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

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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).

Introduction

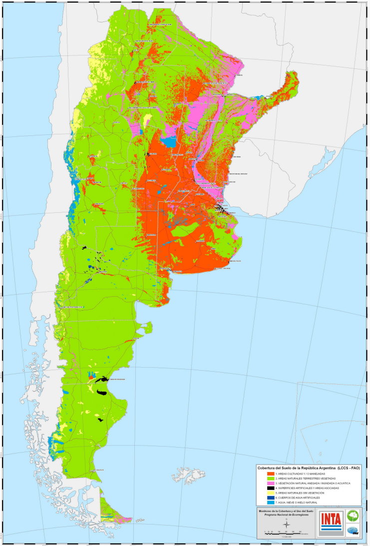

Figure 1: Land cover, INTA

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

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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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Introduction


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lanacionar

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)

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.

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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:

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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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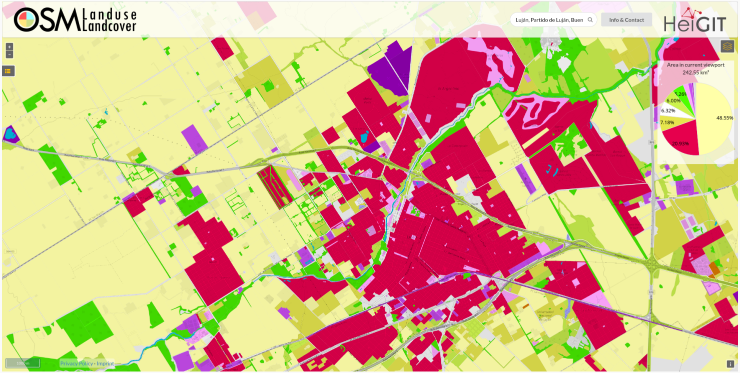
Introduction

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.

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 has been contributed to OSM as part of projects carried out 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.

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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. These images were captured between 2016 and 2022.

JOSM: Java editor for OSM

package implementation

The package is in its early stages of development

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

package implementation

The package comprises a number of features aiming at:

1) Downloading a set of land use related data from OSM using the overpass API: (**get_osmlanduse function**);
2) Removing overlaps, measuring polygon area and classifying polygons by mapping OSM tags to user-defined classes (**classify_osmlandse function**).
3) Providing example data sets for the translation of OSM land use related tags into other classification systems, such as the CORINE Land Cover and FAO Land Cover Classification System.
4) Creating a land use classification map (**map_osmlandse function**).

1. ***get_osmlanduse* function**

The *get_osmlanduse* function requires two arguments;

1) *area*: An objective region, defined as a polygon element in *sf* (simple features) format or as a character string containing the name of a region.

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

2) *crop_to*: A character string indicating if the final result should be cropped to the area polygon or to the bounding box.

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R package implementation

1. ***get_osmlanduse* function**

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

At present, only the polygon objects are taken into account in the function implementation.

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

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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 and removes overlapping polygons and measures the area of elements.
- assigns a land use class to each polygon by matching existing OSM tag values to a user-defined list of class names.

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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).

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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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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: Land use map of Luján

Example application: Land use map of Luján

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

```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: Land use map of Luján

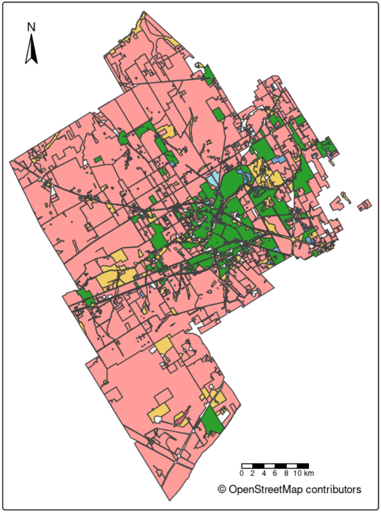
- The result can then be classified into the classes of the CORINE Land Cover scheme

```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, ...
```

Example application: Land use map of Luján

```
map_osmlanduse(lujan.clc)
```



Land use class	Area (ha)
Arable land	41916.4
Artificial non-agricultural vegetated areas	687.5
Forests	2687.9
Industrial, commercial and transport units	451.6
Inland wetlands	28.7
Mine, dump and construction sites	182.4
Open spaces with little or no vegetation	82
Pastures	15175.9
Permanent crops	51.3
Shrub and/or herbaceous vegetation associations	3233
Urban fabric	7105.7
Water bodies	140.5

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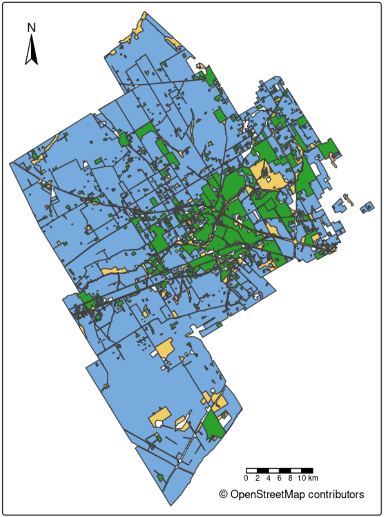
##

Example application: Land use map of Luján

Example application: Land use map of Luján

```
map_osmlanduse(lujan.intafao)
```



Land use class	Area (ha)
Agua, nieve o hielo natural	140.5
Áreas cultivadas y/o manejadas	56580.1
Areas naturales terrestres vegetadas	4918.6
Superficies artificiales y áreas asociadas	10058.7
Vegetación natural anegada/inundada o acuática	28.7

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Example application: Land use map of Luján

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

- 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 and measure areas were successfully accomplished,
- and the existing tags were matched against a user-defined list of land use classes.

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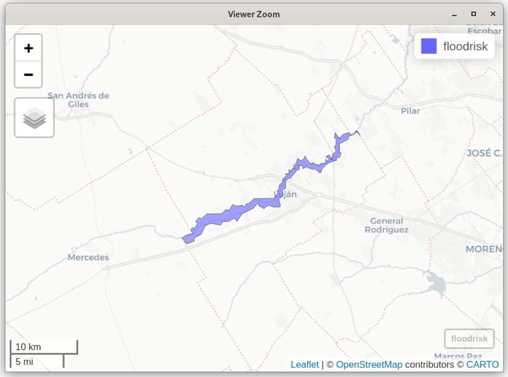
Example application: Flood risk and land use classes in Luján

Example application: Flood risk and land use classes in Luján

The government of the province of Buenos Aires has produced flood risk maps for the Luján River basin. The corresponding area for the city of Luján was selected:

```
mapview::mapview(floodrisk)
```



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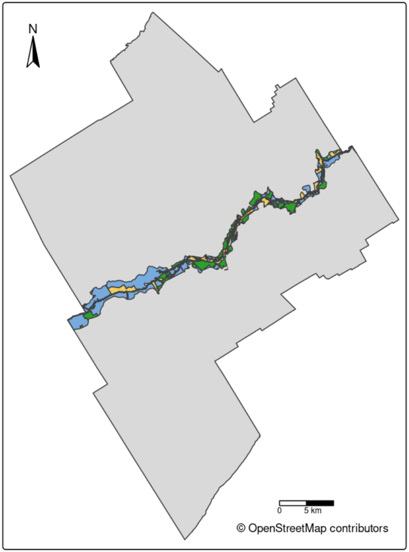
Example application: Flood risk and land use classes in Luján

```r
fr <- get_osmlanduse(floodrisk)
fr.intafao <- classify_osmlanduse(fr$osmlanduse,
                intafao$osm_tag,
                intafao$class_name)
frmap <- map_osmlanduse(fr.intafao)
tm_shape(lujan$area) + tm_polygons() + frmap
```

Example application: Flood risk and land use classes in Luján



Land use class	Area (ha)
Agua, nieve o hielo natural	47
Áreas cultivadas y/o manejadas	1667.1
Areas naturales terrestres vegetadas	625.4
Superficies artificiales y áreas asociadas	753.3

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Future work and new features.

Future work and new features.

Linear elements

Such as road and rail networks or waterways, could be included making the appropriate assumptions about their width.

Inference from other map elements

Elements such as POIs, buildings, road network, tag combinations could be used as indicators.

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Future work and new features.

Filling gaps

The information available in OSM could be used as training areas for supervised classification of remote sensing data (Schultz et al. 2017; Simoes et al. 2021).

Map accuracy

Is necesary to continue working to add a method for estimating the accuracy of a classification derived from other sources or constructed by other methods in a given area.

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Future work and new features.

OpenStreetMap data improvements

One feature to be added in future work is the ability to integrate the package with workflows for enhancing OSM map data.

Detection of problems such as overlapping, tag consistency, invalid geometries,

or to select the areas in which information is needed.

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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

Finally, the approach of *osmlanuseR* enables a systematic analysis of the information available in OSM,

Resulting in a new tool that can be integrated into participatory mapping processes.

And can be used to enhance initiatives for open and public access to information.

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Thank you! - ¡Muchas gracias!

osmlanduseR

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