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Deliverable D2.14

Land Use Mapper web service

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Abstract of deliverable	The objectives of the Ground Truth 2.0 Land Use Mapper are to enable worldwide mapping and updating of land-use to improve the availability of land-use data; to improve the consistency of time series of land-use maps; and to improve the accessibility to land-use information. The approach for this task was completely rewritten and a new description of activities was made, considering not only GT2.0 contributions, but also identified existing contributions from two universities. The approach for the Land Use Mapper has shifted and this document has been elaborated to reflect this progress and update of the methodology.

Versions and Contribution History

Version	Date	Modified by	Modification details
v.01	08.03.2018	Cristina Muñoz	Draft Outline
v.02	19.04.2018	Alberto Masa, Cristina Muñoz, Hans van der Kwast	Draft for review
v.03	25.04.2018	Hans van der Kwast	Final draft after review
v.04	26.04.2018	Alberto Masa, Cristina Muñoz	Final for layout

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CO	Citizen Observatory
GL30	Globeland30
GT2.0	Ground Truth 2.0
LULC	Land Use/Land Cover
LUM	Land Use Mapper
OSM	OpenStreetMap

Executive Summary

The Ground Truth 2.0 Land Use Mapper has three objectives:

- to enable worldwide mapping and updating of land-use to improve the availability of land-use data;
- to improve the consistency of time series of land-use maps;
- to improve the accessibility to land-use information.

The initial idea was to derive a Land Use Mapper from the vector data available from OpenStreetMap. The context of this proposal has changed since the start of the project, while researching current initiatives and the state-of-the-art in this field. The first conclusion was the existence of two main similar initiatives developed by the Heidelberg University (UHEI) and the University of Coïmbra. After analysing both initiatives and the above three objectives, the conclusion was that it is more convenient to join forces with both universities for further development on top of their current progresses. Thus, the approach for this task was completely rewritten and a new description of activities was made, considering not only GT2.0 contributions, but also those coming from the universities.

Thus, the approach for the Land Use Mapper has shifted and this document has been elaborated to reflect this progress and update of the methodology.

1 Introduction

More than ever before, planners and policy makers need tools to anticipate and assess the impact of their decisions on the areas that they have to manage. Land-use maps are one important input data for the decision support tools. Typically, the required time series of land-use maps based on identical and consistent mapping methodologies, legends and scales are missing. Existing products, such as CORINE or data products from Copernicus services, lack the flexibility in terms of spatial, temporal and thematic resolution in order to be useful for many kinds of uses, such as land-use change modelling, air pollution modelling, hydrological modelling, flood early warning systems, DSS tools, etc. Furthermore, remote sensing data are useful for deriving land-cover maps, but there are challenges in deriving land-use maps, which relates to the way people actually use the land.

The Land Use Mapper (LUM) is a web-based tool to create land-use maps of any area selected by the user. The aims of the Land Use Mapper are (1) to improve the availability of land-use data, (2) to improve the consistency of time series of land-use maps, and (3) to improve the accessibility of land-use information. Mainly, the LUM uses vector data from OpenStreetMap as a data source to derive land-use classes.

Through the Land Use Mapper interface (see Figure 1) land-use maps can be generated for any place in the world. All generated maps will be archived for historic land-use analysis and the service will be registered in GEOSS and connected to the Copernicus Land Service. The Land Use Mapper will also be connected to other tools developed in the different demonstration cases that need actual land-use data. For the development of the business model different options for added value services will be investigated, such as more flexibility in choice land-use classes, historical analysis, indicators for environmental management, etc.

The land-use maps are derived from features that have been mapped by citizens through the OpenStreetMap platform. OpenStreetMap represents physical features on the ground (e.g., roads or buildings). In areas where OpenStreetMap data is scarce, other multiple data sources will be used to fill the gaps or improve the quality of the generated land-use maps.

In the original proposal, it was proposed that the Ground Truth 2.0 project would develop a Land Use Mapper. It became clear, however, that other projects and research groups had developed similar ideas and that prototypes were already online. It was decided to continue the development of the Land Use Mapper in partnership with other developers. The Land Use Mapper will now be developed in cooperation with the University of Heidelberg and the University of Coïmbra. From the Ground Truth 2.0 project this task will be led by IHE Delft in cooperation with CREAF, VITO, Upande Ltd. and Starlab. It will be ready in May 2019.

Besides the three objectives from the original proposal, the new approach will also add the feature of choosing a nomenclature (number and definition of the thematic classes) that matches the requirements of users of the Land Use Mapper.

Figure 1 Land use mapper interface

1.1 First approach

In the original approach the Ground Truth 2.0 project would develop the Land Use Mapper in the following way. Different land-uses are composed of different objects (features) that together determine the land use. The features are mapped by citizens through the OpenStreetMap (OSM) platform. OSM represents physical features on the ground (e.g., roads or buildings) using tags attached to its basic data structures (its nodes, ways, and relations). Algorithms will be developed that can classify different configurations of features to land-use classes. This task will consist of the following subtasks:

- Development of decision rules for the classification of OSM features into land-use classes;
- Calibration and validation of the decision rules. Calibration will be done on two case studies (the Netherlands and Belgium) and validation will be done on two other case studies (Spain and Sweden). These calibration and validation sites are chosen because of the large availability of OSM features and reference land-use data;
- Translation of the decision rules to spatial queries on the OSM geospatial database;
- Development of blending functionality for data poor areas where the crowd-sourced data will be complemented by other existing web services to fill the gaps;
- Implementation of the API for the Land Use Mapper enabling automatic mapping of areas chosen by the user through a graphical user interface. The interface will have a free version and a premium service. The free version will generate a land-use map with a standard legend at a fixed spatial resolution. In the premium service the user can choose other legends and spatial resolutions. All generated maps will be archived for historic land-use analysis.

Finally, the Land Use Mapper web service can be connected to tools and data platforms developed in the different demonstration cases that need actual land-use data.

1.2 Review of work to date

On 29 and 30 June 2017, GT2.0 participated in the OSM LULC, LandSense demo case 1 workshop in Heidelberg. The objective of the meeting was to exchange and discuss ongoing efforts of OSM Land Use/Land Cover (LULC) activities.

On June 29 Michael Schultz (University of Heidelberg) gave an overview of current OSM LULC products. The main OSM based LULC tools presented were http://osmlanduse.org and an online tool by University of Coïmbra (Cidália Fonte and Joaquim Patriarca). GT2.0 presented the concept of section 1.1. Benjamin Herfort presented the work on the MapSwipe app (https://mapswipe.org/) for preselection of areas to be mapped during mapathons. The LacoWiki app (https://laco-wiki.net) was tested during a Mapathon on

June 29. Laco-Wiki is a web-based solution for validating land cover and land use maps. There is also a mobile version (Laco-Wiki Mobile) for validation in the field.

On June 30, a concept for a global LULC map was elaborated and potential funding sources were discussed. A follow up teleconference with Steffen Fritz (coordinator LandSense), Michael Schultz (University of Heidelberg) and Cidália Fonte (University of Coïmbra) has been organized on October 18 2017. During the meeting it was agreed to collaboratively work on the concept. A first step was to use the existing products to generate LULC maps for the 6 demo cases of GT2.0. Therefore, Hans van der Kwast would collect shapefiles with the boundaries of the demo cases and send it to Michael and Cidália who would then produce the LULC maps.

Meeting minutes and relevant publications have been shared.

1.3 Outcomes

1.3.1 The new approach

It was decided to change the original approach due to the fact that similar concepts have been already worked out into prototypes and beta version web services by University of Coïmbra and University of Heidelberg (outputs of the LandSense project). A parallel development of a Land Use Mapper by the GT2.0 project would not be useful. It was concluded that joining forces to develop a Global LULC Map with the different partners would be a better approach. The different projects and expertise can contribute to the implementation of different parts of the concept.

1.3.2 Agreements

During the meetings, and after discussion with the project director and WP2 leader, it was agreed by GT2.0, LandSense, University of Heidelberg and University of Coïmbra to join forces in the implementation of the concept of the Global LULC Map.

1.4 Characteristics of Land use mappers

Many land-use products exist (examples in Table 1). However, there are only very few experimental web-services for automatic generation of land-use maps. Through Google Earth Engine it is possible to classify remote sensing images using Landsat images in the cloud. These products and services mostly rely either on remote sensing classifications with fixed nomenclatures and a low temporal availability.

In the following sections we introduce two experimental web-services that are based on deriving LULC from OpenStreetMap vector data. The proposed Global LULC map, will integrate both existing LULC products and the results of the two web-services. In this way the Global Land Use Mapper will be more robust in areas where either OSM data is scarce or remote sensing acquisition is hampered by frequent cloud cover.

1.4.1 Solution 1 Overview

OSM Landuse Landcover (http://osmlanduse.org) is a WebGIS application to explore the OpenStreetMap database specifically in terms of land-use and land-cover information. It translates OSM tags into LULC classes. The absence of tags results in data gaps. Machine learning techniques using remote sensing can be used for gap filling (Schultz et al., 2017).

The classification used in this web application has similar classes as CORINE level 2.

Table 1 Mapping OSM tags to CORINE Level 2 classes. Source: Janek-Lukas Voß, University of Heidelberg

CORINE Class	OSM tags
1.1 Urban Fabric	residential, garages
1.2 Industrial, commercial and transport units	railway, industrial, commercial, retail, harbour, port, lock, marina
1.3. Mine, dump and construction sites	quarry, construction, landfill, brownfield
1.4. Artificial, non-agricultural vegetated areas	stadium, recreation_ground, golf_course, sports_center, playground, pitch, village_green, allotments, cemetery, park, zoo, track, garden, raceway
2.1. Arable Land	greenhouse_horticulture, greenhouse, farmland, farm, farmyard
2.2. Permanent Crops	vineyard, orchard
2.3. Pastures	meadow
3.1. Forests	forest, wood
3.2. Shrub and/or herbaceous vegetation associations	grass, greenfield, scrub, heath, grassland
3.3. Open spaces with little or no vegetation	cliff, fell, sand, scree, beach, mud, glacier, rock
4.1. Inland wetlands	marsh, wetland
4.2. Coastal wetlands	salt_pond, tidal
5. Water bodies	water, riverbank, reservoir, basin, dock, canal, pond

The service consists of the following components: database, services and client. The OSM data is loaded into a database. The database links to the following services: GeoServer, Node.js service and Mapproxy. These services link to the web client at osmlanduse.org. The screenshot below (Figure 2) illustrates the web service for the city of Mechelen (Belgian Demo Case). Besides the map also the area of classes in the viewport (area seen visible in the web browser) is visualized in a pie chart.

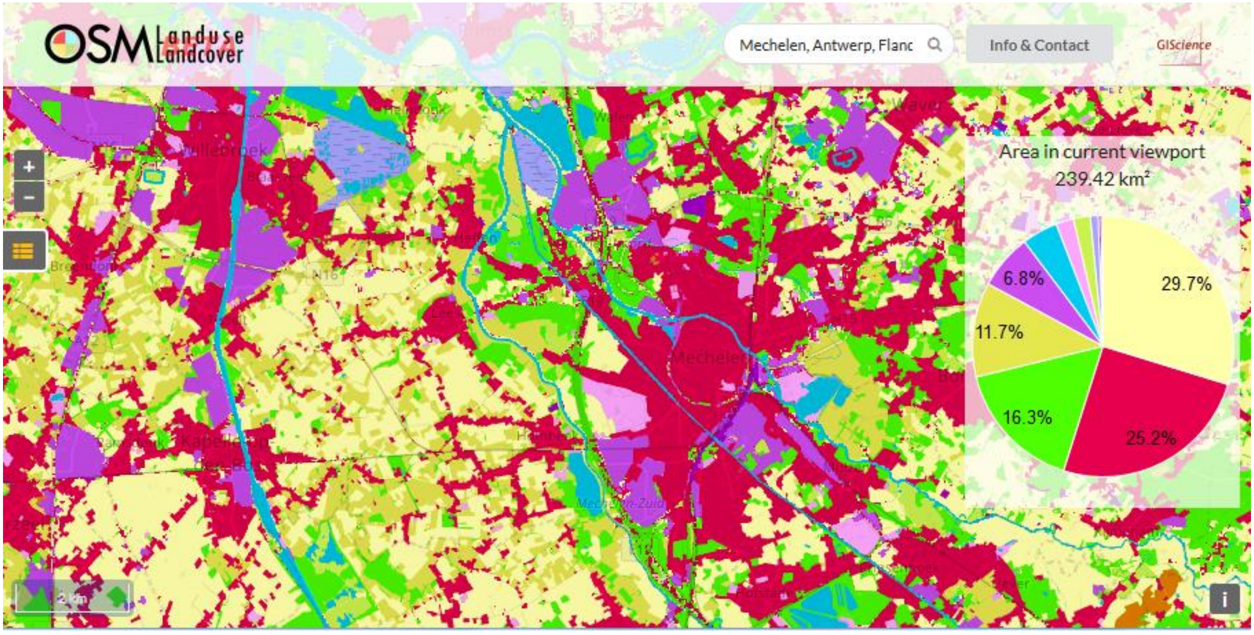

Figure 2 Web service for the city of Mechelen

1.4.2 Solution 2 Overview

The University of Coïmbra (Fonte et al., 2017) has developed a prototype of a service for automatic conversion of OSM data into LULC nomenclatures. The LULC nomenclatures used are Urban Atlas, CORINE Land Cover and Globland 30.

The following methodology has been used (Fonte et al., 2017).

First the tags (key=value) of OSM are associated with the LULC classes of the nomenclature of interest. Next, the custom decision rules with user defined parameters are defined. Then the conversion process is run. The result is corrected for inconsistencies (e.g. overlapping regions assigned to different classes). Finally, if a minimal mapping unit (MMU) is considered, all regions with a smaller area are merged with neighboring features. Figure 3 below shows the workflow.

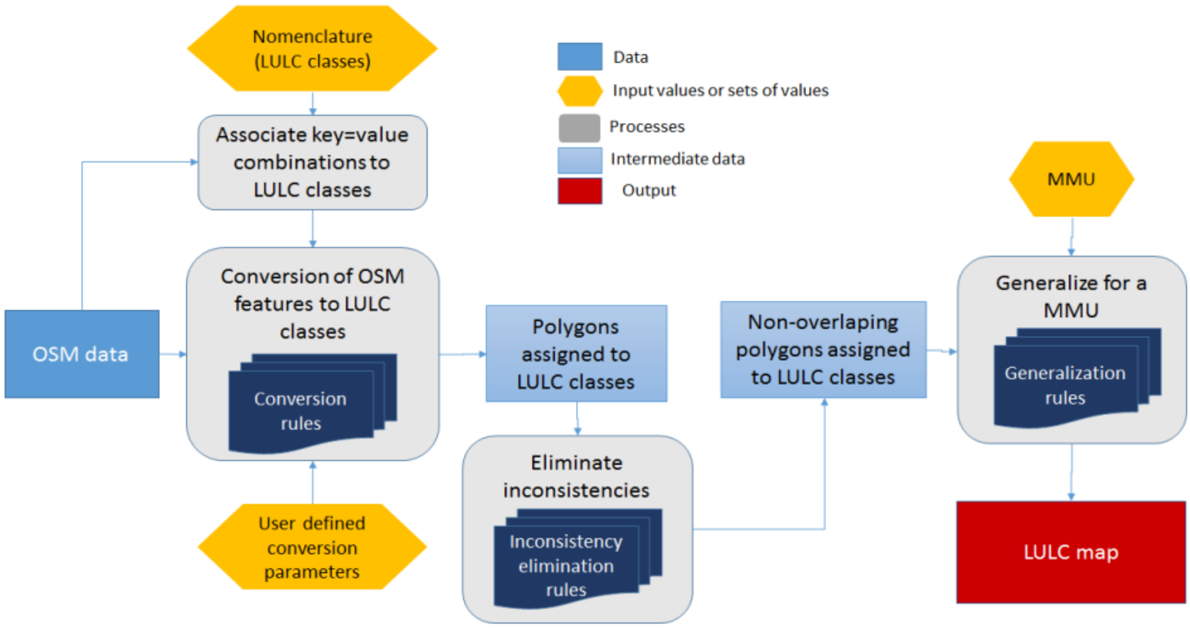

Figure 3 Flowchart of OSM Land Use Mapper of University of Coïmbra

The service is available at http://vgi.mat.uc.pt/vgi/osm/osm2lulc. A login is required for access.

The service uses the following Open Source software: Python, GRASS GIS 7, GDAL/OGR, PostgreSQL 9.5 with PostGIS 2.2, osm2pgsql tool, Osmosis tool, Python Django, Angular JS.

1.4.3 Discussion and conclusions

The two presented web-services are both deriving LULC maps for a user-defined area using OpenStreetMap vector data. No ancillary datasets are used.

The OSM Landuse Landcover web-service will give very good results when the crowd-sourced OSM data has the correct LULC tags mapped by citizens. Often however, LULC tags are less frequently mapped than other OSM features, leading to missing data in many parts of the world. This web-service is limited to deriving the CORINE classes, while the web-service from the University of Coïmbra gives a choice for nomenclatures.

The web-service from the University of Coïmbra uses the OSM features that are more frequently mapped by citizens to derive LULC maps. This will give good results when (1) many features in an area are correctly mapped by citizens, and (2) the conversion rules are well defined and applicable globally. There is a need to calibrate and validate the conversion rules over a diverse set of landscapes. Using the GT2.0 Demo Cases as reference sites for LULC, the conversion rules can be improved and it can be evaluated if different rule sets are needed for different areas in the world. In under-mapped areas gaps can be filled using a combination of existing LULC products and remote sensing classifications.

2 Objectives of the new approach

Ground Truth 2.0 cooperates with other projects to develop a Global Land Use Mapper with four objectives:

1. to enable worldwide mapping and updating of land-use to improve the availability of land-use data;
2. to improve the consistency of time series of land-use maps;
3. to improve the accessibility to land-use information;
4. to provide land-use maps with classes based on the user needs by giving a choice of different nomenclatures.

These objectives will consist of the following sub-objectives:

- Harmonising land-use data from different sources;
- Gap filling in data poor areas using remote sensing streams;
- Calibration and validation using in-situ data and tools from the 6 Demo Cases;
- Production of a quality layer to estimate the quality of the generated products;
- Implementation of a history API that stores and retrieves all generated LULC products to create time series;
- Development of a business model to sustain the Global Land Use Mapper web service;
- Connect the Land Use Mapper web service to tools and data platforms developed in the different demonstration cases that need actual and historic land-use data.

3 Methodology

Various global maps and services exist depicting global land use or land cover. Table 2 shows some examples. These, however, are not updated frequently, are inconsistent in thematic classification and quality and do not use all available data to produce the best maps. Also their thematic classification (nomenclatures) cannot easily be translated from one to another, limiting their use for many purposes.

Table 2 Example LULC resources

LULC product	URL
Google Earth Engine Global Forest Map	https://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.2.html
Global Land Cover USGS + UMD products	https://landcover.usgs.gov/glc/
Globeland30	http://www.globallandcover.com
Copernicus Global Land Service	http://land.copernicus.eu/global/
CORINE	https://land.copernicus.eu/pan-european/corine-land-cover

The Global Land Use Mapper will fuse various data streams and has frequent updates as new contributions, for instance OSM edits or time series analysis results come in. Different concepts for fusing data streams can be found in literature (e.g. Schultz et al., 2017, Jung et al., 2006).

Figure 4 shows an example of the workflow.

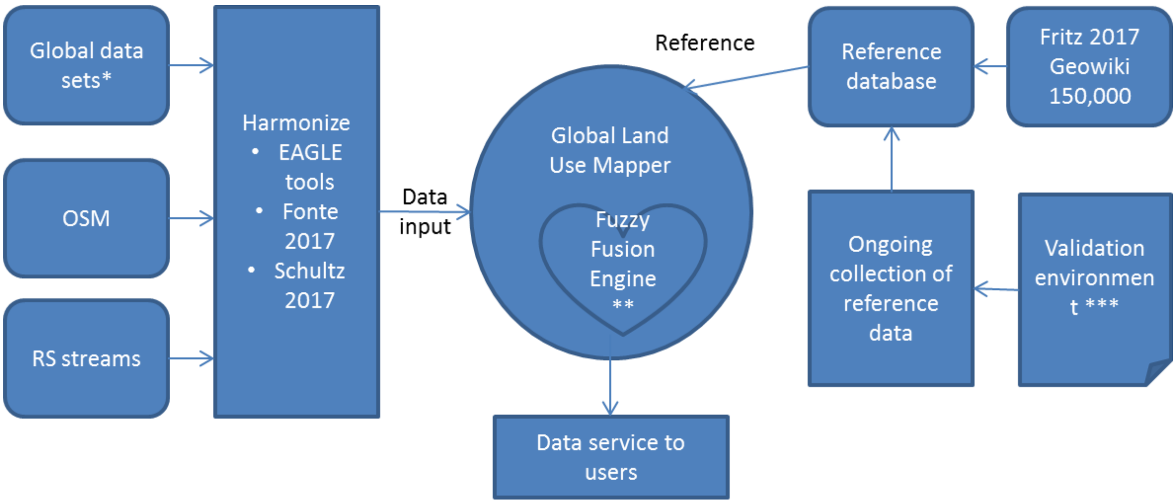

Figure 4 Simplified flowchart of the global mapper concept

The proposed method consists of different tasks:

1. Harmonising land-use data from different sources:
   - Global datasets, such as mentioned in Table 2
   - OpenStreetMap (http://www.openstreetmap.org)
   - OSM Land Use Mapper (EAGLE/LandSense), see section 0
   - OSM2LULC (Coïmbra), see section 0.

2. Gap filling using remote sensing streams
   - Task 1 and 2 result in a Global Map. For each pixel/feature the processing flow and source data (lineage) is stored in the metadata.
3. Calibration and validation will be done with in-situ data collected using citizen science tools, such as GeoWiki, LacoWiki, OSM apps, etc. In addition, different tools and platforms used in the GT2.0 Demo Cases will be used for this task. This data will be stored in a reference database.
4. A quality layer is produced with the land-use maps.
5. All calculated data will be stored for time series analysis. The OSM history API will be developed to use historic data from OSM.

Finally, the Land Use Mapper web service can be connected to tools and data platforms developed in the different GT2.0 Demonstration Cases that need actual land-use data. OGC services will be implemented to guarantee optimal interoperability.

3.1 Harmonising land-use data

This task involves the harmonization of land-use data from diverse sources that differ in thematic, spatial, and temporal resolution, nomenclatures, minimal mapping unit, data types, etc. These sources are Global datasets; OpenStreetMap; OSM Land Use Mapper (EAGLE); OSM2LULC (Coïmbra).

Task 1 will be done by Heidelberg University (UHEI) and University of Coïmbra. The GT2.0 demo case areas are used as reference sites, because of their diversity of land uses and data availability from the different sources. The GT2.0 demo cases can provide (1) local knowledge on land use, (2) local needs for land-use data. This will be analysed using a questionnaire. To explain well the definition and purpose of land-use and land-cover maps, a video will be shared with the GT2.0 Demo Cases.

UHEI and Coïmbra will work together to enable the use of the nomenclatures to generate maps with a flexible number of classes and choice for thematic classes. The UHEI and Coïmbra OSM mapping services are now being used to classify the land use in the 6 demo cases. The result will give insight in the diversity of the areas.

Links to the OSM mapping services:

- http://osmlanduse.org/
- http://vgi.mat.uc.pt/vgi/osm/osm2lulc/

3.2 Gap filling

In data poor areas it will be necessary to fill gaps or improve the generated LULC product by adding data from remote sensing automatic or semiautomatic classifications. In task 2 an algorithm needs to be developed to identify areas where the quality of the different land-use data sources is insufficient and remote sensing data needs to be used to fill the gaps. The algorithm will be developed by GT2.0 (Upande, Starlab, VITO and IHE Delft) and UHEI.

3.3 Calibration and validation of data

In task 3 calibration and validation will be done with in-situ data collected using citizen science tools, such as GeoWiki, LacoWiki, OSM apps, etc. In addition, different tools and platforms used in the GT2.0 Demo Cases will be used for this task. This data will be stored in a reference database.

UHEI and GT2.0 will make an inventory of tools available for collecting in-situ land-use data. These are partly tools developed by UHEI in the frame of LandSense and by project partners of GT2.0. UHEI and GT2.0 will develop the reference database. The tools will be tested in the GT2.0 demo cases to collect the reference data in the diverse areas using local expertise from citizens and other stakeholders.

3.4 Quality layer

Together with the generated land-use maps, a quality layer will be provided. A quality layer of the map product needs to be produced based on the reference database and other data in combination with statistical analysis. In task 4 the algorithms will be developed by CREAF in cooperation with UHEI.

3.5 Time series

LULC change is an important topic in many applications. In task 5 we will develop a tool for LULC time series. The tool will use all generated data from the land use mapper at different time frames. In addition, the OSM history API will be developed to use historic data from OSM. In this wiki (http://wiki.openstreetmap.org/wiki/History_API_and_Database) the requirements of such an API has been elaborated. This historical data will be used to further improve the land-use map using spatial-temporal analysis. Upande and IHE Delft will lead this task.

4 Expected result

4.1 Study area

The GT2.0 demo case areas are used as reference sites, because of their diversity of land uses and data availability from the different sources.

The thematic focus of GT2.0 is on flora and fauna, as well as water availability and water quality, for land and natural resources management. The project uses mobile apps and social media analytics to collect explicitly and implicitly-sensed citizen data. As such, citizens are enabled to share data about the environment and to take on a new, crucial role in environmental monitoring, decision making, cooperative planning and environmental stewardship.

4.1.1 Overall Description of the Demo Cases

The project is setting up and validating six citizen observatories in real conditions, in four European and two African demonstration cases.

- In Zambia, GT2.0 will improve citizen participation in the measurement of land-use changes, particularly a) wildlife sightings; b) human-wildlife conflict; and c) agricultural activities. These data are important for the recognition of wildlife and tourism as viable livelihoods, and for conservation-based development.
  Attempts to put up a monitoring system earlier have been hampered amongst others by limited awareness and engagement. Two Community Resource Boards – representing 24 Village Action Groups – have been elected by the community and will act as co-managers and coordinating body of the observatory. The collected data will be aggregated and visualised to stimulate discussion between communities and decision makers. Potentially useful reference in-situ data is collected that can be used for calibration and validation of the land use mapper.
- In Kenya, the Mara National Reserve is administered by Narok County government. In order to manage the reserve and to create sustainable business opportunities for its citizens and tourists, the county government needs reliable biodiversity data. These are currently lacking. The Ground Truth 2.0 citizen observatory will build on the VirtualKenya platform and aims to initiate communication between local governments, policy makers and reserve managers on the one hand and Mara visitors on the other.
  Through an app, visitors, tour guides, researchers, wardens and others can highlight biodiversity and environmental issues. The app also logs vehicle movement and speed and warns when official tracks are deserted. In addition, meteorological data are collected by one of the partners to predict species distributions. Big screens at lodges will feature all the observations. Data from the CO platform will provide useful reference data for the land-use mapper. In return, land-use maps generated by the land-use mapper can be validated and integrated in the CO tools.
- In Sweden, one of the most challenging environmental problems facing is eutrophication (nutrient pollution) of land and water. The main sources of this pollution are agriculture, industry and municipal wastewater treatment plants. Existing data are dispersed, and environmental monitoring by citizens is disconnected from decision making.
  In this demo case, Ground Truth 2.0 partners will work in two pilot municipalities (Eskilstuna and Skarpnak) to engage citizens in environmental data gathering via the FreshWater Watch Platform by Earthwatch. Schools, NGOs, local government bodies and corporates will be targeted. In addition, citizens' social network discussion are analysed to get a picture of local, regional and

national needs. Stakeholder interaction will take place through, for example, serious gaming with the ultimate goal of cooperative planning. It will be studied how this demo case can provide calibration/validation data for the land-use mapper and if there's a need to integrate the land-use mapping service in the demo case tools.

- In Spain, crops are very sensitive to small variations in climate. Phenological data (e.g. flowering, breeding) are a useful proxy for detecting climate change. Local people are uniquely placed to observe the change in phenology. However, current observations of phenological phenomena are isolated and disconnected.
  This demo-case will establish the systematic collection of phenological data through a mobile app. The citizens that will be involved include hikers, farmers and weather enthusiasts. Land-use maps from the land-use mapper will be provided to guide them to the best spot for observations. In return, data collected in the demo-case could be useful for the reference database for calibration/validation of the land-use mapper products.
  The data will be linked and compared with meteorological data from the Meteorological Service of Catalonia and with satellite observations. Understanding climate change on local phenological phenomena will help improve local policies and practices, and as such, will increase agricultural productivity, decrease fire risks and save (irrigation) water.
- In the Netherlands, climate change leads to excessive local rainfall. This causes severe floods, especially in cities. In order to have effective flood-resilience policies and practices in place, accurate rainfall information and geo-information is needed. However, the national rainfall monitoring networks are modest in size, and the number of official monitoring stations is very limited.
  In this demonstration case, GT2.0 will create a platform in which rainfall monitoring of water authorities, weather institutes, professionals and weather enthusiasts will be integrated into one collection of historical, actual and forecasted rainfall information. Citizens will be able to share actual and forecasted information on the state of the environment through freely available apps. As a result, stakeholders can engage in co-operative urban planning and flooding can be prevented. It will be evaluated how the demo case can use or provide data for the land-use mapper.
- In Belgium, the Northern region Flanders is one of the most urbanized in the world, with a population density close to 500 inhabitants/km². This leads to pressure on the environmental quality. Ground Truth 2.0 aims to improve dialogue between citizens and decision makers by creating a platform where they can share information on the local living environment, specifically on air and water quality, noise, waste and open space. With such a platform, local problems can be signalized, better monitored, be put on the political agenda and improved.
  This demo case targets the public at large, but two cities have been selected for piloting: Mechelen and Hooglede. It will be evaluated how the demo case can use or provide data for the land-use mapper.

4.1.2 Worldwide deployment

The global land use mapper will cover the whole world. Data from the six demo cases will be used for calibration and validation of the generated land-use maps. Their diversity in LULC justifies the global application of the web service. Results will improve when more data becomes available.

For global uptake of the global land use mapper, WP4 will assist in the dissemination activities. WP3 will assist in the development of the business model that is needed to sustain the global land use mapper beyond the duration of the project.

4.2 Land use/land cover classes

The global land use mapper will not dictate a specific fixed land-use/land-cover classification scheme. Instead it will allow for choosing different nomenclatures. Nomenclatures define the different LULC classes. Annex 1 includes examples of nomenclatures from Urban Atlas, CORINE Land Cover and GlobeLand30 (GL30).

4.3 Datasets used in the analysis

Table 3 shows the datasets that will be used. Please note that the list is not complete, since there are many other sources that are potentially useful. Please note that with classification of satellite images only land cover can be derived.

Table 3 Datasets characteristics

Datasets	Source	Format
Satellite images	USGS, NASA, ESA Different sensors	Multiband raster
OpenStreetMap	http://www.openstreetmap.org	Vector, OSM/XML file, spatial database
LULC products	See Table 2	Raster/vector, spatial database, OGC service
VGI apps	Existing apps, incl. from the GT2.0 demo cases.	Diverse

4.4 Image processing

4.4.1 Image preprocessing

Depending on the processing level of the input remote sensing images, preprocessing procedures need to be applied to assure that the products are useful for remote sensing classification and fusion with other data in the land-use mapper. Preprocessing could include geometric rectification and radiometric normalization.

4.4.2 Performance of the Land Use Mapping service

Using the Global Land Use Mapping service, users can select an area and generate a land-use map with a selected nomenclature. The data can be downloaded in (GIS) different formats. Users will also be able to give feedback on the generated land-use maps. Historic time-series can also be downloaded depending on availability.

4.5 Accuracy assessment

The reference database that includes in-situ data from the Demo Cases and additional data will be used to assess the accuracy of the LULC map. Apps like Laco Wiki will be used during Mapathons and in the field to validate the generated LULC maps. Contingency matrices will be used to calculate accuracy statistics. Additional metrics will be used to indicate the accuracy. This information will be used to generate a quality layer that will be provided with the generated LULC maps.

4.6 Change detection

The historic LULC data will be available through the web-service for change detection and temporal analysis. Added value products such as environmental indicators can be derived from this data and provided to interested stakeholder. This opportunity will be considered in the development of the business model.

5 Conclusions

This document described the updated approach to develop a Global Land Use Mapper. The new approach was needed, because the original proposed approach has already been implemented in a similar way by other researchers. Together with researchers from University of Heidelberg and University of Coïmbra a new concept was developed with the aim to use different sources of LULC maps (derived from remote sensing or derived from OSM) in order to give more robust results globally. The methodology includes harmonizing diverse land-use data sources, filling of gaps, calibration and validation of algorithms using reference data, including data from the GT2.0 Demo Cases, producing quality indicators and lineage, and providing time series of LULC maps.

The next steps are:

- During the next GT2.0 F2F meeting in Kenya, the concept will be discussed in a workshop. The objective is to define (1) how the DCs can contribute to the reference database for calibration and validation, and (2) how the Global Land Use Mapper can be useful in the DCs;
- During this F2F meeting also the partners assigned to the tasks will be discussed and adjusted if needed;
- After the F2F meeting a detailed planning needs to be ready for the implementation of the tasks.

6 References

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Annex 1 Nomenclatures

Urban Altas (UA) nomenclature			CORINE Land Cover (CLC) nomenclature		
Level 1	Level 2	Level 3	Level 1	Level 2	Level 3
1.Artificial Surfaces	1.1 Urban Fabric	1.1.1 Continuous urban fabric 1.1.2 Discontinuous urban fabric 1.1.3 Isolated Structures	1.Artificial Surfaces	1.1 Urban Fabric	1.1.1 Continuous urban fabric 1.1.2 Discontinuous urban fabric
	1.2 Industrial, commercial, public, military, private and transport units	1.2.1 Industrial, commercial, public, military and private units 1.2.2 Road and rail network and associated land 1.2.3 Port areas 1.2.4 Airports		1.2 Industrial, commercial, public, military, private and transport units	1.2.1 Industrial or commercial units 1.2.2 Road and rail network and associated land 1.2.3 Port areas 1.2.4 Airports
	1.3 Mine, dump and construction sites	1.3.1 Mineral extraction and dump sites 1.3.3 Construction sites 1.3.4 Land without current use		1.3 Mine, dump and construction sites	1.3.1 Mineral extraction 1.3.2 Dump sites 1.3.3 Construction sites
	1.4 Artificial non-agricultural vegetated areas	1.4.1 Green urban areas 1.4.2 Sports and leisure facilities		1.4 Artificial non-agricultural vegetated areas	1.4.1 Green urban areas 1.4.2 Sports and leisure facilities
2. Agricultural, semi-natural areas, wetlands			2.Agricultural areas	2.1 Arable land	2.1.1 Non-irrigated arable land 2.1.2 Permanently irrigated land 2.1.3 Rice fields
				2.2 Permanent crops	2.2.1 Vineyards 2.2.2 Fruit trees and berry plantations 2.2.3 Olive groves
				2.3 Pastures	2.3.1 Pastures
				2.4 Heterogeneous agricultural areas	2.4.1 Annual crops associated with permanent crops 2.4.2 Complex cultivation patterns 2.4.3 Land principally occupied by agriculture, with significant areas of natural vegetation 2.4.4 Agro-forestry areas
3. Forests			3. Forest and semi natural areas	3.1 Forests	3.1.1 Broad-leaved forest 3.1.2 Coniferous forest 3.1.3 Mixed forest
				3.2 Scrub and/or herbaceous vegetation associations	3.2.1 Natural grasslands 3.2.2 Moors and heathland 3.2.3 Sclerophyllous vegetation 3.2.4 Transitional woodland-shrub
				3.3 Open spaces with little or no vegetation	3.3.1 Beaches, dunes, sands 3.3.2 Bare rocks 3.3.3 Sparsely vegetated areas 3.3.4 Burnt areas 3.3.5 Glaciers and perpetual snow
....			4. Wetlands	4.1 Inland wetlands	4.1.1 Inland marshes 4.1.2 Peat bogs
				4.2 Maritime wetlands	4.2.1 Salt marshes 4.2.2 Salines 4.2.3 Intertidal flats
5. Water			5. Water	5.1 Inland waters	5.1.1 Water courses 5.1.2 Water bodies
				5.2 Marine waters	5.2.1 Coastal lagoons 5.2.2 Estuaries 5.2.3 Sea and ocean

GlobeLand30 Nomenclature

Class Code	Class Name	Class Description
10	Cultivated land (CL)	Arable land (cropland): dry land, paddy field, land for greenhouses, vegetable fields, artificial tame pastures, economic cropland in which shrub crops or herbaceous crops are planted, and land abandoned with the reclamation of arable land
20	Forest (F)	Broadleaved deciduous forest, evergreen broad-leaf forest, deciduous coniferous forest, evergreen coniferous forest, mixed broadleaf-conifer forest
30	Grassland (GL)	Typical grassland, meadow grassland, alpine grassland, desert grassland, grass
40	Shrubland (SL)	Desert scrub, mountain scrub, deciduous and evergreen shrubs
50	Wetland (WL)	Lake swamp, river flooding wetlands, seamarsh, shrub/forest wetlands, mangrove forest, tidal flats/salt marshes
60	Water bodies (WB)	Open water: lakes, reservoirs/fishponds, rivers
70	Tundra (T)	Brush tundra, poaceae tundra, wet tundra, bare tundra, mixed tundra
80	Artificial surfaces (AS)	Settlement place, industrial and mining area, traffic facilities
90	Bareland (BL)	Saline-alkali land, sand, gravel, rock, microbiotic crust
100	Permanent snow/ice (SI)	Permanent snow, ice sheet and glacier