NeWater

THE ADVANCED MONITORING AND INFORMATION SYSTEM (AMIS)

A GIS-based System for Soil Salinity Assessment and Monitoring

Part 1: Integration of Local Knowledge

MANUAL

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CHAPTER 1

Introduction

This document is a manual for soil salinity assessment and monitoring using the Advanced Monitoring and Information System (AMIS) prototype software. The AMIS was developed within the frame of the European Project NeWater. The functionality of the system was tailored to the requirements of the Amudarya case study in Uzbekistan. Together with local scientists, farmers, and persons working in soil salinity monitoring and water management in the Khorezm oblast, a methodology to assess the state of soil salinization of agricultural fields was developed. The data used to assess soil salinity is divided into two parts: (1) local knowledge that is provided by farmers, and (2) expert knowledge that is provided using scientific methods. Information about soil salinity is collected and entered into the system at the field scale. Therefore, a vector map of agricultural fields is an important prerequisite. Spatial as well as temporal data about soil salinity are stored and administered in a database. A Geographic Information Systems (GIS) is used to enter, access, and visualize the data. The objectives of the implementation of AMIS in the study area are twofold. On the one hand it provides functions to integrate local and expert knowledge in order to improve soil salinity assessment at the field scale, and on the other hand the system can be used to monitor trends of soil salinization in the long term. Please note that the current version of the soil salinity assessment approach has not yet been applied and needs to be verified on various test sites.

This manual guides the user through the soil salinity functionalities of the AMIS and is focusing on following aspects:

- Creating a soil salinity map
- Soil salinity data input
- Loading soil salinity data from the database
- Visualization of the soil salinity map
- Comparison of soil salinity at different time steps
- Reporting tool (monitoring of soil salinity trends)

1.1 Software components

The AMIS consists of various software components: (1) the Geographic Information System SAGA GIS (http://sourceforge.net/projects/saga-gis/); (2) the object-relational database management system PostgreSQL (www.postgresql.org); (3) the spatial extension PostGIS

(http://postgis.refractions.net/); and (4) a GIS-database interface (GDI). Freely available and open source software was used in all of this.

SAGA GIS is the main component of the AMIS and acts as user interface. The GDI was integrated into the GIS and provides functions to exchange spatial and temporal data between GIS and database. Specific functions tailored for soil salinity assessment and monitoring, such as data input, visualization, comparison, and reporting, were implemented in the GDI.

In order to avoid the storage of data in various files, the PostgreSQL database is used to store and administer all available data. The benefit of this approach is that the database can be installed on a server and data provided to any system that has access to the server. Thus, the system can be used in a multi-user mode. Alternatively, the database can be installed on the same PC as the GIS. In this case it is a single-user system. The extension PostGIS enables the database to deal with geographic data in vector format. This is necessary to be able to manage spatial data, such as the map of agricultural fields for soil salinity assessment and monitoring. The OGC (Open Geospatial Consortium) Simple Features were implemented for this purpose.

- The modified SAGA version *SAGA AMIS* (including the GDI and all soil salinity monitoring functions) is available on the following website: http://www.ufz.de/index.php?en=17262
- PostgreSQL, object-relational database management system, open source, freely available, (http://www.postgresql.org/)
- PostGIS http://postgis.refractions.net/, the spatial extension for PostgreSQL

1.2 System requirements

Although, the system is based on platform independent software components, it is currently available for Windows operating systems (2000/XP) only. Windows Vista has not yet been tested.

In the future it is planned to provide the system also for Linux. For this purpose the modified SAGA GIS version must be compiled under Linux.

Hardware requirements have not been tested.

1.3 Installation

SAGA

SAGA GIS runs without installation. In other words: administration rights on the computer, which are usually necessary to install software, are not required.

Copy the SAGA directory to any directory on your hard disk and double-click in a file manager on 'saga_gui.exe' in order to start the program. Theoretically it is also possible to start SAGA from a USB memory stick, but in this case you will probably suffer from a lack of performance, so it is not recommended.

PostgreSQL/PostGIS

Please, see the installation instructions provided on the PostgreSQL and PostGIS hompages.

CHAPTER 2

Creating a Soil Salinity Base Map

In order to avoid the storage of soil salinity data in various files, all data – spatial as well as temporal data – are stored in a database. In this chapter is explained how a map that represents agricultural fields will be converted to a soil salinity base map and exported to the database. The monitoring approach is designed to collect and store information on soil salinity at the field scale. Therefore, the field map is the basis to give the collected data a spatial reference. Please note that this step must be performed only once.

If the soil salinity base map already exists, this chapter can be skipped.

2.1 Loading a basis map into SAGA GIS

The basis to realize the soil salinity assessment and monitoring is a map of agricultural fields of the area of investigation. Hence, the first step is to load an existing vector polygon map to the SAGA Workspace. Oftentimes, such a map is available in the ESRI shape file format. To load a map into SAGA GIS use function *Load Shape File* from the menu *File* ► *Shapes* ► *Load* Shapes as shown in Figure 1 below. If such a map does not exist, it must be created first, e.g. by digitizing.

Figure 1. Loading an ESRI shape file

Note:

*It is important that the map is of type POLYGON, where each agricultural field is represented by **one** polygon. Polygons are closed features and cannot be represented by closed lines for instance. If the map is not of the proper type it is impossible to export it to the database and to use it for this purpose.*

2.2 Modifying the attribute table

The step described in this sub-section is not necessarily required, but recommended in order to increase the performance of the system later on and to avoid redundant information. Usually, a shape file has an attribute table containing information that is not required for the purpose of soil salinity assessment and monitoring. All attributes (columns) that are not necessary in this context should be deleted, except for columns used to identify the fields, such as field number, name of owner etc. Probably, you do not want to delete these columns from the original shape file. Hence, **first save a copy** of the shape file. Therefore, right-click on the shape file in the SAGA Workspace to open the context menu (see Figure 2). Choose a name for the copy and load this copy *File* ► *Shapes* ► *Load Shapes* into the SAGA Workspace again.

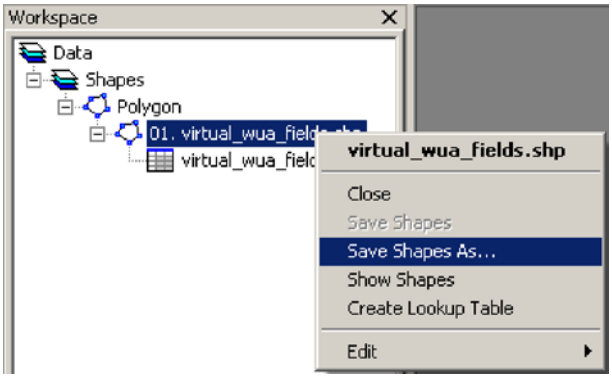

Figure 2. Saving a copy of the original shape file

How to delete columns from an attribute table is described in the following. Click on the ⊞ symbol next to the *copied* shape file in the SAGA Workspace as shown in Figure 3 below. Double-click on the attribute table to open it. Use the delete function in the menu *Table* ► *Delete Fields* to delete the fields that are not required.

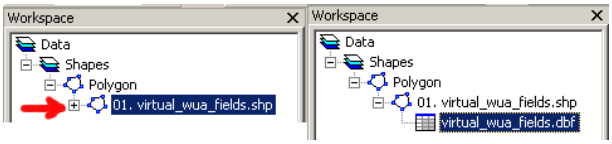

Figure 3. Open attribute table

2.3 Database connection

Before the map (shape file) can be exported to the database make sure that a connection between GIS and database exists. Use menu *Database* ► *Connect to Database* to open the required dialog (see Figure 4 below). Table 1 gives an explanation of the connection parameters of the dialog. If the database is located on the same PC the host is usually *localhost* and the port number *5432*. Moreover, the *database name*, the *user name*, and a *password* are required to connect to the database. If the database is located on a server, the IP address is required additionally.

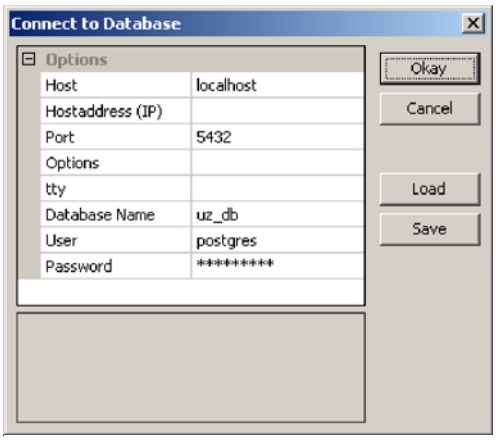

Figure 4. Database connection dialog

Table 1. Database connection parameters

Option	Description
Host	Name of host to connect to. On machines without Unix-domain sockets, the default is to connect to ***localhost***.
Hostaddress (IP)	Numeric IP address of host to connect to. This should be in the standard IPv4 address format, e.g., 172.28.40.9. If your machine supports IPv6, you can also use those addresses.
Port	Port number to connect to at the server host, or socket file name extension for Unix-domain connections. If the host is localhost, the port is usually ***5432***
Options	Command-line options to be sent to the server. *Usually not required in this application, leave it blank.*
tty	Ignored (formerly, this specified where to send server debug output). *Usually not required in this application, leave it blank.*
Database Name	The database name to connect to.
User	PostgreSQL user name to connect as.
Password	Password to be used if the server demands password authentication.

After assigning the required parameters press button *Okay*. If the connection command was successful, the entries of the database menu are activated, as shown in Figure 5.

2.4 Creating and exporting the soil salinity base map

After the basis map of agricultural fields has been modified and loaded into the SAGA Workspace and the connection to the database is established, as described in the previous sub-sections, the soil salinity base map can be created and exported to the database. Therefore, use function: *Database* ► *Soil Salinity Assessment* ► *Create Soil Salinity Base Map* as shown in Figure 5 below.

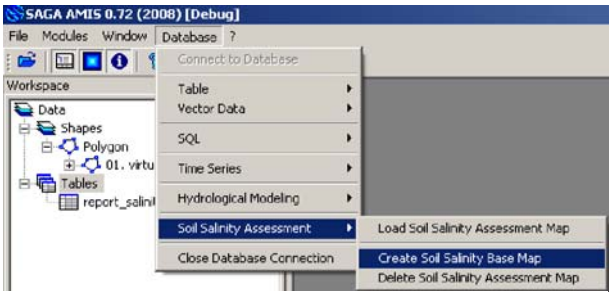

Figure 5. Menu create soil salinity map

A dialog to select the basis map of agricultural fields (polygon shape file) will pop up (see Figure 6 below).

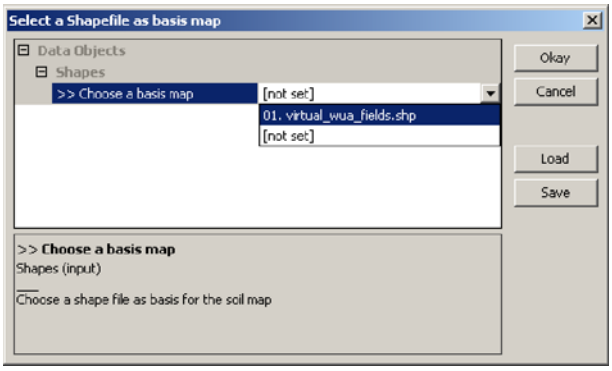

Figure 6. Select basis map dialog

Select the desired shape file and press button *Okay*. The following dialog (Figure 7) will then be displayed. Specific attributes (listed in Table 2) are required by the soil salinity assessment method and will be added to the map's attribute table in the database automatically. An important column in this context is column "FID". Each feature (agricultural field) gets a unique identifier (integer number) which is required by the database management system.

Choose a map name, but do not use any special characters, such as: "+ - * / % & $ § ?" and do not use upper case letters. Blank spaces are also prohibited. If you want to separate the map name use the underscore "_" instead of a minus "-". It is suggested to add a prefix like "ssm_" to the map name, where ssm stands for **s**oil **s**alinity **m**ap for instance.

The option *Primary Key Column* allows you to select an existing column to be used as primary key in the database. It is strongly recommended **not** to modify the suggested column (FID).

Usually, you do not have to care about the settings in the section *Geometry Columns*. Use the default settings.

In section *Spatial Reference System* you need to specify the spatial reference system of your basis map. If you do not have any information about the used reference system type in the value "-1". Finally press the *OK* button to export the map to the database.

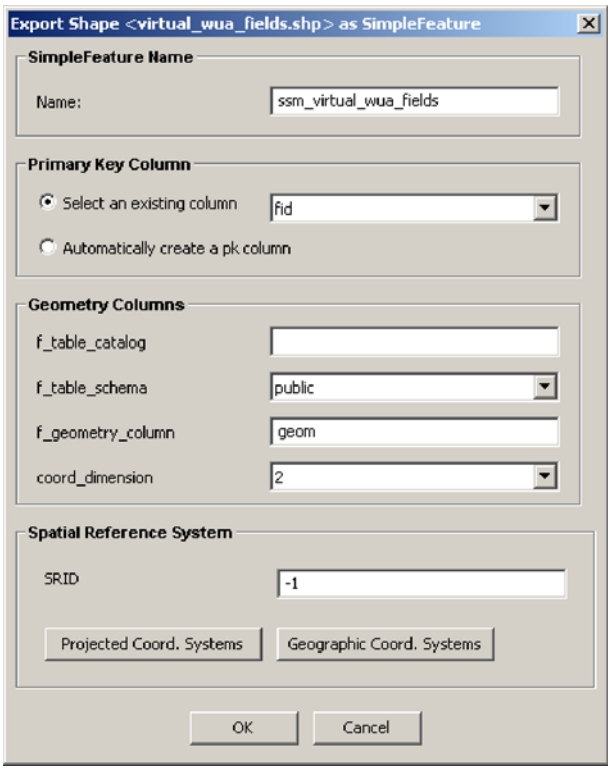

Figure 7. Map export dialog

Table 2. Required soil salinity attributes

Attribute name	Description
FID	**Feature identification** number (agricultural field). This will be an integer number and automatically act as the primary key in the database.
yr	The **year** in which the soil salinity assessment has been accomplished.
mnth	The **month** in which the soil salinity assessment has been accomplished.
SALINITY	The salinity value as a word: *low, medium* or *high.*
SALINITY_V	The **salinity value** as a number between 0 and 1.
SALINITY_L	The salinity value estimated by using factors representing **local knowledge**.
SALINITY_E	The salinity value estimated by using factors representing **expert knowledge**.
MS_LOW	The **degree of membership** to the fuzzy membership function low. A value between 0 and 1.
MS_MEDIUM	The **degree of membership** to the fuzzy membership function medium. A value between 0 and 1.
MS_HIGH	The **degree of membership** to the fuzzy membership function high. A value between 0 and 1.
PLANT	The **plant** that was growing in the period before the soil salinity assessment.

After pressing button *OK* in the export dialog (Figure 7) the geometries of the base map will be exported to the database in the OGC (Open Geospatial Consortium) conform Simple Feature format. Depending on the file size this process could take a while. After a successful export the soil salinity map will be automatically loaded into the SAGA Workspace as data type *SimpleFeatures*. Additionally, three attribute tables are stored and connected to the soil salinity map in the database. These tables **must not** be deleted, otherwise the system does not work properly or breaks down. The nomenclature of the attribute tables is a combination of a specific prefix + map name as described below.

- The table with the prefix "_attr_" stores all information about soil salinity. In case the name of the soil salinity map is: "*soil_salinity_map*" the name of the attribute table is: "*_attr_soil_salinity_map*". If this table gets lost, all information will be deleted and can not be replaced or recovered easily.
- The table with the prefix "_settings_" contains the parameter settings of the soil salinity assessment input dialog (Figure 10) for each field and time step.
- The table with the prefix "_weights_" contains the current settings of weighting factors. Each soil salinity parameter has a weighting factor (degree of importance).

2.5 Deleting a soil salinity map from database

There are different ways to delete a soil salinity map from the database.

- **Deleting the entire soil salinity project:** In case you want to delete the entire soil salinity project (the map and all corresponding attribute tables) use function *Delete Soil Salinity Assessment Map* as shown in Figure 5 above. Be aware that **all soil salinity data will be lost** in this case. Please read chapter 5 if you want to make a backup before deleting the data.
- **Deleting the soil salinity map only:** If you want to delete only the map but keep the soil salinity data in the database you can use function *Database* ► *Vector Data* ► *Delete SimpleFeature.* In this case only the map will be deleted but the three attribute tables, described in the previous sub-section, will be kept in the database.

CHAPTER 3

Soil Salinity Data Input

In this chapter is described how information about soil salinity at the field scale can be entered into the system. The existence of a soil salinity base map in the database is a precondition to accomplish this. In case such a map does not exist, please read the previous chapter (Creating a Soil Salinity Base Map) first in order to learn how to create and export a map to the database.

3.1 Loading a soil salinity map from the database

In order to access and enter soil salinity data into the system, load a soil salinity map from the database using function *Load Soil Salinity Assessment Map* from the menu *Database* ► *Soil Salinity Assessment* ► *Load Soil Salinity Assessment Map* (see Figure 8). It is important to use this function to load the map, because only then SAGA GIS "knows" that the map is not any map, but a soil salinity map. Otherwise, specific soil salinity functions are not available later on.

Figure 8. Menu load soil salinity map

Choose the desired map in the import dialog and press button *Okay*. The map will be loaded into the SAGA Workspace as data type *SimpleFeature* and displayed automatically.

3.2 Soil salinity assessment input dialog

Figure 9 shows a virtual soil salinity map (*ssm_virtual_wua_fields*). Use the *Action Tool* from the map toolbar in order to select any field in the map and right-click on it to open the context menu. If the context menu does not pop up, please have a look into section 6.5 Context menus for help.

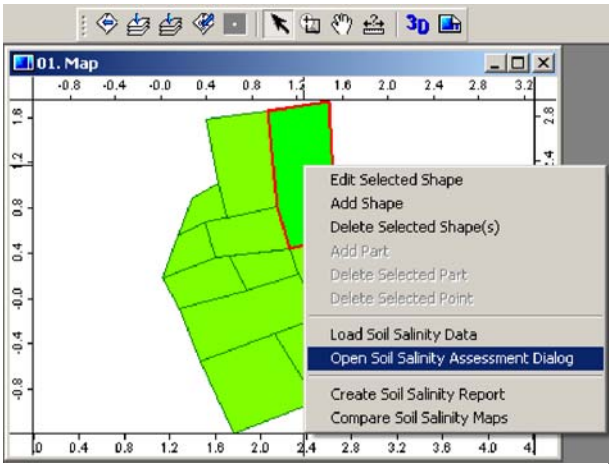

Figure 9. Load Soil Salinity Assessment Dialog

The command *Open Soil Salinity Assessment Dialog* opens the dialog shown in Figure 10 below that is used to enter and modify soil salinity information.

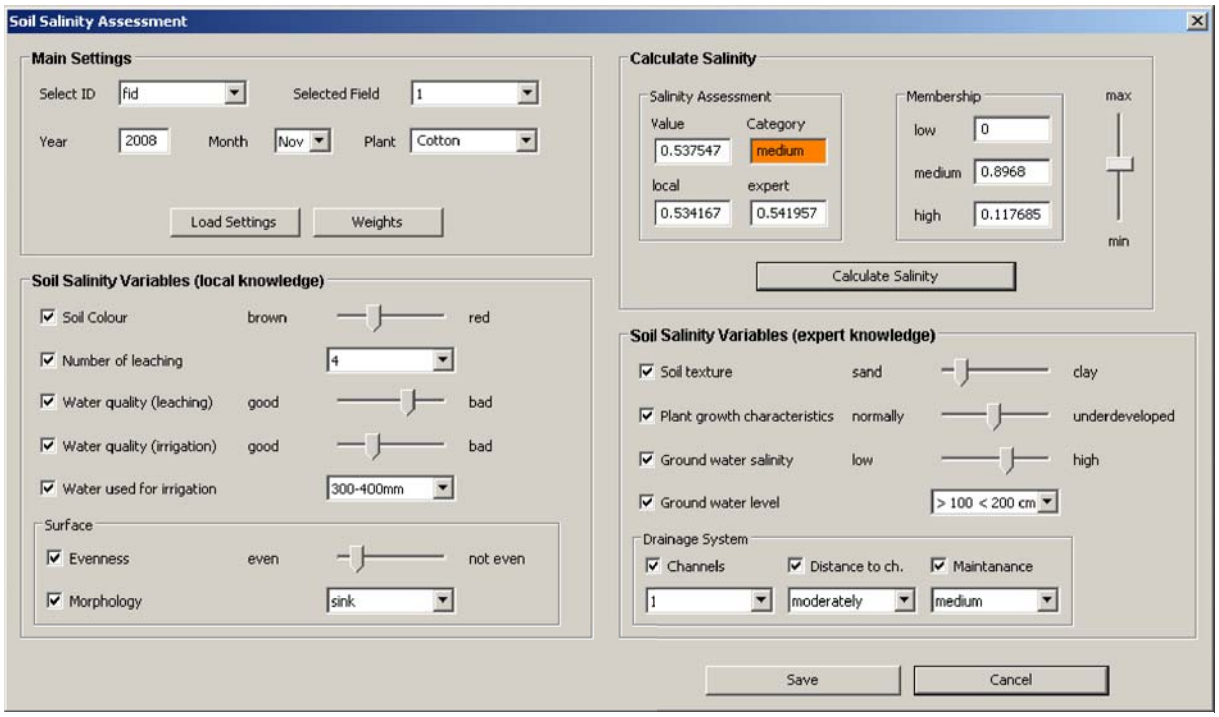

Figure 10. Soil salinity assessment input dialog

Use the controls of the dialog to enter all available information. Select the agricultural field and the date in the *Main Settings* part. Information on soil salinity can be entered into the *Soil Salinity Variables* sections for local and expert knowledge. The checkboxes ☑ before each parameter can be used to activate or deactivate the corresponding parameter. Unmark the box if no information is available. In this case the parameter is not taken into account in the salinity calculations. All parameters of the soil salinity assessment input dialog are described in the following tables. Table 3

describes parameters of the “Main Settings”, Table 4 “local knowledge”, Table 5 “expert knowledge”, and Table 6 “Calculate Salinity”.

Table 3. Soil salinity assessment “Main Settings”

Parameter	Description
Select ID	Defines the column that is used to identify the agricultural fields. In the example the FID column is used to identify the fields.
Selected Field	The selected agricultural field to which the data will be assigned to. If the field selection changes, the field selection in the soil salinity map will change accordingly. Thus, the user is always aware to which field the data will be assigned to.
Year	The year (4 digits) of data collection, use FORMAT (YYYY)
Month	Select the month of data collection. **Note**: If data are collected in different month, but belong to the same data collection period choose the same month. In the Khorezm Oblast data are collected after the harvesting time in November, thus always choose Nov in this case.
Plant	The plant that was growing on the field before harvest. Type in the name of the plant or select a plant from the drop down control.
Button *Load Settings*	This button loads previous settings (if exist) of all parameters according to the selected *field*, *year,* and *month*. This option is useful to avoid the input of information that is more or less static, like *Evenness, Morphology, Soil texture, Channels,* and *Distance to channel*. Hence, if you like to input data for the year 2008 (November) to field number 1, you can first load the settings from the previous year 2007 (November). Therefore, type 2007 in the control *Year*, select the field number 1 in the control *Selected Field,* and press the *Load Settings* button. If data are available the settings of the controls will change accordingly.
Button *Weights*	Each parameter has an importance degree or weight, respectively. This is important for the soil salinity estimation. The higher the importance of a factor the more weight it has in the salinity estimation method. The relative importance of each parameter was defined during a workshop with WUA (Water User Association) chairmen in April 2008 in Urgensh. The default values of the importance according to the workshop results are shown in Table 9. By pressing the button *Weights* the dialog shown in Figure 12 opens. The dialog can be used to modify the weighting factors.

Table 4. Soil salinity variables (local knowledge)

Parameter	Description
Soil Colour	The range is from *brown* to *red*. These are the terms used by the farmers, where brown means low or no salinity, and red determines a highly salinized soil.
Number of leaching	The number of leaching processes performed before the last growing season. The number of leaching processes is an indicator for the salinity before the growing season.
Water quality (leaching)	Farmers distinguish between *good* and *bad* water quality according to the origin of the water. If the water comes directly from the river it is *good* (not transparent) water with a high content of clay and nutrients and usually no or low salinity. If the water comes from a reservoir it is clear and contains no or less clay and nutrients and is saline to certain degree. Usually: the better the water the less leaching processes are required. Thus, assumed the number of leaching is equal: the usage of *good* water is an indicator for higher soil salinity than the usage of *bad* water.

Water quality (irrigation)	See parameter water quality (leaching). But, in opposition to water quality of the leaching process, the usage of *good* water (lower salinity) leads to lower soil salinization than water of *bad* quality.
Water used for irrigation	Approximately the amount of water used for irrigation. Classes range between 0-100; 100-200; 200-300; 300-400; and >400mm. The more water was used the higher the vulnerability to salinization due to high ground water levels.
Evenness (Surface)	The more even a field the better the conditions for leaching and irrigation.
Morphology (Surface)	Here we distinguish between *hill*, *sink*, and *in between* in relation to neighboring fields. If a field is on a hill it is less subject to salinization due to ground water influence than a field in a sink position.

Table 5. Soil salinity variables (expert knowledge)

Parameter	**Description**
Soil texture	The value range is between sand and clay, where the higher the sand content the higher the negative impact on salinization.
Plant growth characteristics	The Hydromeliorative Expedition is using this parameter to identify fields with similar degrees of salinity in order to define homogeneous areas. The more the plants are underdeveloped the higher the salinity of the field.
Ground water salinity	The higher the salinity the higher the risk for soil salinity.
Ground water level	The higher the level the higher the higher the risk for soil salinity.
Drainage system	
• Channels	The number of channels surrounding an agricultural field. The more drainage channels surround a field the better the drainage conditions. If the field is surrounded by at least one field, parameter *Distance to ch.* is not active.
• Distance to ch.	The distance to the nearest channel. This parameter is only taken into account, if the value of parameter *Channels* is zero. The closer the nearest channel the better the drainage conditions.
• Maintenance	The maintenance of the drainage network.

Table 6. Salinity calculation results

Parameter	**Description**
Salinity Assessment	
• Value	The salintiy value (0.0 – 1.0). 0.0 = no salinity 1.0 = high salinity The value is calculated by taking all activated parameters into account.
• Category	low, medium, high
• Local	The salinity value estimated using only the local knowledge parameters.
• Expert	The salinity value estimated using only the expert knowledge parameters.
Membership	
• Low	The degree of membership to the category low.
• High	The degree of membership to the category medium.
• Medium	The degree of membership to the category high.
Button *Calculate Salinity*	By pressing this button the salinity value is calculated.

Table 7. Soil salinity assessment "Save" and "Cancel" buttons

Parameter	Description
Button *Save*	By pressing this button the soil salinity data and the control settings are saved to the database according to the selected agricultural field, year, and month. If a dataset with these attributes already exists in the database the user will be asked whether he wants to overwrite it or not.
Button *Cancel*	This button closes the dialog without saving the data to the database.

3.3 Soil salinity calculation

The methodology to estimate soil salinity using local and expert knowledge factors (described in Table 4 and Table 5) is based on a rather simple approach. Weighting factors (degrees of importance) are assigned to each soil salinity factor.

The salinity value is calculated as following:

$$Salinity = \frac{\sum_{i=1}^{n} f_i w_i}{\sum_{i=1}^{n} w_i}$$

where f = soil salinity factor, w = weighting factor, and n = number of factors used.

The definition of importance degrees was done during a workshop with chairmen of water user associations in April 2008 in Urgensh. These weighting factor default values can be modified by the user. This function was implemented in order to make the system more flexible during the testing phase. How to modify and load the weighting factor settings is described in the following sub-section.

A fuzzy logic approach is used to classify the estimated salinity value. Three different categories are used: *low*, *medium*, and *high*. Additionally, the degree of membership of the salinity value to each category is calculated using the functions shown in Table 8 below. The degree of membership is a value between 0 and 1, where the higher the value the stronger the degree of membership. As shown in Figure 11 below, the fuzzy set membership functions have an overlap of 50 percent. The classification method allows on the one hand the assignment of the value to a certain category, on the other hand the degree of membership gives an impression to which direction the value tends. A salinity value of 0.396, for instance, belongs to the category *medium*. Using the membership functions shown in Table 8, the degree of membership to category *low* is 0.32, to category *medium* is 0.83, and to category *high* is 0. Hence, a salinity value of 0.396 has a tendency to the classification *low*, but no tendency to category *high* as illustrated in Figure 11 below.

Table 8. Fuzzy membership functions

Fuzzy set	Membership function
low	$y = \cos(Salinity * \pi)$
medium	$y = \sin((Salinity + \pi / 4) * \pi^{1.587})$
high	$y = \cos(Salinity * \pi + \pi)$

Information about membership degrees are provided in the soil salinity assessment input dialog in the *Calculate Salinity* section (see Figure 10).

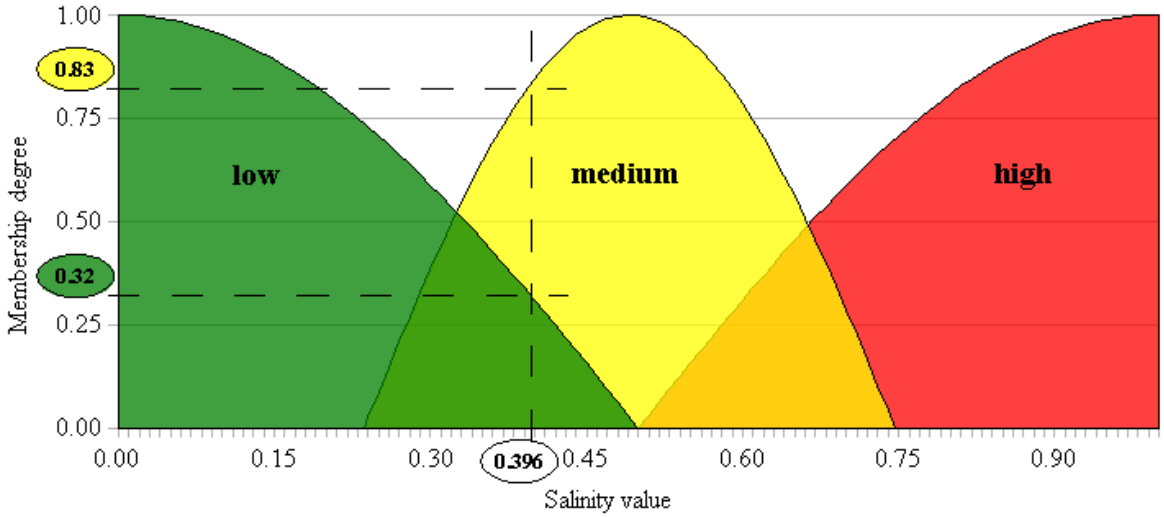

Figure 11. Salinity membership degrees

3.4 Weighting factors

Each parameter that is used to estimate soil salinity has an importance degree or weight, respectively. The default settings (defined during a workshop with water user association chairmen, see Table 9) are stored in the software itself. By creating the soil salinity map (as described in chapter 2) the default settings are copied to the weights attribute table "_weights_+ map name". By loading the soil salinity map from the database the settings currently stored in the weights attribute table are loaded and used. In order to modify these settings the dialog shown in Figure 12 below can be used. To open the weighting factor dialog use button *Weight* from the soil salinity assessment input dialog, shown in Figure 10. The dialog provides three buttons: (1) *Load default* to load the default settings; (2) *Save* to save the user settings to the weight table "_weights_+ map name"; and (3) *Cancel* to close the dialog without saving the settings.

The controllers to modify the weights represent values ranging from 1 to 10, where the value 1 stands for low importance and 10 for high importance. The weighting factors are used in the salinity equation as explained in the previous sub-section.

Table 9. Importance of soil salinity factors

Factors	Importance degree
Local Knowledge	
Soil colour	Medium
Number of performed leaching	High
Water quality for leaching	High
Water quality for irrigation	High
Amount of water for irrigation	Medium
Surface characteristics	High
Expert Knowledge	
Soil texture	Medium
Plant growth characteristics	Low
Ground water salinity	Medium
Ground water level	High
Number of channels	Medium
Distance to earest channel	High
Maintenance	High

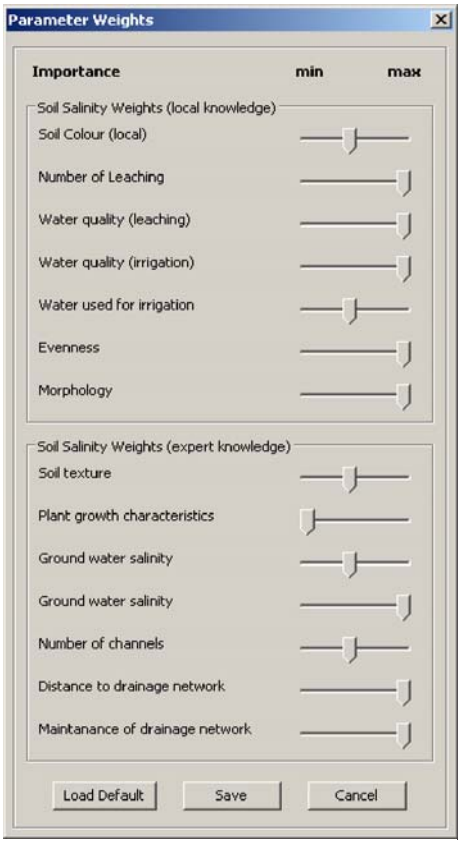

Figure 12. Dialog weighting factors

CHAPTER 4

Visualizing and Analysis of Soil Salinity Data

4.1 Load soil salinity data

If the soil salinity map is displayed in the GIS and activated in the SAGA Workspace click with the right mouse button anywhere in the map in order to open the context menu shown in Figure 13. In case one or more fields (features) are selected the context menu will contain two more options. Click with the left mouse button on an empty area in the map in order to unselect the fields and right-click again to open the context menu. Select *Load Soil Salinity Data* to open the dialog shown in Figure 14. If the context menu does not pop up, please read section 6.5 Context menus.

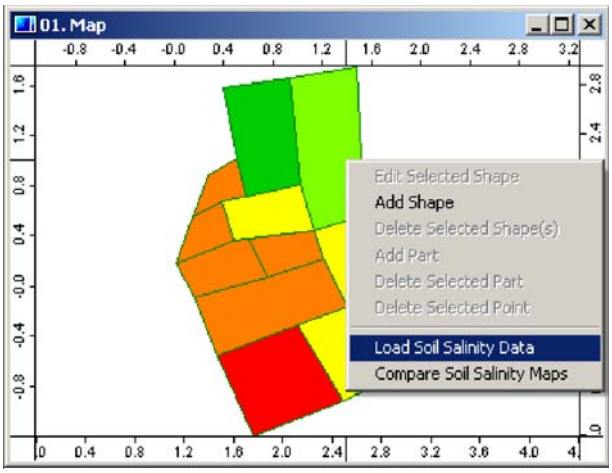

Figure 13. Context menu load soil salinity data

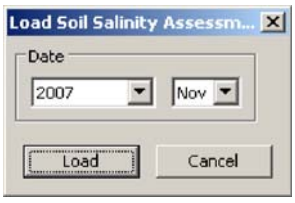

Figure 14. Load soil salinity data dialog

Select the desired year and month in the dialog and press button *Load* to load the corresponding data from the database into the map's attribute table. The map's colors will change automatically according to the salinity values of the fields. Open the map's attribute table in order to show the data. Please read section 6.6 if you do not know how to open an attribute table.

A soil salinity legend was implemented directly into the system. Please read section 6.8 in order to learn how to create or modify the legend manually. The predefined legend consists of five categories which are explained in Table 10.

Table 10. Predefined legend of the soil salinity map

Color	Classification	Salinity values
(light green)	low	0.0001 – 0.149
(green)	low - medium	0.15 – 0.29
(yellow)	medium	0.3 – 0.49
(orange)	medium - high	0.5 – 0.749
(red)	high	0.75 – 1.0
(black)	No data	0.0

4.2 Comparing soil salinity maps

For the purpose of soil salinity monitoring a function was implemented to visualize trends in soil salinization of the area under study. The user can easily compare soil salinity of two different time steps. Therefore, right-click on the soil salinity map and select *Compare Soil Salinity Maps* in order to open the comparison dialog (see Figure 15).

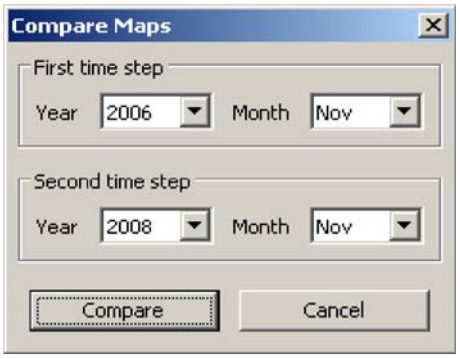

Figure 15. Soil salinity map comparison dialog

Select the year and month of the first and second time step and press button *Compare*. A new map ("ssm_comparison") containing salinity differences of each agricultural field will be added to the workspace and displayed automatically. A predefined legend is used to show the differences or trends, respectively (see Table 11).

Note: *there is still a small bug in the function. If the dialog (Figure 15) is closed by the user, the comparison map jumps to the background and will be covered by other maps. To solve the problem, simply click on the comparison map's window in order to bring it to the front again.*

Table 11. Legend of the comparison map

Color	Classification	Salinity values
(green)	positive trend	0.0 – 1.0
(yellow)	slightly negative trend	(-0.001) – (-0.1)
(dark yellow)	negative trend 1	(-0.1001) – (-0.2)
(orange)	negative trend 2	(-0.2001) – (-0.35)
(red)	negative trend 3	(-0.35) – (-1.0)

4.3 Soil salinity reporting function

The reporting function was implemented to support monitoring and trend analysis. The result is a table containing soil salinity data and statistical information about trends and changes of the agricultural fields. It summarizes all available data of currently selected fields. Please note that the report will be created for selected fields only. If the map contains a lot of fields you should avoid to select too many fields per report. Otherwise the report table becomes confusing due to a large number of columns. In order to create the report table select the desired agricultural fields in the soil salinity map (see section 6.7) and right-click on the map to open the context menu (see Figure 16)

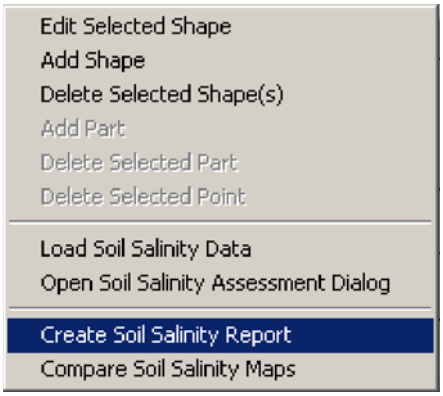

Figure 16. Context menu create soil salinity report

Select function *Create Soil Salinity Report* to create the report table, shown in Figure 17 below. For each selected field one column will be created. The agricultural fields can be identified by the column name (Field + FID number) – where FID is the feature identification number that is automatically added to the attribute table (see section 2.4).

report_salinity

	Year	Field 1	Field 3	Field 4	Field 5	Field 6	Field 7	Field 9
1	2006	0.491509	0.573302	0.607442	0.532642	0.297642	0.125581	0.397170
2	2007	0.453962	0.391792	0.650233	0.441698	0.517453	0.559057	0.468679
3	2008	0.549523	-1.000000	-1.000000	-1.000000	0.297642	0.424528	-1.000000
4	2009	-1.000000	-1.000000	-1.000000	-1.000000	-1.000000	0.623302	-1.000000
5	Mean	0.498365	0.482547	0.628837	0.487170	0.370912	0.433117	0.432925
6	Min	0.453962	0.391792	0.607442	0.441698	0.297642	0.125581	0.397170
7	Max	0.549523	0.573302	0.650233	0.532642	0.517453	0.623302	0.468679
8	Diff_max_min	0.095561	0.181510	0.042791	0.090944	0.219811	0.497721	0.071509
9	Trend	0.058114	-0.181510	0.042791	-0.090944	0.000000	0.497721	0.071509

Figure 17. Report table

The report table will be added to the SAGA Workspace (Data) in the *Tables* section. The name of the table is: *report_salinity.*

The attribute table shows available salinity values for each year. Moreover, it gives information about:

Salinity (year)	The salinity value. The negative value (-1.0) indicates that no data are available for the corresponding year.
Mean salinity	The mean salinity value over the entire period.
Min	The minimum salinity value.
Max	The maximum salinity value.
Diff_max_min	The difference between the maximum and minimum salinity value.
Trend	The difference between the first salinity value (first year) and the last value (last year). If the trend value is positive, the salinization in the last year is worse than in the first year. If the value is negative, salinzation of the last year is less than in the first year.

The salinity values can be visualized easily using a spreadsheet application like OpenOffice Calc or Microsoft Excel. Therefore, save the table to the hard disk (see 6.4) in dBase format and open it with the spreadsheet application.

Please note that this functionality is still under construction. Specific requirements need to be discussed with (potential) users.

CHAPTER 5

Backup

Two alternatives to make a backup of the soil salinity database are described in this chapter. You can either make a backup of the entire database (see 5.2) or export only the desired tables as text files to any storage media (see 5.1). If the database is installed on a PC, it is strongly recommended to frequently save backups on an external hard disk, flash drive, DVD etc. At least after a lot of time has been spent to enter huge amounts of data.

5.1 Exporting a single table to hard disk

In order to export a table from the database to the hard disk use function *Database* ► *Table* ► *Table to .csv* (see Figure 18). A dialog will pop up where you select the desired table from the database and the directory on the hard disk where you want to save the copy. The table will be exported as text file in *Comma Separated Value* (.csv) format. This format can be opened with any text editor or spreadsheet application like Open Office Calc or Microsoft Excel.

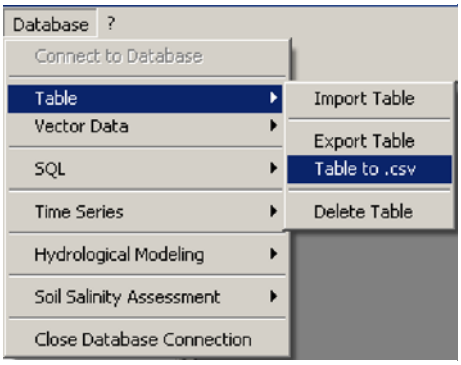

Figure 18. Export table to .csv

5.2 Making a database backup (dump file)

Making a database backup using the program pgAdmin III. Figure 19 shows how to start the program pgAdmin III which will be automatically installed during the PostgreSQL installation.

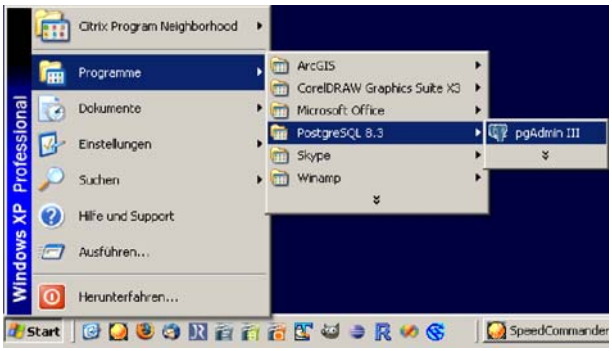

Figure 19. Starting pgAdmin III

pgAdmin III is an administration tool for PostgreSQL that requires the database administrator passwort. Figure 20 shows how to open the database backup dialog. Therefore, right-click on a database item displayed in the database tree and select *Backup...*in the context menu.

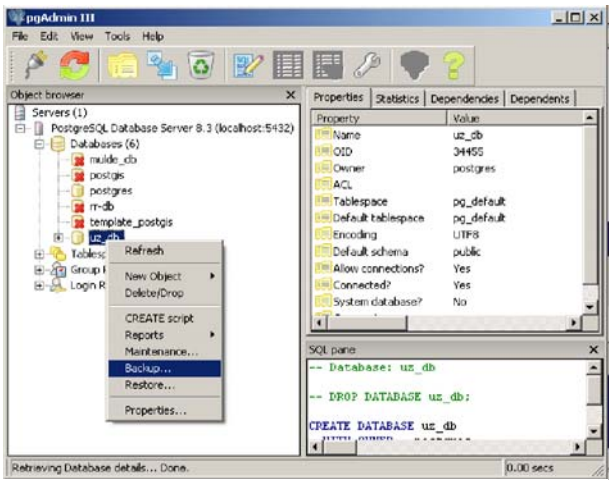

Figure 20. Open backup dialog

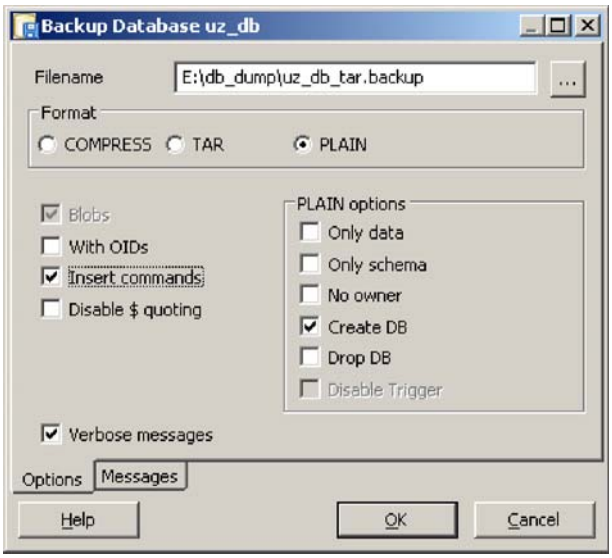

Figure 21. PostgreSQL database backup dialog

In the database backup dialog (see Figure 21) the user can define the options to create a database backup file. Depending on the size of the database one should use option PLAIN or COMPRESS. The option PLAIN produces an ASCII text file containing all SQL commands to restore the database and data. This option can be used for "small" databases. For huge databases the option COMPRESS should be used which reduces the file size of the database dump file.

5.3 Restoring the backup (dump file)

Restoring a database backup using the program pgAdmin III. Figure 20 shows the context menu with functions to administer the PostgreSQL database. The option *Restore* is below the entry *Backup.*

5.4 *pg_dump*

Alternatively to pgAdmin III the command line tool *pg_dump* can be used by advanced users to backup and restore a database. A detailed description is given here:

http://www.postgresql.org/docs/current/static/app-pgdump.html

CHAPTER 6

Some SAGA Features

This chapter gives an overview about some useful basic SAGA features.

6.1 Toolbars

The standard toolbar

6.2 SAGA Workspace

In the *Data* Tab of the SAGA Workspace the user finds all data (Shapes, SimpleFeatures, Tables, Grids, and TIN's) that were loaded into the GIS. Double-click on an item displays the corresponding feature in a map. Click on the icon  in the standard toolbar in order to open or close the workspace window.

Figure 22. SAGA Workspace

6.3 Messages

Almost all commands executed by the user send a message to the SAGA message window. Here the user gets information about the successfulness of the commands. In case the window is not displayed use button from the standard toolbar or menu *Window* ► *Show Message Window* to open it.

6.4 Saving features from workspace to hard disk

Right-click on an item in the workspace (see Figure 23) to open the context menu and choose the *Save as* function of the corresponding item (*Save Shapes as...; Save Table as...; etc.*).

6.5 Context menus

In case a map's context menu does not pop up on mouse right-click make sure that the map is activated in the SAGA Workspace. Perform a left-click on the map item in the Workspace to activate the feature as shown in Figure 23 below.

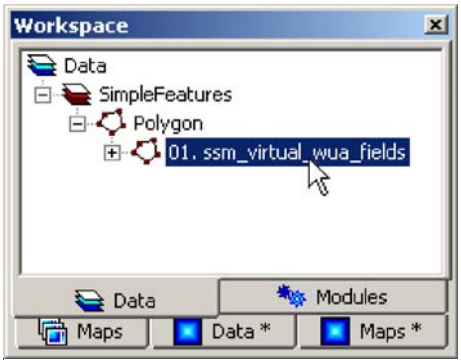

Figure 23. Activate a map

6.6 Opening an attribute table

Click on the ⊞ symbol next to a *SimpleFeature* or *Shape file* in the SAGA Workspace as shown in Figure 24 (left). Double-click on the attribute table Figure 24 (right) to open it.

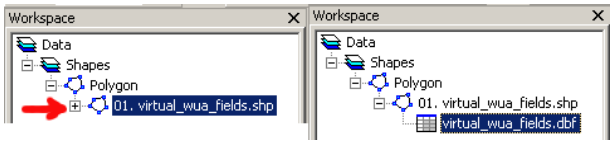

Figure 24. Open attribute table

6.7 Selecting one or more fields in a map

In order to select one or more fields (features) in a map first select the action tool from the map toolbar and left-click on a field to select a single field. Press and hold the Shift key and left-click on other features to add them to the selection. Alternatively you can draw a rectangle with the mouse by

using the left mouse button. All features touched by the rectangle will be selected. In order to deselect a feature from the selection, hold the Shift key and left click on the feature.

DON'Ts

Never delete an attribute table manually from the database! If you want to delete a soil salinity project,use function *Database* ► *Soil Salinity Assessment* ► *Delete Soil Salinity Assessment Map*. This automatically deletes the corresponding attribute tables.