

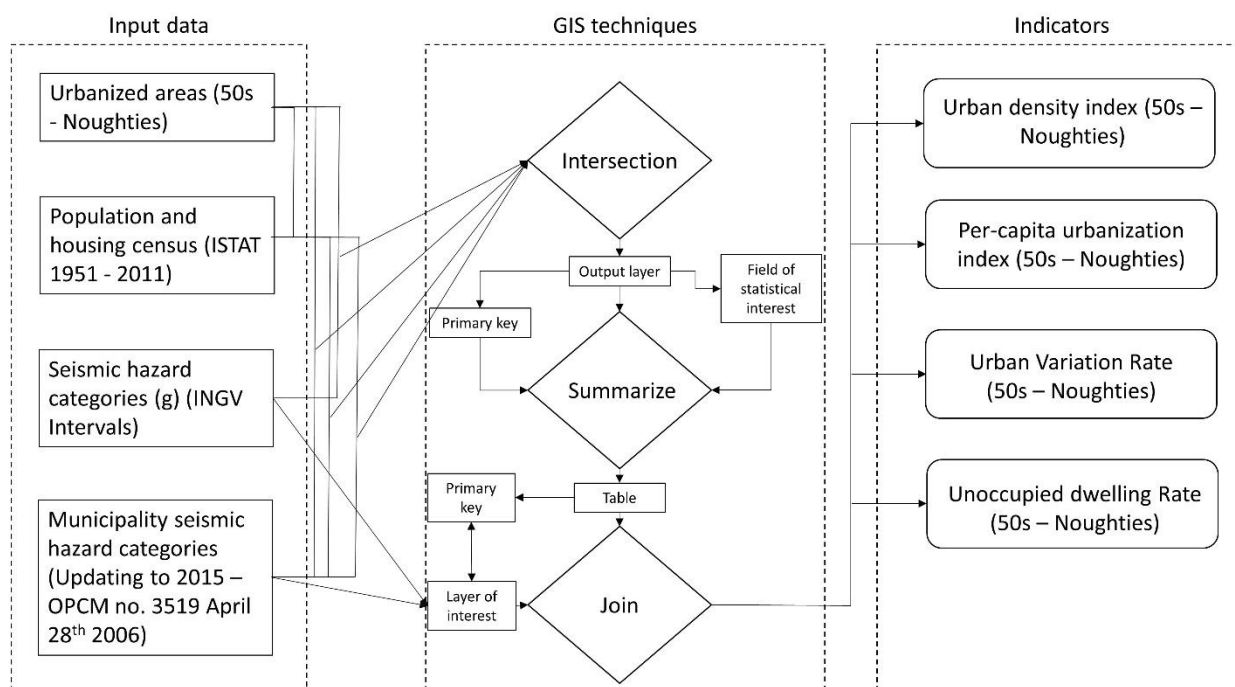
# SUPPLEMENTAL MATERIAL

| Regions        | Regional Area (km <sup>2</sup> ) | Total number of municipalities | Number of Apennines municipalities | Area of Apennines municipalities (km <sup>2</sup> ) | Apennine municipal ratio (%) | Apennine municipal area ratio (%) |
|----------------|----------------------------------|--------------------------------|------------------------------------|-----------------------------------------------------|------------------------------|-----------------------------------|
| Piedmont       | 25386,69                         | 1202                           | 91                                 | 1635,05                                             | 7,57                         | 6,44                              |
| Liguria        | 5416,08                          | 235                            | 120                                | 3442,15                                             | 51,06                        | 63,55                             |
| Lombardia      | 23862,99                         | 1528                           | 13                                 | 362,456                                             | 0,85                         | 1,52                              |
| Emilia Romagna | 22452,09                         | 334                            | 125                                | 9710,966                                            | 37,43                        | 43,25                             |
| Tuscany        | 22986,58                         | 279                            | 103                                | 7832,277                                            | 36,92                        | 34,07                             |
| Umbria         | 8464,11                          | 92                             | 89                                 | 8420,372                                            | 96,74                        | 99,48                             |
| Marche         | 9401,15                          | 236                            | 79                                 | 4542,949                                            | 33,47                        | 48,32                             |
| Lazio          | 17231,78                         | 378                            | 158                                | 5344,529                                            | 41,80                        | 31,02                             |
| Abruzzo        | 10831,49                         | 305                            | 205                                | 8101,468                                            | 67,21                        | 74,80                             |
| Molise         | 4460,43                          | 136                            | 118                                | 3536,669                                            | 86,76                        | 79,29                             |
| Puglia         | 19540,48                         | 258                            | 27                                 | 1548,040                                            | 10,47                        | 7,92                              |
| Campania       | 13670,58                         | 550                            | 332                                | 9623,919                                            | 60,36                        | 70,40                             |
| Basilicata     | 10073,11                         | 131                            | 115                                | 7620,061                                            | 87,79                        | 75,65                             |
| Calabria       | 15221,61                         | 409                            | 409                                | 15221,612                                           | 100,00                       | 100,00                            |
| Sicilia        | 25831,99                         | 390                            | 176                                | 7419,841                                            | 45,13                        | 28,72                             |
| <b>Total</b>   | <b>234831,16</b>                 | <b>6463</b>                    | <b>2160</b>                        | <b>94362,3589</b>                                   | <b>33,42</b>                 | <b>40,18</b>                      |

Supplemental material 1 – Regional areas in the Apennines

| Regions        | 50s                                                                 |                |          | Noughties                            |                |          |
|----------------|---------------------------------------------------------------------|----------------|----------|--------------------------------------|----------------|----------|
|                | Type of map                                                         | Reference year | Scale    | Type of map                          | Reference year | Scale    |
| Piedmont       | 25 V Series - published by IGMI                                     | 1963           | 1:25.000 | Regional Technical Map + buffer 20 m | 2008           | 1:5.000  |
| Liguria        | 25 V Series - published by IGMI                                     | 1940           | 1:25.000 | Land Use Map                         | 2000           | 1:10.000 |
| Lombardia      | Photointerpretation of the IGMI-GAI flight of 1954 - (Land Use Map) | 1954           | 1:33.000 | Land Use Map                         | 2009           | 1:10.000 |
| Emilia Romagna | Photointerpretation of the IGMI-GAI flight of 1954 - (Land Use Map) | 1954           | 1:33.000 | Land Use Map                         | 2008           | 1:25.000 |
| Tuscany        | 25 V Series - published by IGMI                                     | 1956           | 1:25.000 | Regional Technical Map               | 2007           | 1:10.000 |
| Umbria         | 25 V Series - published by IGMI                                     | 1956           | 1:25.000 | Geobotanical Land Use Map            | 2002           | 1:10.000 |
| Marche         | 25 V Series - published by IGMI                                     | 1954           | 1:25.000 | Land Use Map                         | 2007           | 1:10.000 |
| Lazio          | 25 V Series - published by IGMI                                     | 1956           | 1:25.000 | Land Use Map                         | 2004           | 1:10.000 |
| Abruzzo        | 25 V Series - published by IGMI                                     | 1956           | 1:25.000 | Land Use Map                         | 2002           | 1:10.000 |
| Molise         | 25 V Series - published by IGMI                                     | 1956           | 1:25.000 | Land Use Map                         | 2002           | 1:10.000 |
| Puglia         | 25 V Series - published by IGMI                                     | 1949           | 1:25.000 | Land Use Map                         | 2006           | 1:10.000 |
| Campania       | 25 V Series - published by IGMI                                     | 1956           | 1:25.000 | Agricultural Land Use Map            | 2009           | 1:25.000 |
| Basilicata     | 25 V Series - published by IGMI                                     | 1956           | 1:25.000 | ISTAT Map                            | 2010           | 1:10.000 |
| Calabria       | 25 V Series - published by IGMI                                     | 1956           | 1:25.000 | ISTAT Map                            | 2010           | 1:10.000 |
| Sicilia        | 25 V Series - published by IGMI                                     | 1968           | 1:25.000 | Land Use Map                         | 2008           | 1:10.000 |

Supplemental Material 2 – Characteristics of data considered in the study.



Supplemental Material 3 – Flowchart of GIS techniques used in the study.

| REGIONS        | N. Municipalities | Area regions (ha) | Urbanized areas (ha) |                  | Urbanization density (%) |              | Resident inhabitants |                 |                 |                 | Demographic density (inhab/kmq) |               | Urbanization per capita (mq/inhab) |               | Mean speed land take (ha/day) |
|----------------|-------------------|-------------------|----------------------|------------------|--------------------------|--------------|----------------------|-----------------|-----------------|-----------------|---------------------------------|---------------|------------------------------------|---------------|-------------------------------|
|                |                   |                   | 50s                  | Noughties        | 50s                      | Noughties    | 1951                 | 1961            | 2001            | 2011            | 50s                             | Noughties     | 50s                                | Noughties     |                               |
| Piedmont       | 91                | 163505,48         | 2991,40              | 8650,47          | 1,83%                    | 5,29%        | 106660               | 90918           | 70222           | 70396           | 65,23                           | 43,05         | 280,46                             | 1228,83       | 0,31                          |
| Lombardy       | 13                | 36245,59          | 382,90               | 1117,68          | 1,06%                    | 3,08%        | 23121                | 19277           | 11657           | 10566           | 63,79                           | 29,15         | 165,61                             | 1057,81       | 0,04                          |
| Liguria        | 120               | 344215,88         | 9713,29              | 22028,96         | 2,82%                    | 6,40%        | 1310685              | 1431874         | 1243585         | 1225382         | 380,77                          | 355,99        | 74,11                              | 179,77        | 0,67                          |
| Emilia Romagna | 125               | 971096,63         | 4511,52              | 35080,81         | 0,46%                    | 3,61%        | 680500               | 556103          | 460896          | 484047          | 70,08                           | 49,85         | 66,30                              | 724,74        | 1,68                          |
| Tuscany        | 103               | 783227,72         | 7566,47              | 43344,67         | 0,97%                    | 5,53%        | 1001461              | 1001777         | 1103590         | 1154243         | 127,86                          | 147,37        | 75,55                              | 375,52        | 1,96                          |
| Umbria         | 89                | 842037,16         | 15638,76             | 29938,21         | 1,86%                    | 3,56%        | 799548               | 790528          | 821290          | 879395          | 94,95                           | 104,44        | 195,59                             | 340,44        | 0,78                          |
| Marche         | 79                | 454294,92         | 4203,79              | 11113,33         | 0,93%                    | 2,45%        | 358617               | 312837          | 255603          | 256507          | 78,94                           | 56,46         | 117,22                             | 433,26        | 0,38                          |
| Lazio          | 158               | 534452,89         | 4744,96              | 15831,06         | 0,89%                    | 2,96%        | 517258               | 482234          | 495983          | 516939          | 96,78                           | 96,72         | 91,73                              | 306,25        | 0,61                          |
| Abruzzo        | 205               | 810146,82         | 4427,96              | 17576,30         | 0,55%                    | 2,17%        | 684489               | 609952          | 505214          | 502935          | 84,49                           | 62,08         | 64,69                              | 349,47        | 0,72                          |
| Molise         | 118               | 353666,86         | 1819,75              | 7971,70          | 0,51%                    | 2,25%        | 325822               | 285712          | 236429          | 226855          | 92,13                           | 64,14         | 55,85                              | 351,40        | 0,34                          |
| Campania       | 332               | 962391,89         | 7913,40              | 33693,00         | 0,82%                    | 3,50%        | 1315501              | 1273706         | 1229751         | 1230583         | 136,69                          | 127,87        | 60,16                              | 273,80        | 1,41                          |
| Puglia         | 27                | 154804,03         | 864,69               | 2591,60          | 0,56%                    | 1,67%        | 128775               | 106367          | 58550           | 52378           | 83,19                           | 33,84         | 67,15                              | 494,79        | 0,09                          |
| Basilicata     | 115               | 762006,12         | 1760,36              | 13381,11         | 0,23%                    | 1,76%        | 488855               | 488883          | 421338          | 401070          | 64,15                           | 52,63         | 36,01                              | 333,64        | 0,64                          |
| Calabria       | 409               | 1507605,35        | 13167,21             | 80476,02         | 0,87%                    | 5,34%        | 2044287              | 2045047         | 2011466         | 1959050         | 135,60                          | 129,94        | 64,41                              | 410,79        | 3,69                          |
| Sicily         | 176               | 741984,06         | 9005,87              | 34007,22         | 1,21%                    | 4,58%        | 1181701              | 1221862         | 1385183         | 1412517         | 159,26                          | 190,37        | 76,21                              | 240,76        | 1,37                          |
| <b>2160,00</b> |                   | <b>9421681,40</b> | <b>88712,32</b>      | <b>356802,15</b> | <b>0,94%</b>             | <b>3,79%</b> | <b>10967280</b>      | <b>10717077</b> | <b>10310757</b> | <b>10382863</b> | <b>116,40</b>                   | <b>110,20</b> | <b>80,89</b>                       | <b>343,65</b> | <b>14,69</b>                  |

Supplemental Material 4 – The data and indicators obtained from the study

| Seismic hazard (g) | Belt area (km²) | Apennine Area (km²) | Belt rate     | Urbanized area (km²) |                | Urbanized area increasing % | Urban Density |             |                   |
|--------------------|-----------------|---------------------|---------------|----------------------|----------------|-----------------------------|---------------|-------------|-------------------|
|                    |                 |                     |               | 50 s                 | Noughties      |                             | 50 s          | Noughties   | Density variation |
| < 0,05             | 221,06          |                     | 0,23          | 5,69                 | 15,46          | 171,8%                      | 2,57          | 6,99        | 2,72              |
| 0,05 - 0,075       | 1840,27         |                     | 1,95          | 61,04                | 143,17         | 134,6%                      | 3,32          | 7,78        | 2,35              |
| 0,075 - 0,100      | 3790,75         |                     | 4,02          | 49,60                | 144,14         | 190,6%                      | 1,31          | 3,80        | 2,91              |
| 0,100 - 0,125      | 4468,74         |                     | 4,74          | 42,01                | 113,37         | 169,8%                      | 0,94          | 2,54        | 2,70              |
| 0,125 - 0,150      | 6952,45         |                     | 7,38          | 88,19                | 354,91         | 302,4%                      | 1,27          | 5,10        | 4,02              |
| 0,150 - 0,175      | 16559,08        | 94216,81            | 17,58         | 150,21               | 671,98         | 347,3%                      | 0,91          | 4,06        | 4,47              |
| 0,175 - 0,200      | 17280,40        |                     | 18,34         | 137,78               | 642,41         | 366,3%                      | 0,80          | 3,72        | 4,66              |
| 0,200 - 0,225      | 15231,52        |                     | 16,17         | 110,64               | 493,89         | 346,4%                      | 0,73          | 3,24        | 4,46              |
| 0,225 - 0,250      | 10765,47        |                     | 11,43         | 107,20               | 358,05         | 234,0%                      | 1,00          | 3,33        | 3,34              |
| 0,250 - 0,275      | 16453,34        |                     | 17,46         | 123,25               | 599,56         | 386,5%                      | 0,75          | 3,64        | 4,86              |
| 0,275 - 0,300      | 653,74          |                     | 0,69          | 6,14                 | 29,01          | 372,5%                      | 0,94          | 4,44        | 4,73              |
| <b>94216,814</b>   |                 |                     | <b>100,00</b> | <b>881,75</b>        | <b>3565,95</b> | <b>304,4%</b>               | <b>0,94</b>   | <b>3,78</b> | <b>4,04</b>       |

Supplemental Material 5 - Growth of urban areas in the seismic hazard categories identified for the Apennines

| Seismic classification | Seismic hazard (g) | REGIONS  |          |         |                |         |        |        |        |         |        |        |          |            |          |        |         | TOTAL |
|------------------------|--------------------|----------|----------|---------|----------------|---------|--------|--------|--------|---------|--------|--------|----------|------------|----------|--------|---------|-------|
|                        |                    | Piedmont | Lombardy | Liguria | Emilia Romagna | Tuscany | Lazio  | Umbria | Marche | Abruzzo | Molise | Puglia | Campania | Basilicata | Calabria | Sicily |         |       |
| 4                      | < 0,05             | 9,77     |          | 0,00    |                |         |        |        |        |         |        |        |          |            |          |        | 9,77    |       |
| 3                      | 0,05 - 0,075       | 25,44    |          | 56,10   |                |         |        |        |        |         |        | 0,59   |          |            |          |        | 82,14   |       |
|                        | 0,075 - 0,100      | 21,74    | 7,00     | 24,16   | 8,41           |         |        |        |        | 0,08    |        | 28,26  | 2,44     | 1,23       | 1,22     |        | 94,54   |       |
|                        | 0,100 - 0,125      |          | 0,39     | 18,53   | 16,03          | 5,01    |        |        |        | 6,37    |        | 13,14  | 2,61     | 2,87       | 6,40     |        | 71,36   |       |
|                        | 0,125 - 0,150      |          |          | 24,30   | 5,23           | 138,46  | 10,36  | 7,89   |        | 2,36    | 0,38   | 3,50   | 13,61    | 5,75       | 42,44    | 12,42  | 266,72  |       |
| 2                      | 0,150 - 0,175      |          |          | 0,74    | 156,38         | 93,47   | 64,59  | 46,28  | 17,41  | 7,94    | 1,11   | 3,51   | 17,34    | 18,70      | 52,00    | 42,29  | 521,76  |       |
|                        | 0,175 - 0,200      |          |          | 0,00    | 78,90          | 69,03   | 17,60  | 24,54  | 44,24  | 31,59   | 5,86   | 5,01   | 32,98    | 29,33      | 100,32   | 65,25  | 504,63  |       |
|                        | 0,200 - 0,225      |          |          |         | 49,53          | 48,95   | 11,51  | 28,33  | 2,86   | 9,48    | 16,07  | 4,88   | 32,92    | 19,00      | 91,85    | 67,87  | 383,25  |       |
| 1                      | 0,225 - 0,250      |          |          |         |                | 3,66    | 17,45  | 33,94  | 3,18   | 16,67   | 16,80  | 0,27   | 35,56    | 14,02      | 61,92    | 47,38  | 250,85  |       |
|                        | 0,250 - 0,275      |          |          |         |                |         | 13,97  | 2,10   | 0,49   | 57,04   | 20,98  |        | 62,15    | 23,45      | 291,26   | 4,86   | 476,31  |       |
|                        | 0,275 - 0,300      |          |          |         |                |         |        |        |        |         |        |        |          |            | 22,87    |        | 22,87   |       |
| TOTAL                  |                    | 56,95    | 7,39     | 123,83  | 314,48         | 358,58  | 135,49 | 143,07 | 68,19  | 131,53  | 61,20  | 17,17  | 236,55   | 115,30     | 666,75   | 247,70 | 2684,20 |       |

Supplemental Material 6 – Variations in urbanised areas (expressed in km<sup>2</sup>) for every seismic hazard category in each of the Apennine regions.

Acceleration with  
Seismic probability of exceeding  
classification equal to 10% in 50 years  
(ag)

|          |              |
|----------|--------------|
| <b>1</b> | 0,25<ag<0.35 |
| <b>2</b> | 0.15<ag<0.25 |
| <b>3</b> | 0.05<ag<0.15 |
| <b>4</b> | ag<0.05      |

Supplemental Material 7 – Parameters to classify municipalities in seismic zones based on peak ground acceleration on stiff ground (OPCM No. 3519 dated April 28<sup>th</sup> 2006).

| Seismic classification | N. municipalities | Area (km <sup>2</sup> ) | %            | Urbanized Area (km <sup>2</sup> ) |                |                |                | Land take mean speed (ha/day) |
|------------------------|-------------------|-------------------------|--------------|-----------------------------------|----------------|----------------|----------------|-------------------------------|
|                        |                   |                         |              | 50's                              | Noughties      | Variation      | Variation rate |                               |
| <b>1</b>               | 656               | 24306,87                | 0,258        | 213,31                            | 963,91         | 750,60         | 351,88%        | 4,11                          |
| <b>2</b>               | 1137              | 55873,5                 | 0,593        | 465,1                             | 1818,2         | 1353,10        | 290,93%        | 7,41                          |
| <b>3</b>               | 285               | 12380,38                | 0,131        | 172,08                            | 694,67         | 522,59         | 303,69%        | 2,86                          |
| <b>4</b>               | 82                | 1656,05                 | 0,018        | 36,64                             | 91,24          | 54,60          | 149,02%        | 0,30                          |
| <b>Total</b>           | <b>2160</b>       | <b>94216,8</b>          | <b>1,000</b> | <b>887,13</b>                     | <b>3568,02</b> | <b>2680,89</b> | <b>302,20%</b> | <b>14,69</b>                  |

Supplemental Material 8 – Development of urbanised areas in the seismic zones identified by OPCM no. 3519 dated April 28<sup>th</sup> 2006.