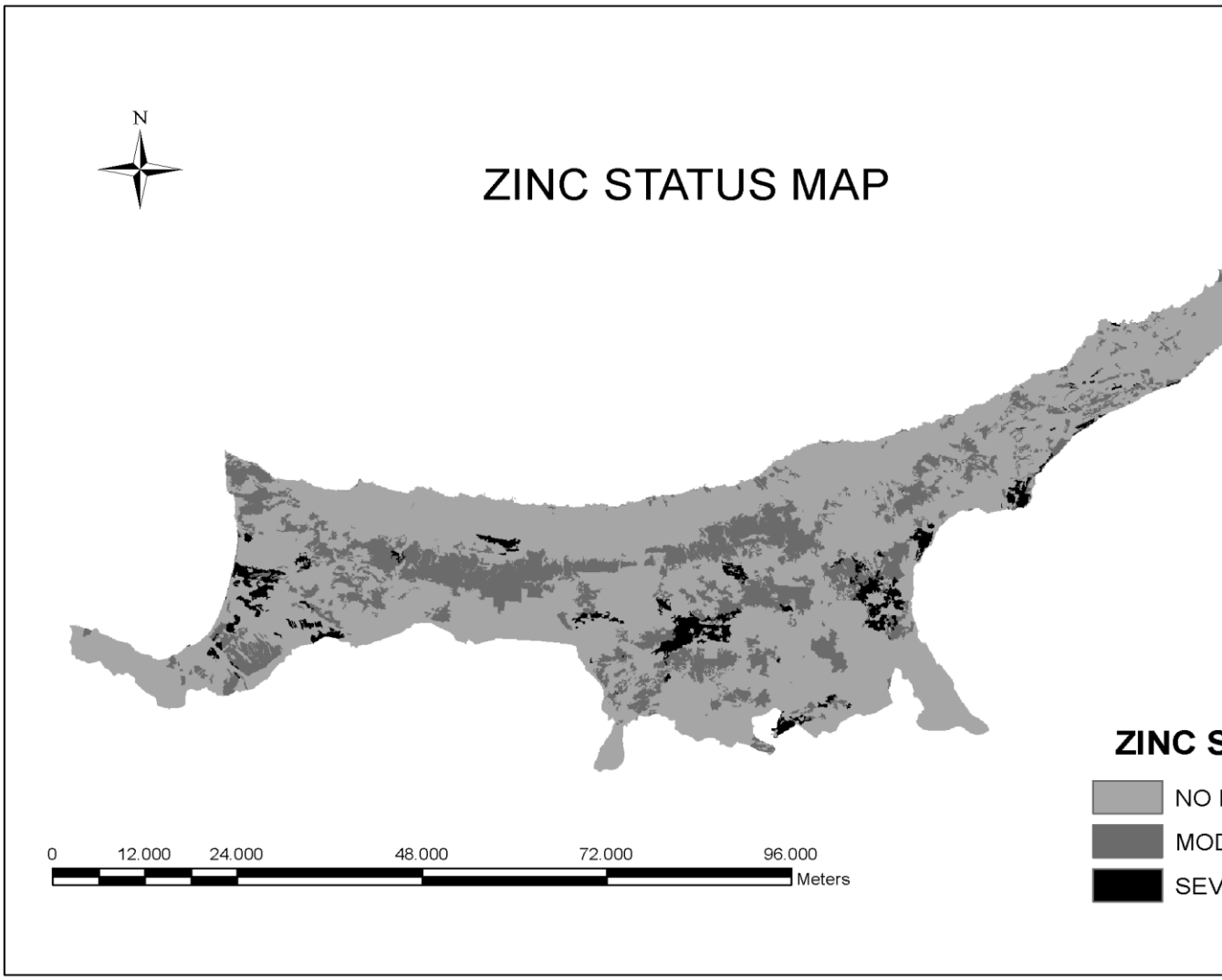

Figure 4. Zinc status map of the soils for the Turkish Republic of Northern Cyprus.

These identified areas provides useful information on soil salinity levels where laying of sub-surface drainage could decrease salinity levels. These kind of data of course can be useful for the identification and application of micro-nutrients on soils where deficiencies are identified.

Zinc status of the soils are also analyzed (Figure 4) and 61 % (203890 ha) of the soils have no zinc deficiency represented as class1. Only 23.7 % of the soils have zinc deficiency with 3.7 % severe deficiency level as class3. The other soils with moderate deficiency covered 20 % (65720 ha) of the country as class2.

Conclusion

The Soil Information Systems could provide critical information for all disciplines, especially for developing countries where sustainable growth has vital importance. Geo-referenced soil data could assist in the decision making process and planning. Hard copy soil maps are rather difficult to understand and interpret for planners from different backgrounds other than soil scientists. Therefore this study will provide essential information, which is easy to produce and interpret by all disciplines. Also its dynamic setup will enable to upgrade and add geo-referenced information with relative ease. Therefore it is also responsive database. The soil information present in the database will enable user to calculate or establish land qualities using pedo-transferic functions. Also data could be cross analyzed or combined with each other in order to produce more complex maps such as; physical suitability maps for individual crops or for a particular type of land use. However this could result high number of classes in which presentations and interpretations could be difficult.

References

Borlaug, N.E. and C.R. Dowswell, 1994. Feeding a human population that increasingly crowds a fragile planet. 15th Congress International Soil Science Society, Acapulco, July 10-16 1994. Keytone lecture. 1-15.

Bouma, J. and A.K. Bregt (eds)., 1989. Land qualities in space and time. Pudoc, Wageningen. 32pp.

Dinç, U., R.M. Derici, S. Şenol, S. Kapur, M. Dingil, A.O. Dinç, E. Öztekin, A. Sarıyev, B. Torun, L. Başyiğit, Z. Kaya, M. Gök, E. Akça, İ. Çelik, İ. Ortaş, M.A. Çullu, N. Güzel, H. İbrikçi, İ. Çakmak, V. Peştemalcı, Ö. Çakmak, C. Karama, H. Özbek, Ş. Kılıç, N. Sakarya, A.K. Çolak, I. Onaç, İ.Yeğingil, K.Y. Gülüt, L. Atatanır, L. Öztürk, G. Büyük, A.Çoşkan ve M. Müjdeci, 2000. Kuzey Kıbrıs Türk Cumhuriyeti Detaylı Toprak Etüd ve Haritalama Projesi. KKTC Tarım ve Orman Bakanlığı Ç.Ü. Ziraat Fakültesi Toprak Bölümü Bilimsel ve Teknik İşbirliği. Lefkoşa. Cilt I, p648.

Finke, P., R. Hartwich, R. Dudal, J. Ibanez, M. Jamagne, D. King, L. Montanarella and N. Yassoglou, 2003. Manuel of Procedures. Georefenced Soil Database for Europe. European Commission Joint Resarch Centre. Italy. p 163.

Haining, R., 1995. Designing spatial data analysis modules for geographical information systems. *In:* Spatial Analysis and GIS. Great Britain Burgess Science Press. pp 45-63.

King, D., A. Burrill, J. Daroussin, C. Le Bas, R. Tavernier and E. Van Ranst, 1995. The EU Soil Geographic Database. *In:* Agriculture; European land information systems for agro-environmental monitoring. European Commission Joint Resarch Centre. Italy. pp:43-60.

Lambert, J.J., J. Daroussin, M. Eimberck, C.Le Bas, M. Jamagne, D. King and L. Montanarella, 2003. Soil Geograp hical Database for Eurasia&The Mediterranean: Intructions Guide for Elaboration at Scale 1:1000000 version 4.0. European Commission Joint Resarch Centre. Italy. p58.

Msanya, B.M., R. Langomr and C. Lopulisa, 1987. Testing and improvenment of a questionnaire to users of soil maps. *Soil Survey and Land Evaluation*. 7: 3-42.