Semantic Interoperability of Volunteered Geographic Information based on Contextual Knowledge

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Research on VGI at IREA - CNR

- **VGI & SDI interoperable management:**
  - **VGI acquisition by development of Smart Apps;**
  - **Applications of VGI for citizen science: agriculture, ecology and biodiversity (LTER) , glaciers monitoring, s-low tourism, emergencies;**
  - **S4A smart App: https://www.youtube.com/watch?v=M3GYIsQAUWc**
  - **"I cammini" http://www.lteritalia.it/it/cammini**
- **VGI quality assessment methods**
  - **G Bordogna, P Carrara, L Criscuolo, M Pepe, A Rampini, A linguistic decision making approach to assess the quality of volunteer Geographic information for citizen science Information Sciences 258, 312-327**
- **Spatio-temporal analysis of social networks (Tweeter)**
  - **P Arcaini, G Bordogna, D Ienco, S Sterlacchini, User-driven geo-temporal density-based exploration of periodic and not periodic events reported in social networks, Information Sciences, 2016**
- **Sensor Web Enablement**

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Open Problem

Interoperable Spatial Data Infrastructures (SDI)

Filling the gap for VGI interoperable management

Volunteered Geographic Information (VGI) created by distinct applications

Need to create a bridge for each VGI application

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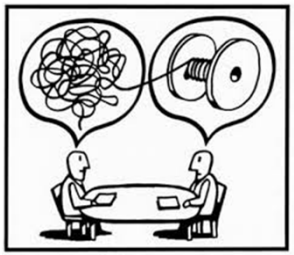
Main Cornerstones for full Interoperable VGI

- OGC services for VGI deploy

- Ontologies for Data Normalization and semantic interoperability



- Uncertainty management by Data conflation to resolve co-references (data associated with the same geographic object)

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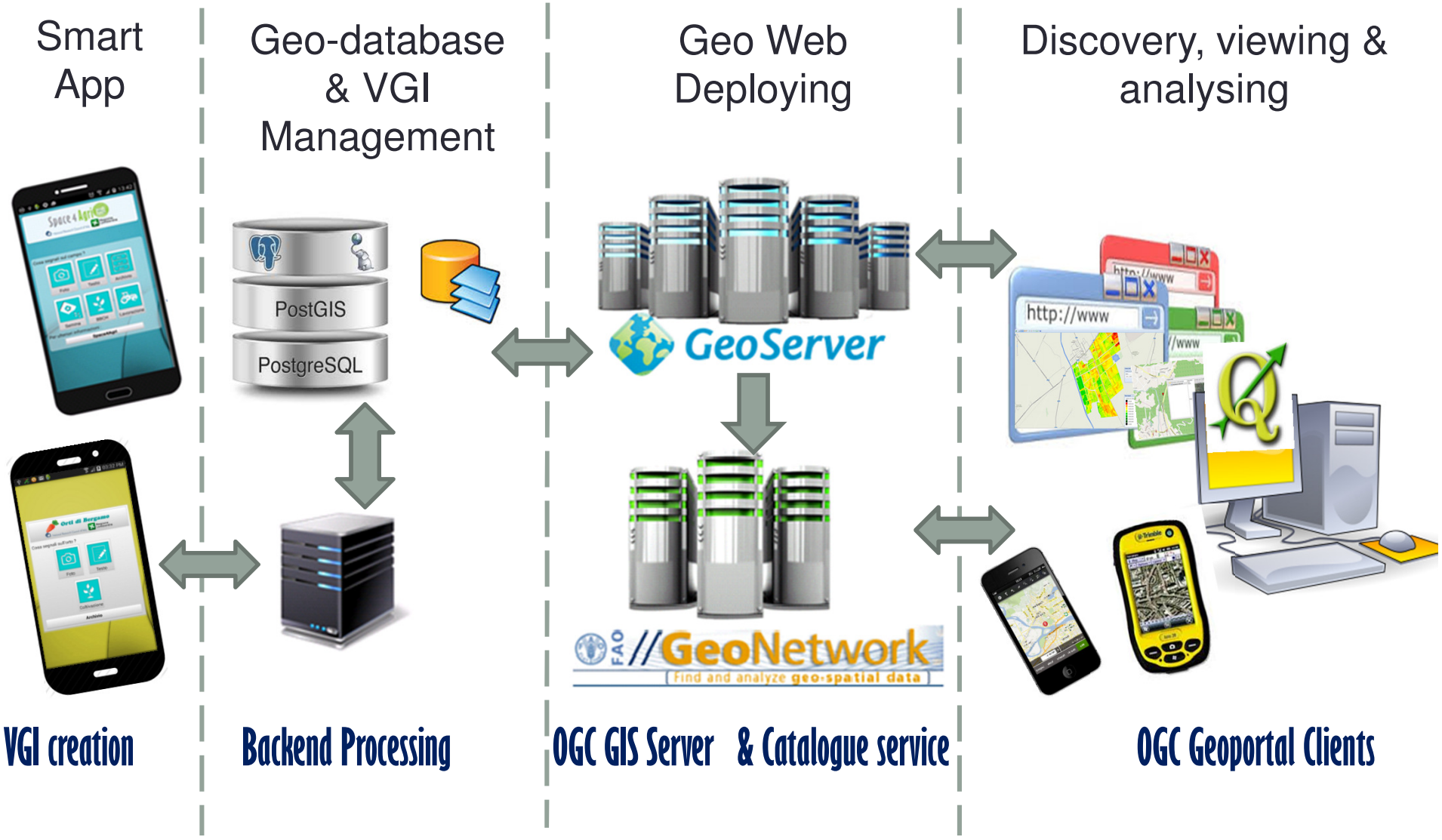
Syntactic interoperability of VGI within an SDI



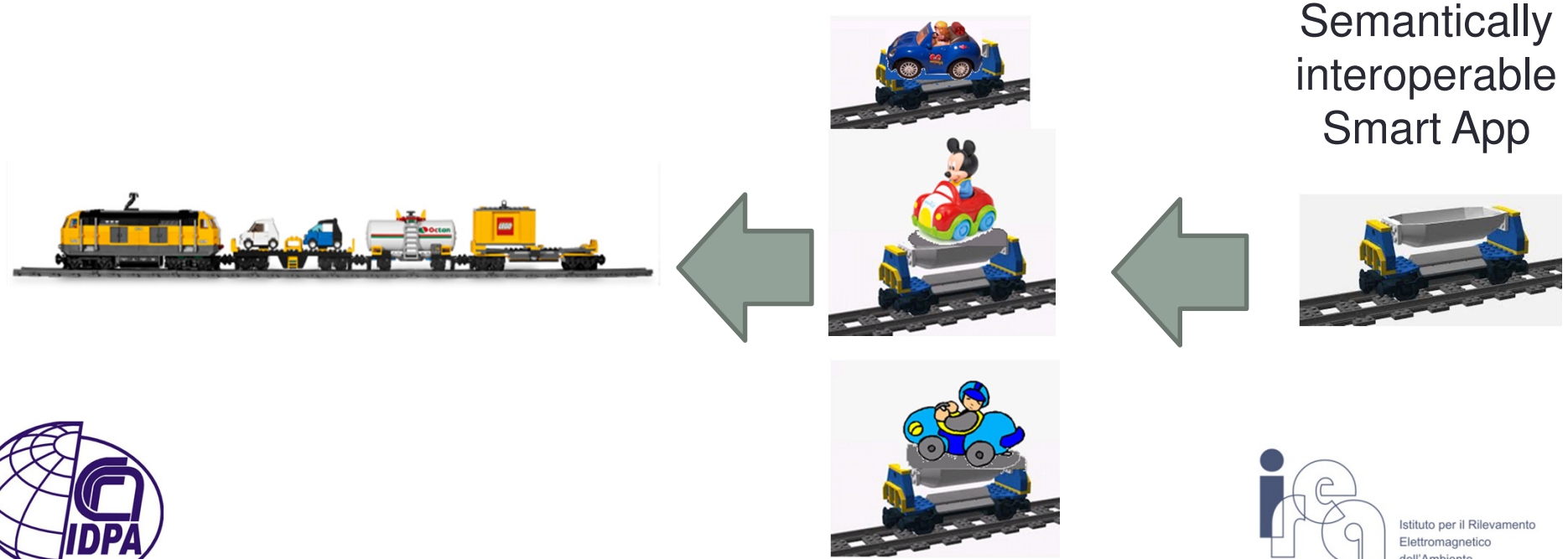
Adopted Solution to support semantic inteoperability

SDI managing semantically interoperable VGI created by a Smart App for citizen science projects

Interoperable Spatial Data Infrastructures

Semantically annotated VGI

Semantically interoperable Smart App



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Smart App for semantically interoperable VGI creation within citizen science projects

Target projects:

- Volunteers contributions about georeferenced features (POIs, entities of interest, etc)

Requirements of the Smart App:

- It must work off-line;
- It must guide the Volunteer;
- It must resolve ambiguities and imprecision in geolocalization of target entities
- It must use a domain language;
- it should allow creation of semantically annotated Free text and pictures;

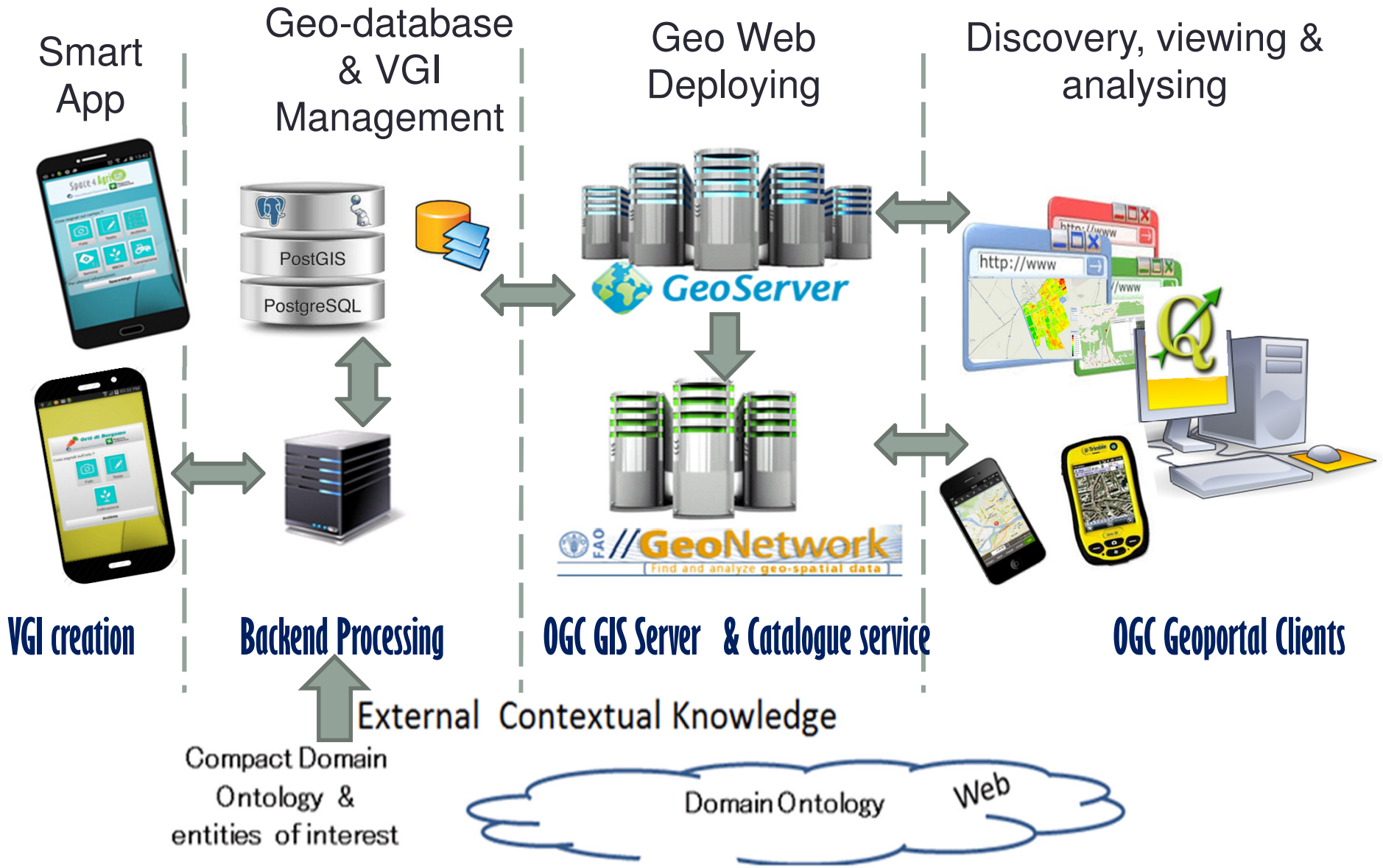
Smart App for semantically interoperable VGI creation within a citizen science project

Proposed solution:

use of contextual knowledge for VGI creation, management, and analysis

- manual repositioning of automatically detected GPS location when creating VGI (to correct possible imprecisions)
- conflation of VGI footprint by the support of a **conflation geospatial data layer** representing the boundaries (or centroids) of entities of interest (to resolve ambiguities)
- **compact domain ontology** stored on the SD card of the device to support creation of categorical VGI
- **extended domain ontolgy** to support analysis of VGI

Semantic & Syntactic interoperability of VGI within an SDI

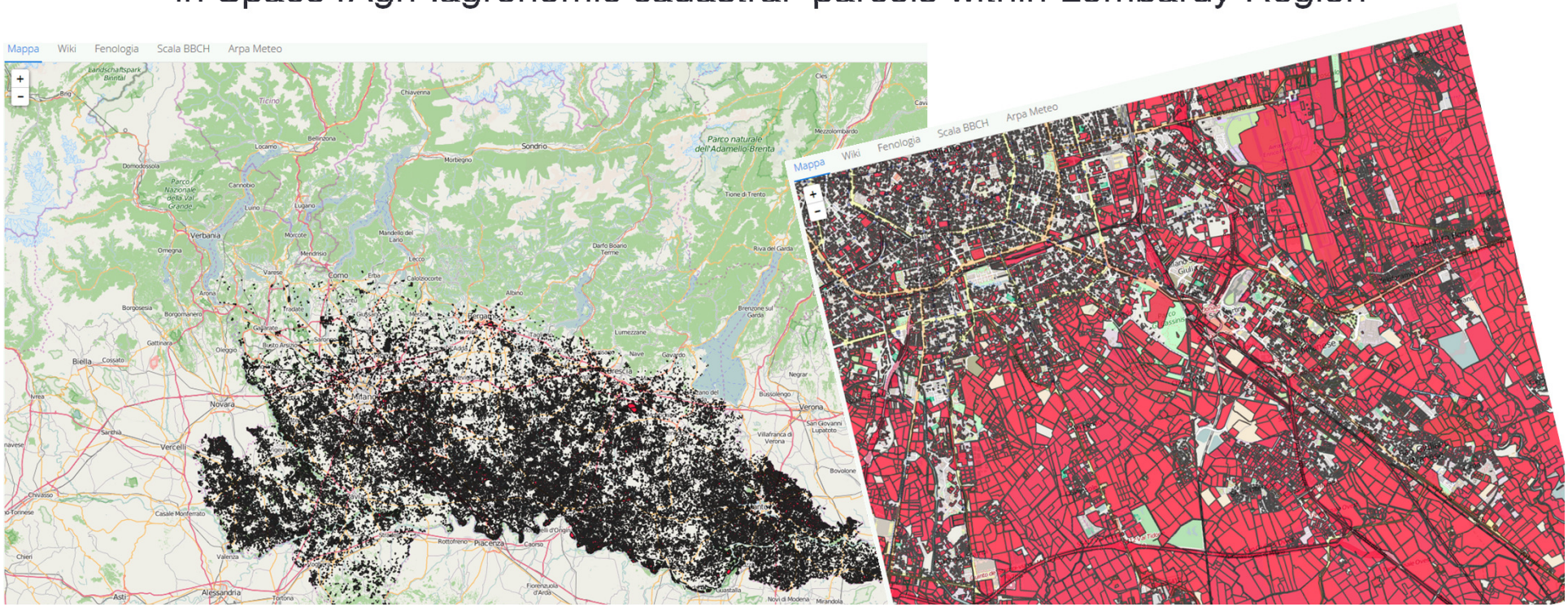


Space4Agri case study: Contextual Knowledge

G Bordogna, T Kliment, L Frigerio, PA Brivio, A Crema, D Stroppiana, ...

A Spatial Data Infrastructure Integrating Multisource Heterogeneous Geospatial Data and Time Series: A Study Case in Agriculture, ISPRS International Journal of Geo-Information 5 (5), 73

- Geospatial data layer of EoI:
  - in vector format stored in the geo-database
    - in Space4Agri :agronomic cadastral parcels within Lombardy Region

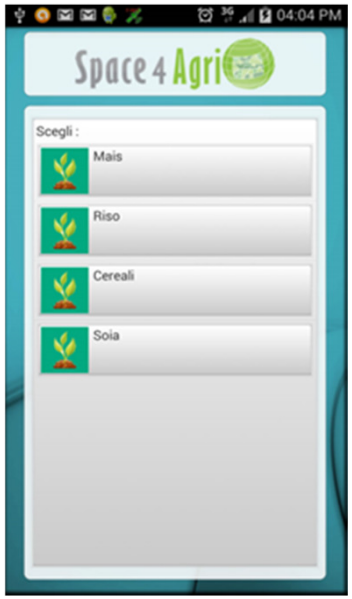


Space4Agri case study: Domain Ontology for VGI creation

- Identification of the domain ontology with the help of citizen science project leaders
  - https://en.wikipedia.org/wiki/BBCH-scale
  - https://www.politicheagricole.it/flex/AppData/WebLive/Agrometeo/MIEPFY800/BBCHengl2001.pdf
- Identification of a useful compact synthesis from the domain ontology
  - **Selection of concepts:**
    - only BBCH for rice, maize, soybean, cereals, vegetable crops
  - Codification of the compact ontology in the form of a **hierarchy of concepts**

Space4Agri case study: Codification of the compact ontology in the form of a hierarchy of concepts

- General Scale
- Cereals, Rice, Maize
- Oilseed rape, Faba bean, Sunflower
- Beta beets
- Potato
- Fruits
- Citrus, Olive, Coffee, Banana
- Grapevine
- Soybean, Cotton, Peanuts
- Hop
- Vegetable crops I
- Vegetable crops II
- Weeds



Stage	Description
0	Germination / sprouting / bud development
1	Leaf development (main shoot)
2	Formation of side shoots / tillering
3	Stem elongation or rosette growth / shoot development (main shoot)
4	Development of harvestable vegetative plant parts or vegetatively propagated organs / booting (main shoot)
5	Inflorescence emergence (main shoot) / heading
6	Flowering (main shoot)
7	Development of fruit
8	Ripening or maturity of fruit and seed
9	Senescence, beginning of dormancy

Space4Agri case study: Codification of the compact ontology in the form of a hierarchy of concepts

Rice Lancashire et al., 1991

Phenological growth stages and BBCH-identification keys of rice (*Oryza sativa* L.)

Code	Description
Principal growth stage 0: Germination	
00	Dry seed (caryopsis)
01	Beginning of seed imbibition
03	Seed imbibition complete (pigeon breast)
05	Radicle emerged from caryopsis
06	Radicle elongated, root hairs and/or side roots visible
07	Coleoptile emerged from caryopsis (in water-rice this stage occurs before stage 05)
09	Imperfect leaf emerges (still rolled) at the tip of the coleoptile
Principal growth stage 1: Leaf development[1, 2]	
10	Imperfect leaf unrolled, tip of first true leaf visible
11	First leaf unfolded
12	2 leaves unfolded
13	3 leaves unfolded
1 .	Stages continuous till . . .
19	9 or more leaves unfolded
Principal growth stage 2: Tillering[3]	
21	Beginning of tillering: first tiller detectable
22	2 tillers detectable
23	3 tillers detectable
2 .	Stages continuous till ...
29	Maximum number of tillers detectable
Principal growth stage 3: Stem elongation	
30	Panicle initiation or green ring stage: chlorophyll accumulates in the stem tissue, forming a green ring
32	Panicle formation: panicle 1–2 mm in length
34	Internode elongation or jointing stage: internodes begin to elongate, panicle more than 2 mm long (variety-dependent)
37	Flag leaf just visible, still rolled, panicle moving upwards
39	Flag leaf stage: flag leaf unfolded, collar regions (auricle and af aligned (pre-boot stage)


```
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  - <element>
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  - <element>
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        prima dello stadio 05)</description>
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```
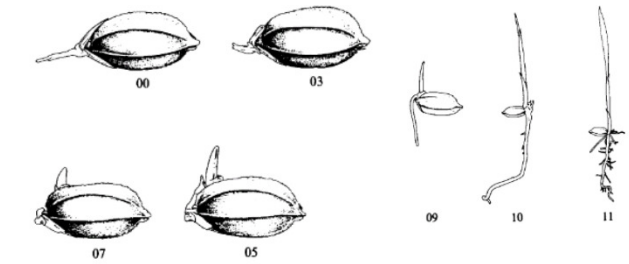
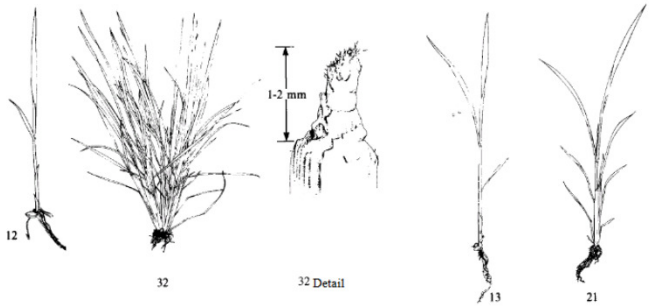


Rice



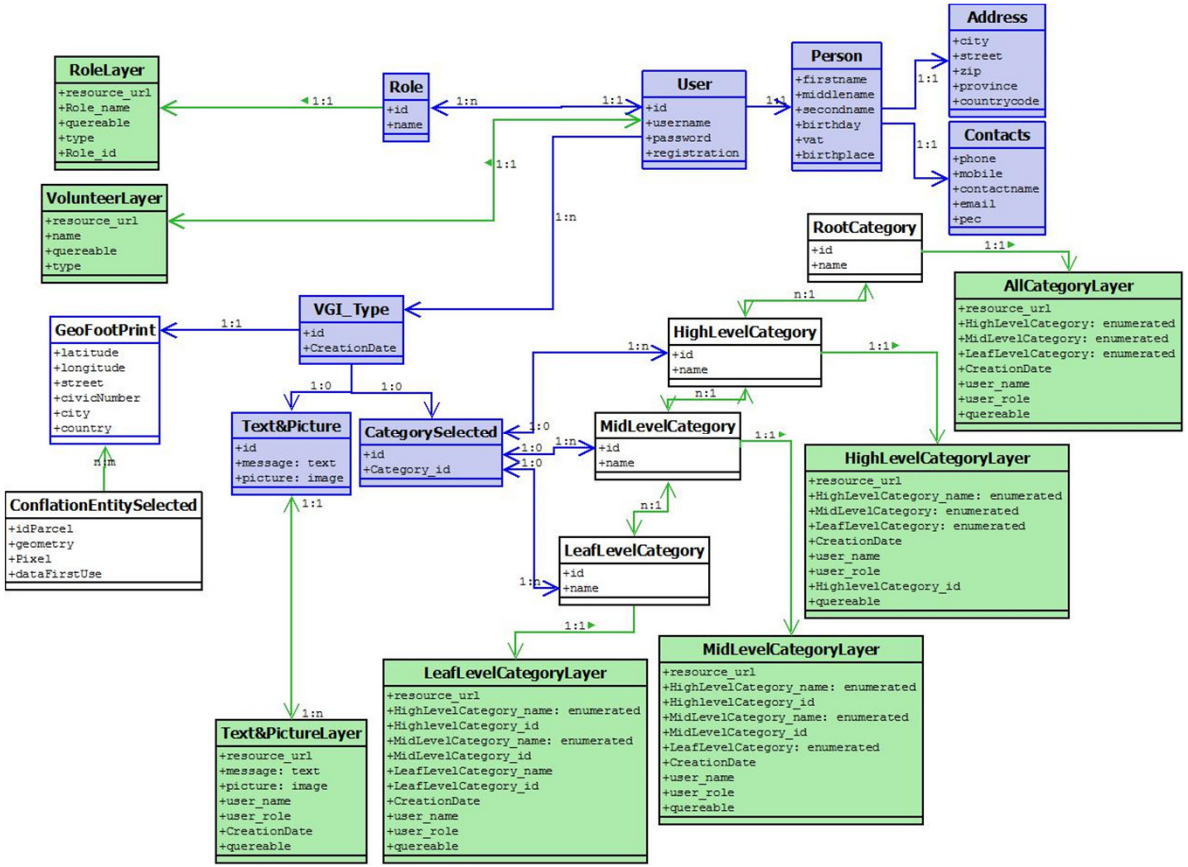


Space4Agri case study: VGI creation by the smart App

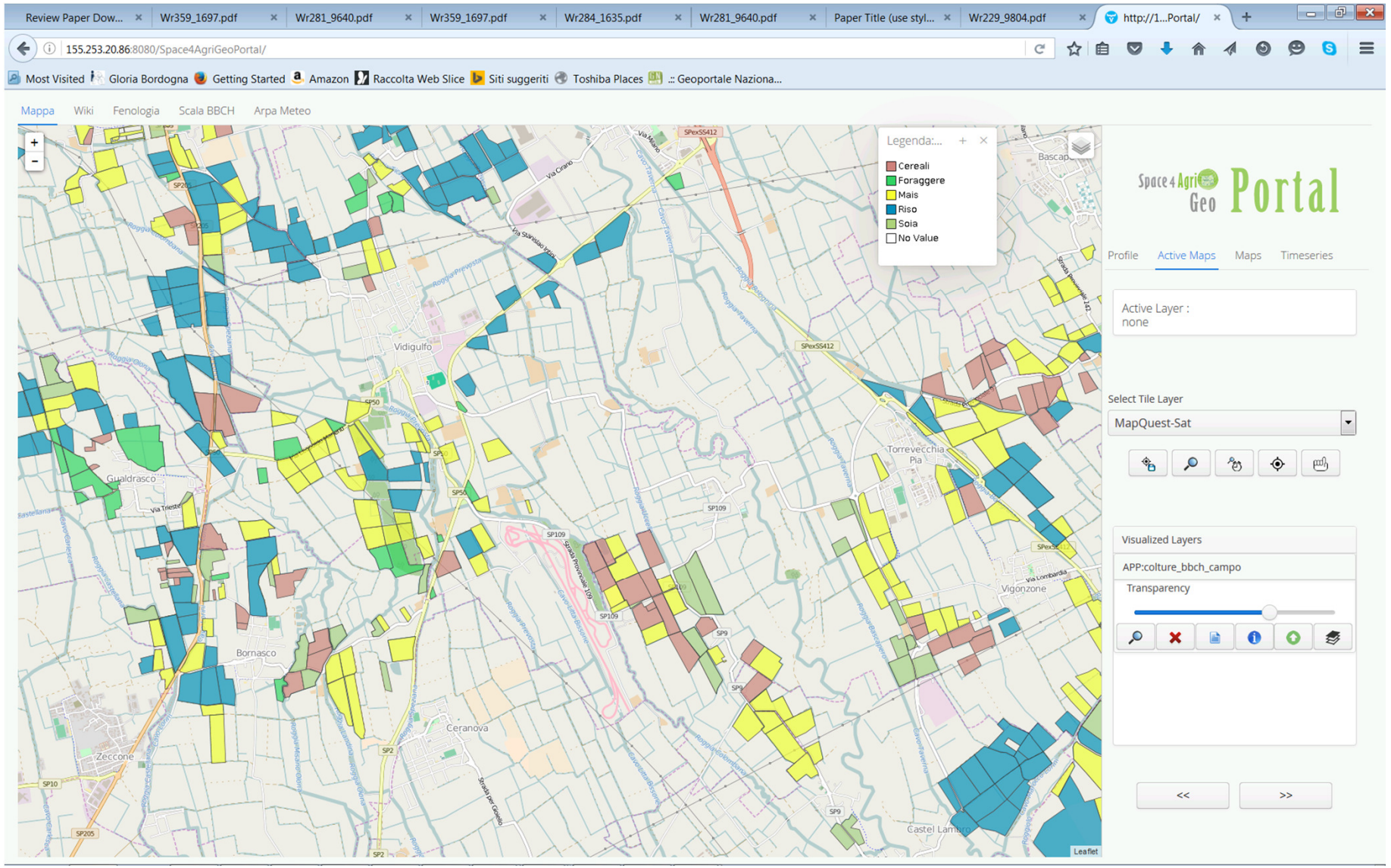
Geo Database Schema for VGI storage

From the Geo database several geospatial data sets are automatically deployed on the Web as data layers:

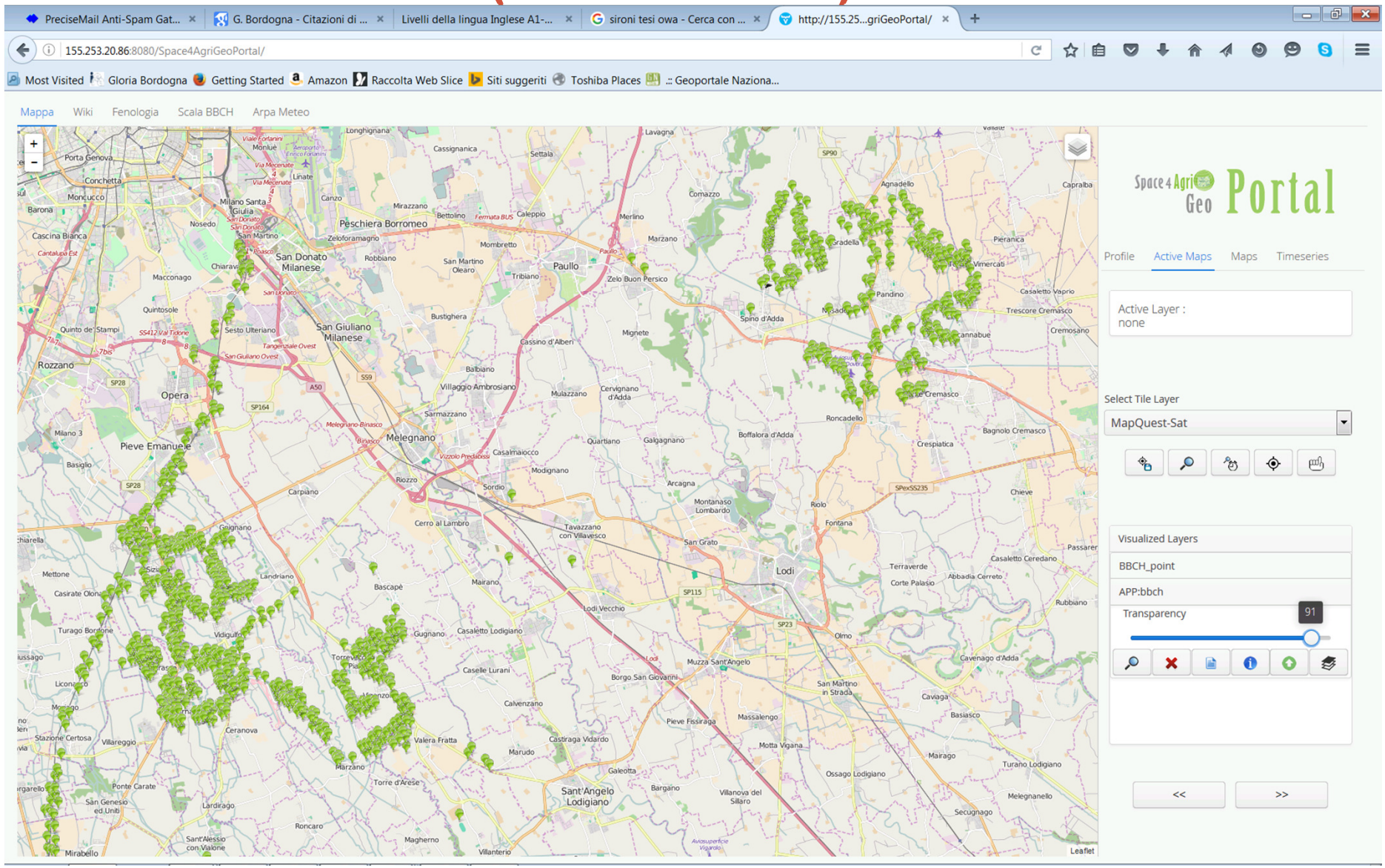
- Layer of textual & picture items
- Layers of categorical items
- Layers of users' roles
- Layers of specific users



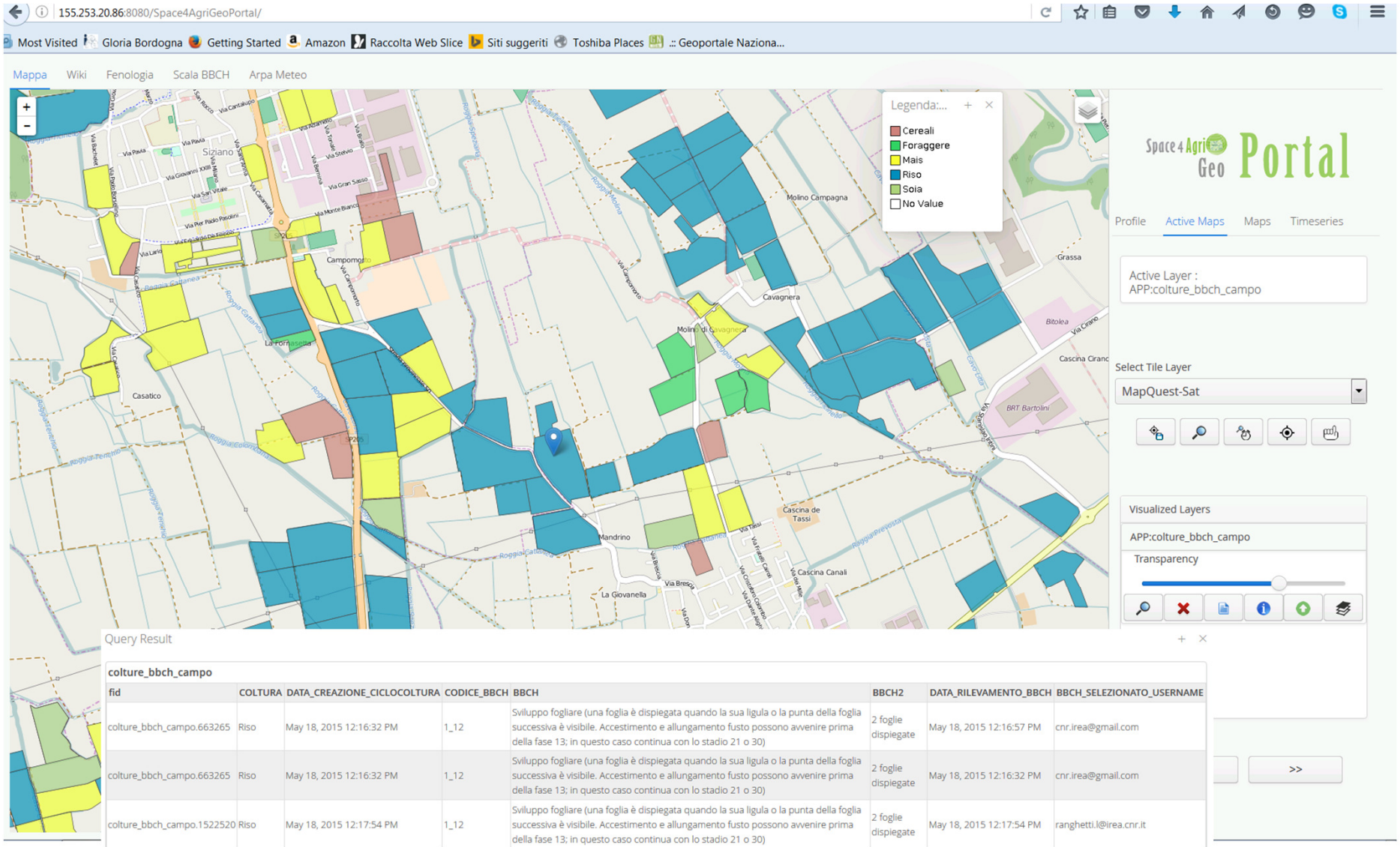
VGI visualization (as Tagged Entities of Interest)



VGI visualization (VGI as Points)



VGI analysis (full concepts descriptions)



fid	COLTURA	DATA_CREAZIONE_CICLOCOLTURA	CODICE_BBCH	BBCH	BBCH2	DATA_RILEVAMENTO_BBCH	BBCH_SELEZIONATO_USERNAME
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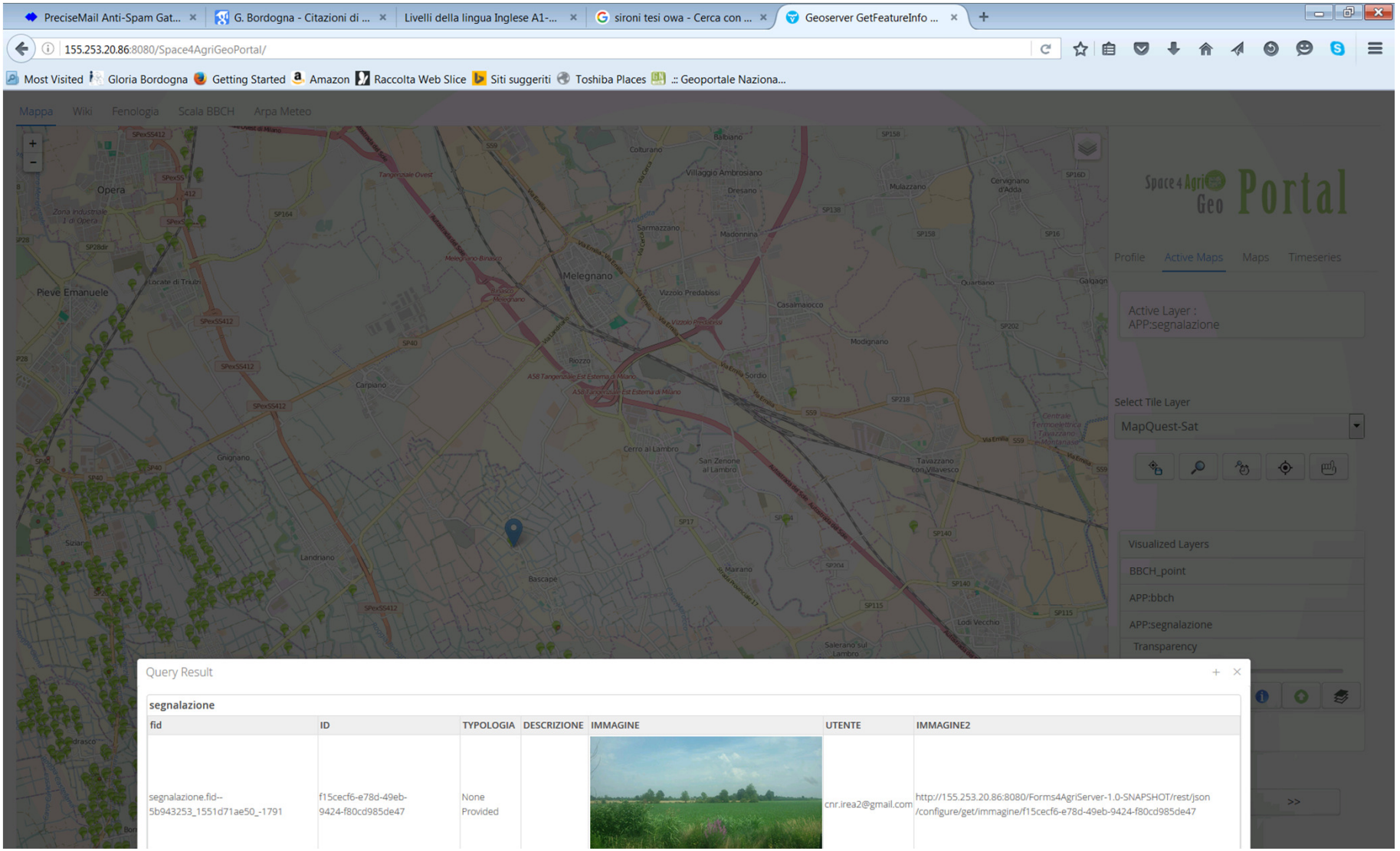
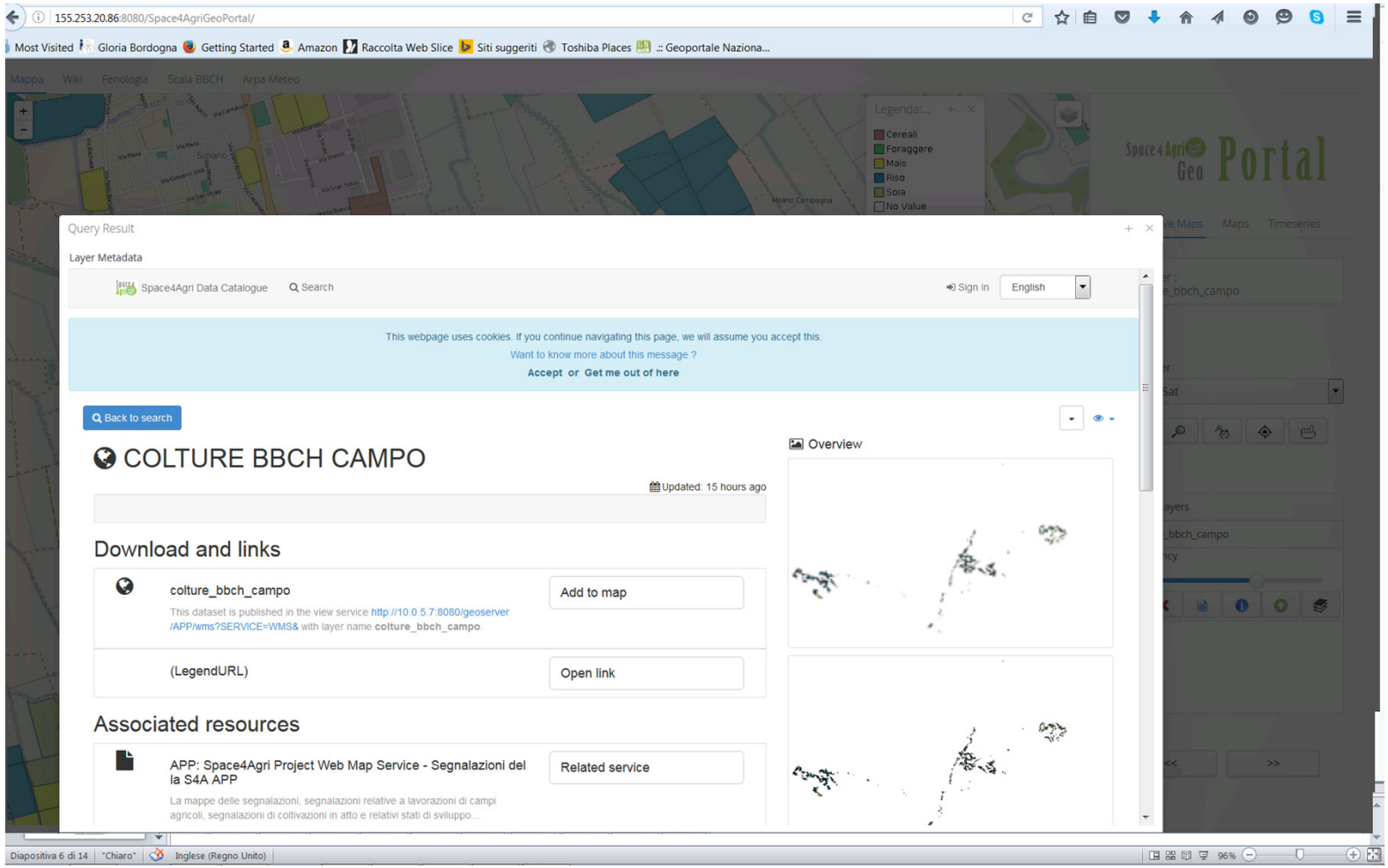
colture_bbch_campo.663265	Riso	May 18, 2015 12:16:32 PM	1_12	Sviluppo fogliare (una foglia è dispiegata quando la sua ligula o la punta della foglia successiva è visibile. Accestimento e allungamento fusto possono avvenire prima della fase 13; in questo caso continua con lo stadio 21 o 30)	2 foglie dispiegate	May 18, 2015 12:16:32 PM	cnr.irea@gmail.com
colture_bbch_campo.1522520	Riso	May 18, 2015 12:17:54 PM	1_12	Sviluppo fogliare (una foglia è dispiegata quando la sua ligula o la punta della foglia successiva è visibile. Accestimento e allungamento fusto possono avvenire prima della fase 13; in questo caso continua con lo stadio 21 o 30)	2 foglie dispiegate	May 18, 2015 12:17:54 PM	ranghetti.l@irea.cnr.it

VGI analysis (full content)



VGI discovery

A Metadata record for each VGI layer is created and managed by a catalogue: it is automatically updated by harvesting WMS service endpoint and completing metadata templates



Lesson Learned within the case study of Space4Agri project

Number of Volunteers that installed the S4A App	85
Number of active Volunteers (who created at least 10 VGI items)	21
Number of farmers	28
Number of VGI items about BBCH stages	2592
Number of VGI items as free text	132
Number of VGI items about agro-practices	137
Number of VGI items reporting seeding dates	223
TOTAL VGI items	3084

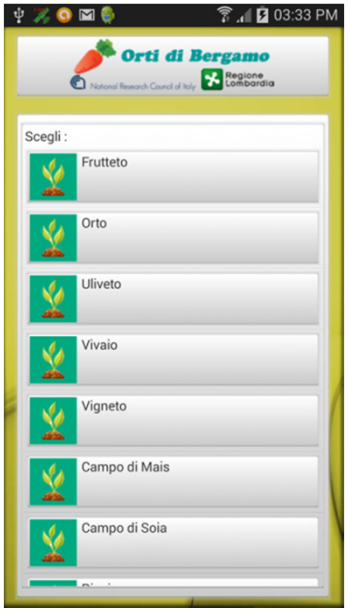
Semantically annotated text is created when volunteers have:

- Doubts in interpreting the meaning of the text associated with a BBCH code;
- Difficulty to clearly distinguish/observe the characteristic aspects of a BBCH code in the crop sample;
- Hesitancy to select a unique BBCH code for several observed crop samples close in space within the same parcel, because of the variability of their characteristics.

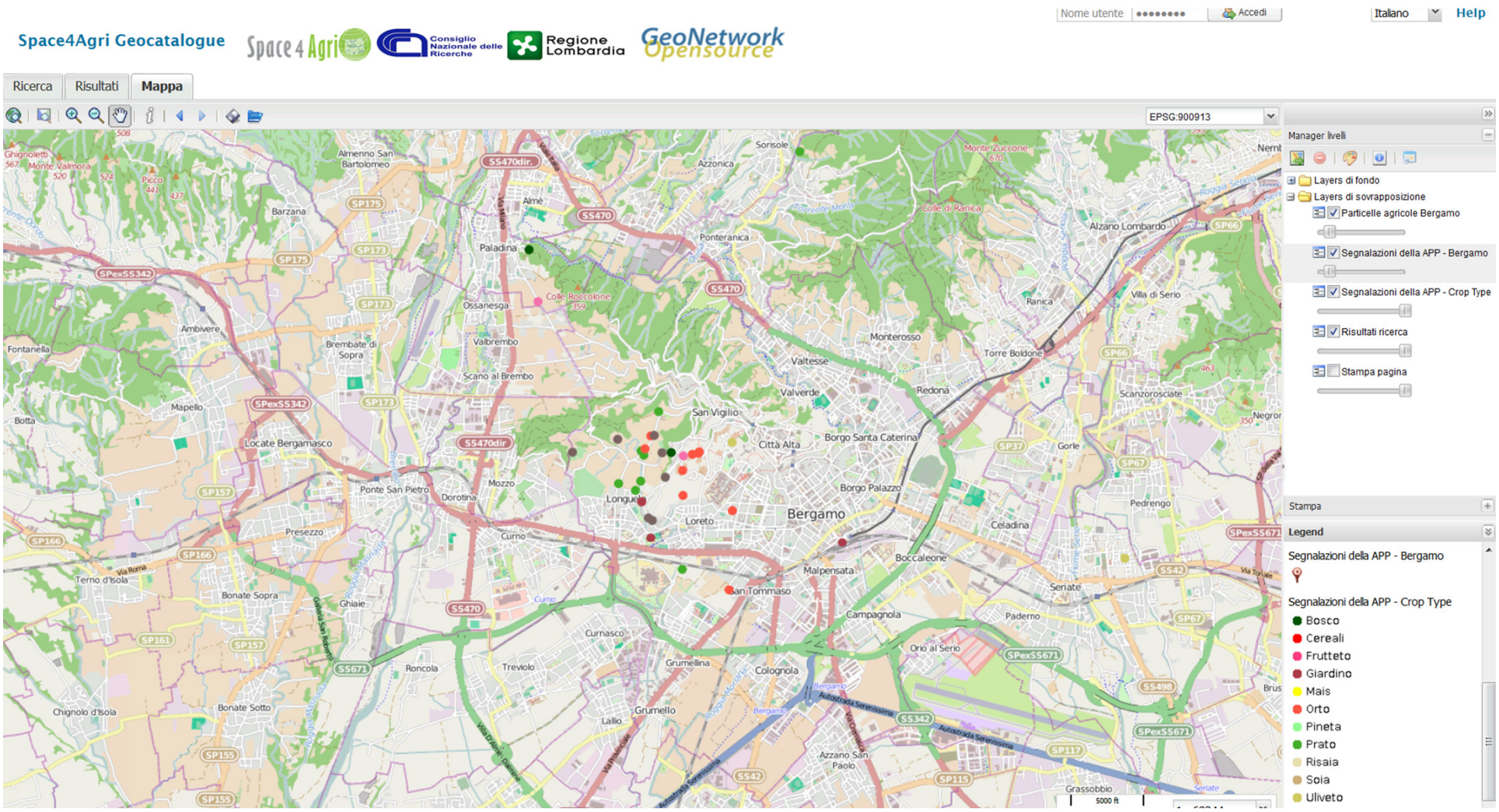
SMART APP Orti di Bergamo

APP for Android devices to tag crops typical of Bergamo area

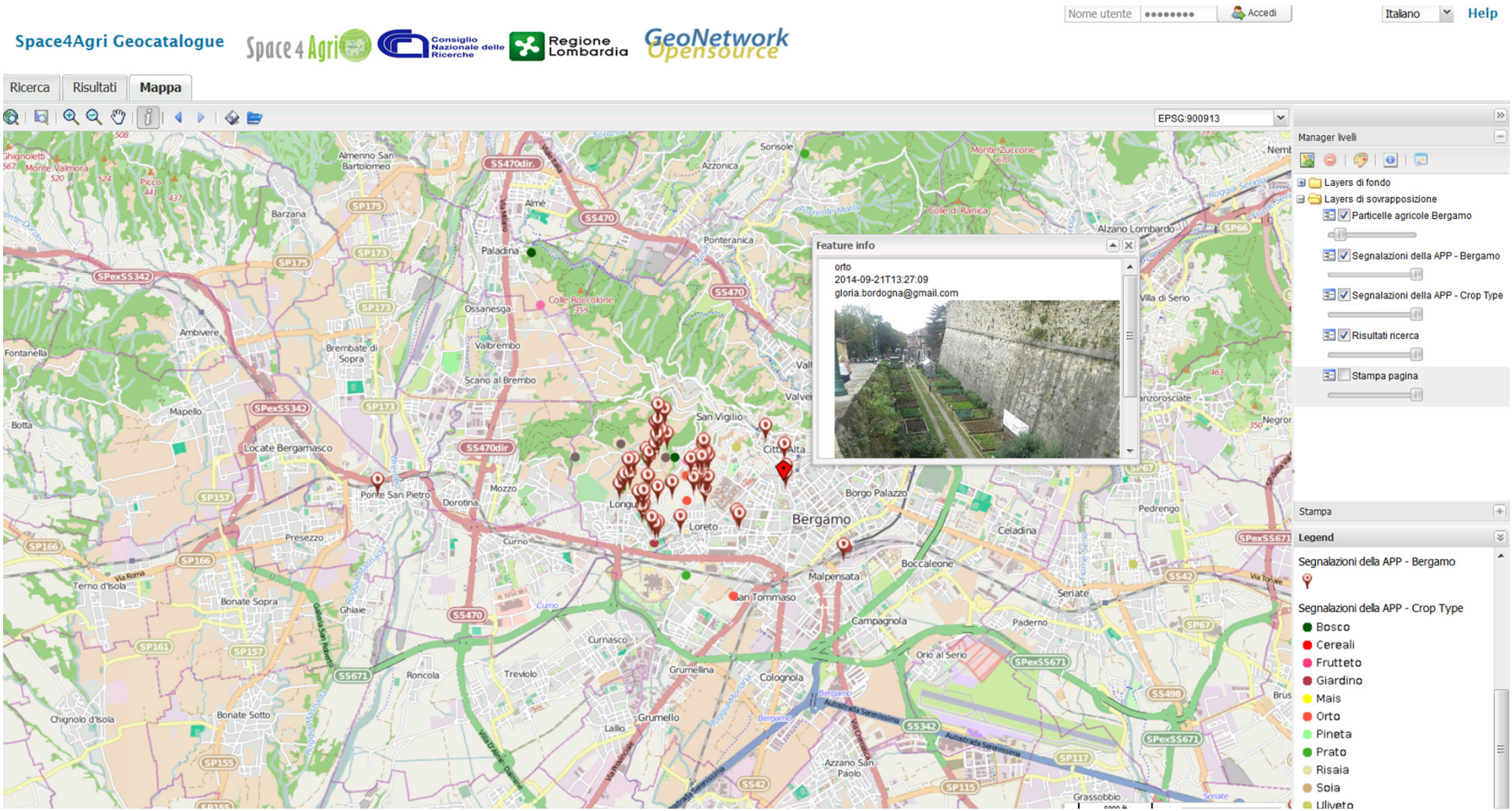
- Orchards, vegetable gardens, vinegards, etc.
- Photos and Texts



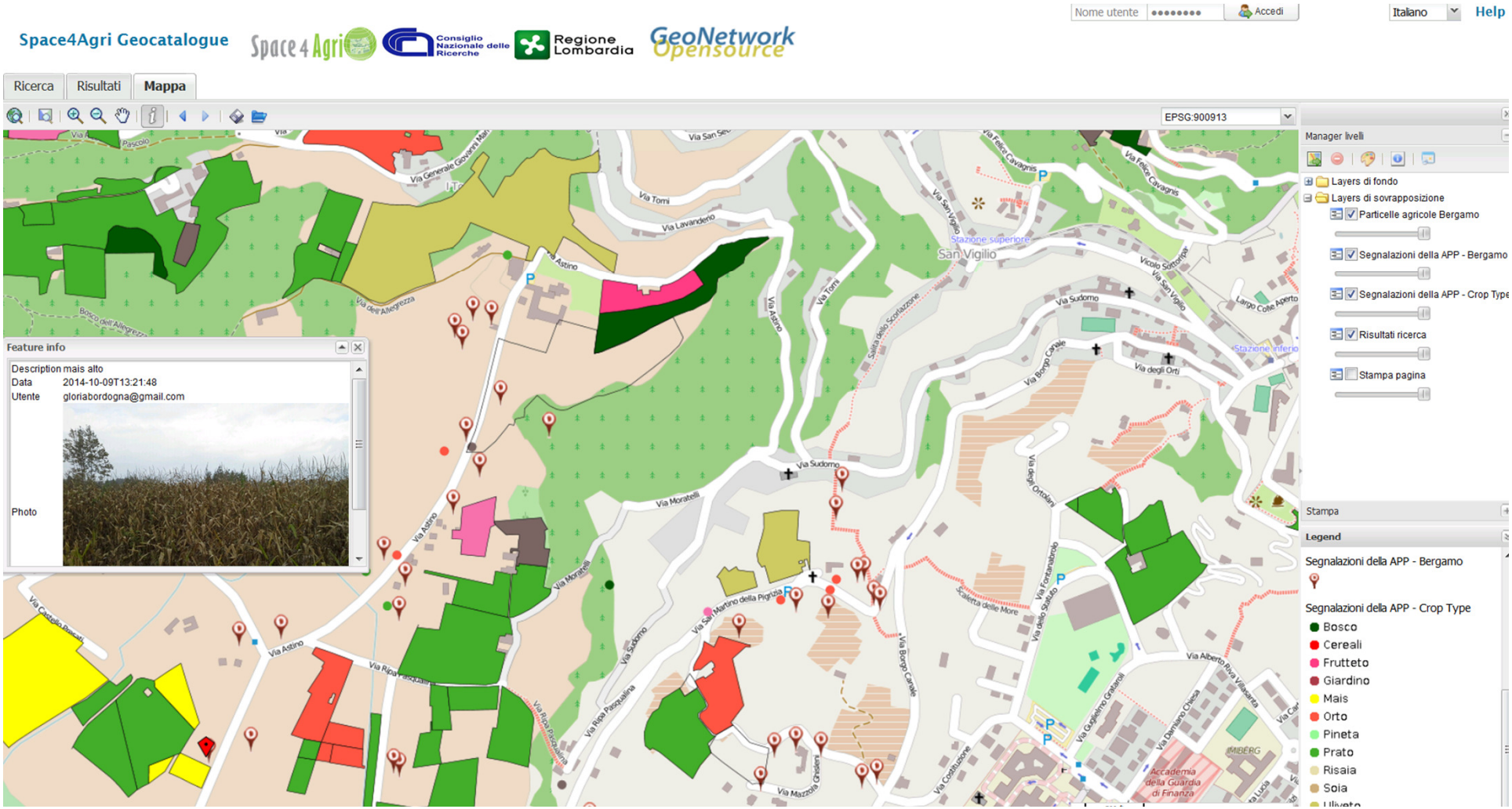
VGI points created by Orti di Bergamo Smart APP



Both Categorial and Photos&text VGI created by Orti di Bergamo Smart APP



VGI points created by Orti di Bergamo Smart APP overlayed with VGI tagged EoI created by Space4Agri smart App



Conclusions

Smart App to create semantically Interoperable VGI :

- Semantic Interoperability of different VGI applications
- Semantic Interoperability with authoritative and scientific geospatial data
- Exploitation of semantically annotated VGI to filter VGI based on quality

Ongoing work

- Adoption of fuzzy ontologies to represent and deal with imprecision of tassonomies and uncertainty of volunteer when creating VGI

Thank you for your Attention!

Something more

CALL FOR CHAPTERS FOR THE BOOK ENTITLED:

Mobile information Systems leveraging VGI for Earth Observation

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CONTENT

A. *EXPERIENCES OF VGI CREATION & EXPLOITATION FOR EO*
B. *TOOLS AND METHODS FOR VGI CREATION BY MOBILE DEVICES AND VGI SHARING ON THE WEB*
C. *QUALITY, PARTICIPATION AND TRUST ISSUES OF VGI USAGE*