VecLI：Vector-based Landscape Index Calculation and Analysis System

Version 2.6.0 (3.0.0 beta)

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Catalogue

1. Product Introduction

1.1. VecLI Product

VecLI is a system for calculating and evaluating landscape indices of land-parcels in vector-based data format, which could be used to calculate landscape indices based on real plots and analyze the landscape similarity between different cities.

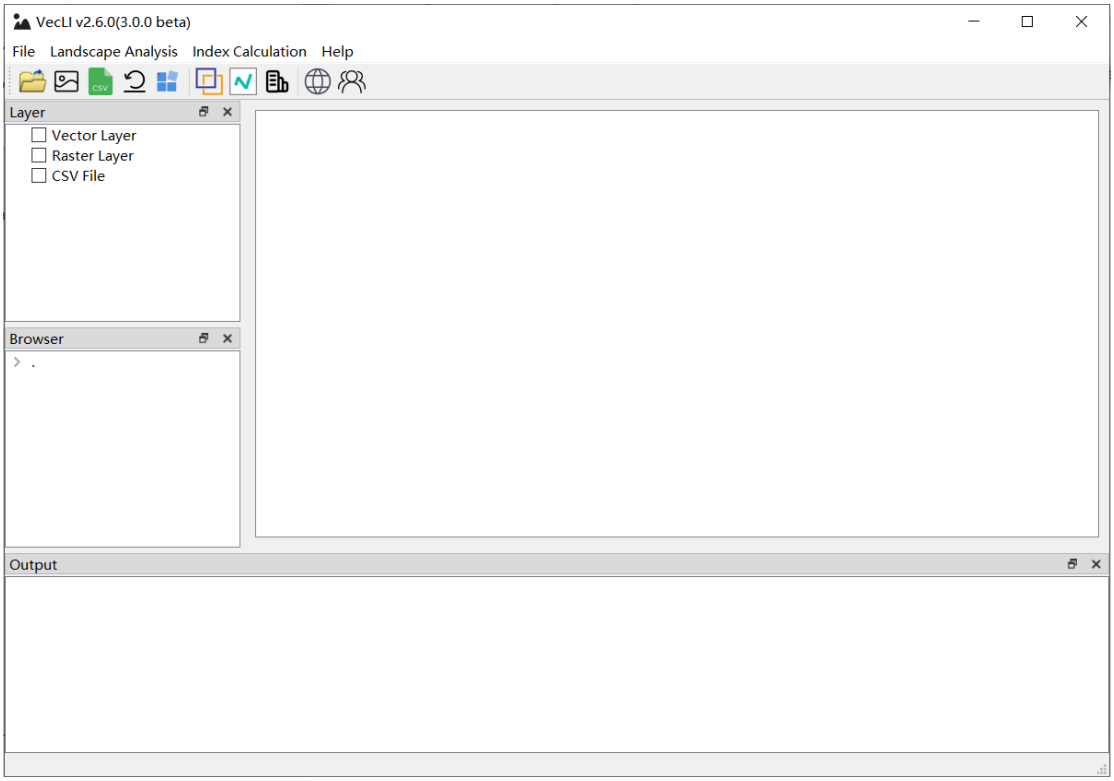
1.2. Target Users

GIS Practitioner, Urban planners and researchers.

1.3. Installation

Please ***unzip*** the program to the full English file path. ***Double-click*** “Setup.exe” in the program directory to start the installation program. After installation ***click*** "VecLI.exe" to run.

1.4. User Interface

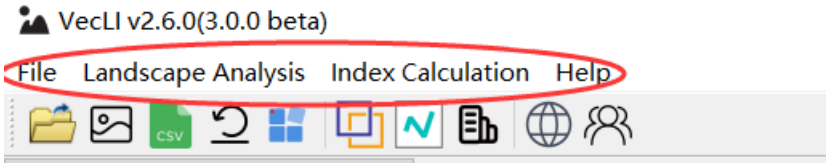


1.5. Software Control Panel Description

1.5.1. Menu Bar

The menu bar of VecLI includes three parts:

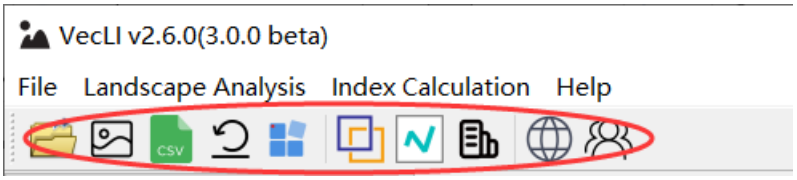
“File”, “Landscape Analysis”, “lndex Caculation” and “Help”.



1.5.2. Tool Bar

The tool bar of VecLI includes 11 parts:

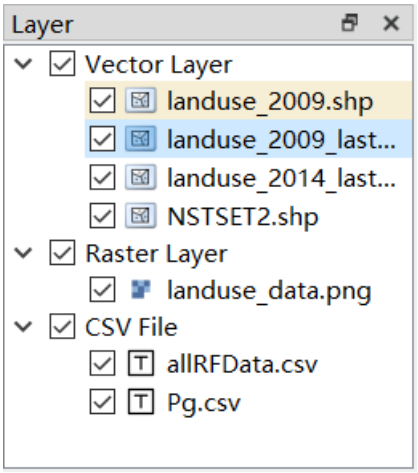
“Open Vector File”, “Open Raster File”, “Open CSV File”, “Open Project File”, “Save Project File”, “Data Preprocessing”, “Parcel Merge”, “Vector FoM”, “Landscape Index”, “Website and Update” and “About Us”.



1.5.3. Data Management Panel

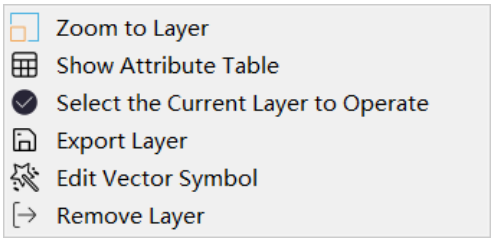
A brand-new IO, operational and roaming interface for operating spatial data (raster and vector data) is designed. Basic functions of GIS such as attribute editing, layer symbolization, zoom in and out operation, etc. are included.

Data imported into VecLI will be displayed and grouped to "vector layer", "raster layer" and " CSV file" layer according to its file format.



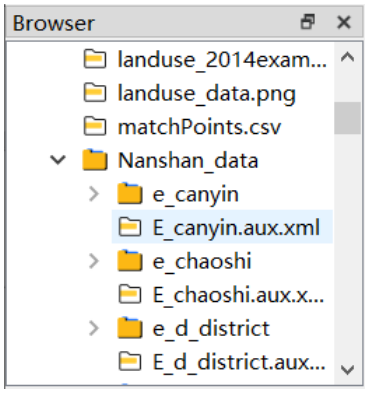
To determine a specific GIS operation, Right-Click the selected data and a GIS operation widget will pop up on hand. Available GIS operations include “Zoom to Layer”, “Show Attribute Table”, “Select the Current Layer to Operate”, “Export

Layer", "Edit Vector Symbol", and "Remove Layer".



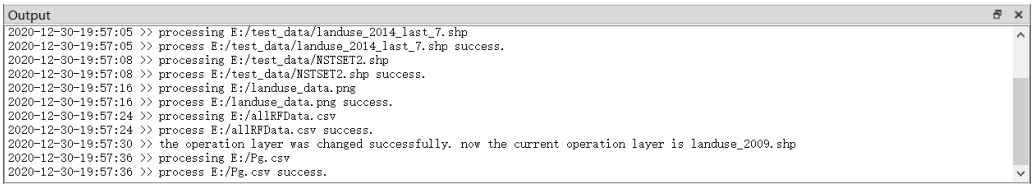
1.5.4. Current Directory Browser Panel

This panel provides directory browser to search, find, view, and open VecLI related directories and files.



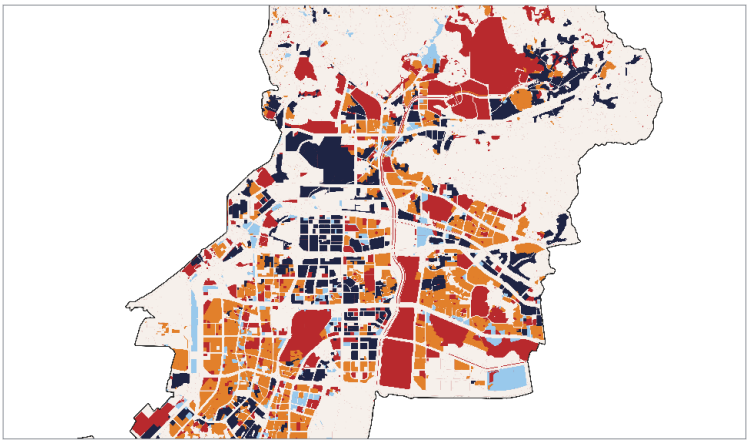
1.5.5. Log Output Panel

VecLI provides a real-time output monitor and generates log files for the whole computation process of vector-based landscape index.



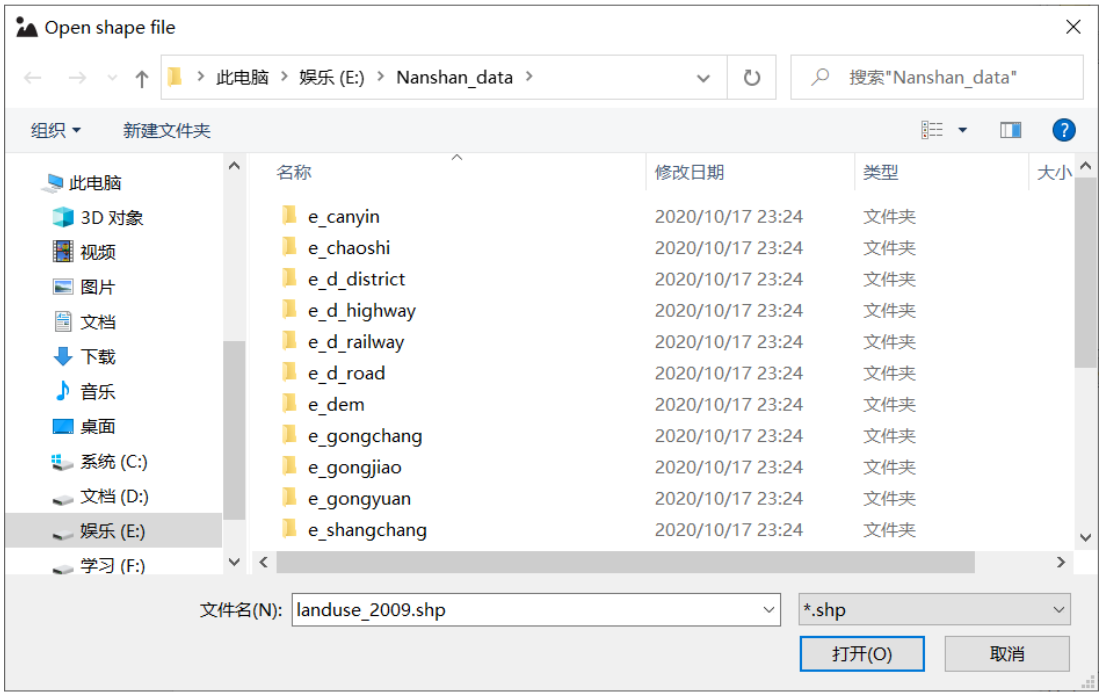
1.5.6. Data Visualization Panel

The panel supports roaming and displaying vector and raster files imported into the system.



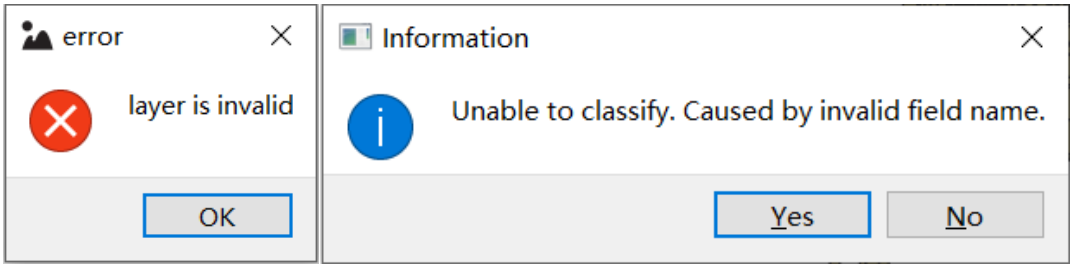
1.5.7. Directory Selection Dialog Box

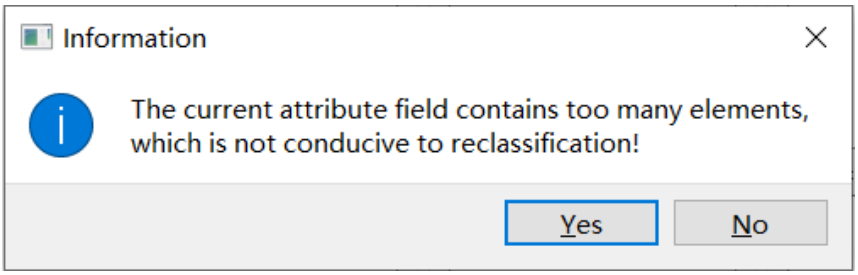
This module provides a UI for directory and file selection, which is used to ***specify*** the location of the importing, saving and exporting data files.



1.5.8. Exception Prompt Dialog Box

These dialog boxes prompt the errors and provide the necessary information to debug.



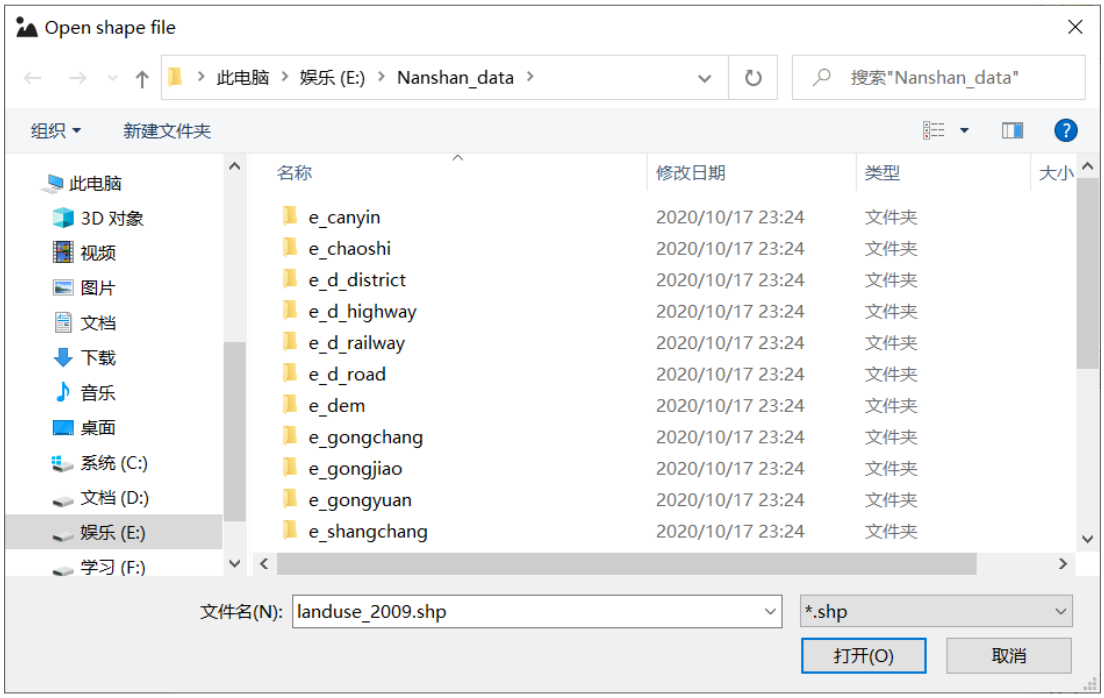


2. Data Display Function

2.1. Basic Function

2.1.1. Import Files

Click the "Open Vector File" button  in the toolbar, it will automatically jump to the Directory Selection Dialog Box for vector file selection.

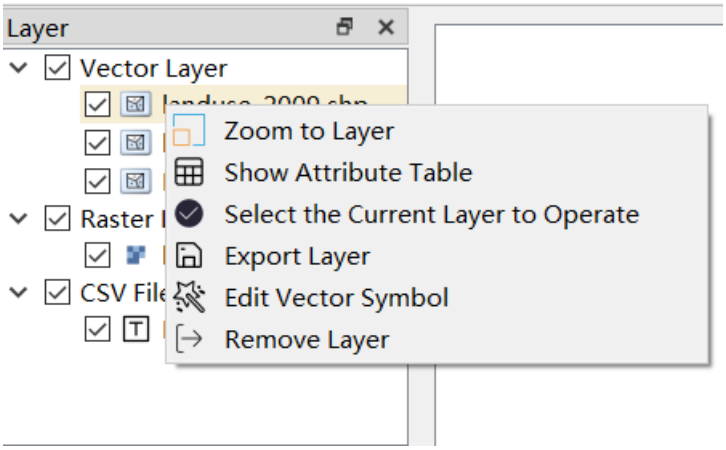


Click the "Open Grid File" button  in the toolbar, it will automatically jump to the Directory Selection Dialog Box for raster file selection.

Click the "Open CSV File" button  in the toolbar, it will automatically jump to the Directory Selection Dialog Box for CSV file selection.

2.1.2. Basic GIS Operations

Right-click the selected data layer, it will pop up a GIS operation widget, as shown in the figure below:



2.1.3. Zoom to Layer

Click the "Zoom to Layer" button to display the data layer in a full view of either a vector or raster data layer.

2.1.4. Show Attribute Table

Click the "Open Attribute Table" button to show the attribute table of a selected CSV file.

Attribute ***edit*** is allowed for each entry, as shown in the figure below:

Attribute Table of "landuse_2009.shp"

	OBJECTID	BSM	YSDM	TBYBH	TBBH	DLBM	DLMC	QSXZ	QSDWDM	QSDWMC	ZLDWDM	ZLDWMC	GDL
1	33757	138.00000000	2001010100	建设	270	102	公路用地	10	440304004001	梅林街道	440304004001	梅林街道	
2	38355	43071.00000000	2001010100	建设	5610	201	城市	10	440306007001	石岩街道	440306007001	石岩街道	
3	38356	43000.00000000	2001010100	建设	5604	201	城市	10	440306007001	石岩街道	440306007001	石岩街道	
4	40054	1364.00000000	2001010100	建设	535	201	城市	10	440304004001	梅林街道	440304004001	梅林街道	
5	40055	1372.00000000	2001010100	建设	536	201	城市	10	440304004001	梅林街道	440304004001	梅林街道	
6	39645	108.00000000	2001010100	农用	249	031	有林地	10	440304004001	梅林街道	440304004001	梅林街道	
7	39315	4044.00000000	2001010100	建设	658	201	城市	10	440304006001	沙头街道	440304006001	沙头街道	
8	40488	1800.00000000	2001010100	建设	398	201	城市	10	440304007001	香蜜湖街道	440304007001	香蜜湖街道	
9	41149	3760.00000000	2001010100	建设	723	201	城市	10	440304006001	沙头街道	440304006001	沙头街道	
10	41654	3793.00000000	2001010100	建设	77	201	城市	10	440304006001	沙头街道	440304006001	沙头街道	
11	41105	4042.00000000	2001010100	农用	72	033	其他林地	10	440304006001	沙头街道	440304006001	沙头街道	
12	41889	3243.00000000	2001010100	建设	722	201	城市	10	440304006001	沙头街道	440304006001	沙头街道	
13	42798	46609.00000000	2001010100	建设	184	201	城市	10	440306010001	新安街道	440306010001	新安街道	
14	43313	451.00000000	2001010100	农用	393	031	有林地	10	440304004001	梅林街道	440304004001	梅林街道	
15	43468	48511.00000000	2001010100	建设	957	201	城市	10	440306010001	新安街道	440306010001	新安街道	
16	43318	1872.00000000	2001010100	农用	176	033	其他林地	10	440304007001	香蜜湖街道	440304007001	香蜜湖街道	
17	43750	45385.00000000	2001010100	建设	5810	201	城市	10	440306007001	石岩街道	440306007001	石岩街道	
18	42472	4046.00000000	2001010100	未利	212	115	沿海滩涂	10	440304006001	沙头街道	440304006001	沙头街道	
19	42473	4104.00000000	2001010100	未利	213	115	沿海滩涂	10	440304006001	沙头街道	440304006001	沙头街道	

2.1.5. Select the Current Layer to Operate

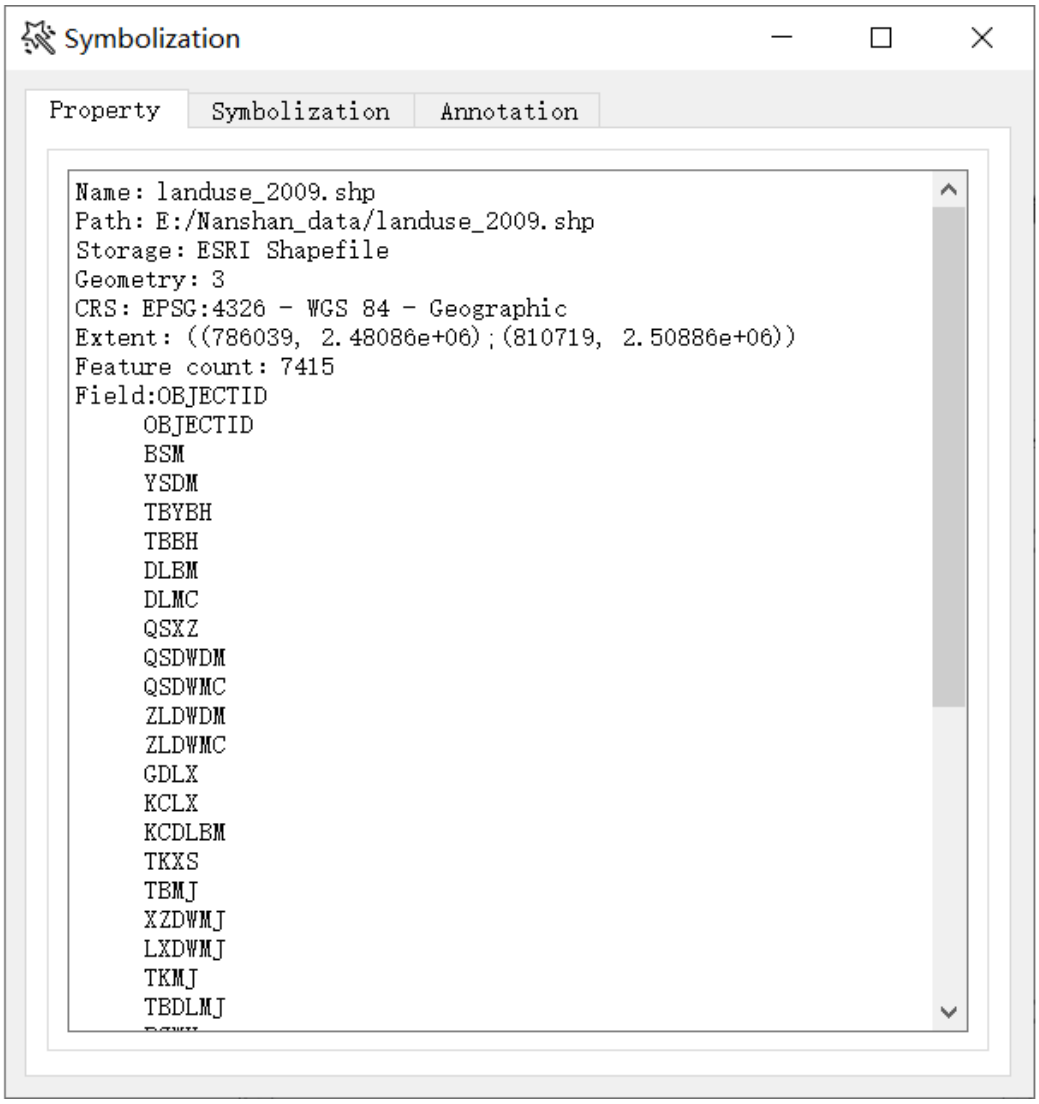
Click the "Select the Current Layer to Operate" button, it will enable the selected layer for the vector symbolization function.

2.1.6. Edit Vector Symbol

Click the "Edit Vector Symbol" button to enable the file property option, symbolization option and annotation option.

- Property

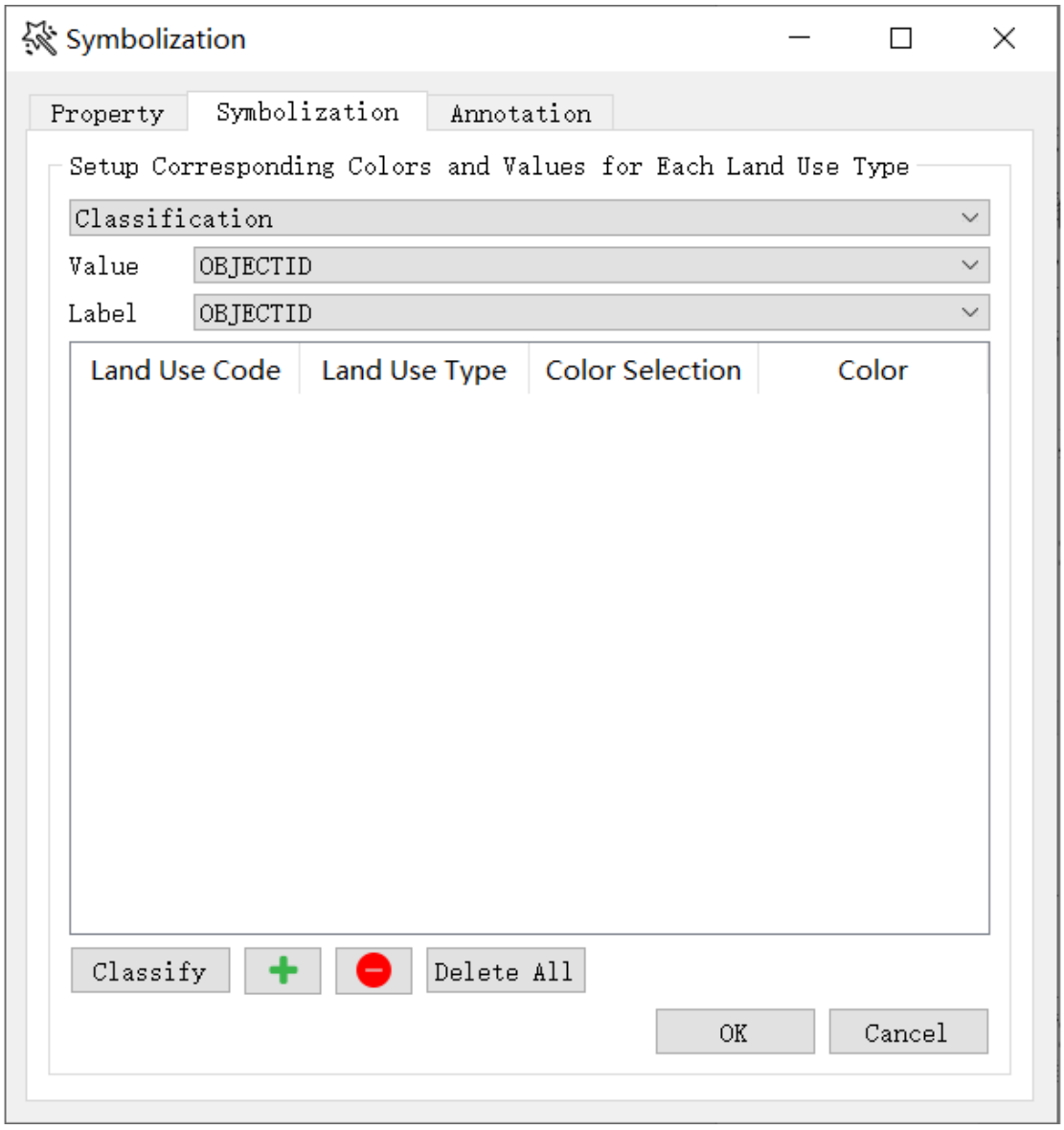
Select "property" to view the property information of the current open vector file:



The property sheet will show contents such as Name, Path, Storage (File type), Geometry, CRS (coordinate reference system), Extent, Feature count (number of features), and Field information of the current layer for users to ***consult***.

- Symbolization

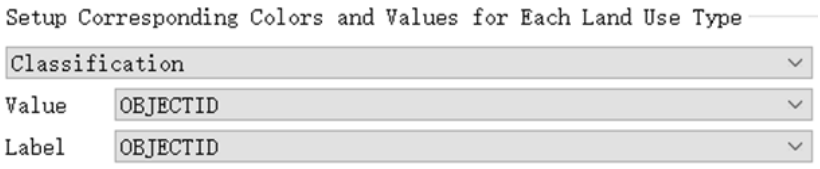
Select "Symbolization" to carry out symbolization operation. Users can set a classified display for different attribute fields:



In the “classification” drop-down box, users can ***select*** a specific Symbolization Method for the currently operating data layer.

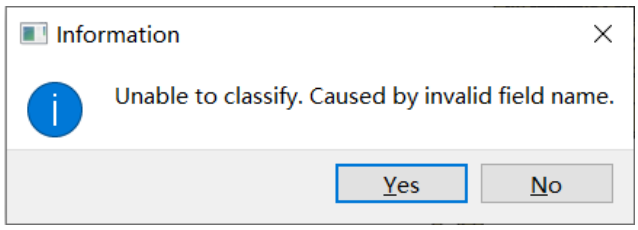
In the “Value” drop-down box, users can ***select*** a specific field name that needs classification.

In the “Label” drop-down box, users can ***select*** a specific field name that labels the category.

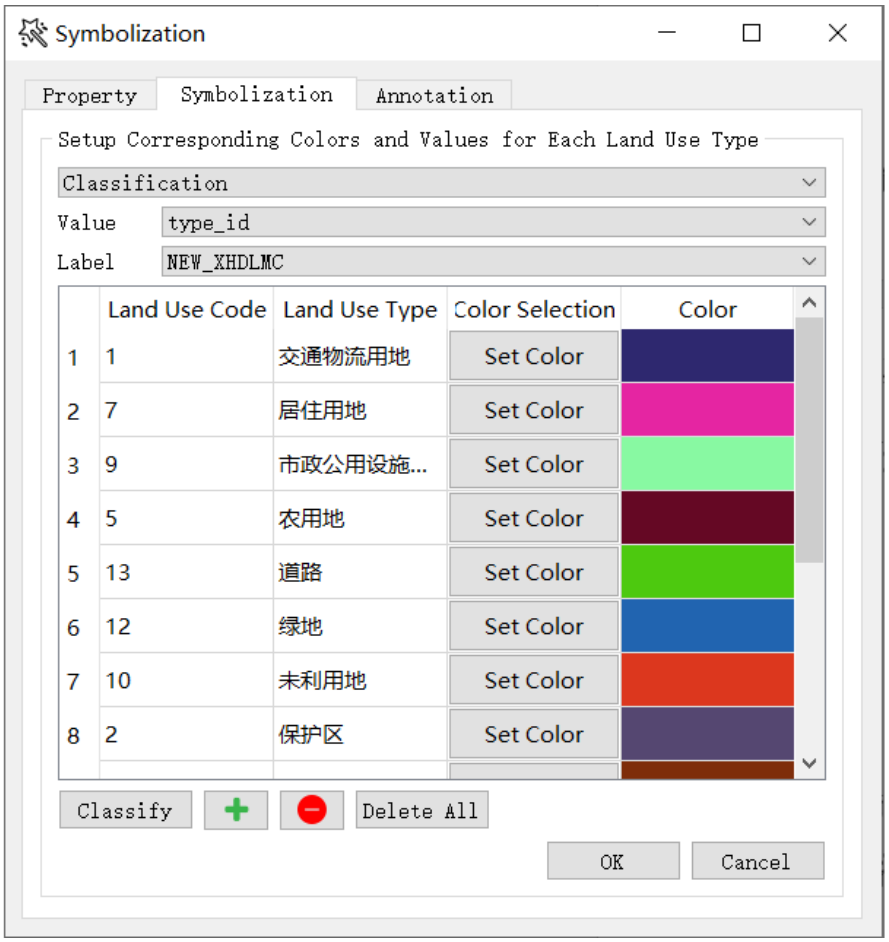


Note: if a non-numeric field is selected in the “Value” drop-down box, Exception

Prompt Dialog Box will pop up and require the user to ***reselect*** a valid field:



Click the "Classify"  button to conduct Vector Symbolization and initialize classification automatically. A sample of classification result is shown as below:

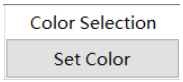


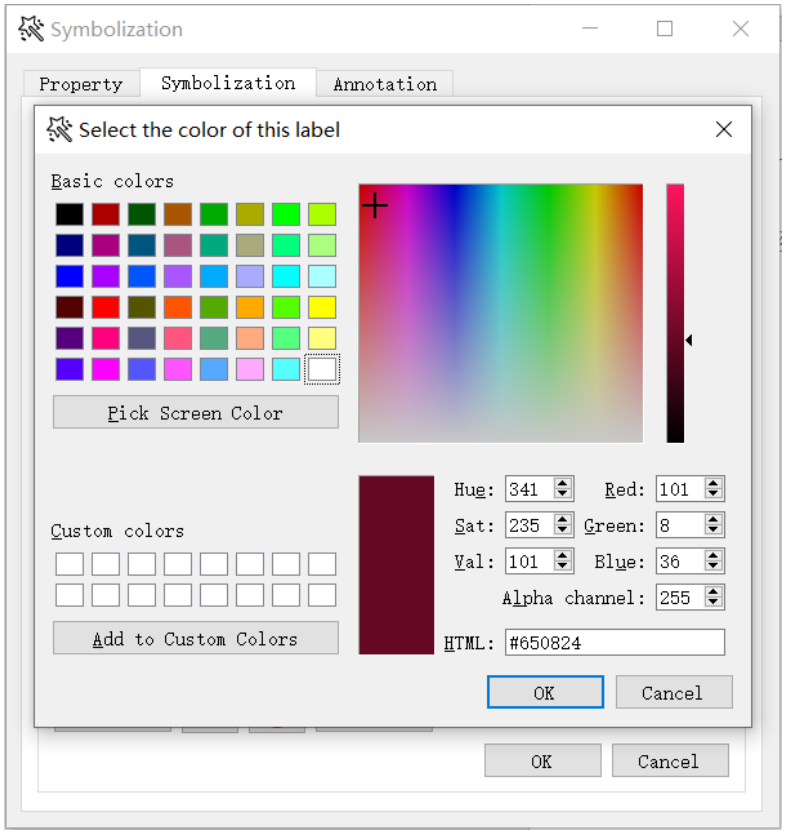
Click the "add a class"  button, the system will automatically add a new category, as shown below:

Click the "delete a class"  button, the system will delete the current selected category, as shown below:

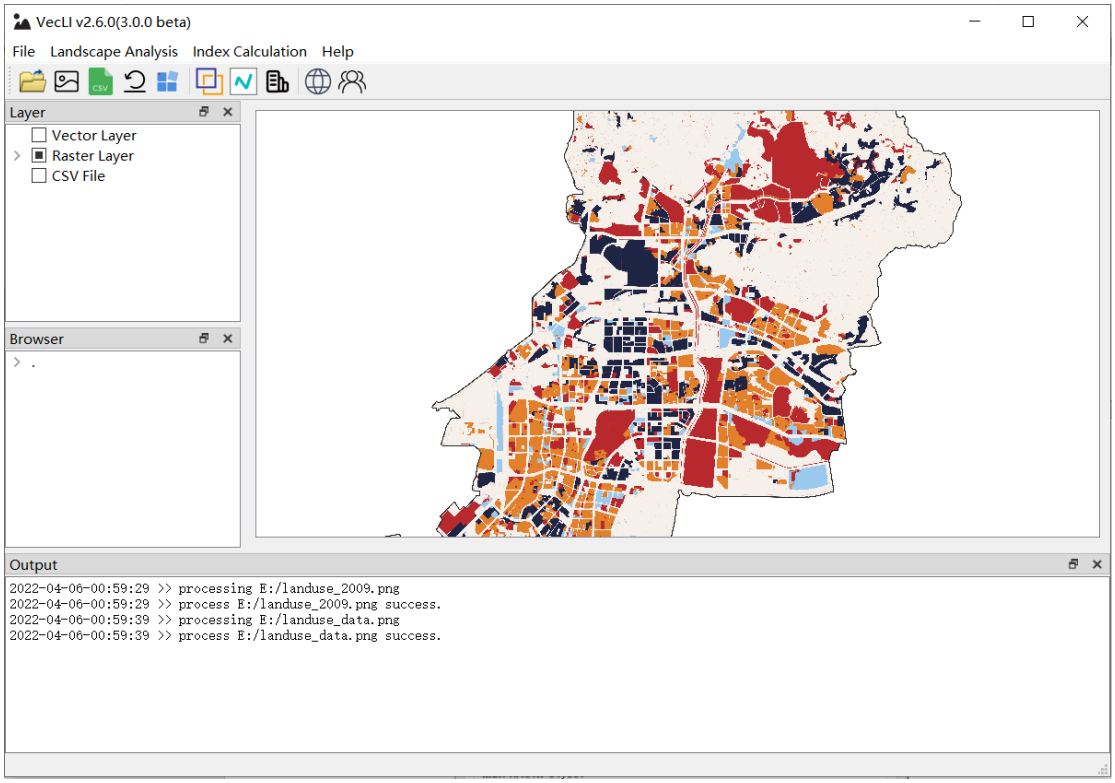
Click the "delete all classes" button, the system will automatically clear the current contents.

Users can ***adjust*** the field in either "Value" or "Label" drop-down box. ***Click*** the "Classify"  button to ***redo*** the classification initialization process.

Click the "Set Color"  button, the system will automatically jump to a color selection widget to select the color of this label, as shown below:

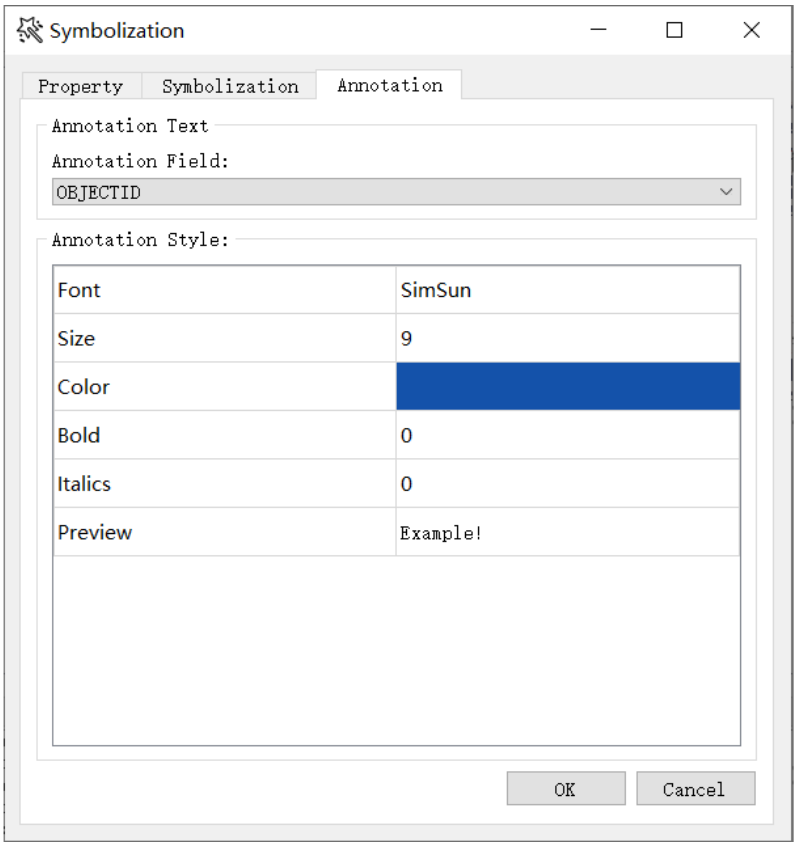


Click the "OK"  button to exit the "Layer Symbolization" interface after all parameter settings are done. The system will refresh the display interface and change the layer style based on user's layer symbolization settings. A sample rendering result is shown as below:



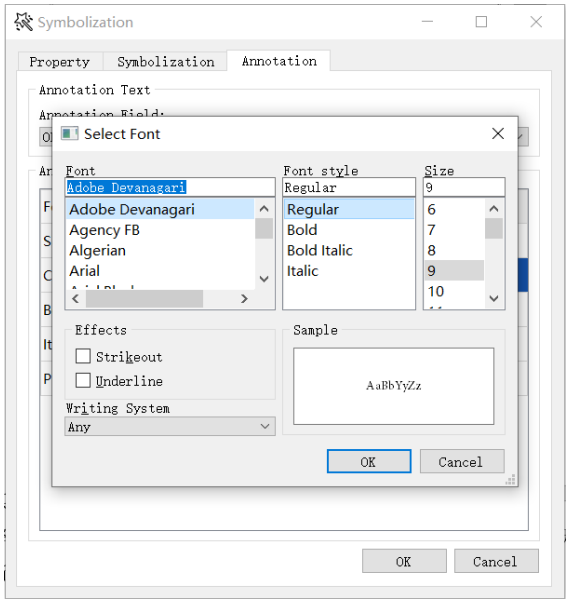
- Annotation

Select "Annotation" to conduct annotation configuration:

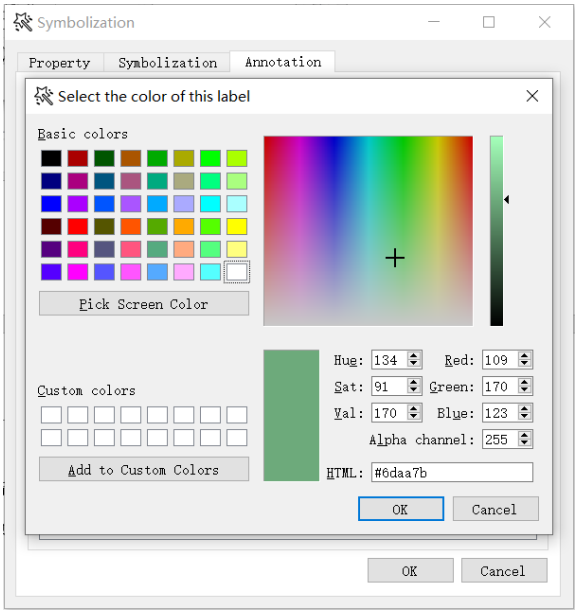


In the “Annotation Field” drop-down box, users can ***select*** a specific attribute which needs annotation setting.

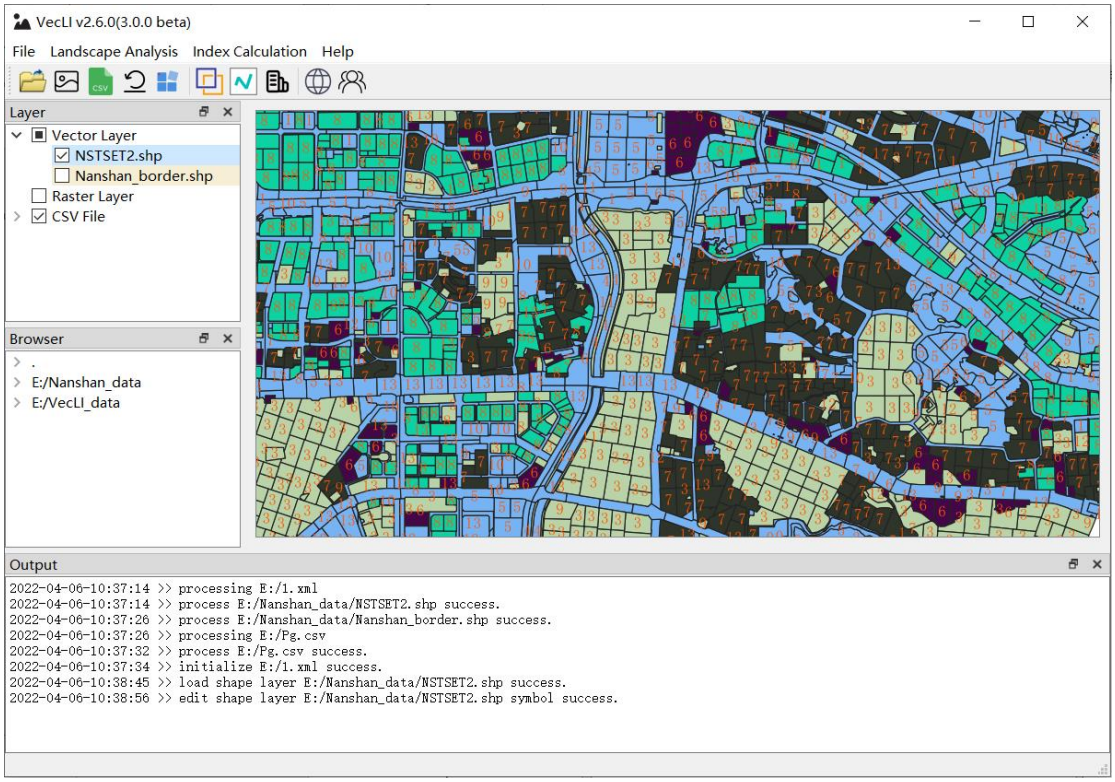
Users can ***configure*** annotation styles including Font, Size, Color, Bold, Italics and Preview as provided by VecLI:



A color selection widget is provided for selecting the annotation color. User can edit the color for annotation by ***clicking*** the color bar Color , as the figure shown below:



Click the “OK”  button to exit the “Layer Symbolization” interface after all parameter settings are done. The system will refresh the display interface and change the layer style based on user’s layer symbolization settings. A sample rendering result is shown as below:

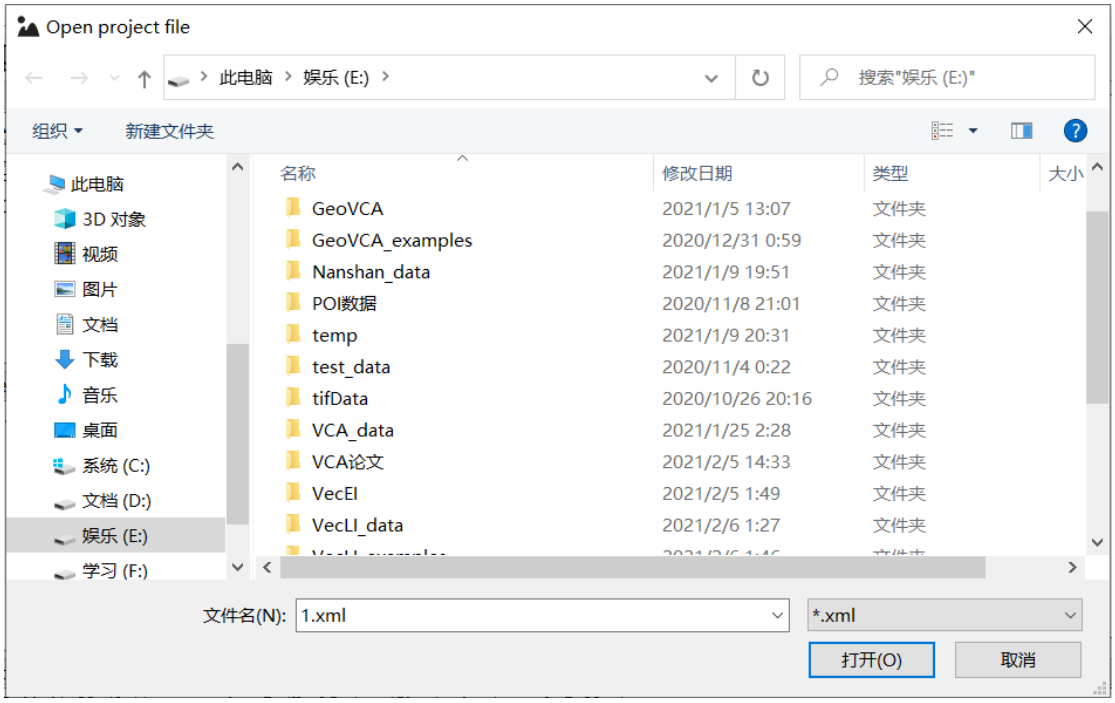


2.1.7. Remove Layer

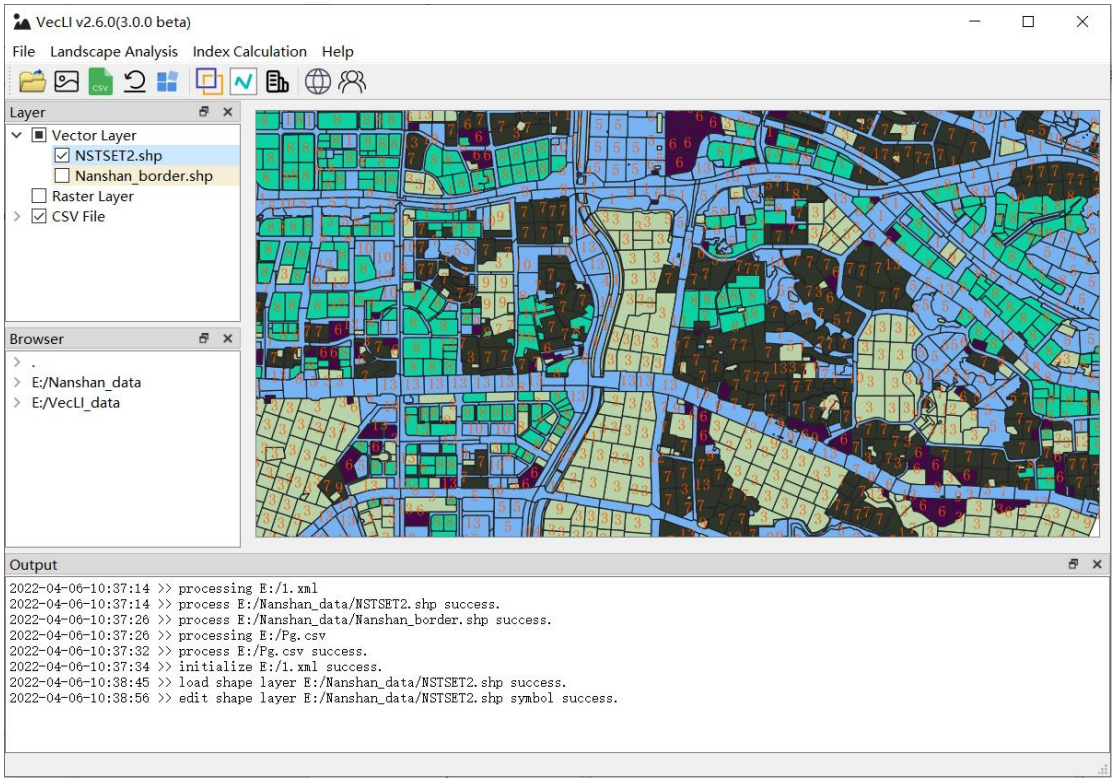
Click the “Remove Layer” button in the GIS operation widget, the selected layer will be removed immediately from the current project.

2.1.8. Open Project File (.xml)

First-Click the “File” in the menu bar and ***choose*** the “Open Project File”, the system will automatically jump to the Directory Selection Dialog Box for opening an existing project. Clicking the toolbar’s  button would work in the same way:

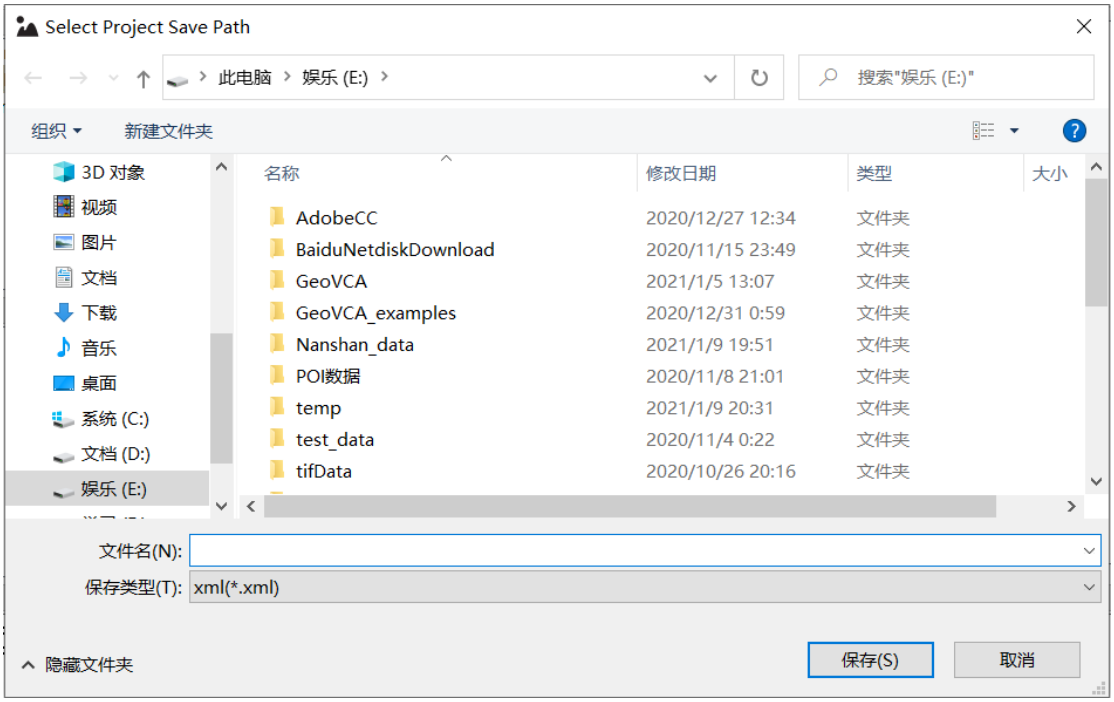


The user interface after opening a project file is as follow:



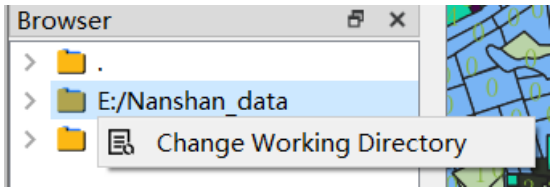
2.1.9. Save Project File (.xml)

First-Click the "File" in the menu bar and ***choose*** the "Save Project File" option, the system will automatically jump to the Directory Selection Dialog Box to save the currently operating project in user's specified directory path. ***Clicking*** the toolbar's  button would work in the same way:

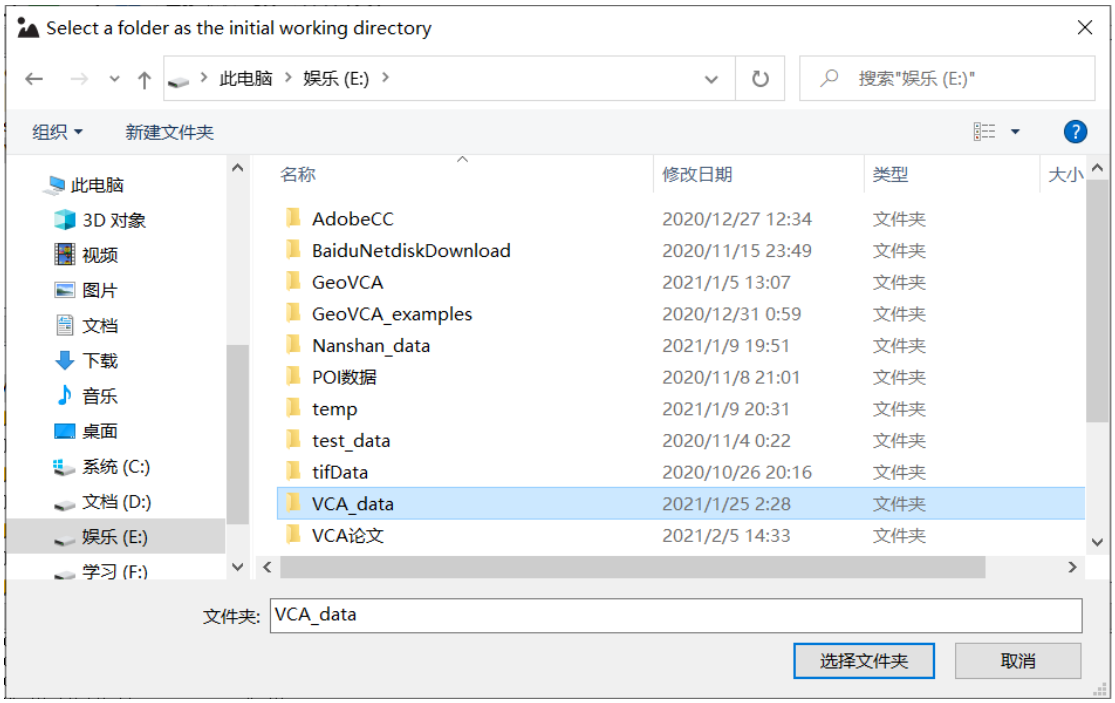


2.1.10. Change Working Directory

Users can change the working directory by ***right-clicking*** the Current Directory Browser Panel, which is shown as below:

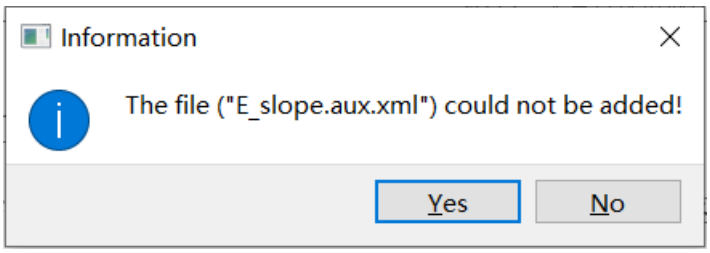


This will automatically open a Directory Selection Dialog Box after ***clicking*** the "Change Working Directory" option, as shown in the figure below:



2.1.11. Import Files from Current Directory Browser Panel

Double-click any file shown in the Current Directory Browser Panel, users can quickly import the corresponding data into the system. Exception Prompt Dialog Box will pop up if the chosen file has an invalid format:

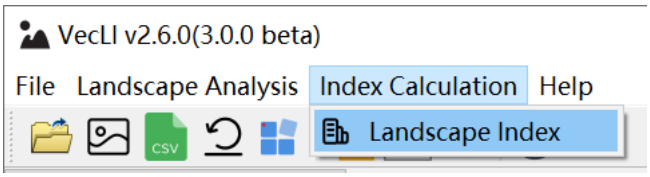


Note: Supported formats are only among vector files, raster files and CSV files.

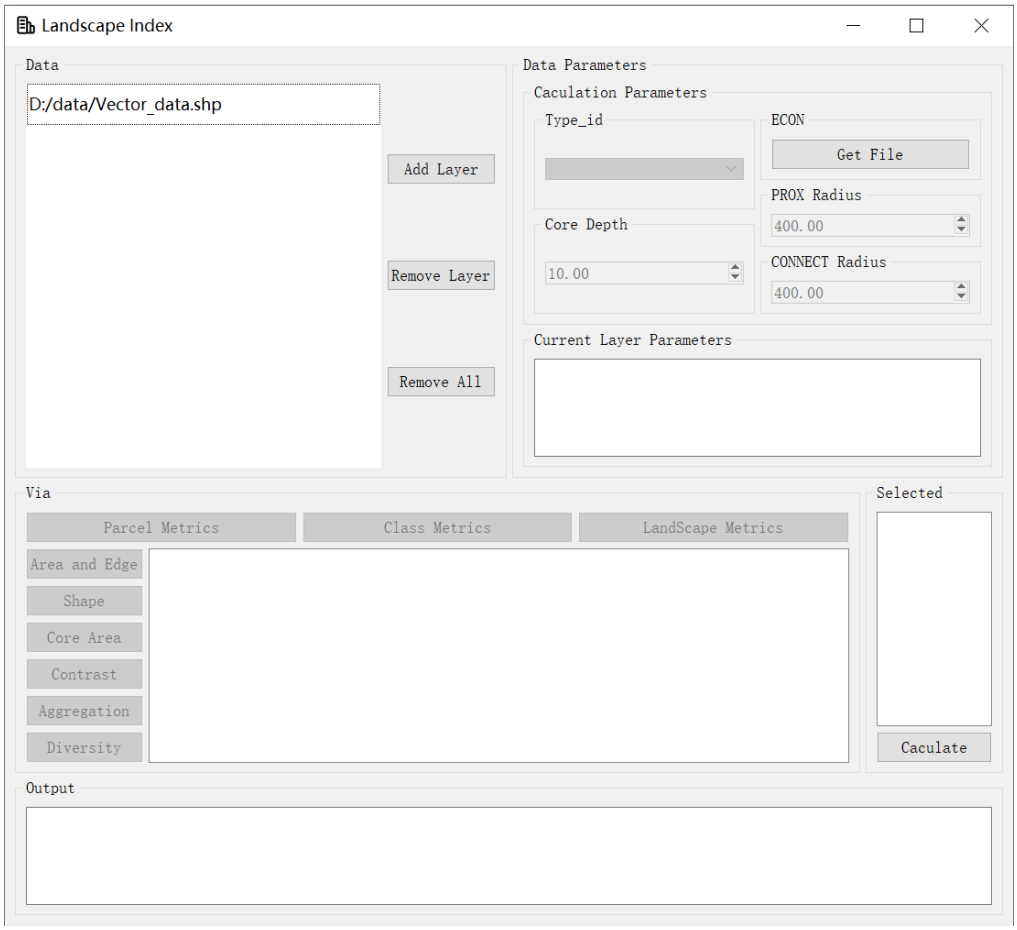
3. Vector-based Landscape Index Calculation and Output Function

This module is designed for the calculation of vector landscape indices.

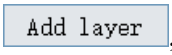
First-Click the "Landscape Index" in the menu bar and ***choose*** the "Landscape Index", the system will automatically jump to the Landscape Index Window.



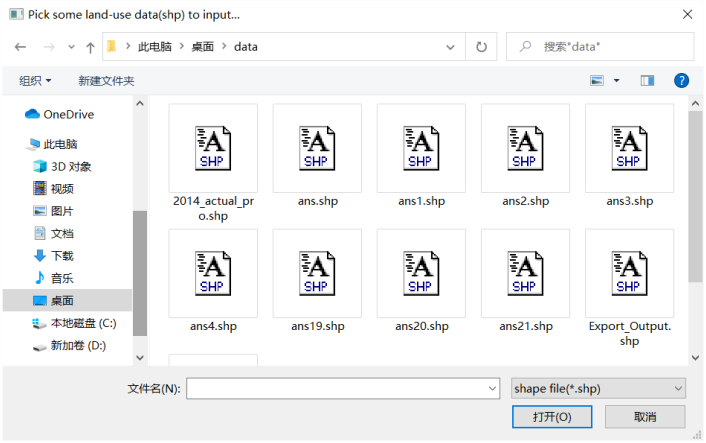
Click the toolbar's  button would work in the same way:

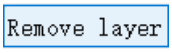


3.1. Operate Files

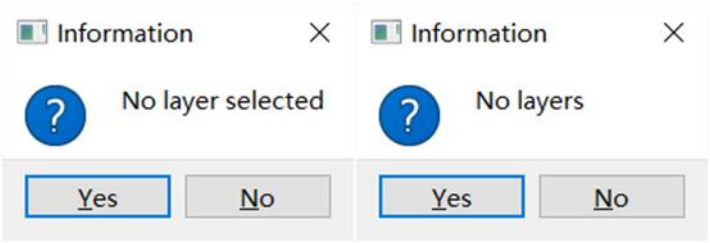
Click the "Vector file Import" button  , the system will automatically

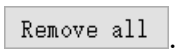
jump to the Directory Selection Dialog Box for vector file selection (vector-based land-parcel files from different times):



Click the "Remove layer" button 

to remove the selected layer, if no layer is selected or the current catalogue does not contain any layers, a pop-up box will be displayed to remind the user.

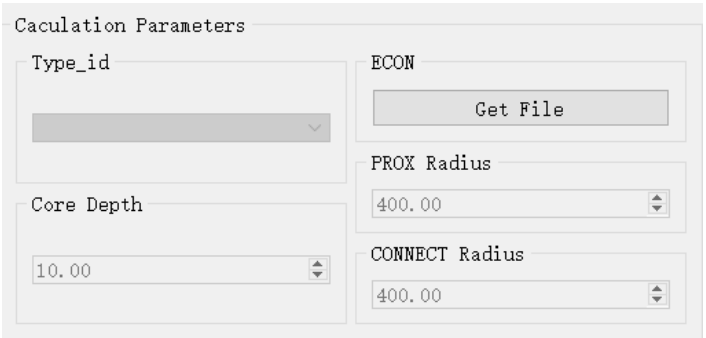


You can also remove all layers by ***clicking*** the "Remove all layers" button 

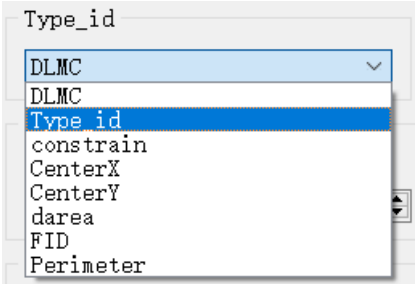
.

3.2. Parameter Settings

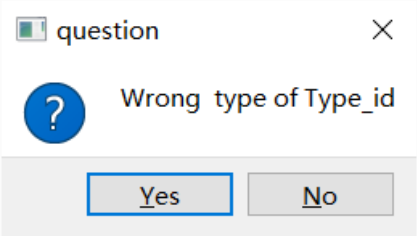
After users have selected vector file, the relevant function buttons are open for use. Users are asked to ***set*** necessary parameters for vector-based landscape index calculation. Parameters include: 1). Land-use Type; 2). ECON; 3). Core Depth; 4). PROX Radius; and 5) CONNECT Radius



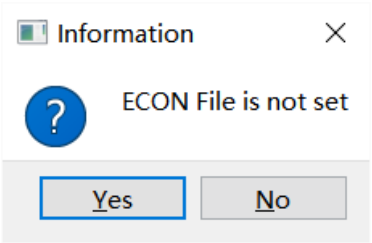
“Land-sue Type” refers to the attribute field name of the vector file labeled parcel type. The drop down box will automatically read all the fields contained in the vector file and users can select the appropriate field in the drop down menu.



Note that exceptions will throw out to notify the cause of failure.



“ECON”, the second parameter, refers to the contrast file between the different types of parcels when calculating the contrast indexs. ***Click*** the "Get File" button to open the corresponding txt file. If no file is selected, the system will pop up a prompt window.



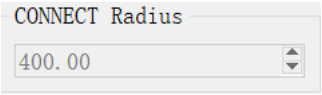
The ECON file format is as follows, each line contains three numbers separated by a space. The first two digits are the land-use type and the third digit is the contrast value (Default value is 1). Users can use the file to set the contrast between different parcel types.

```
1 2 0.8
1 3 1.2
1 4 0.9
2 3 1.0
2 4 1.1
3 4 1.0
```

“Core Depth”, the third parameter (Default value is 10 metres), is the depth of the edge set to find the core area of the parcel. The smaller the Core Depth, the larger the core area. If users do not select an index for the core area, the value of “Core Depth” will have no effect on the results of the other indices.

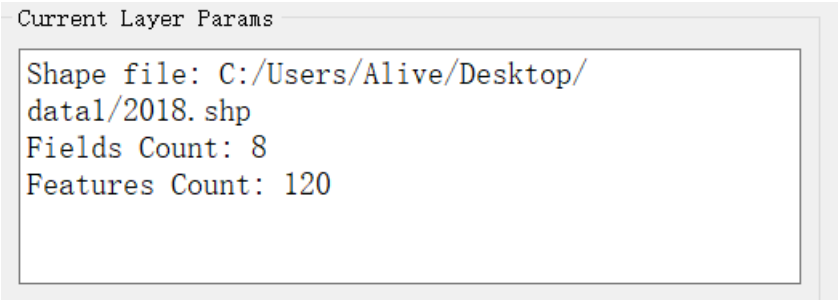
"PROX Radius", the forth parameter (Default value is 400 metres), refers to the radius when calculating the PROX index, using the centre of mass of the parcel as the centre of a circle to find the surrounding parcels. If users do not select an index related to the core area, the value of "PROX Radius" will have no effect on the results of the other indices. To ensure the efficiency of the calculation, "PROX Radius" is also the radius of SIMI index.

"CONNECT Radius", the last parameter (Default value is 400 metres), refers to the radius of a parcel when calculating the CONNECT index. When other parcel in the mass of a parcel as the centre is of the same type, the parcel is judged to be within the neighbourhood. If the user does not select an index relating to the core area, the value of CONNECT Radius will have no effect on the results of the other indices. "CONNECT Radius" should be manually entered by users:



3.3. Overview of parameter settings

After selecting the vector file, the window will display some of the parameters of the file, including the file name, the number of attribute fields and the number of parcels.

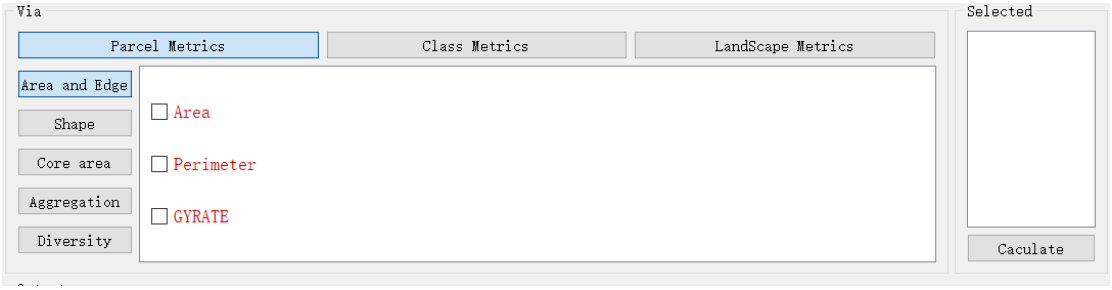


In this new version, users do not need to select fields such as area and perimeter, and the software simplifies the input parameters for easy operation.

3.4. Landscape index setting

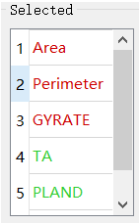
As the software supports a large number of vector landscape indices, users can

select a specific landscape index for their needs. As shown in the figure below:



Click the three buttons above to select the index module. For the index to be calculated, click on the box in front of the index to put a check mark.

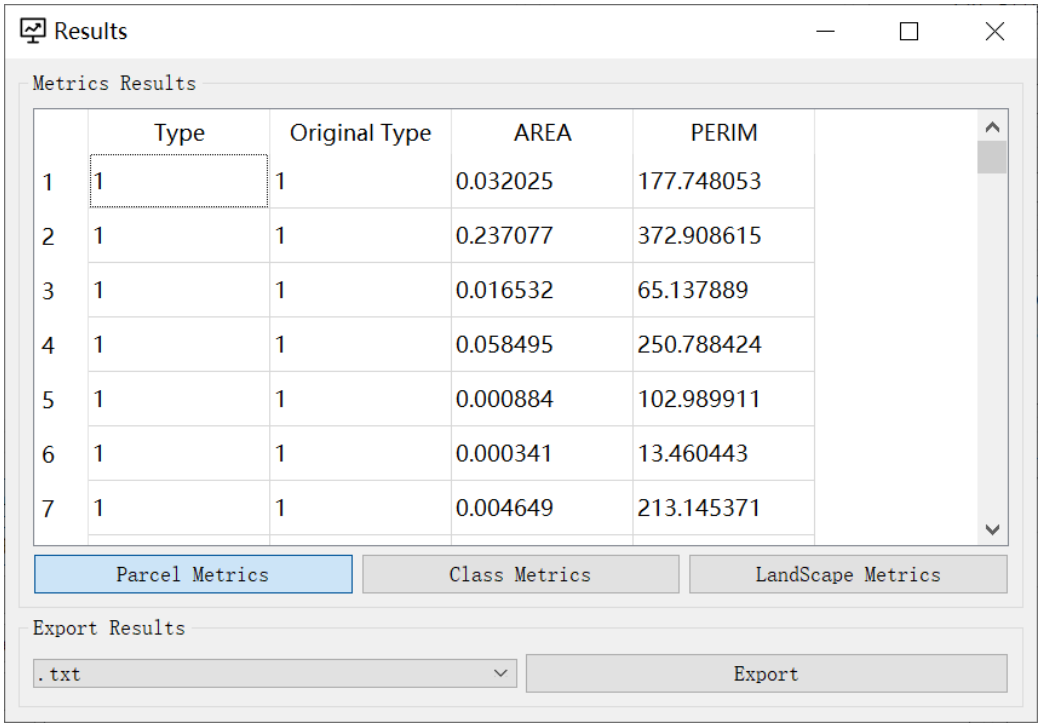
To make it easier for users to keep track of the indices that have been ticked, there is a table of selected indices on the right side of the indices module for easy access so that users do not miss a tick or make a mistake.



3.5. Vector-based Landscape Index Calculation

Click the "Calculate" 

button to start the vector-based landscape index calculation after all the parameter settings are done.

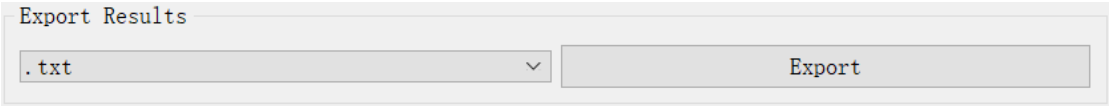


For parcel-level indices, the first column shows the type id used in the calculation and the second row shows the actual type id.

Click the button above to display the results of the index calculation for the different modules.

3.6. Results Export

Once the results have been calculated, users can export the results.

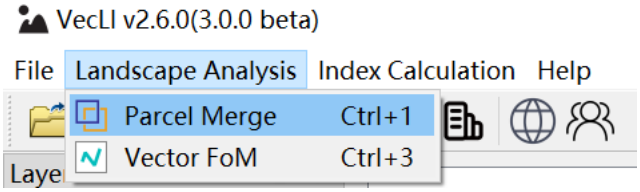


Users can save to Shape File, TXT File and CSV File. The Shape File will only save indices at the parcel level, while the CSV File and TXT File will save all indices.

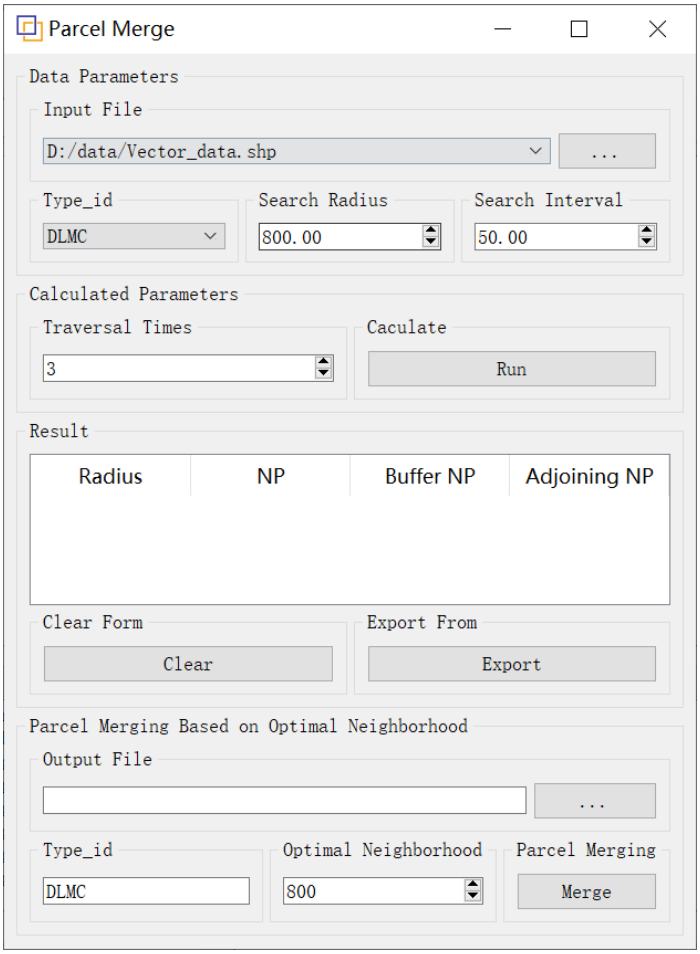
4. Domain Effects Exploration and Parcel Consolidation

This module calculates the optimal neighborhood radius based on the imported vector data and sets the neighborhood radius to enable the parcel consolidation.

First-Click the "Landscape Analysis" in the menu bar and choose the "Parcel Merge", it will automatically jump to the Parcel Merge Window:



Click the toolbar's button  would work in the same way:

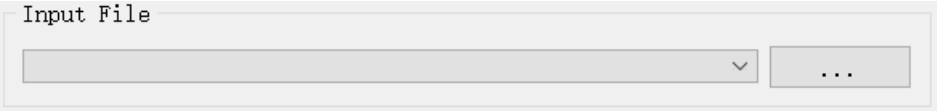


4.1. Domain effects exploration

4.1.1. Import File

First, users should select a vector file for processing. Options in the "Input File"

drop-down box include all the vector files that have been imported into the system. The drop-down box for selecting vector files is shown as below:



Click button  to import new vector files.

4.1.2. Parameter Settings

Type_id is the field of land use type in the vector file. After selecting the file, the drop-down box will automatically read all the fields contained in the vector file and users can select the correct field of Type_id.

4.1.3. Calculate

Click button "run" to start the search of optimal neighborhood radius. After completing the calculation, the results will display in the table.

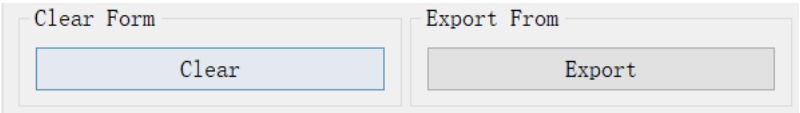
Result

	Radius	NP	Buffer NP	Adjoining NP
1	650.0	65	4378	62
2	700.0	130	11198	62
3	750.0	195	20869	62
4	800.0	260	33571	62
5	850.0	324	49482	63

The software uses a breadth-first search method to search for neighborhood parcels. In the form, Radius is neighborhood radius, NP is the number of parcels after consolidation at that radius, Buffer NP is the sum of the number of parcels in all neighborhoods when searching for parcels in the neighborhood at that radius, Adjoining NP is the sum of the number of neighboring parcels when searching for parcels in the neighborhood at that radius.

4.1.4. Export Results

Click button "Export" to export results and click button "Clear" to clear the form.



4.2. Parcel Consolidation

4.2.1. Parameter Settings

Output path

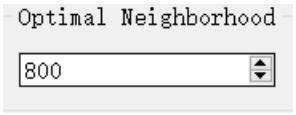
Click button  to open Select Vector File Window and set Output path.

Land use type

The field of Type_id is automatically aligns with the search in the Domain effects exploration.

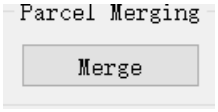
Optimal Neighborhood Radius

This parameter refers to the optimal neighborhood radius when parcels are combined.



4.2.2. Calculate

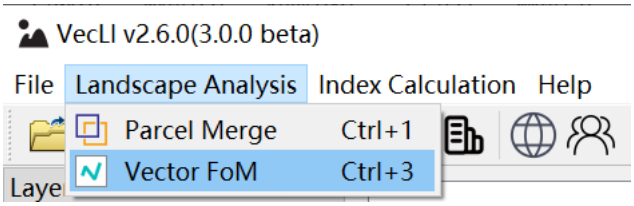
Click button “Merge” to start of parcel consolidation.



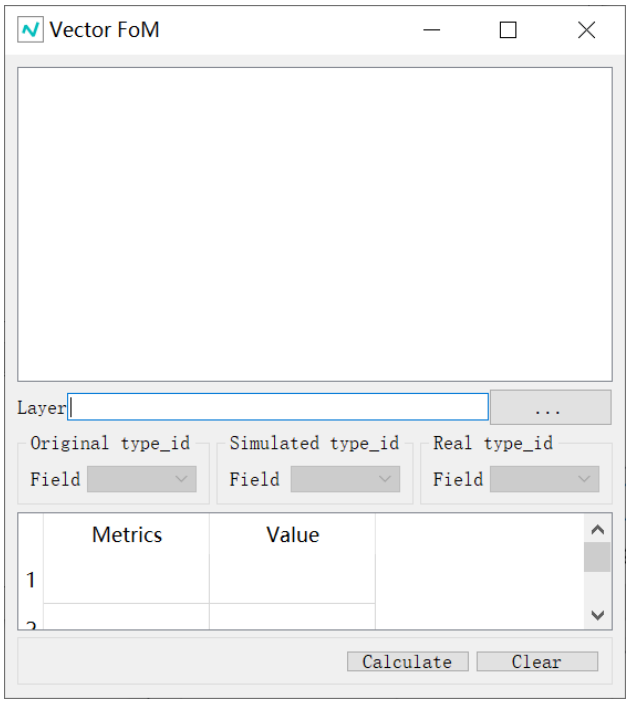
5. Vector FoM Calculation

This module is mainly used to calculate FoM metrics based on the imported vector data.

First-Click "Landscape Analysis" in the menu bar, and select "Vector FoM" in the pop-up menu to open the corresponding interface:

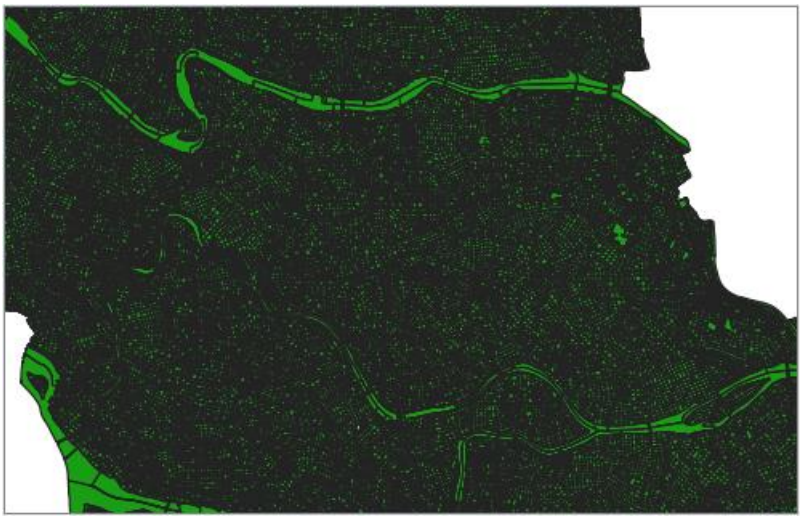


Click the toolbar's button  would work in the same way:



5.1. Import File

Click button  to import new vector file and data will be displayed in the canvas.



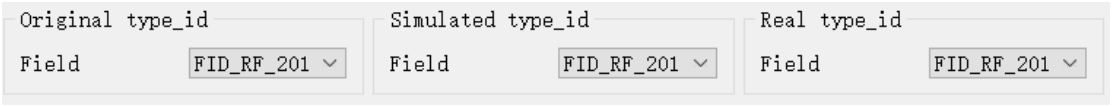
5.2. Parameter Setting

"Original type_id" indicates the land use type before the simulation.

"Simulated type_id" indicates the land use type after the simulation.

"Real type_id" indicates the land use type after the real development.

Users can intersect the simulated data with the real data to connect all the attribute fields.



5.3. Calculate

Click button "calculate" to start calculation and results will display in the form.

Metrics	Value
Fom	0.123
PA	0.218
UA	0.219

6. Introduction of the Landscape Index

The landscape indices provided by VecLI are modularly divided into three categories, including parcel, category and global levels. The indices at each level are divided into five categories, namely area and edge indicators, shape indicators, core area indicators and agglomeration indices, with the plot level indices containing a plot diversity index. For the parcel-level indices, each parcel corresponds to a result. The following indices are described in the help file for Fragstats v4.2.

Area_edge	
Parcel	
P1	Parcel AREA (AREA)
P2	Parcel Perimeter (PERIM)
P3	Radius of Gyration(GYRATE)
Class	
C1	Total (Class) Area (CA)
C2	Percentage of Landscape (PLAND)
C3	Largest Patch Index (LPI)
C4	Total Edge (TE)
C5	Edge Density (ED)
C6-C11	Patch Area Distribution (AREA_MN, _AM, _MD, _RA, _SD, _CV)
C12-C17	Radius of Gyration Distribution (GYRATE_MN, _AM, _MD, _RA, _SD, _CV)
Landscape	
L1	Total (Landscape) Area (TA)
L2	Largest Patch Index (LPI)
L3	Total Edge (TE)
L4	Edge Density (ED)
L5-L10	Patch Area Distribution (AREA_MN, _AM, _MD, _RA, _SD, _CV)
L6-L11	Radius of Gyration Distribution (GYRATE_MN, _AM, _MD, _RA, _SD, _CV)

Shape	
Parcel	
P1	Perimeter-Area Ratio (PARA)
P2	Shape Index (SHAPE)
P3	Fractal Dimension Index (FRAC)
P4	Related Circumscribing Circle (CIRCLE)

P5	Linearity Index LINEAR)
Class	
C1	Perimeter-Area Fractal Dimension (PAFRAC)
C2-C7	Perimeter-Area Ratio Distribution (PARA_MN, _AM, _MD, _RA, _SD, _CV)
C8-C13	Shape Index Distribution (SHAPE_MN, _AM, _MD, _RA, _SD, _CV)
C14-C19	Fractal Index Distribution (FRAC_MN, _AM, _MD, _RA, _SD, _CV)
C20-C25	Linearity Index Distribution (LINEAR_MN, _AM, _MD, _RA, _SD, _CV)
C26-C31	Related Circumscribing Square Distribution (SQUARE_MN, _AM, _MD, _RA, _SD, _CV)
Landscape	
L1	Perimeter-Area Fractal Dimension (PAFRAC)
L2-L7	Perimeter-Area Ratio Distribution (PARA_MN, _AM, _MD, _RA, _SD, _CV)
L8-L13	Shape Index Distribution (SHAPE_MN, _AM, _MD, _RA, _SD, _CV)
L14-L19	Fractal Index Distribution (FRAC_MN, _AM, _MD, _RA, _SD, _CV)
L20-L25	Linearity Index Distribution (LINEAR_MN, _AM, _MD, _RA, _SD, _CV)
L26-L31	Related Circumscribing Square Distribution (SQUARE_MN, _AM, _MD, _RA, _SD, _CV)

Core area	
Parcel	
P1	Core Area (CORE)
P2	Number of Core Areas (NCA)
P3	Core Area Index (CAI)
Class	
C1	Total Core Area (TCA)
C2	Core Area Percentage of Landscape (CPLAND)
C3	Number of Disjunct Core Areas (NDCA)
C4	Disjunct Core Area Density (DCAD)
C5-C10	Core Area Distribution (CORE_MN, _AM, _MD, _RA, _SD, _CV)
C11-C16	Disjunct Core Area Distribution (DCORE_MN, _AM, _MD, _RA, _SD, _CV)
C17-C22	Core Area Index Distribution (CAI_MN, _AM, _MD, _RA, _SD, _CV)
Landscape	
L1	Total Core Area (TCA)
L2	Number of Disjunct Core Areas (NDCA)
L3	Disjunct Core Area Density (DCAD)

L4-L9	Core Area Distribution (CORE_MN, _AM, _MD, _RA, _SD, _CV)
L10-L15	Disjunct Core Area Distribution (DCORE_MN, _AM, _MD, _RA, _SD, _CV)
L16-L21	Core Area Index Distribution (CAI_MN, _AM, _MD, _RA, _SD, _CV)

Contrast	
Parcel	
P1	Edge Contrast Index (ECON)
Class	
C1	Contrast-Weighted Edge Density (CWED)
C2	Total Edge Contrast Index (TECI)
C3	Edge Contrast Index Distribution (ECON_MN, _AM, _MD, _RA, _SD, _CV)
Landscape	
L1	Contrast-Weighted Edge Density (CWED)
L2	Total Edge Contrast Index (TECI)
L3	Edge Contrast Index Distribution (ECON_MN, _AM, _MD, _RA, _SD, _CV)

Aggregation	
Parcel	
P1	Euclidean Nearest Neighbor Distance (ENN)
P2	Proximity Index (PROX)
P3	Similarity Index (SIMI)
Class	
C1	Interspersion & Juxtaposition Index (IJI)
C2	Landscape Shape Index (LSI)
C3	Number of Patches (NP)
C4	Patch Density (PD)
C5	Splitting Index (SPLIT)
C6	Landscape Division Index (DIVISION)
C7	Effective Mesh Size (MESH)
C8-C13	Euclidean Nearest Neighbor Distance Distribution (ENN_MN, _AM, _MD, _RA, _SD, _CV)
C14-C19	Proximity Index Distribution (PROX_MN, _AM, _MD, _RA, _SD, _CV)
C20-C25	Similarity Index Distribution (SIMI_MN, _AM, _MD, _RA, _SD, _CV)
C26-C31	Connectance (CONNECT)
Landscape	
L1	Interspersion & Juxtaposition Index (IJI)
L2	Landscape Shape Index (LSI)

L3	Number of Patches (NP)
L4	Patch Density (PD)
L5	Splitting Index (SPLIT)
L6	Landscape Division Index (DIVISION)
L7	Effective Mesh Size (MESH)
L8-L13	Euclidean Nearest Neighbor Distance Distribution (ENN_MN, _AM, _MD, _RA, _SD, _CV)
L14-L19	Proximity Index Distribution (PROX_MN, _AM, _MD, _RA, _SD, _CV)
L20-L25	Similarity Index Distribution (SIMI_MN, _AM, _MD, _RA, _SD, _CV)
L26-L31	Connectance (CONNECT)

The calculation of some common indices is shown below:

6.1. Parcel Level Index

Name	Area	Abbreviation	Area
Formula	$\text{Area} = a_{ij}/10000$ a_{ij}: Area of parcel		
Unit	Hectare		
Range	$Area > 0$		
Description	Area of parcel.		

Name	Perimeter	Abbreviation	Perimeter
Formula	$\text{Perimeter} = p_{ij}$ p_{ij}: Perimeter of parcel		
Unit	Meter		
Range	$Perimeter > 0$		
Description	Perimeter of parcel.		

Name	Radius of Gyration	Abbreviation	GYRATE
Formula	$\text{GYRATE} = \sum_{i=1}^{z} \frac{h_{ijr}}{z}$ h_{ijr}: Distance from each subcellular center of mass to the center of mass of the synthesized parcel z: Number of plots before combination		
Unit	Meter		
Range	$GYRATE > 0$		

Description	The average distance between the centre of mass of each metacellular parcel before the parcels are combined and the centre of mass of the combined parcel.

Name	Perimeter-Area Ratio	Abbreviation	PARA
Formula	$\mathrm{PARA} = p_{ij}/a_{ij}$ a_{ij}: Area of parcel p_{ij}: Perimeter of parcel		
Unit	metres per hectare		
Range	$PARA > 0$		
Description	Ratio of perimeter to area.		

Name	Fractal Dimension Index	Abbreviation	FRAC
Formula	$\mathrm{FRAC} = \frac{2 * \ln 0.25 * p_{ij}}{\ln a_{ij}}$ a_{ij}: Area of parcel p_{ij}: Perimeter of parcel		
Unit	/		
Range	$0 < \mathrm{FRAC} < 2$		
Description	For describing the complexity of parcels.		

Name	Related Circumscribing Circle	Abbreviation	CIRCLE
Formula	$\mathrm{CIRCLE} = 1 - a_{ij}/a_{ij}^{circle}$ a_{ij}: Area of parcel a_{ij}^{circle}: Area of the Minimum Circumscribed Circle per parcel		
Unit	/		
Range	$0 < \mathrm{CIRCLE} < 1$		
Description	/		

Name	Core Area	Abbreviation	CA
Formula	$CA = a_{ij}^{core}/10000$		

	a_{ij}^{core}: Core Area of parcel
Unit	Hectare
Range	$CA > 0$
Description	Area within the parcel beyond a specified depth distance from the edge of the parcel.

Name	Core Area Index	Abbreviation	CAI
Formula	$CAI = \frac{a_{ij}^{core}}{a_{ij}} * 100$ a_{ij}^{core}: Core Area of parcel a_{ij}: Area of parcel		
Unit	/		
Range	$0 \leq CAI < 100$		
Description	Ratio of Core Area to Area.		

Name	Euclidean Nearest-Neighbor Distance	Abbreviation	ENN
Formula	$ENN = h_{ij}$ h_{ij}: Distance of the parcel to the nearest parcel of the same category		
Unit	Meter		
Range	$ENN > 0$		
Description	Distance from the centre of mass of the parcel to the centre of mass of the nearest parcel of the same category. Distance from the centre of mass of the plot to the centre of mass of the nearest parcel of the same category.		

Name	Proximity Index	Abbreviation	PROX
Formula	$PROX = \sum_{S=1}^{m} \frac{a_{ijs}}{{h_{ijs}}^2}$ a_{ijs}: The area of a parcel within a distance h_{ijs}: Average distance between parcels and parcels of the same type within a certain range		
Unit	/		
Range	$PROX > 0$		

Description	/

Name	Patch Richness	Abbreviation	PR
Formula	$PR = n$ n: Number of parcel types		
Unit	/		
Range	$PR > 0$		
Description	/		

Name	Patch Richness Density	Abbreviation	PRD
Formula	$PRD = \frac{\mathrm{m}}{\mathrm{A} * 10000 * 100}$ m: Number of parcel types A: Total landscape area		
Unit	/		
Range	$PRD > 0$		
Description	Number of parcel types per 100 ha area		

Name	Shannon's Diversity Index	Abbreviation	SHDI
Formula	$\mathrm{SHDI} = -\sum_{i=1}^{m}(P_i * \ln P_i)$ P_i: Proportion of landscape area occupied by type i		
Unit	/		
Range	$\mathrm{SHDI} > 0$		
Description	Reflects the abundance of land masses in a given area.		

Name	Simpson's Diversity Index	Abbreviation	SIDI
Formula	$\mathrm{SIDI} = 1 - \sum_{i=1}^{m}({P_i}^2)$ P_i: Proportion of landscape area occupied by type i		
Unit	/		
Range	$0 \leq \mathrm{SIDI} < 1$		
Description	/		

Name	Modified Simpson's Diversity Index	Abbreviation	MSIDI
Formula	$\mathrm{MSIDI} = -\ln \sum_{i=1}^{m} ({P_i}^2)$ P_i: Proportion of landscape area occupied by type i		
Unit	/		
Range	$\mathrm{MSIDI} \geq 0$		
Description	/		

Name	Shannon's Evenness Index	Abbreviation	SHEI
Formula	$\mathrm{SHEI} = \frac{-\sum_{i=1}^{m}(P_i * \ln P_i)}{\ln m}$ m: Number of parcel types P_i: Proportion of landscape area occupied by type i		
Unit	/		
Range	$0 < \mathrm{SHEI} \leq 1$		
Description	/		

Name	Simpson's Evenness Index	Abbreviation	SIEI
Formula	$\mathrm{SIEI} = \frac{1 - \sum_{i=1}^{m}({P_i}^2)}{1 - (\frac{1}{m})}$ m: Number of parcel types P_i: Proportion of landscape area occupied by type i		
Unit	/		
Range	$0 < \mathrm{SIEI} \leq 1$		
Description	/		

Name	Modified Simpson's Evenness Index	Abbreviation	MSIEI
Formula	$\mathrm{MSIEI} = \frac{-\ln \sum_{i=1}^{m}({P_i}^2)}{\ln m}$ m: Number of parcel types P_i: Proportion of landscape area occupied by type i		

Unit	/
Range	$0 \leq \text{MSIEI} \leq 1$
Description	/

6.2. Other landscape indexs

6.2.1. Distributive Indexes

For larger scale studies in the landscape pattern, the calculation of the distribution of each landscape index is of great significance. VecLI offers the following distributed indexs of parcel level:

Name	Formula	Description
Mean (MN)	$\text{MN} = \frac{\sum_{j=1}^{n} X_{ij}}{n_i}$	The sum of the corresponding index values for all parcels of the corresponding parcel type divided by the number of parcels of the same type.
Area-weighted Mean (AM)	$\text{AM} = \sum_{j=1}^{n} (X_{ij} \left(\frac{a_{ij}}{\sum_{j=1}^{n} a_{ij}} \right))$	The sum of the corresponding parcel metric values for all parcels of the corresponding parcel type multiplied by the proportional abundance of the parcels.
Median (MD)	$\text{MD} = X_{50\%}$	The metric of the median value in the middle of the order.
Range (RA)	$\text{RA} = X_{max} - X_{min}$	Difference between the maximum and minimum observation.
Standard deviation (SD)	$\text{SD} = \sqrt{\frac{\sum_{j=1}^{n} (X_{ij} - MN)^2}{n_i}}$	Degree of dispersion of each parcel metric.
Coefficient of variation (CV)	$\text{CV} = \frac{SD}{MN} \cdot 100$	Standard deviation divided by the mean.

VecLI offers the following distributed indexs of overall level:

Name	Formula	Description
Mean (MN)	$\text{MN} = \frac{\sum_{i=1}^{m} \sum_{j=1}^{n} X_{ij}}{N}$	The sum of the corresponding index values for all parcels of the corresponding parcel

		type divided by the number of parcels of the same type.
Area-weighted Mean (AM)	$\mathrm{AM} = \sum_{i=1}^{m}\sum_{j=1}^{n}(X_{ij}\left(\frac{a_{ij}}{\sum_{i=1}^{m}\sum_{j=1}^{n}a_{ij}}\right))$	The sum of the corresponding parcel metric values for all parcels of the corresponding parcel type multiplied by the proportional abundance of the parcels.
Median (MD)	$\mathrm{MD} = X_{50\%}$	The metric of the median value in the middle of the order.
Range (RA)	$\mathrm{RA} = X_{max} - X_{min}$	Difference between the maximum and minimum observation.
Standard deviation (SD)	$\mathrm{SD} = \sqrt{\frac{\sum_{i=1}^{m}\sum_{j=1}^{n}(X_{ij} - MN)^2}{N}}$	Degree of dispersion of each parcel metric.
Coefficient of variation (CV)	$\mathrm{CV} = \frac{SD}{MN} \cdot 100$	Standard deviation divided by the mean.

6.2.2. Category Level Index

Name	Total Area	Abbreviation	TA
Formula	$TA = A/10000$ A: Total landscape area		
Unit	Hectare		
Range	$TA > 0$		
Description	Area of all included parcels.		

Name	Percentage of Landscape	Abbreviation	PLAND
Formula	$PLAND = P_i = \frac{\sum_{j=1}^{n} a_{ij}}{A}(100)$ P_i: Proportion of landscape area occupied by type i a_{ij}: Area of parcel A: Total landscape area		
Unit	/		

Range	$0 \leq PLAND \leq 100$
Description	Percentage of the area of the corresponding type of parcel to the total landscape area.

Name	Largest Patch Index	Abbreviation	LPI
Formula	$LPI = \frac{max(a_{ij})}{A}(100)$ a_{ij}: Area of parcel A: Total landscape area		
Unit	/		
Range	$0 \leq LPI \leq 100$		
Description	Percentage of the largest area of the corresponding type of parcel to the total landscape area.		

Name	Total Edge	Abbreviation	TE
Formula	$TE = \sum_{k=1}^{m} e_{ik}$ e_{ik}: Total length of edge of parcel of corresponding type i in the landscape		
Unit	Meter		
Range	$TE > 0$		
Description	Total length of edge of parcel of corresponding type i in the landscape.		

Name	Edge Density	Abbreviation	ED
Formula	$ED = \frac{\sum_{k=1}^{m} e_{ik}}{A}$ e_{ik}: Total length of edge of parcel of corresponding type i in the landscape A: Total landscape area		
Unit	metres per square metre		
Range	$ED > 0$		
Description	Ratio of the total length of edge of parcel of corresponding type i to the total area of the landscape.		

Name	Perimeter-Area Fractal Dimension	Abbreviation	PAFRAC

Formula	$PAFRAC = \frac{2}{\frac{\left[n_i \sum_{j=1}^{n}(lnp_{ij} * lna_{ij})\right] - \left[\left(\sum_{j=1}^{n} lnp_{ij}\right)\left(\sum_{j=1}^{n} lna_{ij}\right)\right]}{\left(n_i \sum_{j=1}^{n} lnp_{ij}^2\right) - \left(\sum_{j=1}^{n} lnp_{ij}\right)^2}}$ a_{ij}: Area of parcel p_{ij}: Perimeter of parcel n_i: Number of parcels of type i
Unit	/
Range	$1 \leq PAFRAC \leq 2$
Description	/

Name	Total Core Area	Abbreviation	TCA
Formula	$TCA = \sum_{k=1}^{m} a_{ij}^{core} / 10000$ a_{ij}^{core}: Core Area of parcel		
Unit	Hectare		
Range	$TCA > 0$		
Description	Total core area of a type.		

Name	Core Area Percentage of Landscape	Abbreviation	CPLAND
Formula	$CPLAND = \frac{\sum_{k=1}^{m} a_{ij}^{core}}{\sum_{i=1}^{m}\sum_{j=1}^{n} a_{ij}} * 100$ a_{ij}^{core}: Core Area of parcel a_{ij}: Area of parcel		
Unit	/		
Range	$0 \leq CPLAND \leq 100$		
Description	Proportion of the core area of a type to the total landscape area.		

Name	Patch Cohesion Index	Abbreviation	COHESION
Formula	$\text{COHESION} = \left[1 - \frac{\sum_{k=1}^{m} P_{ij}}{\sum_{k=1}^{m} P_{ij}\sqrt{a_{ij}}}\right]\left[1 - \frac{1}{\sqrt{A}}\right]^{-1} * 100$		

	a_{ij}: Area of parcel p_{ij}: Perimeter of parcel A: Total landscape area
Unit	/
Range	$0 \leq \text{COHESION} \leq 100$
Description	/

Name	Number of Patches	Abbreviation	NP
Formula	$NP = n_i$ n_i: Number of parcels of type i		
Unit	/		
Range	$NP \geq 0$		
Description	Number of parcels of the corresponding type.		

Name	Patch Density	Abbreviation	PD
Formula	$PD = \frac{n_i}{A} * 10000 * 100$ n_i: Number of parcels of type i A: Total landscape area		
Unit	/		
Range	$PD \geq 0$		
Description	/		

Name	Landscape Division Index	Abbreviation	DIVISION
Formula	$\text{DIVISION} = \left(1 - \sum_{i=1}^{m}\sum_{j=1}^{n}\left(\frac{a_{ij}}{A}\right)^2\right) * 100$ a_{ij}: Area of parcel A: Total landscape area		
Unit	/		
Range	$0 \leq \text{DIVISION} \leq 100$		
Description	/		

Name	Splitting Index	Abbreviation	SPLIT
Formula	$\text{SPLIT} = \frac{A^2}{\sum_{j=1}^{n} {a_{ij}}^2}$ a_{ij}: Area of parcel		

	A: Total landscape area
Unit	/
Range	$\mathrm{SPLIT} > 1$
Description	/

Name	Connectance Index	Abbreviation	CONNECT
Formula	$\mathrm{CONNECT} = \frac{\sum_{j=k}^{n} c_{ijk}}{\frac{n_i(n_i-1)}{2}} * 100$ c_{ijk}: Number of connections between parcels of the same parcel type for a given threshold condition n_i: Number of parcels of type i		
Unit	/		
Range	$0 \leq \mathrm{CONNECT} \leq 100$		
Description	Sum of the number of functional connections between all parcels of the corresponding parcel type for a given threshold condition.		

6.2.3. Overall Level Index

The overall level indices are calculated in a similar way to the given category level indices and will not be elaborated upon.

7. Copyright and Contact

More indices are designed to VecLI V2.6/V3.0 beta (a total of 218 landscape indices are supported). If you have questions about the software or need to add new indices to the software, please contact us by leaving a comment on our website.

VecLI: Vector-based Landscape Index Calculation and Analysis System

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