AHNI calculation for the study sites

Table S1: Ranking scheme of the hazard factors (HF) and the control factors (CF). The former are referred to agricultural activities which produce or may produce impacts on the aquifers; the latter are referred to parameters which modify the hazard factors in positive, negative or null way (based on: Padovani and Trevisan, 2002; Capri et al., 2009).

Hazard Factors		**Control actors**	
Mineral Fertilizers **HF_{fm}**	Hazard classes are estimated on the base of the amounts of nitrogen for the different adopted crops, deduced by Carta dell' Utilizzo Aagricolo del Suolo (CUAS).	Content of nitrogen **CF_{fa}**	The content of nitrogen in the soil has been deduced comparing "*I Sistemi di Terre* Map" with pedologic features.
Hazard Classes: 1÷5		**Assignable scores:** 0.96÷1.04 Assigned score: 0.96÷1.02	
Organic Fertilizers **HF_{fo}**	Hazard classes are estimated on the base of the nitrogen concentrations, linked to the manures and referred SAU municipal, deduced from CUAS. ISTAT data have given information on the kinds of breeding and number of livestock in every municipality. Through the ERSAL coefficient the weight of dejections has been calculated and then the produced nitrogen.	Clime **CF_{fc}**	The scores are determined on the base of meteo-climatic data referred to mean annual values of precipitation and temperature, collected to the stations near interested area.
Hazard Classes: 1÷5		**Assignable scores:** 0.94÷1.10 Assigned score: 1.02	
Depuration muds **HF_{fd}** Hazard classes, defined on the base of the kind of muds reused in agriculture. The source of data is the Centro Tematico Nazionale Territorio e Suolo dell'ISPRA (or APAT; APAT-CTN_TES).		Agronomy practices **CF_{pa}** **Assignable scores:** 0.94÷1.04	Agronomy practices deduced by CUAS, have been compared to the possible reuse of the manures.
Hazard Classes: 1÷5 Assigned hazard classes: 1*		Irrigation **CF_i** **Assignable scores:** 1÷1.06	The scores are assigned on the base of the irrigation for the kinds of crops indicated in the CUAS.
*Lower hazard class has been assigned because the amount of depuration muds reused in agriculture, in Campania, is avoid.			

HF_{fm} - Mineral Fertilizers

Hazard classes are estimated on the base of the amounts of nitrogen for the different adopted crops (Table S2), deduced by CUAS.

Table S2. Nitrogen supply from the different adopted crops

Supply of NO_3 (kg/ha)	**Crops**	**HF_{fm}**
0	legumes (soy, pea, ...)	1
1-25	meadow, apple, pear	2
26-100	oats, rye, beetroot, sunflower, flax, rapeseed, vine	3
100-180	wheat, barley, rice, potato	4
> 180	corn, olive, poplar	5

Table S3. HF_{fm} scores for the different crops recognized in the study area, based on CUAS

CUAS Type	Concentration of NO_3 (Kg/ha)	HF_{fm}
111 - cereals crop	100 - 180	4
122 - horticultural crops	100 - 180	4
125 - industrial crops	26 - 100	3
131 - rotation grass	1 - 25	2
21 - vineyards	1 - 25	2
22 - fruit trees and berry plantations	1 - 25	2
23 - olive groves	1 - 25	2
24 - citrus orchards	1 - 25	2
31 - pastures	100 - 180	4
41 - annual crops associated with permanent crops	100 - 180	4
51 - broad-leaved forest	> 180	5
61 - natural grasslands	100 - 180	4
62 - sparsely vegetated areas	1 - 25	2
72 - bare rocks	0	1
91 - urban areas and artificial lands	0	1
92 - water bodies	0	1

The attribution of the nitrogen load and the related hazard class was carried out on the basis of the following assumptions:

- For each agro-forestry unit on which the practice of more crops is foreseen, which involve different nitrogen concentrations and consequently with different hazard classes, the highest class has been assigned;
- Hazard class 2 has always been attributed to tree crops (vineyards, orchards, olive groves)
- Sparsely vegetated bushes and shrubs were intended as lawns, attributing class 2
- To the units: urban environment, inland waters, bare rocks and outcrops, the hazard class attributed is 1 because, analyzing the nitrogen load deriving from agricultural activities alone, they do not influence this estimate.

HF_{fo} - Organic Fertilizers

Hazard classes are estimated on the base of the nitrogen concentrations, linked to the manures and related municipal Utilized Agricultural Area (UAA), deduced from CUAS. ISTAT data have given information on the kinds of breeding and number of livestock. The weight of dejections has been calculated and then the produced nitrogen.

Known the tons of live weight per year (tons) of manure produced by each farmed species (corresponding to 340kg of NO_3) and the total number of species, it is possible to calculate the total quantity of NO_3 produced compared to the Utilized Agricultural Area (UAA in ha) defines the NO_3 contribution per unit area (ha) and therefore the hazard factor / class according to the table

Table S4. HFfm scores for the different crops recognized in the study area, based on CUAS

Bred Species	Average Weight per Year (t) Manure, Dung, Muck
swines	3
cattles	4
poultry	2.1
rabbits/	2.4
sheep	3.4
equine	4

where**:**

- the buffaloes have been included in cattle farms,
- ostriches in poultry farms,
- goats and sheep were included in a single category: sheep and goats.

The UAAwere derived from the CUAS excluding the polygons relating to:

- Inland waters
- Urbanized environment

- Broad-leaved woods
- Outcrop bare rocks.

HF_{fd} - Depuration sludge

Hazard classes, defined on the base of the kind of sludge reused in agriculture. The source of data is the Centro Tematico Nazionale Territorio e Suolo dell'ISPRA (or APAT; APAT-CTN_TES).
Based on their data for the Campania Region, the reuse of sewage sludge is null (Corniello, 2006). Therefore, based on Table 1, the hazard class attributed to this factor is 1.

CF_a – Soil nitrogen content

The soil nitrogen content has been deduced comparing the Land Systems of the Campania with pedologic features (Table S5). From the identification of the soil classes, they were classified on the basis of the nitrogen content to which the hazard classes were subsequently assigned.

Table S5: The main soil types found and relationship between soil and nitrate concentration

Order	Sub-Group	Land Sub-System	Soil Classification	Soil Nitrogen Content (%)	CF_a
Andosols	Molli-Vitric	A1.1 - B4.1	rich	0.22-0.5	1.02
	Molli-Eutrisilic	A1.1	overly endowed	> 0.5	1.04
	Vitric	B4.1	well endowed	0.15-0.22	1
	Epileptic-Vetric	B4.1	well endowed	0.15-0.22	1
	Luvi-Vitric	D3.1	well endowed	0.15-0.22	1
Cambisols	Calcaric	D3.1 - I1.1	poor	< 0.1	0.96
	Calcaric-Fluvic	I1.1	poor	< 0.1	0.96
Calcisols	Haplic	D3.1	poor	< 0.1	0.96
Luvisols	Andic	B1.3	poor	< 0.1	0.96
	Cutanic-Andic	B1.3	poor	< 0.1	0.96
	Chromy-Gleyic	H3.1	moderately endowed	0.1-0.15	0.98
Regosols	Skeletic-Calcaric	D1.1	poor	< 0.1	0.96

Considering that each Land Sub-System can be made up of different types of soil that affect the nitrogen content and consequently the relative scores to be attributed, it was decided to always assign the highest score.

CF_c - Clime

The scores are determined on the base of meteo-clime data referred to mean annual values of precipitation and temperature, collected to the stations near interested area. Since there is no climatic data for the area, given the absence of monitoring stations, the highest score was assigned for the entire area.

CF_{pa} - Agronomy practices

Agronomy practices deduced by CUAS have been compared to the possible reuse of the manures. The AHNI score to be attributed to agronomic practices is estimated on the types of fertilization used. For the studied areas, not having specific feedback on the types of fertilization used, a type of fertilization method is proposed for each agro-forestry unit based on direct observations conducted on the territory (Table S6).

Table S6. Correlation between CUAS type and Fertilization type.

CUAS type	Fertilization Type	CF_{pa}
111 - cereals crop	traditional	1
122 - horticultural crops	traditional	1
125 - industrial crops	traditional	1
131 - rotation grass	traditional	1
21 - vineyards	localized	0.96
22 - fruit trees and berry plantations	fertigation system	1.04
23 - olive groves	localized	0.96
24 - citrus orchards	fertigation system	1.04
31 - pastures	none	0.94
41 - annual crops associated with permanent crops	traditional	1
51 - broad-leaved forest	none	0.94
61 - natural grasslands	none	0.94
62 - sparsely vegetated areas	none	0.94
72 - bare rocks	none	0.94
91 - urban areas and artificial lands	none	0.94
92 - water bodies	none	0.94

CF_i - Irrigation

The scores are assigned on the base of the irrigation for the kinds of crops indicated in the CUAS. The score was assigned by discriminating between irrigated and non-irrigated areas by CUAS and by identifying the types of agricultural products for each agro-forestry unit. Where different agricultural productions are indicated, to which different types of irrigation are associated, the highest score was attributed (Table S7).

Table S7. Correlation between CUAS type and Irrigation systems.

CUAS Type	Irrigation System	CFi
111 - cereals crop	drip irrigation	1.02
122 - horticultural crops	drip irrigation	1.02
125 - industrial crops	lateral flow irrigation	1.04
131 - rotation grass	no irrigation	1
21 - vineyards	drip irrigation	1.02
22 - fruit trees and berry plantations	drip irrigation	1.02
23 - olive groves	drip irrigation	1.02
24 - citrus orchards	drip irrigation	1.02
31 - pastures	no irrigation	1
41 - annual crops associated with permanent crops	drip irrigation	1.02
51 - broad-leaved forest	no irrigation	1
61 - natural grasslands	no irrigation	1
62 - sparsely vegetated areas	no irrigation	1
72 - bare rocks	no irrigation	1
91 - urban areas and artificial lands	no irrigation	1
92 - water bodies	no irrigation	1

Appendix
Land Systems of the Campania

For each group, the characteristics and types of soil found are defined:

A Alta Montagna: includes the top of mountains and the high mountain slopes of the calcareous, marly-arenaceous and marly-calcareous reliefs.

A1: includes the areas of high limestone mountains, with soils developed on volanoclastic fall deposits.

A1.1: groups top and slopes of high limestone mountains covered by volcanic ashy fall deposits, with steep or very steep soils, moderately deep (Types of soils: Molli-Vitric, Andsols ; Molli-Eutrisilic, Andsols).

Steep or very steep soils, from superficial to moderately deep, rocky, stony, on ash deposits covering limestone, medium texture, with good availability of oxygen, pebbly (Types of soils: Molli-Eutrisilic, Andsols (Epileptic), Molli-Eutrisilic, Andsols (Endoleptic)).

B Limestone Mountains: includes all the lower part of the limestone mountains.

B1: groups all the summits and the steep or very steep slopes of the internal calcareous reliefs, with pedological coverings of ash falls.

B1.3: lower slopes of internal calcareous reliefs with conoid slope deposits with very sloping to moderately steep, deep soils, developed on ancient conoid deposits, with moderately fine or fine texture, with good or moderate availability of oxygen, gravelly in depth (Types of soils: Cutani-Andic Luvisols, Profondi-Andic Luvisols). Soils of anthropogenic terraces, from moderately steep to steep, from moderately deep to deep, rocky, stony, on ash deposits covering the limestone, with medium or moderately coarse texture, with good oxygen availability, pebbly (Types of soils : Molli-Vitric Andosols (Endoleptic), Molli-Eutrisilic, Andosols (Endoleptic)).

B4: Includes the summits and steep or very steep slopes of the pre-Apennine limestone reliefs, with soils developed on pyroclastic deposits.

B4.1: Central-northern pre-Apennine reliefs with pyroclastic coverings.

Moderately steep to very steep, deep soils on pumice and ash deposits with a moderately coarse texture, with good availability of oxygen (Types of soils: Vitric Andosols; Molli-vitric Andosols).

B4.3: deep steep soils on volcanic fall deposits, moderately coarse texture, with good availability of oxygen (Vitric Andosols, Molli-Vitric Andosols). Steep, moderately deep, thin soils on fall deposits covering the limestone rock, with a moderately coarse or medium texture, gravelly, with good availability of oxygen.

D Internal Hill: includes the internal hills.

D1: Clayey hill

D1.1: Moderately steep to steep, moderately deep to deep soils on clay, fine to moderately fine texture, with good or moderate oxygen availability (Soil type: Skeletic-Calcaric Regosols).

Rough, steep or very steep, moderately deep to deep, stony mineral soils on fine to moderately fine-textured clays, with good or moderately gravelly oxygen availability (Soil type Skeleti-Calcaric Regosols).

D3: groups together the marly-arenaceous and marly-calcareous hills.

D3.1: includes low relief hills on sandstone and Campanian Gray Tuff.

Soils gently sloping to steep, deep, on medium to moderately fine sandstone texture (Soil types: Calcaric Cambisols; Haplic Calcisols)

Softly sloping to very deep sloping soils on ash deposits covering the Campanian Gray Tuff with medium texture on the surface, moderately fine in depth (Types of soils: Luvi-Vitric Andosols).

G Foothills plain: includes areas morphologically higher than the base level of the alluvial plain.

G1: foothills plains of the pre-Apennine limestone reliefs.

G1.1: shallow, sub-flat soils, on fall deposits covering the Campanian Gray Tuff and locally the Neapolitan Yellow Tuff, with medium texture on the surface, moderately fine in depth, with good availability of oxygen (Luvi-Vitric Andosols, Molli-Vitric Andosols).

H Alluvial terraces: Includes the terraces and alluvial fans

H3: Terraced basins of the ancient lake basins.

H3.1: Soils from flat to very sloping, deep, on terraced ancient fluvial-lacustrine deposits, with moderately fine or fine texture, with moderate or imperfect oxygen availability. (Type of soils: Chromi-Gleyic Luvisols)

I Alluvial plain:

I1: coastal floodplains

I1.1: Flat, very deep soils on current alluvial deposits, with moderately fine or fine texture, with good or moderate oxygen availability (Types of soils: Calcaric Cambisols, Calcaric-Vitric Cambisols, Haplyc Cambisols).

I2.4: flat, deep soils, on alluvial sediments with intercal flat, deep soils, on alluvial sediments with intercalations of fall products, from medium texture (on the surface) to moderately fine (in depth), with moderate availability of oxygen (Molli-Vitric Andosols (Calcaric, Fluvic).