TOLOMEO
TOoLs for Open Multi-risk assessment using Earth Observation data

WP3 - DERA

1. Original DERA Processing chain

WP 3 is embedded within the framework of TOLOMEO and as such is targeted to provided effective solutions in terms of open source routines and modules, especially designed for multi-risk assessment in forested areas, like fire, shallow cut, the uprising of new deforestation foci and activities that cause forest degradation (e.g. selective logging), focussing on the Legal Brazilian Amazon Forest.

- WP 3 tasks

This WP basically comprises three tasks, described as follows:

Task 3.1 – DERA tool design: collaborative design of the tool by means of a study of the
availability of data and the user requirements in a WG.

Task 3.2 – DERA tool implementation: implementation in the ORFEO framework of a tool to automatically analyze data sets with different resolution and coming from sensors at various wavelengths, and to extract risk information in form of maps or GIS layers.

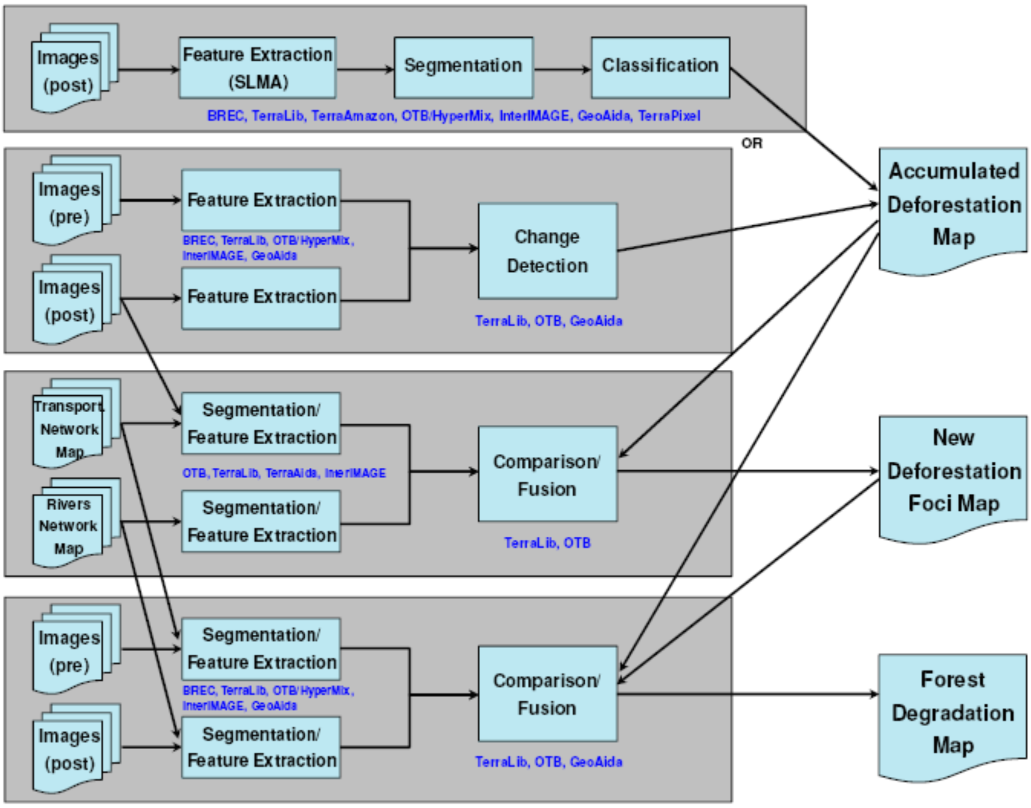
Task 3.3 – DERA tool optimization: improvement of the tool after comments and suggestions by the community and the WG interactions, to improve its effectiveness and easiness of usage as per requests by the users.

- WP 3 objectives

WP 3 aims at defining a tool for the monitoring of large forested areas, such as Amazonia, which are subject to many different risks, from fire to illegal logging, using the available remotely sensed data, especially the free ones already distributed in various forms on the web.

- Block-based graphical representation and generic description of what each block represents.

The processing chain for WP 3 – Deforestation Risk Analysis (DERA) is presented below.



In the processing chain of WP 3, fire detection was excluded, for it involves complex tasks executed over meteorological imagery and data.

The other three basic output products of DERA are illustrated in the blocks to the right:

Accumulated Deforestation Map, New Deforestation Foci Map, and Forest Degradation Map.

The first one, Accumulated Deforestation Map, can be generated either through region-based classification (as in PRODES) or change detection techniques. In the first case, images acquired after deforestation are subject to feature extraction, more precisely the spectral linear mixture analysis. The soil fraction image is segmented and then classified. In the second case, images acquired before and after deforestation are subject to feature extraction, and change detection techniques are applied on them.

For the New Deforestation Foci Map, images acquired after deforestation and GIS layers of transportation and drainage network are subject to feature extraction and/or segmentation. These images and GIS layers together with the Accumulated Deforestation Map undergo a comparison (or fusion) process, so as to unravel new deforestation foci.

And for the third and last product, the Forest Degradation Map, images acquired before and after deforestation and GIS layers of transportation and drainage network are subject to feature extraction and/or segmentation. These images and GIS layers together with the Accumulated Deforestation Map and the New Deforestation Foci Map undergo a comparison (or fusion) process in order to assess the forest degraded areas.

2. DERA version 1 implementation (May 2013)

2.1.Introduction

The WP3 - DERA tool was developed as a compact platform to extract information from remotely sensed imagery, target to detect deforested areas or illegal selective logging with a friendly graphical user interface. This platform has its own database management system (DBMS), rendering the execution of its routines easy and fast.

2.2.Methodology

The platform used for this protocol is Spring v5.2.3. The following sections describe the commands and related operations designed for creating and activating a database and a project, importing images, creating and applying the linear spectral mixture analysis (LISA), executing the region growing segmentation, creating database categories and classes, applying the ISOSEG classifier, and performing the classification validation.

The dataset used for this protocol is composed by Landsat/TM bands 3, 4, and 5, which have 30 m of spatial resolution.

The methodological sequence for the above-mentioned operations are described next.

1. Creating a database in Spring

- **click** in **File** - **Database...**in the main menu or in the  icon in the tools bar, if the window does not open;
- **click** in **Directory...** to select a directory where the Database will be created. The **"Select a Directory"** window is shown;
- **type** the Database **Name** that will be created, you can use at most 32 characters without spaces;

- **click** in **Manager** and select among **Dbase, Access, Oracle, MySQL, PostgreSQL or SQLite**
- **click** in **<u>Create</u>** to create a Database. Notice that the name typed will be included in the list above.
    - for the Access manager, it will be asked if the user wants to define a password to protect the Database. Answer "Yes" to add a password;
        - the window **"Define the Database Password..."** is shown;
    - for the **Oracle** manager, the Database name will be requested (**Databases**) local or remote, the user name (**User**) has to have permissions to create tables in the Database and a password (**Password**) for this user;

NOTES:

1. - Use only letters and numbers in the Database name. Special characters (! @ # $ % ^ & * ( ) - + = | \ { [}] : ; " ', < > . / ?) or blanks will be automatic deleted from the name when you click in **<u>Create</u>**.
2. - As SPRING automatically saves any handled data, we would like to emphasize that you should make security copies of the files you are handling periodically, because any interruption in the system execution or if the power goes down, can damage the data integrity.
3. - The SPRING knows how to recognize any Database created in the current path, because some files in the Database folder will help SPRING system to recognize the folder in the Database list.

2. Activating a database in Spring

- **click** in **<u>File</u>** - **<u>Database...</u>**in the main menu or in the  icon in the tools bar;
- **click** in **<u>Directory...</u>** to select a directory where the Database is stored. The **"Select Directory"** window is shown. Do not forget that the path for the Database directory has to point to a directory one level above so SPRING can recognize the Database.
- **select** the **Database** from the list;
- **click** in **<u>Load</u>**. If there is an active Database a confirmation message will be shown asking you to confirm deactivation of the Database. **Notice** that the name of the active Database is presented in SPRING title bar between brackets ([Df]). Confirming the deactivation the window closes and the new Database becomes active.
    - if the Database was created with an **Access** manager with a password, the system will ask for the password. In this case the **"Access Database password..."** window is presented.

NOTES:

1. Closing the "**Spring**" module, SPRINGDB variable will be automatically updated if the **Spring next session** in the " <u>Environment setup</u>" window the **Current Configuration** is selected. In this case the last used Database will be automatically selected when SPRING starts a new session. Otherwise the user can always select a Database following the steps described above. If SPRINGDB variable has no value the system will automatically asks for a Database.
2. In order to define or change a password in an **Access** Database it is first required to activate the Database.

3. Creating and activating a project in Spring

- **Click** on **File Project...** in the main menu or on  icon. The **"Project"** dialog box is presented.
- **Provide** a **name** for the project, thirty two (32) characters maximum. Use only alphanumeric characters in the project name. Special characters (! @ # $ % ^ & * ( ) - + = | \ { [}] : ; " ',< > ./ ?) or spaces will be automatically removed when you click on **<u>Create</u>** or **<u>Change</u>**.
- **Click on <u>Projection...</u> to inform the cartographic parameters to be used in the project. The "Projection" dialog box is presented (it is recommendable to consult the coordinates of the Prodes images to be further used);**
- **After defining the projection define the Bounding Box in** <u>Geographic</u> or <u>Planes coordinates</u> (in meters). The two points should be diagonally opposite, such that the first (1) is the lower left corner while the second (2) is the upper right corner (see figure below);
    - For **Geographic** coordinates the syntax should be as follows:

Ex: Long1 w 23 14 00 Long2 w 23 09 00
Lat1 s 45 55 00 Lat2 s 45 50 00

- For Planes coordinates (meters) it is necessary to inform the **Hemisphere** – **N**orth or **S**outh, mainly when you're using the UTM projection, in which case the values for Y1 and Y2 will be automatically added by 10.000.000 whenever any of the points lies above Equator. The syntax in this case is as follows:

Ex: X1 350000 X2 380000
Y1 7950000 (S) Y2 980000 (N)

Obs: In this example the Y values lie within the 7.950.000 to 1.980.000 interval;

- **Click on <u>Create</u>** to insert a project in the database and **<u>Load</u>** to activate it.

4. Importing images in a Spring database

- load a **<u>Database</u>** () and define the categories that will receive the external data, in case they do not exist.
- load a **<u>Project</u>** () that will have to enclose the coordinates of the data from the external file, or the parameters to create one will be requested, in case one is not loaded;
- **click** on **<u>File</u>** and select **<u>Import</u>** -> **<u>Import Vectorial and Matricial Data</u>**. The **"Import"** window will be show;
- in the **Data** menu, use the button **<u>File...</u>** and then on the button Files of Type, select the **TIFF/<u>GeoTIFF</u>** file to be imported;
- go to the directory where the **TIFF/<u>GeoTIFF</u>** files are located, select one band at once and click open;
- in the **Conversion** Menu, choose Nearest Neighbour as the Interpolator, and in the **Output** menu, click the Category button, select **CAT_Image** and click Execute;
- in the **IL** (Infolayer) field, type the name to be assigned to the image band being imported, e.g., LS_5_YM_B3;
- click **Apply,** and when the procedure is finished, click **Close**;
- repeat the procedure for the remaining bands.

5. Executing the Linear Spectral Mixture Analysis - LISA

Creating a Mixture Model:

- **click on <u>Image - Mixture Model...</u>** on the main menu. If there is no Mixture Model on the current directory, answer the question by clicking on **<u>Continue</u>** and you will see the **"Mixture Estimator"** window;
- in **Model, click on Layers Selection** (the option **Apply** will be presented below) to create a new model or modify an existing one. This is the system *default* option;
- **click on <u>Directory...</u>** and a window will be presented for the **directory selection**. In this directory the Mixture Model file will be created. By default, the directory where SPRING is installed will be selected.
- **click on <u>Create...</u>** at the "**Mixture Estimator**" window. The window **<u>"Create/Modify Mixture Model"</u>** will be presented. This is the same window as the one used to edit or modify an existent model;
- at the window **"Create Mixture Model"**, **type** on the **Name:** field, a name for the model, **replacing** the text "model" that is already there. The data will be saved in a file with an extension ***.mix***;
- you will have two lists, the first bands are chosen on the model, these bands are stored in ***"SpectralBands"*** which is in the directory, under which SPRING is installed. This file contains the names of bands, the code of the band and spectral range (in microns) to which it belongs, and the second are the images that will be implemented in the model. See that there is a relationship between the first band selected with the first image, or choose the first band and it relates to the first image that will be applied in the model. The relationship is shown in the list of bands in the model. To remove the relationship, and just click over the image selected again;
- now, inform the model components: **click on <u>Create...</u>** and you will see the windows **"Create/Edit Mixture Components" and "Graphic"**. You should have in mind which components will be defined (for instance, water, shadow, forest etc.) and the acquisition of reflectance values (from the image by clicking directly on the concerned targets in the image, typing on the keyboard or retrieving them from a spectral library). In the WP3 test case, the model comprised soil, vegetation, and shadow;
- after editing the mixture components, **click on <u>Save</u>** to store the crated model. A file named**<model_name>.mix** will be created containing all information provided above.

Applying a Mixture Model:

- **click on <u>Image - Mixture Model...</u>** on the main menu. The **"Mixture Estimator"** window will be presented, in case it is not opened yet;
- **click on** a model from the **Models** list and then click on **Apply**... . **Observe** that the window is changed and the chosen model becomes active. Click on **View...** if you want to see the data related to the selected model. In this case, you will see two windows: one with a Graphic and another with the summary of all components (check the description later in this page);
- In the window **IL´s Interest...** must choose the ILs that will be used to apply the model. The "default" implies all categories of the model image, but click the option button and then on **<u>Input Category...</u>**. Use the **<u>"Category List"</u>** dialog box to choose (filter) which Image category will be considered. After choosing a category then click Run this last window. **<u>NOTE:</u>** These must be the same bands defined in the model. You can also change the name of the IL output and apply the images of error.
- **click on <u>Bounding Box...</u>** in case you want to change the area where the model will be applied. If not informed, Spring will use the bounding box of the active IL;

- After specifying the IL of interest, modify the output names, request images of error and the rectangle of interest, if desired, then **click on <u>Execute</u>**. At this time, a window is displayed **"Selected Images from different bands of the Model. Continue?"**, **Click yes**. And even if the exit plans already exist, a new window will be shown if you intend to replace them, in which the user has the names of **Proportion Images** and **Error Images**;
- returning to the window **Mixture Model**, define an **Estimator**: **M.Q.P.**(***Weighted Minimum Square***), **M.Q.R.** (**Restricted Minimum Square** - ***3 components***) or **PRINCO** (***Principal Components***);
- **define** on the window the parameters to calculate: **Mean Error, Generate Error Images** or **Normalize[0,1]**.
- **click on <u>Execute...;</u>**
- at the end of the processing, **a new window** will display the generated images and the calculation of total error and error for each band, if they were requested.

  If you wish to change data (**components, bands and values**), you should go back to the **"Mixture Estimator"** window and **click on <u>Change...</u>** . Then, on the **"Modify Mixture Model"** window, change what you want as if you were defining a new model.

6. Executing the Region Growing Segmentation

- **select** on the **"Control Panel"** an image and **click** on **<u>Image - Segmentation...</u>** on the main menu;
- **select** the image(s) that you want to use for segmentation;
- **choose** a segmentation **Method**: **Region Growing** or **Basin Detection**. In WP3, the Region Growing method used only the soil fraction image;
- **type in** a value, integer and greater than zero, that will be used as **Similarity** limit;
- **type in** a value, integer and greater than zero, that will be used as a minimum size of **Area**, in pixels, that represents the segmented region;
- **choose** a **Band of Exclusion** in case you do not want the image region, defined by this band, to be considered during the classification process. The band of exclusion is used for defining regions where you do not want to segment the chosen image.
- **type in** a name for an IL that will contain the **Segmented Image** to be created;
- in **Arc Smoothing**, **choose Yes** if you want to smooth the borders or **No** if you do not. In WP3, no smoothing was applied to the segmentation;
- **click** on **<u>Bounding Box...</u>** to define an area smaller than the project's area, in case you want to perform a segmentation only in part of the image (see about the **<u>bounding box</u>** operation);
- **click** on **<u>Apply</u>** to perform the segmentation.

Notes:

1. The Similarity measure is based on the Euclidean distance between the average values of gray levels of each region. Therefore, two regions are considered different if the distance between their averages is greater than the Similarity limit chosen.
2. Regions with areas smaller than the minimum chosen are absorbed by adjacent regions more similar to them.

7. Creating a Category or Class

Category

The **category** concept put together the same type of data in the Database, defining a data class. Each category is always associated to a unique data model and may have several Information Layers in different projects but in the same Database. The Information Layer can only be created once a Category was created.

For the **non-spatial** data model it is required to define a table's name. An attribute's table in the Dbase 4 format can be automatically related to the Spring Database if the table's name is properly informed and the table is defined in the Spring Database directory.

Creating categories before using them does not mean that the user has to define them all at once. Usually, tables are created when they are required in a project.

Creating Categories:

- **click** in **File** - **Data Model...** in the main menu or in  icon;
- **select** the **Model** type you want to create: **Image, DTM, Thematic, Object, Cadastral, Network or Non-Spatial. Image will be used for importing the Prodes images, and Thematic will be used for the classification layers of such images**;
- **define** the category's **Name**. The category's name may have up to 32 characters, including blanks or special characters, such as:! @ # $ % ^ & * ( ) - + = | \ { [ ]} : ; " ',< > / or ?;
- **define** the attribute's **Table** name for a **Non-Spatial** Category;
- **click** in **Create**, - repeat the last three steps if you want to create other categories;
- **click** in **Apply** to create the categories in the Database.

Thematic Classes

For the **Thematic Model** it is required to create **Thematic Classes**. You will see also that it is possible to define a unique non-spatial attributes table for all thematic classes. In the Soils Category example, for each class, we can define attributes such as texture, granulometry, color, pH etc.

Creating Thematic Classes:

- **select** from the **Categories** list a thematic model item;
- **select Thematic Classes** tab.
- **give** the class **Name**. The name may have up to 32 characters, including blanks;
- **click** in **Create** to add a class in the list;
- **click** in **Apply** so the classes will be added to the Database. Once a class is created it cannot be removed from the Database but the class name and the class visual aspects can be changed.

IMPORTANT: **Before** clicking the **Apply** button it is possible to remove a class from the list; simply click the **Delete** button.

NOTE: At any time the user can come back to the **"Data Model"** window and add new **classes** or even change the name and **visual** aspects of the existing ones.

After creating a category, you can define data graphical presentation characteristics, which are also defined and stored with the Database directory. Click in **Visual...** to define the areas, lines, points and texts characteristics or the thematic classes in an active Database.

8. Applying the Isoseg Classifier

The user has to follow the steps presented next to generate a classification using a segmented image:

8.1. **Create a Context File** - this file stores the bands that will be used in the regions classification process.

- after clicking on **Create...** at the **"Classification"** window, you should define a new context file to classify the image;

- at the **"Context Creation"** window, **type in** the file **Name** on the text box;

- at **Analysis Type** select **Regions;** select the **Band(s)** and the **Segmented Image** that was previously created at the Segmentation; In WP3, the TM bands 3, 4, 5 were used, using a 99% acceptance threshold.

- click on **Apply** to save the context file. This window is closed and you can proceed with the **"Classification"** process.
- after having executed the segmentation, having defined the context file (by regions) and having executed the **Regions Extraction**, the user can use the segmented image as a sample contour.
- **choose** the **Classifier: Isoseg**.
- **provide** the **Acceptance-Threshold** (%): 100, 99.9, 99, 95, 90 or 75. In WP3, the 99% acceptance threshold was used;
- Set the **Name** to be created for classified image and click **Category...** (If you want to change the category where the image is saved Classified);
- **click** on **Classify**;

8.2. **Execute the Classes Mapping** - it allows to transform the classified image (Image category) for a thematic raster map (Thematic category).

- There are two ways to access this function: through the **Image** menu (Mapping Classes for thematic image) or through the window **"Classification"** **click** on **Mapping....** and the window **"Class Mapping"** will be presented;
- all the categories from the thematic model of the active database will be presented in **Categories**; **click** on anyone from the list. Notice that the list of **Classes** presents the classes and colors of the selected category;
- **click** on the list of **Classified Images** and **choose** the one you want to map;
- **click** on a theme that will correspond to the chosen class (the classes should have been created previously using the option **File - Data Model...**);
- **associate** all themes with the thematic classes existent on the database;
- **click** on **Apply**. Observe that the thematic image will be available on the **"Control Panel"**.

9. Performing the Classification Validation

Importing the reference data from PRODES and associating classes to it:

- **import** the Prodes classified images in shapefile format in the Thematic Category using the command Import, Import Vectorial and Matricial Data. The scale is 1/60000;
- **click** on **Execute - Draw** or in the active window to visualize the IL to be edited;
- **click** on **Thematic - Vector Editing** or **Vector - Editing** in the main menu, to show the **"Topology Editor"** window;
- **click** on **Classes**.... The**"Thematic Classes Editor "** window is presented;
- in **Current Category** the category that has the IL being edited is presented;
- **select** in the **Classes** list the class to be associated to the entity (point, line, or polygon);
- the **visual** of the selected class (current) is presented on the side. If the user wants to change it, just click on the "Visual" button;
- **select** the **Operation Associate** button, to associate the entity (point, line, or polygon) to a class. In case the entity is already associated to another class answer YES or NO to change by the other, or **Dissociate** to remove the association;
- **click** on **Apply to All**, to **classify all** entities that do not have a class with the active class (current); or even, if desired, **dissociate all** the entities of the current class;
- **select** the entity type with the mouse left button which is associated or dissociated: **Point, Line or Polygon**. In the case of WP3, only polygons were associated to the classes "forest" and "deforestation";
- **click** on **Close** after finishing the polygons association/dissociation.

Executing a cross-tabulation between the classified and the reference images:

- click on **<Analysis> <Legal..>** in the **Main Menu**. The "**Algebra**" window is presented;
- in the "**Algebra**" window click on **<Directory...>** to select the folder where the program will be stored, or**type** the path and click on the **<CR>**. It is recommended to create a folder inside the database folder, so when a backup is created all the programs will be stored with the Database;
- in the **Name** text box type the Program's name and click on the <**Create...**> button. The **"Model Editor"**window is presented;
- in the **"Model Editor"** window type the program's name. In WP3, the following program was used:

```
{
//ACCURACY ASSESSMENT
Tematico clas2011, ref2011, result ("CAT_Thematic");
// ENUNCIATION
clas2011 = Recupere (Nome = "Classif_IsoB345-T");
ref2011 = Recupere (Nome = "Reference");
result = Novo (Nome = "accuracy", ResX=0.000269000011031,
ResY=0.000269000011031, Escala=60000);
//OPERATION
```

```
result = Atribua (CategoriaFim = "CAT_Thematic")
{
"forest_agreement" : (clas2011.Classe == "forest" &&
ref2011.Classe=="forest"),
"deforestation_agreement" : (clas2011.Classe == "deforestation" &&
ref2011.Classe=="deforestation"),
"def_omission" : (clas2011.Classe == "forest" &&
ref2011.Classe=="deforestation"),
"def_commission" : (clas2011.Classe == "deforestation" &&
ref2011.Classe=="forest")};
}
```

• click on the <**Save**> button or the **<Save as...>** button to store the typed program;
• in the "**Algebra**" window click on the <**Apply**> button.
NOTE: If there are syntax errors or invalid commands, the message ***"Syntax error in program. Verify errors in the console!"*** will be presented. When clicking on the **OK** button, the **"Model Editor "** window will be presented, displaying the errors and the corresponding line number. Make the required corrections in the program, save them, and try to execute the program again.

Computing Measurements (Area) of Classes:

• **activate** using the "Control Panel" the thematic information layer used for the computation;
• **select** in the main menu **Thematic - Measurements of Classes...**;
• **click** the **Thematic Image** button and/or **Vector Map**. If the active IL has both representations, both buttons will be available;
• **click** on **Apply**. The report is presented in the window's central part. The area report shows:
  - IL name,
  - representation type,
  - area values by class,
  - classes total area,
  - total area of the non classified polygons (vector case), and information layer total area.

The length report (only for the associated classes) shows:

  - IL name,
  - length value by class,
  - classes total length, and
  - total length for the non classified lines.

• **click** on **Save...** to store the displayed report as a text file. The "Save As" window is presented. Type a name and **click** on **Save**.
• **click** on **Export Worksheet...** to store the report in a spreadsheet format in a text file (ASCII). The **Save As** window is displayed. Select or Change the name and **click** on **Save.**
• The suggested name corresponds to the category that generates the second column (CATEG_<categoryname>) ;

• if the file already exists, the "substitution" will happens as follows: the previous file will be kept with a new name (<filename>_OLD.txt), the new file will be created with all lines from the old file, plus all the new lines, and the classes consistency will be kept (new classes will generate new columns);
• the spreadsheet is cumulative and can be imported from an "EXCEL" file to compute the classes area summation from several projects;
• exported spreadsheet via "Cross Tabulation" can be used to accumulate "Measurement of Classes" data and vice-versa;
• column delimitation = semi-colon character (;);
• numerical data : decimal separator = dot character (.) and thousands separator = none (non-existent).

★ **Export the generated table in text file to Excel and compute the Kappa index:**

$$K = \frac{n\sum_{i=1}^{k} n_{ii} - \sum_{i=1}^{k}(n_{i+}n_{+i})}{n^2 - \sum_{i=1}^{k}(n_{i+}n_{+i})} \quad (1)$$

where:

n_{ii} – total number of correctly classified samples as class k;

n_{i+} – total number of samples classified as class k;

n_{+i} – total number of collected samples for class k; and

n – total number of samples.

3. Improvements in DERA version 2 (May 2014)

1) Implementation of a visualization module for TerraLib databases (themes and views).

2) Creation of a tool for saving the Terralib information.

3) Development of a plug-in to allow external software developers to create new tools for a software system providing to it new specific functionalities.

4) Incorporation of other Database Management Systems (DBMS), like SQLITE, which is similar to DBase.

4. Improvements in DERA version 3 (November 2014)

1) Implementation of a thinning tool for raster data.

2) Development of a wizard plug-in for database creation.

3) Implementation of a resampling tool.

4) Creation of a tool for line simplification.

5) Implementation of a routine for radiometric correction of CBERS-2B images.