PANDORA 3.0 model setup

Raffaele Pelorosso & Federica Gobattoni

January 28th 2016

PANDORA 3.0 model setup

Raffaele Pelorosso, Federica Gobattoni

Index

1. Short introduction

PANDORA model allows the assessment of landscape connectivity in terms of energy, called Bio-Energy Landscape Connectivity (BELC). The energy considered by the model is linked with the vegetation metabolism through the BTC index. The latter describes the flux of energy (Mcal/m^2/year) that an ecological system has to dissipate in the environment to maintain its level of metastability (Gobattoni et al., 2011). An opportune BTC value can be assigned to every vegetation type in the world on the basis of specific data available in literature or on the basis of a direct assessment in the field. Thus, the PANDORA model assesses the biological energetic state of the landscape and the bio-energy exchanges among defined Bio-Energy Landscape Units. The model was developed to meet the needs of planners and practitioners involved in the environmental assessment procedure and it was proposed as an operative decision support system to assess the impact of different scenarios of land use change. The last version of the model, PANDORA 3.0 (Pelorosso et al., 2016), analyses the contribution of each patch of land mosaic to global BELC and, consequently to the functionality and resilience of the entire system to which it belongs. Moreover, PANDORA 3.0 allows the selected patches to be evaluated in terms of Ecosystems Services for Biodiversity conservation considering both habitat type (as defined by information derived from Land use/land cover maps) and Bio-Energy Landscape Connectivity.

The PANDORA 3.0 model is a free and open source plugin for QGIS written in python language.

The full description of PANDORA 3.0 model can be found in Pelorosso et al. (2016). In this document, the description of model set-up is presented.

For citations: *Pelorosso R., Gobattoni F. (2016). PANDORA 3.0 model set-up.*

2. Installation

PANDORA 3.0 model needs to install the followings packages of QGIS:

Commandline:
python-tcltk

Desktop:
Qgis
Grass

Libs:
gdal
gdal-python
libgeotiff
libspatialindex
libtiff
matplotlib
proj
spatialite
sqlite3
tcltk

After the installation of QGIS, the plugin PANDORA has to be copied in the following directory:
C:\OSGeo4W64\apps\qgis\python\plugins

The PANDORA plugin should appear in the list of plugins.

If correctly installed, the icon of PANDORA 3.0 (fig. 1) appears in the toolbar plugin (see fig. 2)

Fig. 1 the PANDORA icon and logo

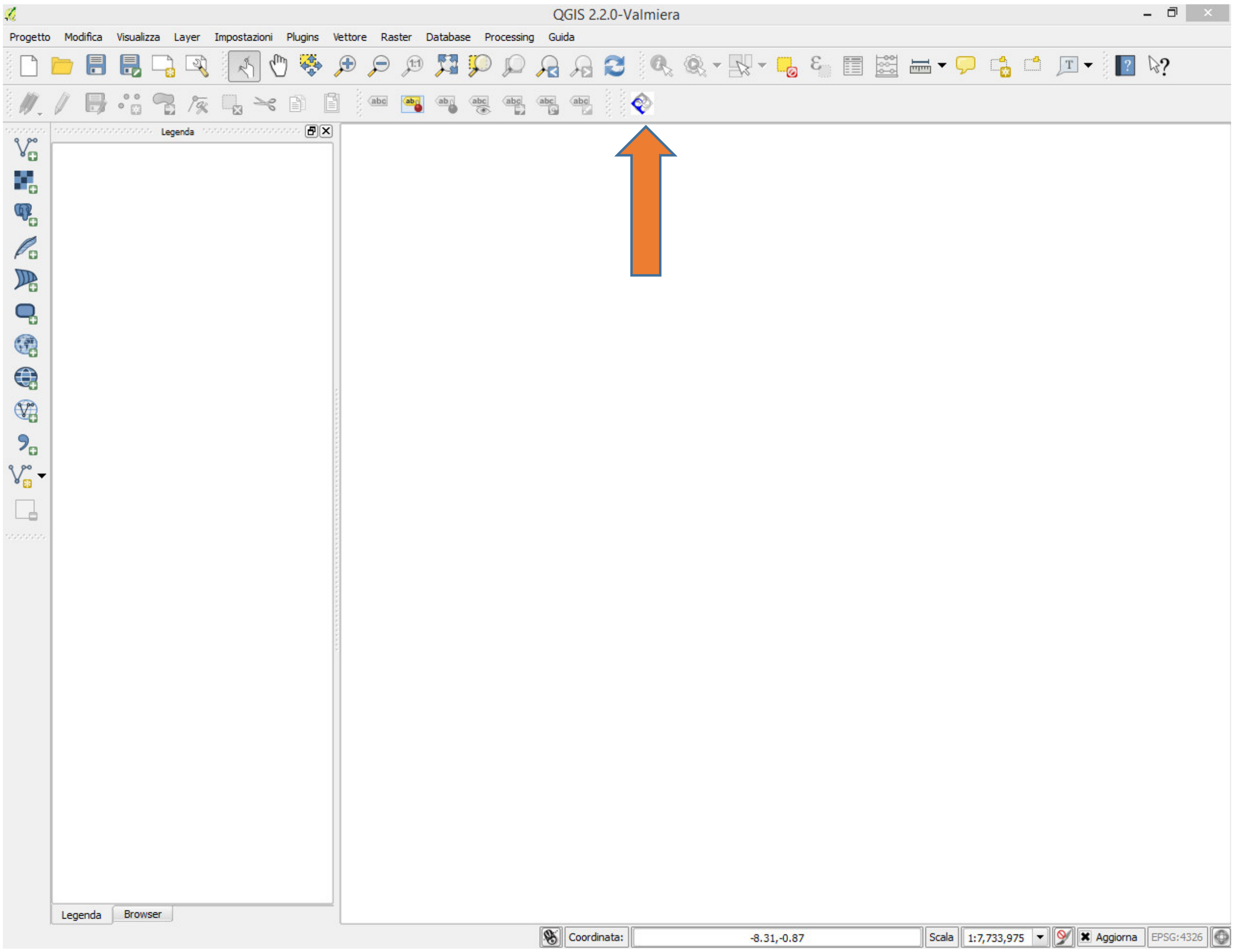

Fig. 2 the installed plugin in QGIS

3. Model description

Clicking on the PANDORA icon a new window appears (Fig. 3).

PANDORA 3.0 works in three steps that are defined by the three panels named as: Base parameters, Model and dMtot/ESV. Moreover, three options named settings, utility and help are available. Settings contains the main model setups. Utility holds a reclassification tool of raster data: this tool could be useful to produce the proper maps of K clima, K aspect and K soil factors. Help gives some information about the developer and the authors of the PANDORA 3.0 plugin; moreover, this document can be downloaded. Before starting with the description of the first panel explaining all the files requested, a view of settings is necessary (Fig. 4). The settings reports the directory of the SQlite database (see description in the Base parameters section), the K to be considered in the model runs and the K mean.

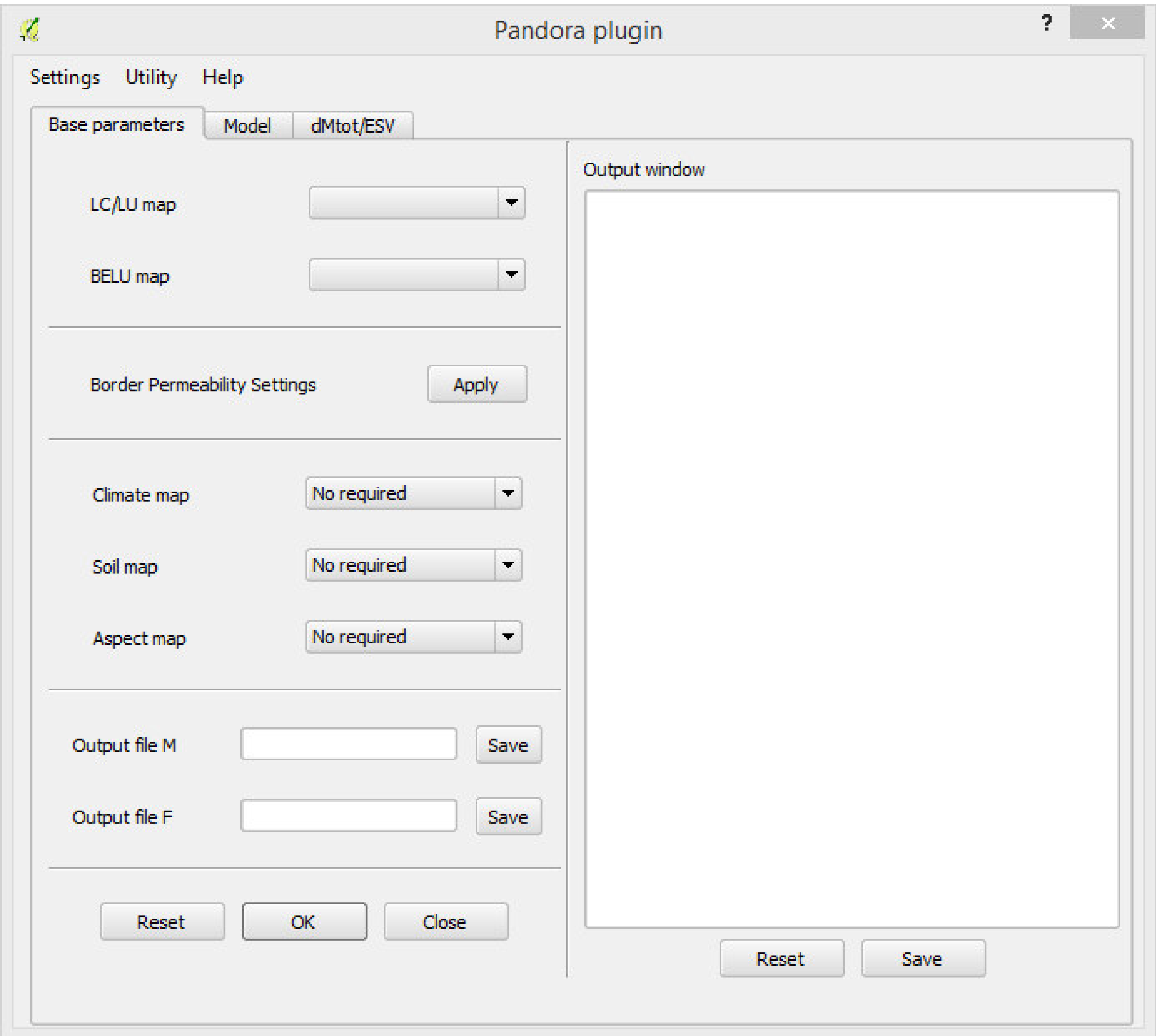

Fig. 3 The interface of PANDORA 3.0.and the Base parameters panel.

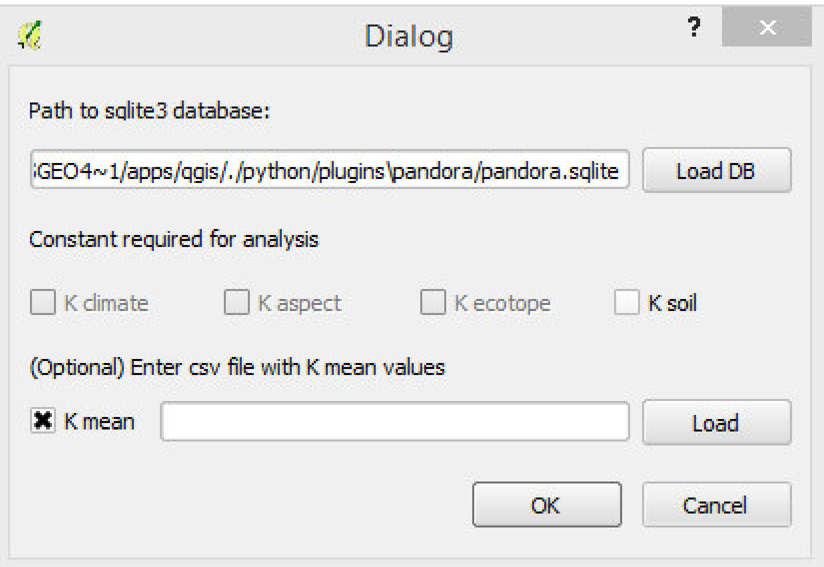

Fig. 4 Model setting preferences

The checked K constants would require the loading of the respective raster maps in QGIS and in Base parameters panel. K ecotope is directly calculated by PANDORA. At least one K parameter is necessary to run the model. Each K constant has 0-1 range values. If K mean is loaded, the other K parameters are not considered in the simulation. K mean is a csv file where for each BELU code is reported a mean value of K separated by "|". K mean file can be used in case of errors in the calculation of the different K from raster maps. Here followings, the standard structure of the K mean csv file is showed (see also data example):

```
1|0.643392570060842
2|0.627805222968894
3|0.582769830026171
4|0.533750270047732
5|0.644695159072291
6|0.647445456616184
7|0.454546446446464
8|0.668564486184597
```

3.1 Base parameters panel

This panel allows to load all the data requested by the model to build the Bio-Energy Landscape Graph (BELG) and calculate all the parameters necessary for the sub sequential steps.

All the vectorial and raster files requested by PANDORA (fig. 3) must be loaded and visualized in QGIS to be used in the plugin.

LC/LU map

LC/LU map is the shape file (see data example) representing the land cover or land use map of the simulated area. Each patch should be isolated and separated by the other ones: PANDORA considers dissolved coverages as a unique patch.

The LC/LU map must report for each patch a Corine Land Cover (CLC) code following the first, second, third or fourth level (e.g. 2 or 21 or 211 or 2112). The attribute table of the LC/LU shape file must have a column (integer) named “COD” reporting the CLC code.

NOTE: This file should have also a further column attribute (named “belu” and integer type) that defines the Bio-Energy Landscape Unit (BELU), which each patch falls in. Indeed, the model points out the assignment of BELU for each patch, but, the overlay between BELU subdivision map and LC/LU map can define some errors because of different QGIS versions and operating systems.

PANDORA will define for each LC/LU patch a BTC value followings the database sqlite already present in the PANDORA plugin folder. This database can be seen or modified by means of opportune software as DB browser (e.g. http://sqlitebrowser.org).

NOTE: the sqlite database (named pandora.sqlite) contains also the Value Coefficient (VC) for each land cover category. VC is reported in the scale 0-5 for supporting biodiversity following the work by Burkhard et al. (2012).

BELU map

BELU map is a shape file (see data example) that represents the subdivision of the simulated area in Bio-Energy Landscape Units. A BELU is defined as a portion of landscape with variable homogeneity characteristics surrounded by recognizable and significant barriers for Bio-Energy fluxes. The identification of each BELU must be realized a priori following the methodology described in Gobattoni et al. (2011) and Pelorosso et al. (2015). The attribute table must report a column named “belu” with an integer numerical code that identifies each BELU.

RASTER maps

The raster maps (climate, soil and aspect map) refers to the K parameters checked in the Settings panel. The map must be in GEOtiff format with a scale of value 0-1 (see data example). The model will calculate a mean value for each BELU from the loaded raster maps and the K ecotope (if checked). NOTE: We suggest verifying the mean K values for each BELU because errors can appear due to the QGIS version and operating system.

Output files (M and F)

The output files must be named and the directory defined. M is the Bio-Energy of each BELU and it is represented as a shape file of points. F represents the shape file of the fluxes of Bio-Energy among BELU. It is a vectorial file of lines among adjacent BELUs.

Border permeability settings

This function allows the user to set the permeability values of each border among BELUs. After setting LC/LU map and BELU map it is possible to click on the Apply button and build a temporary vectorial file named “commonborder” that will appear in the QGIS view.

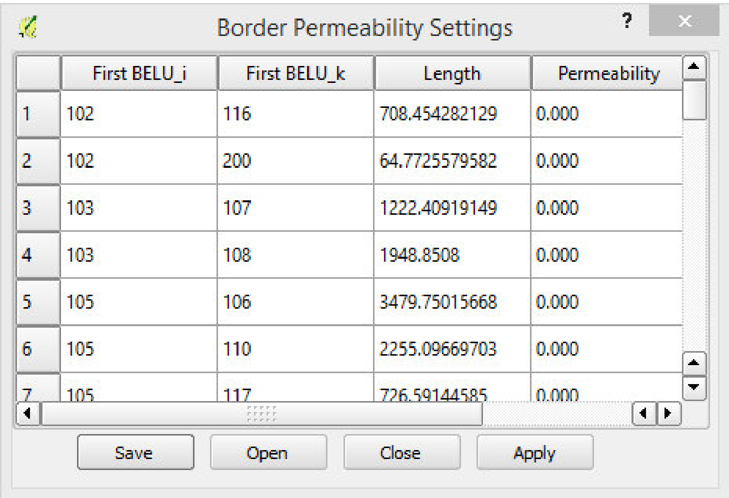

Fig. 5. Border Permeability Settings

After a while, a new window named "Border Permeability Settings" will appear on the screen (see fig. 5). With the support of "commonborder" file and the table attributes reported in the window (BELU_i, BELU_k and Length of the border), the user can insert the proper permeability value of each border (range between 0 and 1). To simplify the value insertion it is possible to save the table or load an already completed file of permeability values (.csv format file).

This is the format of the border permeability file (see data example):

```
1-14,0.3
1-2,0.05
1-66,0.9
10-107,0.9
10-11,0.3
10-17,0.3
```

After loading all the permeability values, click on Apply button and close the window.

When all the data in the Base parameters tab are completed it will be possible to click on OK button to run the first part of PANDORA model. In this stage the followings output will be pointed out:

-A shape file of M,
-a shape file of F,
-a report on all the parameters defined in the model.

The shape file can be modified and used to build the BELG while the report appears in the output windows on the left side. This report can be copied selecting the text and clicking on the button "Save". This report data now can be pasted on a new word or txt file.

If all is ok, at the end of the report the following sentence will appear:

"Now Pandora 3.0 can be implemented"

After checking that a proper value has been calculated for each parameter and BELU (e.g. Ksoil, Kaspect etc), the user can then go on the followings Model panel.

3.2 Model panel

In this panel the PANDORA 3.0 is run (Fig. 6).

The user must define the name and the directory where updated BELUs and LC/LU values are saved. The number of temporal steps can be defined in order to reach asymptotic values of Bio-Energy. Moreover, by flag the Update LC/LU shapefile option, the LC/LU map will be updated with new values (consider that this option will require further run time).

In this plugin, there is the possibility to set two constants named a and b. They are referred to the followings equations of the algebraic hierarchy modified from Pelorosso et al. (2016):

$$B_{ji}(t_s) = \frac{c_i(t_{s-1}) - \boldsymbol{a}h_i\boldsymbol{b}U_i}{d_{ji}(t_{s-1})e^{[-(c_i(t_{s-1})-\boldsymbol{a}h_i\boldsymbol{b}U_i)\Delta t]+c_i(t_{s-1})}}$$

$$d_{ji}(t_{s-1}) = \frac{c_i(t_{s-1}) - \boldsymbol{a}h_i\boldsymbol{b}U_i - c_i(t_{s-1})B_{ji}(t_{s-1})}{B_{ji}(t_{s-1})}$$

Where **a** is the weight to be given to h_i and goes from 0 to 1 with three decimal places (e.g. 0003); **b** is the weight to be attributed to U_i and it is always between 0 and 1 with three decimal places.

If you do not want to change the weights, you can leave 1 by default.

These weights can be modified in highly urbanized areas where the green spaces are limited. In this case the contribution to BELC of these residual green areas may be minimal and not be evaluated by the model. In these cases, the allocation of a minor weight to the factors that limit the spread of bio-energy (i.e. U and h) may allow an assessment of the priorities of intervention and a comparison of scenarios.

To run the model click on Apply button. A state of advancement bar is present.

A report window is present on the left while on the right the user can see and evaluate the model results in terms of Bio-Energy (M) evolution for the whole system and for each BELU. Several visualization and exportation functions of the graphs are available.

After running the model the user can proceed with the calculation of dMtot index and Ecosystem Services evaluation.

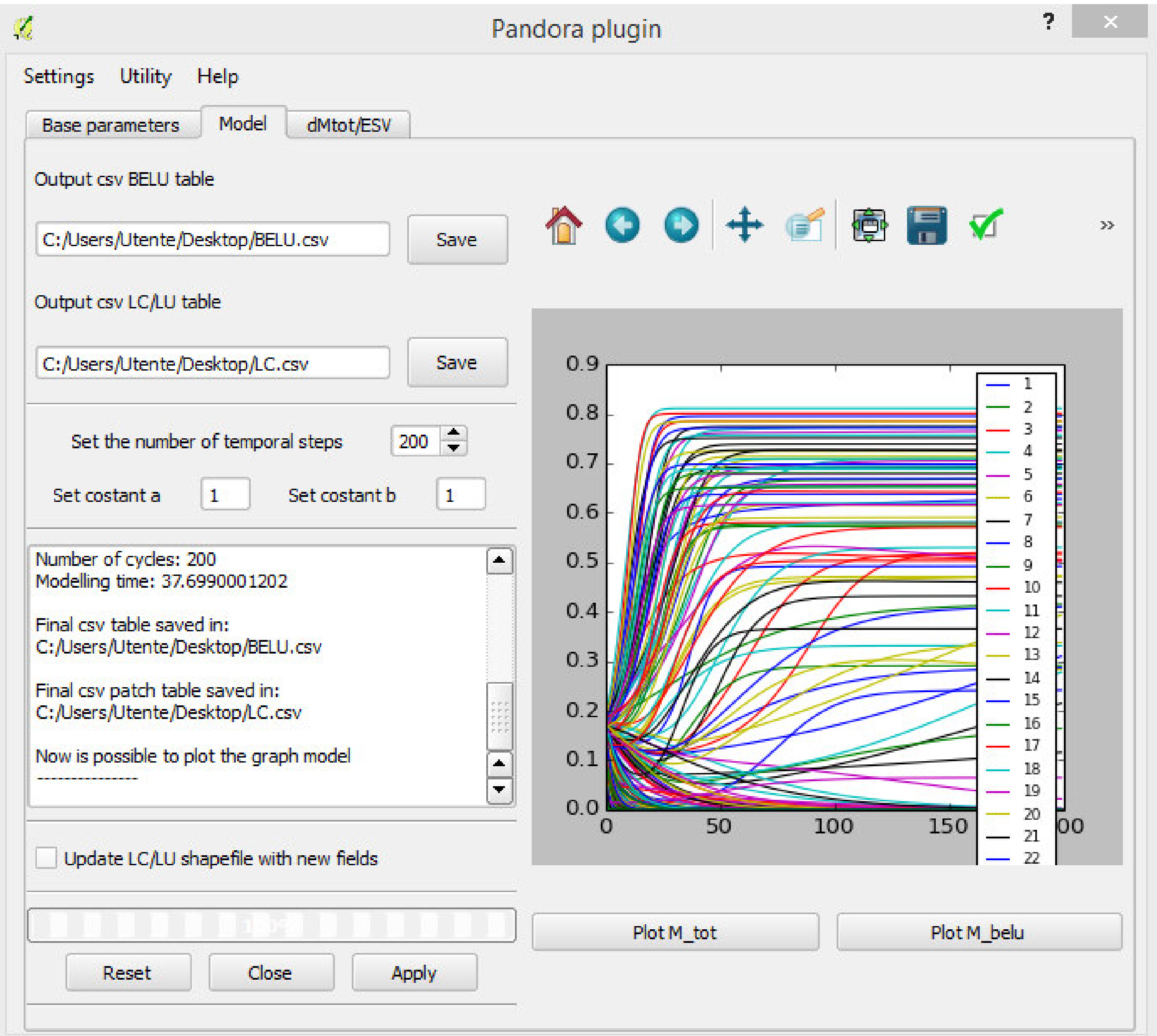

Fig. 6. The model panel

The csv BELU table will report for each BELU (row): the Bio-Energy (M) of the best case (maximum value) and the calculated Bio-Energy (M) of each step starting from the actual state.

The csv LC/LU table will report for each patch (row): the BELU id, the patch area, and the calculated BTC value of each step starting from the actual state.

Only the final values of BTC will be added to the LC/LU shape file.

3.3 dMtot/ESV panel

In this panel (Fig. 7) it is possible to calculate the index of BELC (dMtot) and the Ecosystem Service Value for Biodiversity conservation (ESV) for the selected patches of LC/LU map. The user must define the output table of dMtot, the number of steps (usually the same of previous model running), the patches to be analyzed, the output Ecosystem Services table (if he wants to calculate them).

To select the patches to be analyzed the user can define a range of them (followings the order presents in the LC/LU map) or load a proper csv file (see data example) with the list of the selected patches as:

12
16
250
569
598

This last patch selection method needs to be fully tested.

Finally, a BTC value of changing patch can be defined. The model was tested for simulation of urbanization processes, i.e. for the conversion of non-urbanized area with a BTC value > 0 to urbanized one with BTC value = 0. However, to allow a wider range of scenarios to be evaluated, the user can set a BTC value different from zero and simulate the effect on BELC of different land use changes.
Two bar of advancement state are present.

The sqlite database (named pandora.sqlite) contains the Value Coefficient (VC) for each land cover category and it is used for the ESV calculation. VC is reported in the scale 0-5 for supporting biodiversity following the work of Burkhard et al. (2012).These VC values can be modified as the user prefers, e.g. also in monetary value (see Pelorosso et al., 2014). The database sqlite already present in the PANDORA plugin folder. The sqlite database can be see or modified by means of opportune software as DB browser (e.g. http://sqlitebrowser.org).

To run the model click the Apply button.

The dMtot results will appear on the left in the report windows and in the csv file. In this last file for each patch (row) will be reported the ID, the value of Mtot at the final steps (asymptotic value) and the dMtot index.
The ESV csv file will report file for each patch (row): the ID patch, the BELU, the area, the dMtot index, the maximum value of Mtot index among the selected patches and the ESV_B. This last data represents then the Ecosystem Service Value for Biodiversity conservation of the patch in terms of BELC and habitat typology.

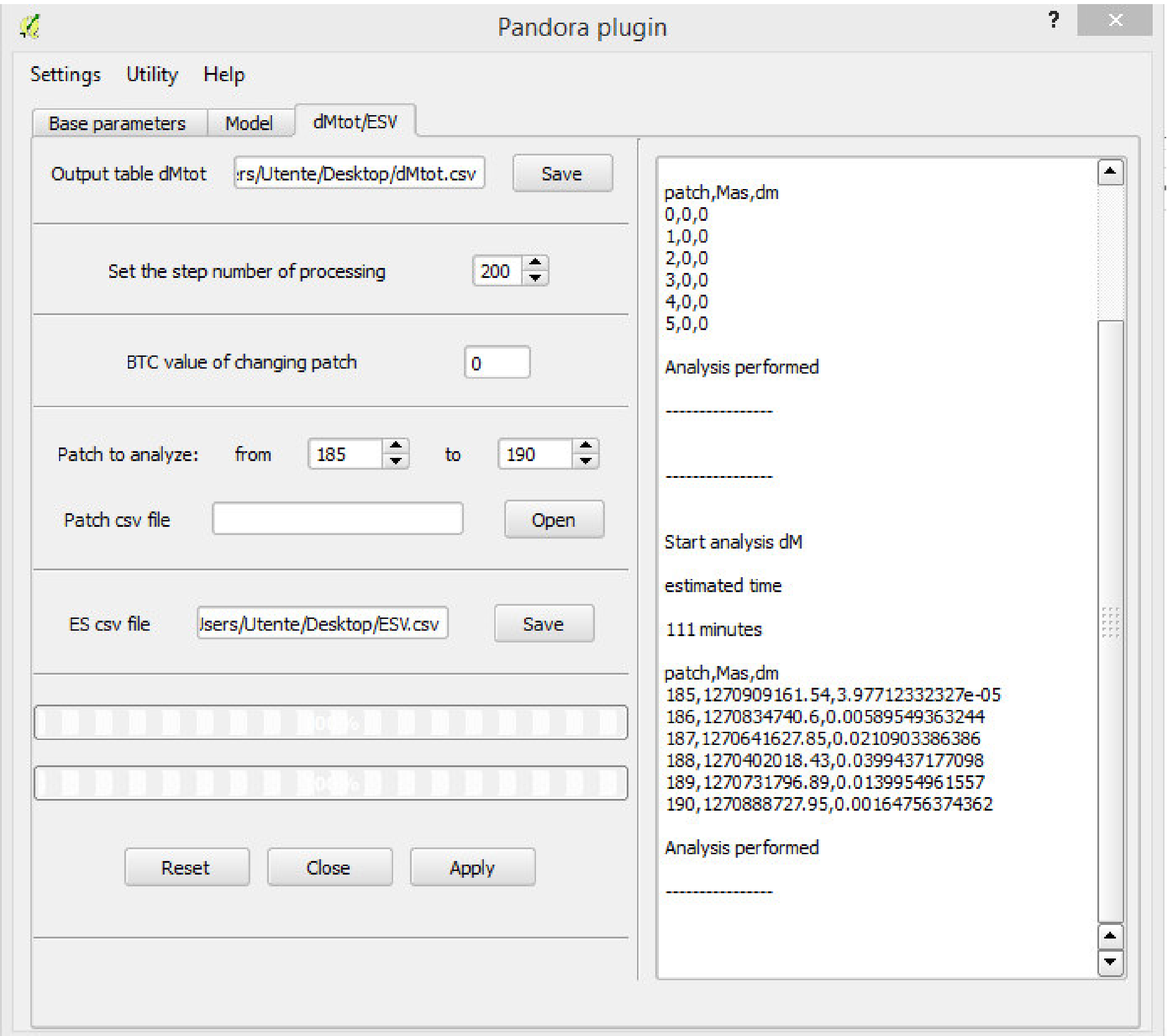

Fig. 7. The dMtot/ESV panel

4. Data example

The Data example folder (downloaded with the plugin) contains some examples of input files useful to implement PANDORA 3.0 model correctly. They are:

1. a LC map (shape file),
2. a BELU map (shape file),
3. a border_permeability file (*.csv),
4. a K soil map (.tif),
5. a K mean file (*.csv),
6. a patch selection file (*.csv).

The first 5 files are useful in the first stage of the model parameters setup, while the last one (named selected_patches.csv) can be used as an example for the definition of the patches to be analyzed in the dMtot/ESV panel.
All the data refer to the municipality of Bari (south Italy).

5. Bibliography

Burkhard, B., Kroll, F., Nedkov, S., & Müller, F. (2012). Mapping ecosystem service supply, demand and budgets. *Ecological Indicators*, *21*, 17–29. doi:10.1016/j.ecolind.2011.06.019

Gobattoni, F., Pelorosso, R., Lauro, G., Leone, A., & Monaco, R. (2011). A procedure for mathematical analysis of landscape evolution and equilibrium scenarios assessment. *Landscape and Urban Planning*, *103*(3-4), 289–302. doi:10.1016/j.landurbplan.2011.08.011

Pelorosso, R., Gobattoni, F., Geri, F., Monaco, R., & Leone, A. (2014). Bio-Energy Connectivity and Ecosystem Services. An assessment by PANDORA3.0 model for land use decision making. *Journal of Land Use, Mobility and Environment*, (Special Issue Eighth International Conference INPUT).

Pelorosso, R., Gobattoni, F., Geri, F., Monaco, R., & Leone, A. (2016). Evaluation of Ecosystem Services related to Bio-Energy Landscape Connectivity (BELC) for land use decision making across different planning scales. *Ecological Indicators*, *61*, 114–129. doi:http://dx.doi.org/10.1016/j.ecolind.2015.01.016