osmlanduseR: An R package for the analysis of land use data contributed to OpenStreetMap

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2024-11-26

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Introduction

Introduction

Over the past 30 years, Argentina has been experiencing changes in its agricultural and urban development model that have drastically altered land use practices and patterns (Palmisano 2018; Pintos and Narodowski 2012).

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Introduction

On a global scale, the expansion of capitalism through a process of accumulation by dispossession prevails. This is characterized by land privatization, the expulsion of farmers, the conversion or suppression of rights to the commons (Harvey 2004).

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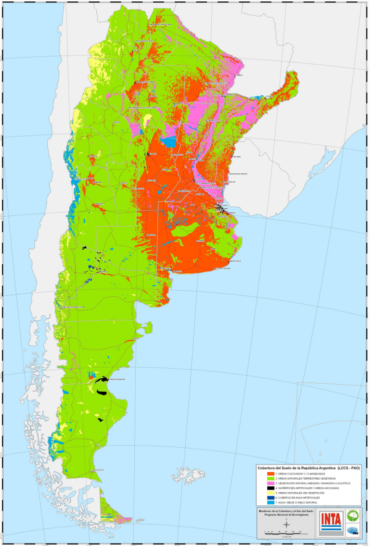

Figure 1: Land cover, INTA

According to the land cover inventory made by the National Institute of Agricultural Technology, (Volante 2009):

- Managed or cultivated areas covered 584353 km^2 (21.64 % of the total) and
- herbaceous crops accounted for 556720 km^2 (95.27 %).

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Introduction


LA NACION > Sociedad

Inundaciones: el agua entró en la Basílica de Luján

La municipalidad dispuso la mudanza de evacuados y el cierre de varias calles y del cementerio

11 de agosto de 2015 • 17:48

lanacionar

These changes have been associated with flooding in several regions (Pal et al. 2021; Pattison and Lane 2012) .

In particular, the Luján River basin (Buenos Aires, Argentina) has experienced extreme events historically.

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The rising incidence and intensity of such events around the world has led to increased concern to study this relationship:

- China: Liu et al. (2023)
- Indonesia: Sugianto et al. (2023)
- Argentina: Pal et al. (2021)
- Brasil: da Silva et al. (2024)

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Introduction

The analysis of these changes in land use requires information typically obtained from remote sensing, which is validated and complemented with sampling programs.

The development of an updated land use map is a basic tool to study territorial phenomena such as flooding or land use change. Such an approach would enable the information to be compared to previously collected data on various scales and time periods.

Introduction

Although, geographic information, its format, or processing tools do not generally allow for its reuse or improvement, and they are not necessarily openly/freely available.

This type of data can be considered a *digital commons* and may be the susceptible of mercantilization processes.

Indeed, publicly produced information and processing tools should be made available in open-source formats and licenses to enforce knowledge construction (J. J. Arsanjani et al. 2015; Duféal and Noucher 2017).

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Introduction

OpenStreetMap (OSM) is currently the main framework for volunteered geographic information, and because it constitutes a standardized database, it also allows it to be a preferred repository for contributions from universities and public sector research initiatives.

Recently, OSM has been registered as a *public good* by an agency affiliated to the United Nations:

Introduction

The data contributed to OSM has already been incorporated into the creation and validation of land use and land cover maps, which are predominantly utilized in Europe:

- Vienna, Austria: A. J. Arsanjani et al. (2013);
- Paris, France; Milan, Italy: Fonte et al. (2016);
- Heidelberg, Germany: Schultz et al. (2017).

These authors have developed methods and algorithms for retrieving, analyzing, and classifying OSM data to produce land use maps.

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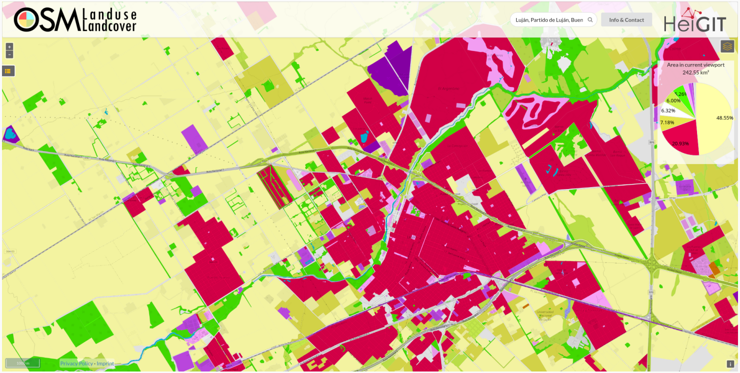
Introduction

From these works also derived the osmlanduse.org initiative, which delivers OSM land-use/land-cover information mapped to CORINE classes as a Web Map Service (WMS).



Introduction

In different countries, the local community of OSM users has contributed a substantial amount of geographic information that could be used for land use analysis, which might be expanded further, particularly in non-urban areas.

The general scheme for describing geographic elements provided by OSM can be applied to land use mapping by combining that information with country-specific classification systems.

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Introduction

On this basis, there is a need for tools that can be applied at the local level to promote interaction with participatory mapping processes.

Such an approach would facilitate harmonization of OSM data with other classification systems, including those created by FAO or defined by users.

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Introduction

- As a consequence, the objective of this study is to present the development of an R package for the analysis of land use data contributed to OSM.
- Overall, the aim is to increase the contribution of publicly generated information and its analysis tools in an open access format, such as those provided by OSM and R (R Core Team 2023).

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Materials and Methods

Creation of a land use map in OpenStreetMap

Since 2016, land use data of the Lujan River's middle basin have been contributed to OSM as part of projects conducted by the National University of Luján.

Land use was visually assessed using satellite imagery, and representative polygons were added with appropriate tags. Geometries were created preferably as multipolygons.

Creation of a land use map in OpenStreetMap

The boundaries of each geometry were drawn to avoid sharing nodes with the road and rail networks.

The JOSM program was used for OSM edition, using imagery available within the program, provided by Bing, Mapbox, Digital Globe, and the National Geographic Institute of Argentina, with capture dates from 2016 to 2020.

JOSM: Java editor for OSM

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package implementation

The package is in the early stages of development

The code repository is accessible in https://github.com/aduhour/osmlanduseR.

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R package implementation

The package comprises a number of features aimed at:

1) Download a set of land use related data from OSM using the overpass API: (**get_osmlanduse function**);
2) Remove overlaps, measure polygon area and classify polygons by mapping OSM tags to user-defined classes (**classify_osmlandse function**).
3) Provide example data sets for the translation of OSM land use tags to classification systems with extended use, such as the CORINE Land Cover and FAO Land Cover Classification System.
4) Create a land use classification map (**map_osmlandse function**).

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R package implementation

1. *get_osmlanduse* function

The *get_osmlanduse* function takes as argument an objective region that can be defined as a polygon element in *sf* (simple features) format or as a character string containing the name of a region.

These input data is used to obtain the bounding box to set the overpass API query.

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R package implementation

1. ***get_osmlanduse*** **function**

The OSM features retrieved are those tagged as $natural = *$, $landuse = *$, $amenity = *$, $aeroway = *$ and $leisure = *$.

At present, only the polygon objects are considered in the function implementation.

Finally, the invalid geometries are fixed and a list containing the objective area and the land use data is returned.

The land use data is optionally intersected by the input polygon or the bounding box.

2. *classify_osmlanduse* function

The *classify_osmlanduse* function takes the output of the previously described function and:

- transforms the data to the selected coordinate reference system,
- detects overlapping polygons and measures the area of the elements.
- assigns a land use class to each polygon, matching existing OSM keys to a user-defined list of class names.

package implementation

2. *classify_osmlanduse* function

Overlaps are resolved by two optional methods:

a) prioritizing the *smaller* polygons according to Schultz et al. (2017).

b) prioritizing polygons in a *hierarchichal* order of land use classes, as suggested by Fonte et al. (2016).

3. Data sets

Two data sets integrate the package to be used in classification:

- The data set *clc* is an example of the legend harmonization between OSM tags and Corine Land Cover classes proposed by Schultz et al. (2017).
- The dataset *intafao* is a translation of OSM tags to the FAO Land Cover Classification System adopted by the National Institute of Agricultural Technology (Argentina) (Volante 2009).

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package implementation

4. *map_osmlanduse* function

The *map_osmlanduse* function takes the classified set of data and returns a land use thematic map.

Dependencies

The implemented procedures use functions from the packages

(Padgham et al. 2017; Pebesma 2018; Tennekes 2018)

Example application

Example application: Basic usage

- By calling the function **get_osmlanduse** with default arguments, the land use data of Luján in Buenos Aires, Argentina is dowloaded:

```r
lujan <- get_osmlanduse()
lujan$osmlanduse
```

```
> lujan$osmlanduse
Simple feature collection with 4111 features and 2 fields
Geometry type: MULTIPOLYGON
Dimension:     XY
Bounding box:  xmin: -59.33842 ymin: -34.80437 xmax: -58.95423 ymax: -34.37462
Geodetic CRS:  WGS 84
First 10 features:
   value     key                       geometry
1  water natural MULTIPOLYGON (((-59.18621 -...
2  water natural MULTIPOLYGON (((-59.11615 -...
3  water natural MULTIPOLYGON (((-59.14118 -...
4   wood natural MULTIPOLYGON (((-59.16937 -...
5   wood natural MULTIPOLYGON (((-59.16727 -...
6   wood natural MULTIPOLYGON (((-59.1238 -3...
7   wood natural MULTIPOLYGON (((-59.16406 -...
8   wood natural MULTIPOLYGON (((-59.12353 -...
9   wood natural MULTIPOLYGON (((-59.06947 -...
10  wood natural MULTIPOLYGON (((-59.06949 -...
```

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Example application: Basic usage

- Then, the result can be classified in the classes of the CORINE Land Cover scheme using the data set *clc*

```r
data(clc)
lujan.clc <- classify_osmlanduse(lujan$osmlanduse,
                                 clc$osm_tag,
                                 clc$class_name)
```

```
> subset(lujan.clc,subset = !is.na(lujan.clc$class_name))
Simple feature collection with 3575 features and 4 fields
Geometry type: GEOMETRY
Dimension:     XY
Bounding box:  xmin: 5560755 ymin: 6148759 xmax: 5595996 ymax: 6196458
Projected CRS: POSGAR 2007 / Argentina 5
First 10 features:
          value     key                                    class_name            area                       geometry
1129 industrial landuse      Industrial, commercial and transport units 0.01632289 [ha] POLYGON ((5588312 6179957, ...
3878       park leisure     Artificial non-agricultural vegetated areas 0.02528940 [ha] POLYGON ((5582932 6175043, ...
1128 industrial landuse      Industrial, commercial and transport units 0.04771547 [ha] POLYGON ((5588306 6180175, ...
279       scrub natural Shrub and/or herbaceous vegetation associations 0.05574416 [ha] POLYGON ((5584017 6173754, ...
915       grass landuse Shrub and/or herbaceous vegetation associations 0.06931497 [ha] POLYGON ((5575766 6171394, ...
625        wood natural                                         Forests 0.09567525 [ha] POLYGON ((5588331 6187822, ...
1064 commercial landuse      Industrial, commercial and transport units 0.10574843 [ha] POLYGON ((5582367 6172797, ...
237       water natural                                    Water bodies 0.11090597 [ha] POLYGON ((5583965 6179873, ...
3962       park leisure     Artificial non-agricultural vegetated areas 0.13647602 [ha] POLYGON ((5579281 6175366, ...
277       scrub natural Shrub and/or herbaceous vegetation associations 0.14119390 [ha] POLYGON ((5583938 6173679, ...
```

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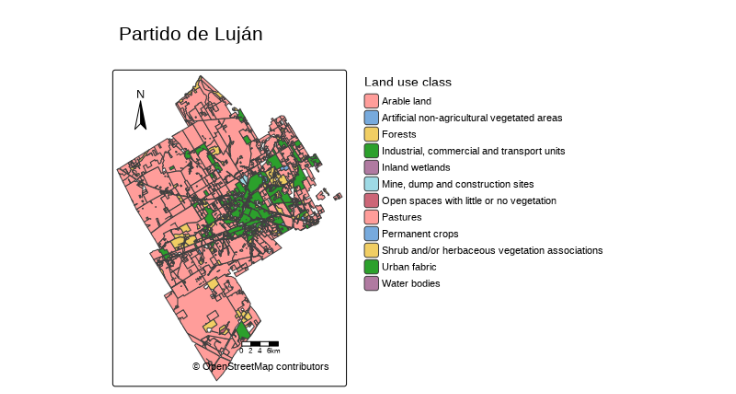
Example application: Basic usage

```
map_osmlanduse(lujan.clc, "Partido de Luján")
```



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Example application: Land use map of Luján

The methods developed in the package *osmlanduseR* were used to download the elements associated with land use from OSM.

The geometric operations oriented to remove overlapping were successfully accomplished, and the matching of the present tags with a user-defined list of land use classes.

The land use polygons retrieved from OSM in the municipality of Luján were found to cover 71742.8 ha, or 92.8% of the total area.

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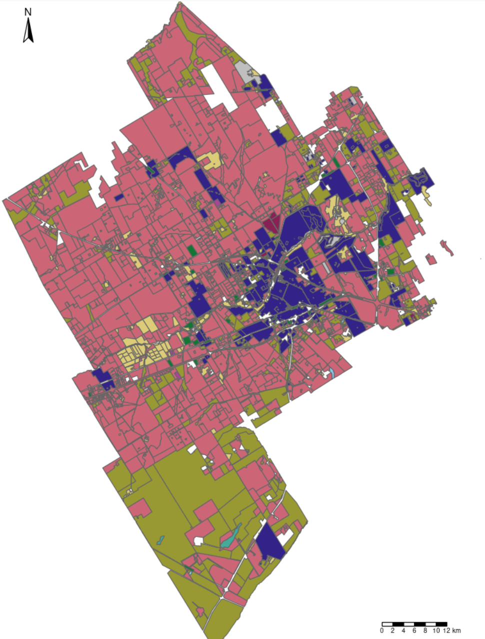
Land use map



Future work and new features.

The results obtained in the development of osmlanduseR represent a preliminary model for the incorporation of additional functions and other features documented in previous research.

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Future work and new features.

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Linear elements

Including linear elements, such as those related to the road and rail network or the waterways into the analysis of land use could be made as proposed by Fonte et al. (2016), provided that the appropriate assumptions are made regarding the width of each linear element.

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Future work and new features.

Inference from other map elements

The current stage of the osmlanduseR package enables the incorporation of a tool that allows the inference of land use from elements such as POIs, buildings, road network, tags combination, etc.

This can be accomplished by using the tree decision approach proposed by A. J. Arsanjani et al. (2013).

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Future work and new features.

Filling gaps

In their study, Schultz et al. (2017) described a method for using the information available in OSM as a training tool for supervised classification of remote sensing data, with the objective of filling data gaps.

Future work and new features.

Map accuracy

An important component to add in the future is a method for estimating the accuracy of a classification derived from other sources or constructed using other methods in a specific area.

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Future work and new features.

OpenStreetMap data improvements

A new feature to add is the integration with workflows for improving OSM map data.

The package can implement the detection of issues, for example those related to overlapping, tag consistency,

Conclusions

Conclusions

The work conducted since the initial development of osmlanduseR has made it possible to use data from OSM for land use analysis and to implement a classification system.

Additionally, the developed package provides a basis for integrating additional complementary methodologies referenced in previous research into a unified platform.

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Conclusions

Among them, it is critical to continue improving osmlanduseR to allow the use of OSM tags as training to categorize unknown areas from remotely sensed imagery, and inferring land use classes from POIs, buildings, or linear features. It is also necessary to incorporate methods for calculating map accuracy.

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Conclusions

This approach enables a systematic analysis of the information available in OSM, resulting in a new tool that can be integrated into participatory mapping processes and used to enhance initiatives for open and public access to information.

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Thank you! - ¡Muchas gracias!

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