# Do land-cover mosaics affect the variability of suspended sediments fluxes in rivers? The case of large river basins in Germany

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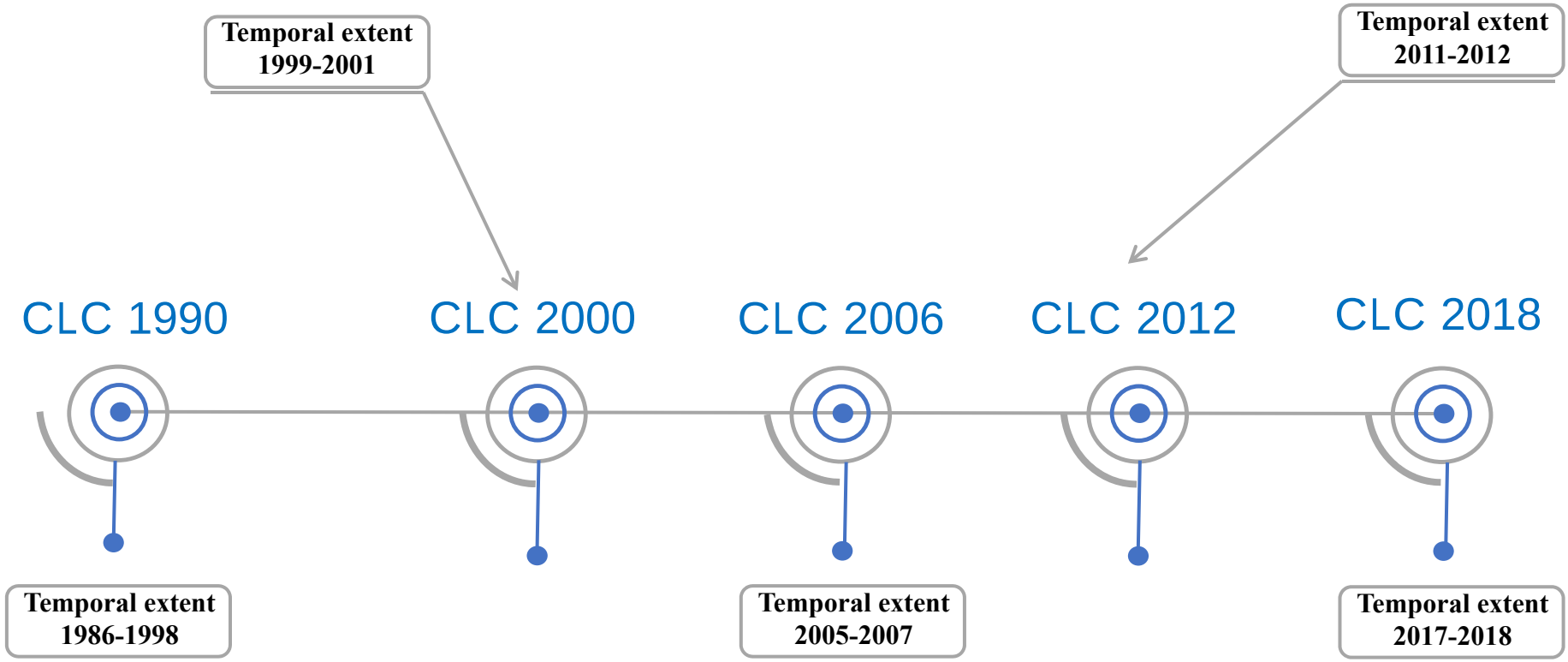
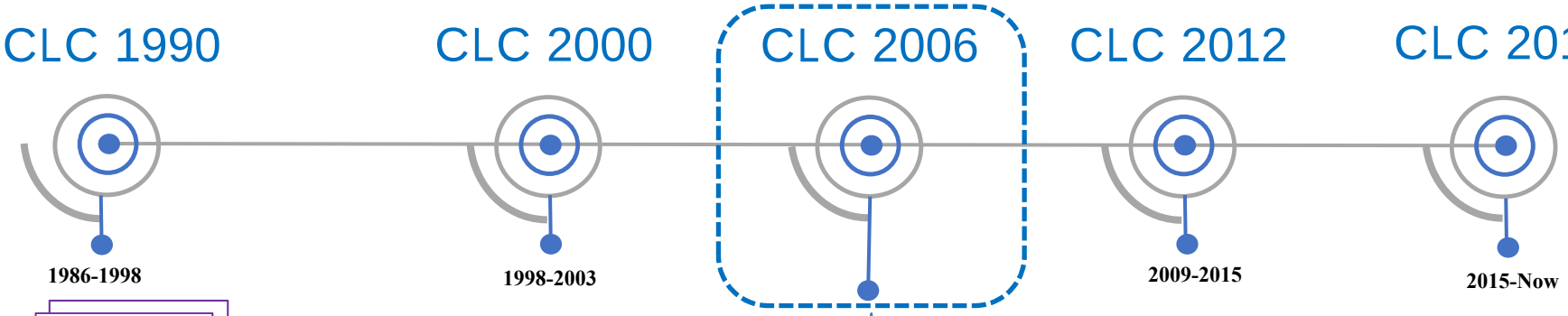
# **Corine Land Cover :** reference years




**Therefore the reference periods considered for SS dynamics corresponding to each CLC are:**


**Note :** considering hydrological year : 01.11.XXXX to 31.10.YYYY

## Corine Land cover datatsets




HydroSHEDS
HydroBASINS
HydroRIVERS

**Clip CLC2006 to the drainage area of each monitoring station**

**Computation of landscape spatial pattern metrics**

**FGA2-S**, 2009 by EEA

**Subset long term times series of SS from 01.11.2003 to 31.10.2009**

**Extraction of rating parameters (a,b) at high and low flow using Qbr = Qgm (geometric mean) using NLS and calclation of mean daily specific load and mean daily specific concentration**

**Whole landscape**
- Division

**Agriculturalscape**
- Connectivity Index (ACI)
- Modified skewness indices (Mineau et al.,(2015))

**Linear structures**
- The Effective Mesh Density (seff)

**landscape spatial pattern indicators**

**Response variables:**
$b_h$ , $Q_{s,median}$ (Kg/day), $SSC_{s,median}$ (mg/l)

**Explanatory analysis : Correlations**

# **Suspended Sediments :** 1. Monitoring data/N.Samples

| ID | start | end | 1986-1998 | 1997-2003 | 2003-2009 | 2009-2015 | 2015-present | RB |
|---|---|---|---|---|---|---|---|---|
| 502 | 1963-11-01 | 2020-05-29 | 4383 | 2114 | 1962 | 2041 | 1351 | |
| 511 | 1991-11-01 | 2020-04-30 | 2557 | 1977 | 1986 | 2037 | 1586 | |
| 512 | 1993-11-01 | 2020-04-30 | 1826 | 2143 | 2002 | 2105 | 1575 | |
| 513 | 1991-11-01 | 2018-12-28 | 2557 | 2180 | 2001 | 2146 | 1114 | |
| 514 | 1991-11-01 | 2020-04-30 | 2557 | 2138 | 1968 | 1981 | 1256 | |
| 515 | 1933-08-01 | 2020-04-30 | 2557 | 2170 | 2031 | 2184 | 1643 | |
| 516 | 1992-11-01 | 2020-04-30 | 2190 | 2191 | 2027 | 2173 | 1634 | |
| 518 | 1991-11-01 | 2018-05-15 | 2557 | 2191 | 2067 | 2138 | 927 | Elbe |
| 519 | 1993-11-01 | 2020-04-30 | 1826 | 2191 | 2036 | 2149 | 1637 | |
| 520 | 1994-11-01 | 2020-04-29 | 1461 | 2107 | 1824 | 1944 | 1455 | |
| 531 | 1991-11-01 | 2020-04-30 | 2557 | 2150 | 2117 | 2149 | 1643 | |
| 541 | 1991-11-01 | 2019-12-30 | 2557 | 2191 | 2098 | 2191 | 1328 | |
| 542 | 1991-11-01 | 2016-11-30 | 2557 | 2191 | 2012 | 2078 | 339 | |
| 543 | 1991-11-01 | 2019-12-30 | 2557 | 2185 | 2029 | 2087 | 1457 | |
| 552 | 1991-11-01 | 2019-12-31 | 2557 | 2191 | 2014 | 2130 | 1516 | |

| ID | start | end | 1986-1998 | 1997-2003 | 2003-2009 | 2009-2015 | 2015-present | RB |
|---|---|---|---|---|---|---|---|---|
| 202 | 1970-11-01 | 2019-12-30 | 4383 | 2135 | 1332 | 2156 | 1513 | |
| 203 | 1970-11-01 | 2013-12-27 | 4383 | 2191 | 2109 | 1518 | 0 | |
| 205 | 1983-11-01 | 2019-12-30 | 4383 | 2191 | 2097 | 2115 | 1372 | |
| 206 | 1977-11-01 | 2013-12-20 | 4383 | 2170 | 2117 | 1438 | 0 | |
| 207 | 1964-11-01 | 2019-12-30 | 4383 | 2191 | 2110 | 2191 | 1496 | |
| 212 | 1971-11-01 | 2019-12-19 | 4383 | 2183 | 1391 | 1238 | 978 | |
| 215 | 1982-11-01 | 2019-12-30 | 4383 | 2092 | 1950 | 1909 | 1347 | |
| 216 | 1978-11-01 | 2019-08-30 | 4383 | 2185 | 1965 | 1267 | 1025 | |
| 217 | 1970-11-01 | 2019-12-30 | 4383 | 2191 | 2090 | 2176 | 1486 | |
| 221 | 1965-11-01 | 2014-04-25 | 4383 | 2151 | 2089 | 1579 | 0 | |
| 222 | 1971-11-01 | 2019-12-30 | 4383 | 2182 | 2054 | 1983 | 1300 | |
| 223 | 1987-11-01 | 2019-12-30 | 4017 | 2191 | 2068 | 1793 | 1355 | |
| 231 | 1972-11-01 | 2005-12-28 | 4383 | 2069 | 701 | 0 | 0 | |
| 232 | 1965-11-01 | 2012-12-28 | 4383 | 2056 | 2075 | 1090 | 0 | |
| 233 | 1973-11-01 | 2014-05-31 | 4383 | 2172 | 2022 | 1291 | 0 | Rhine |
| 235 | 1986-11-01 | 2005-12-31 | 4381 | 2185 | 721 | 0 | 0 | |
| 236 | 1986-11-01 | 2005-12-30 | 4381 | 2191 | 706 | 0 | 0 | |
| 237 | 1987-11-01 | 2019-12-30 | 4017 | 2075 | 2052 | 2028 | 1414 | |
| 239 | 1986-11-01 | 2012-02-29 | 4381 | 2191 | 2108 | 851 | 0 | |
| 241 | 1970-11-01 | 2019-12-19 | 4383 | 1876 | 1536 | 1924 | 1408 | |
| 242 | 1986-11-01 | 2007-08-23 | 4381 | 2152 | 1005 | 0 | 0 | |
| 251 | 1974-11-01 | 2019-12-30 | 4383 | 2191 | 2057 | 2191 | 1521 | |
| 257 | 1981-11-01 | 2011-02-28 | 4383 | 2124 | 1980 | 414 | 0 | |
| 258 | 1981-11-01 | 2009-09-25 | 4383 | 2104 | 1288 | 0 | 0 | |
| 260 | 1973-11-01 | 2019-12-29 | 4383 | 2191 | 2029 | 2129 | 1520 | |
| 277 | 1976-11-01 | 2019-12-19 | 4018 | 2191 | 2073 | 2005 | 1269 | |
| 281 | 1972-11-01 | 2019-12-20 | 4383 | 2124 | 1977 | 2100 | 1457 | |
| 282 | 1972-11-01 | 2019-12-30 | 4383 | 2180 | 2065 | 2184 | 1521 | |

| ID | start | end | 1986-1998 | 1997-2003 | 2003-2009 | 2009-2015 | 2015-present | RB |
|---|---|---|---|---|---|---|---|---|
| 401 | 1920-12-01 | 2019-12-30 | 4383 | 2191 | 2115 | 2050 | 1462 | |
| 402 | 1965-11-01 | 2019-12-30 | 4383 | 2191 | 2115 | 2048 | 1463 | |
| 403 | 1964-11-01 | 2019-12-30 | 4383 | 2182 | 2000 | 2139 | 1491 | |
| 405 | 1969-11-01 | 2020-05-29 | 4383 | 2154 | 2109 | 2185 | 1672 | |
| 406 | 1979-11-01 | 2019-12-31 | 4383 | 2191 | 2066 | 2177 | 1513 | Weser |
| 407 | 1983-11-01 | 2019-12-27 | 4383 | 2191 | 2111 | 2191 | 1474 | |
| 408 | 1985-11-01 | 2019-12-20 | 4383 | 2153 | 1899 | 2131 | 1489 | |
| 411 | 1971-11-01 | 2019-12-31 | 4383 | 2155 | 1982 | 2114 | 1504 | |
| 412 | 1972-11-01 | 2019-12-31 | 4383 | 2117 | 2034 | 2158 | 1493 | |
| 421 | 1965-11-01 | 2006-04-13 | 4383 | 2185 | 745 | 0 | 0 | |

| ID | start | end | 1986-1998 | 1997-2003 | 2003-2009 | 2009-2015 | 2015-present | RB |
|---|---|---|---|---|---|---|---|---|
| 102 | 1982-11-01 | 2019-12-30 | 4383 | 2191 | 549 | 2158 | 1314 | |
| 105 | 1966-11-01 | 2019-12-30 | 4383 | 2182 | 2006 | 2138 | 1453 | Danube |
| 106 | 1974-11-01 | 2019-12-30 | 4383 | 2147 | 2029 | 1838 | 981 | |
| 107 | 1974-11-01 | 2019-12-31 | 4383 | 2133 | 1975 | 2181 | 1522 | |

| ID | start | end | 1986-1998 | 1997-2003 | 2003-2009 | 2009-2015 | 2015-present | RB |
|---|---|---|---|---|---|---|---|---|
| 601 | 1991-11-01 | 2019-12-20 | 2557 | 2113 | 1873 | 1775 | 1248 | |
| 602 | 1991-11-01 | 2019-12-23 | 2557 | 2098 | 1922 | 1920 | 1370 | Oder |
| 603 | 1991-11-01 | 2019-12-20 | 2557 | 2153 | 1972 | 2006 | 1436 | |

| ID | start | end | 1986-1998 | 1997-2003 | 2003-2009 | 2009-2015 | 2015-present | RB |
|---|---|---|---|---|---|---|---|---|
| 301 | 1964-11-01 | 2019-11-29 | 4383 | 2006 | 2115 | 2123 | 1363 | Ems |
| 303 | 1966-11-01 | 2019-12-30 | 4383 | 2191 | 2046 | 2135 | 1521 | |

# **Suspended Sediments :** 2. Rating parameters

Sediment rating curve

$$SSC = aQ^b$$

Rating curve segmentation at $\boldsymbol{Q}_{\mathrm{gm}}$(geometric mean)

↓

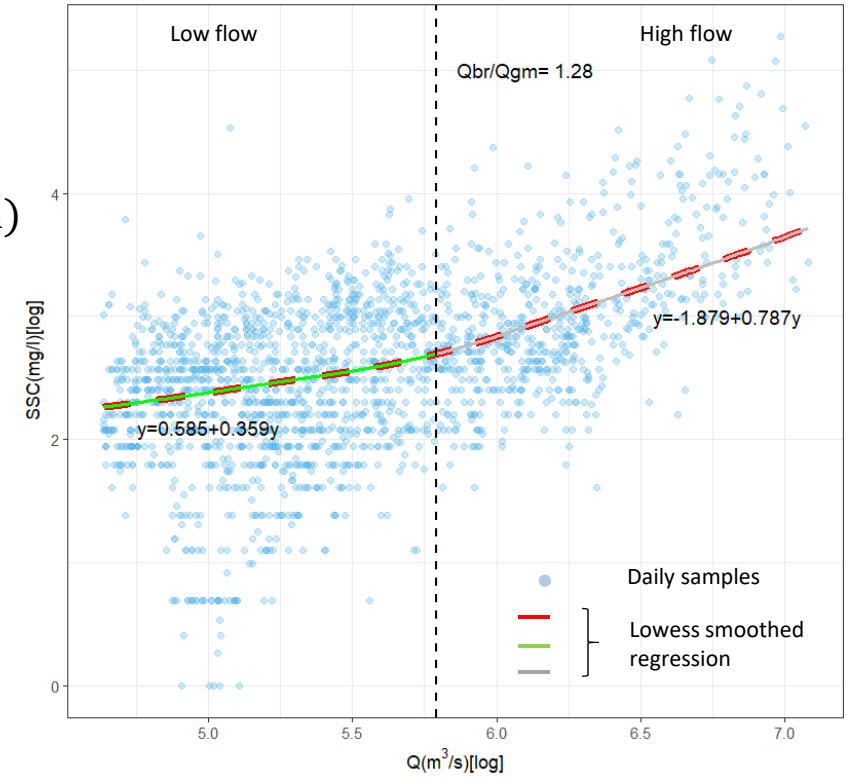
high (Q > $Q_{gm}$) and low (Q < $Q_{gm}$) flows

↓

Estimation of the rating parameters (a and b) at high and low flows using 2 methods:

**1.** Log-linear regression (LL)

**2.** Nonlinear least-squares regression (NLS)




=> I opted for rating exponent extrated at high flows using NLS since it can catch high values of pairs (SSC, Q) and gives more significant slopes although $R^2$ is not always the highest

## Landscape descriptors :

Land cover configuration : Division (from Landscape pattern metrics)

**Formula**:

$$1 - \sum_{i=1}^{m} \sum_{j=1}^{n} \left(\frac{a_{ij}}{A}\right)^2$$

n: number of patches

m: number of classes

(McGarigal and Marks, 1995)

| | | |
|---|---|---|
| 1 | 2 | 3 |
| 4 | 5 | 6 |
| 7 | 1 | 2 |

$1 - ((\frac{1}{9})^2 * 9) = 0.88$

| | | |
|---|---|---|
| 1 | 1 | 1 |
| 2 | 2 | 2 |
| 3 | 3 | 3 |

$1 - ((\frac{3}{9})^2 * 3) = 0.66$

| | | |
|---|---|---|
| 1 | 1 | 1 |
| 1 | 1 | 1 |
| 2 | 2 | 2 |

$1 - ((\frac{6}{9})^2 + (\frac{3}{9})^2) = 0.44$

| | | |
|---|---|---|
| 1 | 1 | 1 |
| 1 | 1 | 1 |
| 2 | 1 | 2 |

$1 - ((\frac{7}{9})^2 + (\frac{1}{9})^2 + (\frac{1}{9})^2) = 0.37$

| | | |
|---|---|---|
| 1 | 1 | 1 |
| 1 | 1 | 1 |
| 1 | 1 | 1 |

$1 - ((\frac{9}{9})^2) = 0$

- ✓ High patchiness => High value for Division
- ✓ Dimentionless metric
- ✓ Ranges from 0 to 1

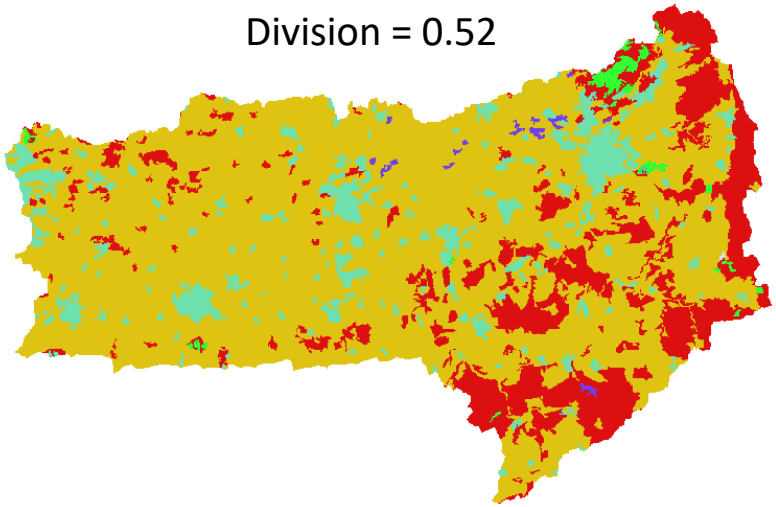
Conclusion : good indicator

## Landscape descriptors :

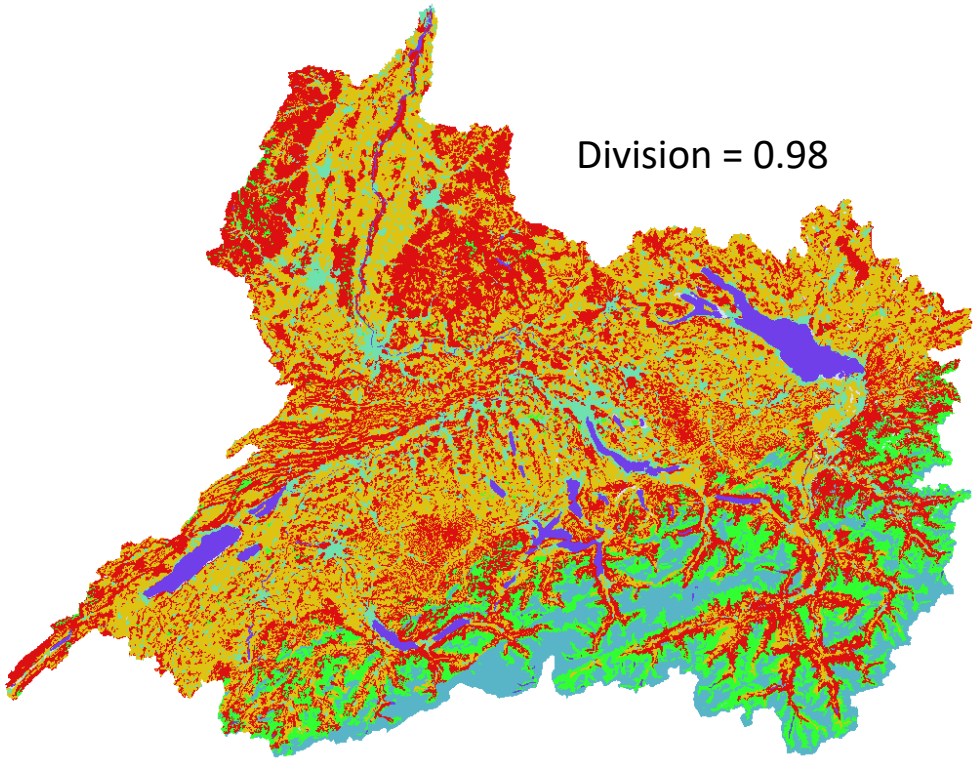
### Land cover configuration : Division

The most contrasting catchments in our dataset

Division = 0.52



Division = 0.98



Artifitial rurfaces
Agricultural areas
Forests
Shrublands
Bare soils
Wetlands
Water bodies

## Landscape descriptors :

### Land cover configuration : Connectivity Index

What does mean connectivity here:

**Concept of patch**

1- Pixels are connected in the sense that they belong to agricultural areas

2- Pixels are geographically connected (they share the same edges, 8-connectdness rule in spatial analysis)

3- Pixels are hydrologically connected in the sense that patches make it to the streams since they are located in their directly contributing area

**Formula**:

$$ACI = \sum_{i=1}^{n} \underbrace{\frac{a_i}{A}}_{\text{term1}} * \underbrace{\left(1 - \frac{DS_{mean,i} - DS_{min}}{DS_{max} - DS_{min}}\right)}_{\text{term2}}$$

A way of normalization to make the index dimensionless

n: number of agicultural patches
A: catchment area
$DS_{mean,i}$ : mean distance to the streams in the patch i
$DS_{max}$ : maximum distance to the streams across all patches in the catchments
$DS_{min}$ : minimum distance to the streams across all patches in the catchments

**Interpretation :** High values of ACI correspond to homogenous agriculturalpescapes where patches are close to streams and thus can deliver SS easily

**Note :**

- ACI can be customised by considering other hydromorphological attribute in the calculation of term2 (e.g., flow accumulation to see patches receiving more flow or flow distances to see th effect of proximity to streams)

## Landscape descriptors :

### Land cover configuration : Connectivity Index