Linking European Land Use Change and Landscape related Sustainability Assessment: Indicators, Methodology and preliminary Results in PLUREL Module 2
Our Objective (WP 2.3, Zalf)

Module 1
Demographic, ecologic and economic scenarios for Europe
Quantification
Land Use Change Modelling (Red/Green)

Module 2
Analysis of Urban Rural Relations on European Level for NUTS X (2/3) Regions
Response Functions for Issues (Settlement, Traffic, Social, Ecologic)

Module 3/4
Impact assessment on different spatial levels
Indicator Framework

Module 5
Sustainability Impact Assessment Tool for Urban Rural Regions SIAT RUR

Develop Response Functions (=Regression models) for landscape parameters!

Do it on NUTS X/3 level!

Link the M1 scenario and LUC outcomes with sustainability issues (M4/5)!

Link to Zalf Objectives:
Response Functions for Biodiversity, Recreation, Agriculture, Soil

Figure: Flowchart showing the modules and their objectives.
Research Conception

Quantitative Change of Land Cover (urban/AC) → CLC and derivatives → Mostly Eurostat

Socio-economic Development

Urban Rural Regime:
- Settlement Morphology
- Degree of Urbanisation
- Planning and Governance
- Bio-physical Constraints

RUR-Typology

- Agricultural Land Use
- Farm Size
- AC Output
- AC Employment

- Urban Fabric
- Artificial Surface

- GDP Change
- Population Dev.
- Employment
- Households
- Mobility

Landscape Structure Changes, Land Use Patterns → Impact on Sustainability

Research Conception
Procedure

1. Finding relevant landscape indicators/metrics

2. find out how they respond to NEMESIS outcomes (socioeconomic, demographic change, urban and agricultural LUC)

3. Create a reliable regression function (Response Function)
Non-interrupted low traffic area and infrastructure network: Fragmentation

Non-interrupted low-traffic areas 1997

Indicator of landscape fragmentation

Background: Landscapes’ potential for biodiversity & recreation is influenced by the size of habitats without physical barriers

Minimum size threshold 100 SQKM at pan-European scale (Lassen 1990)
Non-interrupted low traffic area

Average Size in km²
- < 25
- > 25 - 50
- > 50 - 75
- > 75 - 100
- > 100 - 200
- > 200 - 500
- > 500 - 1000
- > 1000
Dependent Variables (2/4)

CORILIS Standard Deviation 2000: Compactness vs. Dispersal

Smoothing of CORINE Land-use data

Shading indicates probability to bump into urban fabric

Further processing: Standard deviation of raster values for each region → expression of degree of compactness of settlement

developed by French Environment Institute (IFEN) and French National Institute for Statistics and Economic Studies (INSEE); Provided by EEA
Dependent Variables (3/4)

Green Background Index 2000: Landscape Fragmentation/Ecologic Potential

Indicator of landscape fragmentation

Background: Landscapes potential for biodiversity & recreation is influenced by the size of habitats without physical barriers

Aggregated Index of CORILIS components for “green” classes (Pastures & mixed farmland, Forests and transitional woodland shrub, Natural grassland, Heathland, Sclerophylous vegetation, Open space with little or no vegetation and Water bodies)

Provided by the EEA
Natural and Semi-Natural Area 1990-2000: Ecologic Value

Considered to be ecologically valuable.

Derived from CORINE LAND COVER.

Aggregation of classes: agricultural area with high share of semi-natural areas, pastures, meadows, grassland, shrub-land, wetlands (243, 321-423).
Annual Changes in Semi-/Natural Area

Annual Changes in %

- Red: <-5.0 - -5.0
- Dark Red: >-5.0 - -2.5
- Orange: >-2.5 - -0.5
- Yellow: >-0.5 - 0.5
- Light Yellow: >0.5 - 2.5
- Green: >2.5 - 5.0
- Light Green: >5.0 - 10.0
- Dark Green: >10
Independent Variables

Urban LU Share 1990/2000, change

AC LU Share 1990/2000, change

Demographic indicators

Economic indicators
Data Availability

<table>
<thead>
<tr>
<th>NUTS 2</th>
<th>1990</th>
<th>2000</th>
<th>2004</th>
</tr>
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<tbody>
<tr>
<td>CLC</td>
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<tr>
<td>Traffic Network Fragmentation</td>
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<td>Farm Size, Agricultural Output, Economic Structure</td>
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<table>
<thead>
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<tr>
<td>CLC</td>
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<td>CORLIS GBI</td>
<td>CLC</td>
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<tr>
<td>GDP, Population, Population Density, GDP/Capita</td>
<td></td>
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<td>CLC</td>
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</table>
## Relations of Independent Variables

### Pearson Correlation Matrix for independent Variables (as basis for influencing factors)

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Area in sqkm</td>
<td>1,000</td>
<td>.301</td>
<td>-.181</td>
<td>.421</td>
<td>-.340</td>
<td>.266</td>
<td>-.403</td>
<td>.038</td>
<td>.206</td>
<td>.212</td>
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<tr>
<td>Population 1990</td>
<td>.301</td>
<td>1,000</td>
<td>-.032</td>
<td>.231</td>
<td>.065</td>
<td>.193</td>
<td>.131</td>
<td>-.034</td>
<td>.049</td>
<td>-.148</td>
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<tr>
<td>Relative population development 1990-2000</td>
<td>-.181</td>
<td>-.032</td>
<td>1,000</td>
<td>-.078</td>
<td>.081</td>
<td>-.068</td>
<td>-.175</td>
<td>.199</td>
<td>.061</td>
<td>.047</td>
</tr>
<tr>
<td>Relative growth of GDP 1990-2000</td>
<td>.421</td>
<td>.231</td>
<td>-.078</td>
<td>1,000</td>
<td>-.368</td>
<td>.731</td>
<td>-.221</td>
<td>.004</td>
<td>.181</td>
<td>.048</td>
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<tr>
<td>GDP per capita 1995</td>
<td>-.340</td>
<td>.065</td>
<td>.081</td>
<td>-.368</td>
<td>1,000</td>
<td>-.222</td>
<td>.552</td>
<td>-.161</td>
<td>-.192</td>
<td>-.306</td>
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<td>.193</td>
<td>-.068</td>
<td>.731</td>
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<td>1,000</td>
<td>-.090</td>
<td>-.023</td>
<td>.247</td>
<td>-.057</td>
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<tr>
<td>Share of artificial surface 1990</td>
<td>-.403</td>
<td>.131</td>
<td>-.175</td>
<td>-.221</td>
<td>.552</td>
<td>-.090</td>
<td>1,000</td>
<td>-.261</td>
<td>-.251</td>
<td>-.466</td>
</tr>
<tr>
<td>Share of agricultural area 1990</td>
<td>.038</td>
<td>-.034</td>
<td>.199</td>
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<td>-.251</td>
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<td>1,000</td>
<td>-.076</td>
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<tr>
<td>Relative change of share of agricultural area 1990-2000</td>
<td>.212</td>
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<td>.047</td>
<td>.048</td>
<td>-.306</td>
<td>-.057</td>
<td>-.466</td>
<td>.149</td>
<td>-.076</td>
<td>1,000</td>
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</tbody>
</table>
Relations of Dependent and Independent Variables: Cross Section

Pearson Correlation Index for dependent and independent Variables in general (static for the year 2000)

<table>
<thead>
<tr>
<th></th>
<th>Share of natural and semi-natural areas</th>
<th>CORILIS 1 standard deviation</th>
<th>Green Background Index</th>
<th>Fragmentation geometry in km/km²</th>
<th>Share of non-interrupted low traffic areas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region size</td>
<td>0.256</td>
<td>-0.283</td>
<td>0.255</td>
<td>-0.358</td>
<td>0.424</td>
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<tr>
<td>Share of artificial surface area</td>
<td>-0.304</td>
<td>0.715</td>
<td>-0.513</td>
<td>0.839</td>
<td>-0.673</td>
</tr>
<tr>
<td>Share of agricultural area</td>
<td>-0.367</td>
<td>-0.127</td>
<td>-0.396</td>
<td>-0.214</td>
<td>0.087</td>
</tr>
<tr>
<td>GDP per person</td>
<td>-0.219</td>
<td>0.427</td>
<td>-0.199</td>
<td>0.542</td>
<td>-0.361</td>
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<tr>
<td>Population density</td>
<td>-0.183</td>
<td>0.443</td>
<td>-0.394</td>
<td>0.640</td>
<td>-0.654</td>
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</table>
Relations of Dependent and Independent Variables: Longitudinal

Pearson Correlation Index for dependent and independent Variables in general (dynamic for the period 1990-2000)

<table>
<thead>
<tr>
<th>Static independent variables</th>
<th>Relative change of share of natural and semi-natural areas</th>
<th>Relative change of share of forest and semi-natural areas</th>
<th>Relative change of the share of urban green</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990 Region size</td>
<td>-0.066(s)</td>
<td>-0.046</td>
<td>0.065(s)</td>
</tr>
<tr>
<td>Share of artificial surface area</td>
<td>0.047</td>
<td>0.026</td>
<td>0.080(s)</td>
</tr>
<tr>
<td>Share of agricultural area</td>
<td>-0.047</td>
<td>0.103(s)</td>
<td>0.028</td>
</tr>
<tr>
<td>GDP per person</td>
<td>0.088(s)</td>
<td>0.022</td>
<td>-0.011</td>
</tr>
<tr>
<td>Population density</td>
<td>0.036</td>
<td>0.011</td>
<td>-0.064</td>
</tr>
<tr>
<td>Share of economically active population</td>
<td>-0.032</td>
<td>0.027</td>
<td>-0.032</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dynamic independent variables 1990-2000</th>
<th>Relative change of share of artificial surface</th>
<th>Relative change of share of agricultural area</th>
<th>Growth of GDP</th>
<th>Growth of GDP per person</th>
<th>Population development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative change of share of artificial surface</td>
<td>-0.028</td>
<td>-0.006</td>
<td>-0.249(s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative change of share of agricultural area</td>
<td>-0.096</td>
<td>-0.269(s)</td>
<td>-0.082(s)</td>
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<td></td>
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<tr>
<td>Growth of GDP</td>
<td>-0.055</td>
<td>0.005</td>
<td>-0.030</td>
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<td></td>
</tr>
<tr>
<td>Growth of GDP per person</td>
<td>-0.040</td>
<td>0.039</td>
<td>0.066</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population development</td>
<td>-0.021</td>
<td>-0.020</td>
<td>0.185(s)</td>
<td></td>
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</tr>
</tbody>
</table>
## Pearson Correlation Matrix for dependent Variables (as basis for composite indicators)

<table>
<thead>
<tr>
<th></th>
<th>Share of natural and semi-natural areas</th>
<th>CORILIS 1 standard deviation</th>
<th>Green Background Index</th>
<th>Fragmentation geometry in km/km²</th>
<th>Share of non-interrupted low traffic areas</th>
<th>Relative change of share of natural and semi-natural areas</th>
<th>Relative change of share of forest and semi-natural areas</th>
<th>Relative change of the share of urban green</th>
</tr>
</thead>
<tbody>
<tr>
<td>Share of natural and semi-natural areas</td>
<td>1,000</td>
<td>-0,271</td>
<td>0,496</td>
<td>-0,392</td>
<td>0,095</td>
<td>-0,036</td>
<td>-0,040</td>
<td>0,082</td>
</tr>
<tr>
<td>CORILIS 1 standard deviation</td>
<td>-0,271</td>
<td>1,000</td>
<td>-0,377</td>
<td>0,698</td>
<td>-0,617</td>
<td>0,045</td>
<td>0,062</td>
<td>-0,131</td>
</tr>
<tr>
<td>Green Background Index</td>
<td>0,0496</td>
<td>-0,377</td>
<td>1,000</td>
<td>-0,425</td>
<td>0,359</td>
<td>0,012</td>
<td>-0,038</td>
<td>0,116</td>
</tr>
<tr>
<td>Fragmentation geometry in km/km²</td>
<td>-0,392</td>
<td>0,698</td>
<td>-0,425</td>
<td>1,000</td>
<td>-0,767</td>
<td>0,073</td>
<td>0,043</td>
<td>-0,091</td>
</tr>
<tr>
<td>Share of non-interrupted low traffic areas</td>
<td>0,095</td>
<td>-0,617</td>
<td>0,359</td>
<td>-0,767</td>
<td>1,000</td>
<td>0,006</td>
<td>0,022</td>
<td>0,048</td>
</tr>
<tr>
<td>Relative change of share of natural and semi-natural areas active population</td>
<td>-0,036</td>
<td>0,045</td>
<td>0,012</td>
<td>0,073</td>
<td>0,006</td>
<td>1,000</td>
<td>0,140</td>
<td>-0,008</td>
</tr>
<tr>
<td>Relative change of share of forest and semi-natural areas</td>
<td>-0,040</td>
<td>0,062</td>
<td>-0,038</td>
<td>0,043</td>
<td>0,022</td>
<td>0,140</td>
<td>1,000</td>
<td>-0,009</td>
</tr>
<tr>
<td>Relative change of the share of urban green</td>
<td>0,082</td>
<td>-0,131</td>
<td>0,0116</td>
<td>-0,091</td>
<td>0,048</td>
<td>-0,008</td>
<td>-0,009</td>
<td>1,000</td>
</tr>
</tbody>
</table>
Procedure

1. Cross Section Regression only!

2. Factorising independent variables to eliminate cross correlations

3. Possibly Composite indicators for dependent variables

4. Integration of RUR-Typology?
Regression 1/2: General

Degree of Fragmentation by TN

Partielles Regressionsdiagramm

Abhängige Variable: ZerschneidungsgeoKMproKM2

R-Quadrat linear = 0,666
Does the RUR Typology (ARCS) help?

1.0 Very Large Monocentric
1.1 Large Monocentric
1.2 Medium Monocentric
2 Urban Polycentric
3 Dispersed Polycentric
4 Rural

→ ANOVA shows relevance for all static dependent variables.
## Regression Results Overview

<table>
<thead>
<tr>
<th>Target Variable</th>
<th>Adjusted $R^2$ general</th>
<th>Adjusted $R^2$ with Typology</th>
</tr>
</thead>
<tbody>
<tr>
<td>CORILIS Standard Deviation</td>
<td>0.569</td>
<td>0.664</td>
</tr>
<tr>
<td>GBI Average</td>
<td>0.268</td>
<td>0.306</td>
</tr>
<tr>
<td>Fragmentation by Traffic Networks</td>
<td>0.679</td>
<td>0.698</td>
</tr>
<tr>
<td>Share of UFLT Area</td>
<td>0.441</td>
<td>0.478</td>
</tr>
<tr>
<td>Share of Natural/ Semi-Natural Area</td>
<td>0.222</td>
<td>0.250</td>
</tr>
</tbody>
</table>
Green Background Index

Index

- > 0 - 10
- > 10 - 25
- > 25 - 40
- > 40 - 50
- > 50 - 60
- > 60 - 75
- > 75 - 90
- > 90
Green Background Index
RUR-Type 1.1 (Very large monocentric)
Green Background Index
RUR-Type 1.2 (Large monocentric)
Green Background Index
RUR-Type 1.3 (Medium monocentric)
Green Background Index
RUR-Type 2 (Urban polycentric)
Green Background Index
RUR-Type 3 (Dispersed polycentric)
Outlook
(or Watch Out?)

1. Better longitudinal results with CLC 2004?

2. Integrating additional variables disaggregated from NUTS 2 using CLC coverage (compare other work being done on usefulness of CLC for inter-regional comparisons)

3. Integrate other non-metric variables like Nation State/Planning System, bio-physical Macro Region Characteristics

4. Harmonisation of Temporal Referencing of Data

5. Customised Landscape Metrics?

6. Relation to M1 NEMESIS and CLUE?