# Using the European CORINE Land Cover Database: A 2011–2021 Specific Review

**Marta Gallardo and David Cocero**

**Abstract** Land use and land cover changes (LULCC) are social, climatic and ecological changes that take place at multiple spatial and time scales. The study of these changes offers us a better understanding of the evolution of the territory and the changes that take place in its natural and cultural values. In Europe, the CORINE Land Cover (CLC) database is crucially important for monitoring these changes. As of today, it includes different maps of the land uses and covers in up to 39 countries, drawn in a standardized way. Within the context of the Sustainable Development Goals proposed by United Nations Agenda 2030 on Life on Earth, CORINE can provide essential information for a full understanding of the current situation of Goal 15 (Life on Land) so as to facilitate the design of sustainable policies for spatial planning and organization. In this paper, we perform a bibliographical review of the use of the CLC database. On the basis of qualitative and quantitative analyses, we analyse 77 publications indexed in the Web of Science Core Collection, published between 2011 and 2021, which include the word "CORINE" in the title. We observe increasing interest in the use of the CLC as a means of tracking the LULCC that have taken place and their impact on environmental issues such as deforestation, the pressures on protected natural areas and the soil erosion risk, among others. Other researchers analyse the CLC itself, assessing its accuracy and applicability with other sources and databases. Most of the papers refer to the maps for the years 2000 and 2006, using Level 3 of the thematic legend to study particular issues or dynamics at a local level. As regards the location of the institutions that use the CLC, those situated in Spain, Poland and Romania stand out. There were few links between the authors of these publications.

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## Introduction

Human beings depend on the Earth for our sustenance and survival. Plants provide approximately 80% of human foodstuffs, and agriculture is therefore a very important economic resource for many countries. In addition, 30% of the land surface is covered by forests, which serve as a habitat for millions of species and provide an essential source of clean air and water (United Nations 2022). Land use and land cover changes (LULCC), brought about above all by human action, are occurring increasingly rapidly, with direct consequences on climate change, biodiversity and ecosystem services (Eitelberg et al. 2016). Ellis (2010) defines land cover change as any alteration in vegetation, water or soil cover and land use change as an adjustment in human activity, related with changes in agriculture, forests, pastures or urban development. In the coming decades, humans are expected to continue to change the ways in which land is used, in response to pressure from environmental degradation and a growing demand for food, animal feed, biofuels and raw materials (De Jong et al. 2021). In this context, the study of LULCC is an effective way of revealing the interactive mechanism between human activities and the natural environment (He et al. 2022). The modelling of these changes and a greater knowledge of their implications are necessary when it comes to drawing up effective planning and environmental strategies (Gallardo and Martínez-Vega 2016).

Sustainable Development Goal number 15 (Goal 15 or SDG 15) refers to "Life on Land" and is one of the 17 Sustainable Development Goals (SDGs) established by the United Nations in 2015. The objective of SDG 15 is to "Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss" (United Nations 2022). Conserving and restoring the use of terrestrial ecosystems, such as forests, wetlands, drylands and mountains, and halting deforestation are of vital importance for mitigating the impact of climate change. Urgent steps must therefore be taken to reduce the loss of natural habitats and biodiversity, which are part of our common heritage (United Nations 2022).

Within SDG 15, there are 12 targets which are considered critical for achieving the main goals. The third of these targets is as follows: "By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world" (UN Women 2022). The following indicator has been proposed as a means of assessing the current status of this target: "Proportion of land that is degraded over total land area". Three other sub-indicators can also be used by the different countries for monitoring purposes and to quantify the proportion of degraded land (United Nations 2017): (a) land cover; (b) land productivity; (c) carbon stocks above and below ground.

Although the land cover products available at a regional scale do not provide the right geographic framework to be considered ideal for the study of Target 15, the use of regional products at a national scale may offer advantages as a way of better characterizing the most important, most specific land covers in each country. One of these regional products is the CORINE Land Cover database (CLC), which covers the 27 Member States of the European Union and various other European countries. These data are based principally on the visual interpretation of satellite images from the Landsat, SPOT and Sentinel programmes. The production is decentralized at the national level in order to create a uniform land use and land cover map of Europe, which provides a complete and consistent set of data for the whole of Europe, in vector format. The CLC database is available for the years 1990, 2000, 2006, 2012 and 2018 (Sims et al. 2021).

In this regard, over more than 20 years, numerous studies have been carried out using this database as a primary or secondary source. In this chapter, we perform a specific bibliometric analysis, detailing the publications listed in the Web of Science (WoS) that make use of the CLC database over the last 11 years. Bibliometric methods have been used to perform a quantitative analysis of written publications, based on the identification of the corpus of literature within a given subject area (Ellegaard and Wallin 2015). Meta-analyses are able to handle large amounts of literature and can provide a summary of a particular field and the heterogeneity of existing studies. In addition, systematic literature reviews tend to include between tens and low hundreds of papers for review and are suitable for fairly restricted or niche research areas (Donthu et al. 2021). In recent years, these methods have become increasingly popular, and various software programmes have been developed to facilitate analysis (Grant and Booth 2009).

We summarize the main characteristics of these studies and how they use CLC, detailing: (a) their trajectory; (b) the research fields within which they fall; (c) where they publish; (d) the number of citations they receive; (e) the subjects they explore; (f) the most commonly used words; (g) the institutions to which the authors belong; and (h) the relations between them. When analysing how they used the CLC, we looked at the cartographic base(s) they used (what year), the level of thematic legend, the study areas and its applications and the relationship with the SDG 15 objective.

## *CORINE Land Cover Database*

The Coordination of Information of the Environment (CORINE) Land Cover programme was created by a resolution of the Council of Ministers of the European Union (CE/338/85), dated 27 June 1985, by virtue of which a decision was taken to embark on "an experimental project for gathering, coordinating and ensuring the consistency of information on the state of the environment and natural resources in the Community" (Pérez Martín et al. 2020).

It provides information about land cover, land use and land cover/use changes over time. Its applications include spatial management, forestry management, water

management, emergency management, etc. Its main characteristics are: It is produced by the member states and is coordinated by the European Environment Agency; it is a standard, homogenous product covering almost all of Europe, using a vector information system with a single polygon layer; it has five versions: 1990, 2000, 2006, 2012 and 2018, that were produced by assisted photograph interpretation of reference images from Landsat 5 or by a generalization of finer national LULC database (1990), Landsat 7 (2000), Spot 4/5 and IRS (2006), IRS and Rapid Eye (2012) and Sentinel 2 (2018) satellites; it has a spatial scale of 1:100.000 and a minimum polygon unit of 25 ha—in the case of change polygons, 5 ha-; it is economically sustainable and periodically updated (IGN 2018; Pérez et al. 2020).

The CLC hierarchical nomenclature contains 44 classes divided into three levels of thematic detail. These classes were defined via the continuous, joint efforts of experts from different European countries who sought to describe all the landscapes existing in Europe today. The first level contains five large groups of classes: artificial surfaces, agricultural areas, forests and semi-natural areas, wetlands and water bodies. These classes are subdivided into a second and third level of detail, and each CLC polygon must be classified at the maximum level of detail. Each class is identified with a three-digit code: the first digit denotes the first level category to which the class belongs, the second refers to the second level, and the third the third level (IGN 2018). This variety of land use/land cover classes and the fact that there are several maps from different years facilitate environmental decision-making, the quantification of loss of natural environments, deforestation and fires, the obtaining of urban expansion variables, the identification of areas that require protection, etc., at a European level. Key issues to monitor and understand if the SDG 15 is to be archived.

The future of the CORINE Land Cover project is guaranteed by the European Union, and the Copernicus Programme is currently developing new methodologies and new CLC products that can satisfy current needs. These revolve essentially around providing greater geometric and thematic detail.

## *Bibliographic Reviews Relating to Land Use/Land Cover Change*

There is increasing interest in the land use and land cover changes (LULCC) that have taken place in the past and in modelling possible changes that may take place in future. It is also important to assess the implications that such changes will have on the environment and on society at global, regional and local levels. In association with the increase in studies of this kind, the development of software programmes and the increasing availability of data online, there has also been an increase in systematic reviews and meta-studies relating to LULCC, the factors and the forces behind them and their implications and consequences, in order to highlight the advances and the opportunities for the future offered by these studies. To cite just a few examples, Agarwal et al. (2002) carried out a review of 136 papers to analyse different types

of land use change models and explore their functionality. Lambin et al. (2003) observed the increasing complexity in the development of LULCC models. De Jong et al. (2021) analysed 62 case studies in order to report on the conditions and causes of land use change conflict. Gomes et al. (2021) detailed 79 papers that related LULC futures with their impact on terrestrial ecosystem services. Nedd et al. (2021) carried out a review of 146 articles and meta-studies, including definitions of LULCC and its classification systems. Or He et al. (2022) detailed the research conducted between 1990 and 2018 on LULCC summarizing its main characteristics and the progress that has been made.

Specific reviews applied to a specific geographic area can be found in Pham et al. (2015), who analysed 17 studies of LULCC in northern and border upland Vietnam; in Fernández and Corbelle (2017), who conducted a meta-analysis of 47 studies by Spanish and Portuguese researchers on LULCC in the Iberian Peninsula. For their part, De Alba-Rosano et al. (2020) analysed 196 papers that referred to this topic in Mexico. Ruiz and Sanz-Sánchez (2020) observed the effects and interactions of LULCC in the Mediterranean basin detailed in 23 studies; in the same field but focusing on Euro-Mediterranean mountains, Jiménez-Olivencia et al. (2021) observed the dynamics in 53 case studies in relation with land use changes, their causal factors and their effects on the landscape.

There are also a number of reviews addressing very specific topics, such as those by Méndez-Rojas et al. (2021), who analysed different studies in order to observe the influence of land use change on rove beetle diversity, or Sasmito et al. (2019), who observed the effect of LULCC on mangrove blue carbon stocks.

In relation with CORINE, Bielecka and Jenerowicz (2019) published a review of 873 documents found on the Web of Science (WoS) between 1985 and 2019 that used this database in their research in order to highlight the intellectual and cognitive structure of its application.

## Methods

We performed a search of the Web of Science (WoS) Core Collection for papers published in the last eleven years (between 1 January 2011 and 31 December 2021), in order to analyse documents available in the last decade that can use both older (1990) and recent (2018) CLC databases. First, we analysed the temporal trend, how many documents where published and the research fields of papers that included the word "CORINE" (TS = (corine)) or "CORINE Land Cover" (TS = corine AND land AND cover). Due to the limited time available for this study, we decided to restrict our selection to publications that included just the word "CORINE" (TS = (corine)) in their title. This was based on the assumption that if the authors decided to use this word in the title, it was because the CORINE Land Cover database played an important role in their research.

This search was conducted on 14 January 2022, and a total of 79 references were obtained. Two of these references dealt with a completely unrelated topic and

were therefore eliminated, leaving a total of 77 papers. These included articles, book chapters and proceedings (see Appendix).

By means of both quantitative and qualitative analyses and following the Search, Appraisal, Synthesis and Analysis (SALSA) analytical framework (Samnani et al. 2017), we analysed who the authors of these papers were and the institutions to which they belonged, observing the possible relations between them. We also observed in which journals they were published and the fields of research to which most of these publications belonged. Other variables included the most frequently used words. We also observed the number of times these articles had been cited in other research publications and the relationships between the citations and the authors.

As regards their use of the CLC database, we analysed the papers contents to find out which version(s) of CORINE (dates) and which thematic scale (hierarchical level of their legend) they used. We also examined the geographical focus of their analyses. Finally, we detailed how they use this cartography and the main topics discussed.

For these purposes, we used the Zotero, Atlas.ti, Excel and VOSviewer software programmes. Zotero was used to organize and manage the bibliography. Excel enabled us to make simple calculations to obtain quantitative data about the publications and how they use CLC. Atlas.ti was used to analyse the information qualitatively, obtaining word clouds of the words appearing, in this case, in the abstracts of these publications. Lastly, VOSviewer was used to observe the relations between the different authors, their citations and co-citations and the institutions at which they work; the maps were created on the basis of bibliographic data, for which we used the doi of the publications. Forty-three of the 77 documents were analysed in VOSviewer, choosing a minimum of one or two publications per author. A minimum of 10 publications per author was applied in the analysis of the citations. The data were entered into the software using crossref, so authors' names and sources may not have a consistent format and may not have been harmonized. In this sense, results of the analyses carried out with the VOSViewer should be interpreted with caution.

## Results

Table 1 shows the number of references found in this database over the study period, using the keyword "CORINE" (TS = corine) or the keywords "CORINE Land Cover" (TS = corine AND land AND cover) and after broadening the search, going beyond just the title of the publication, to include papers that mention them anywhere in the text or in the abstract. This produced over 800 publications with the word "CORINE" over the last eleven years. This fell to almost 750 with the search for "CORINE Land Cover". About 720 papers contained the word CORINE in the abstract, while 642 contained the words CORINE Land Cover.

The only filtered results were those relating to the search for the word "CORINE" in the title. The broader searches were not filtered, so the results obtained may include

**Table 1** Number of manuscripts published between 2011 and 2021 in the WoS according to the keyword or keywords selected and the place where they appear

| Keyword | Place | Nº publications |
|---|---|---|
| CORINE | Whole article | 821 |
| | Abstract | 720 |
| | Title | 79 |
| CORINE Land Cover | Whole article | 747 |
| | Abstract | 642 |
| | Title | 57 |

*Source* the authors

references to CORINE or to CORINE Land Cover that are not related with the topic of land uses and covers.

As regards the research fields within which these publications with the word CORINE in the title can be classified, we should highlight Environmental Sciences Ecology, with 84 publications, Biodiversity Conservation with 63 and Geography with 50 (Fig. 1).

If we broaden the time period for our search for "CORINE" in the title of the papers to include the whole period covered by the CLC database, we obtain 121 publications related with this topic. In Fig. 2, we can see how interest in the use of the CLC database

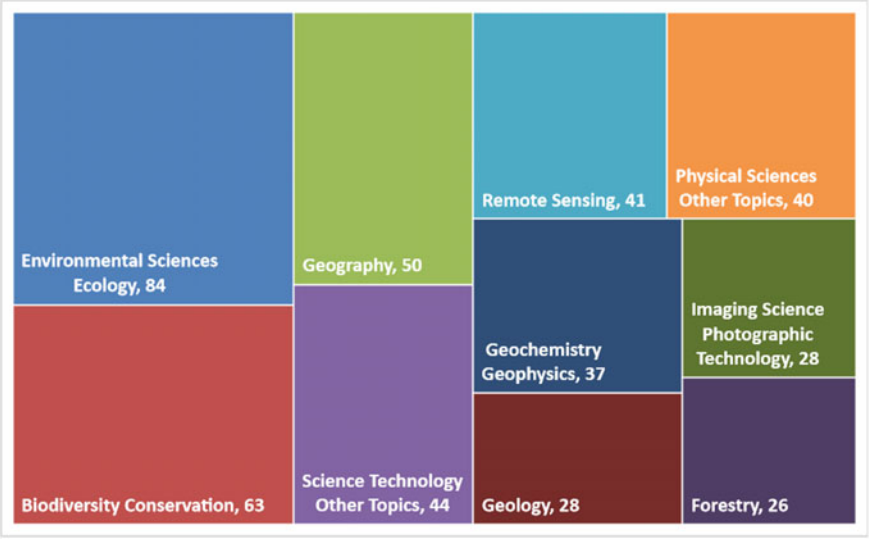


**Fig. 1** Research fields and number of publications available in the WoS that contain the word "CORINE" in the title published between 2011 and 2021. The size of the rectangles is proportional to the number of publications. Drawn up by the authors on the basis of data from the WOS Core Collection

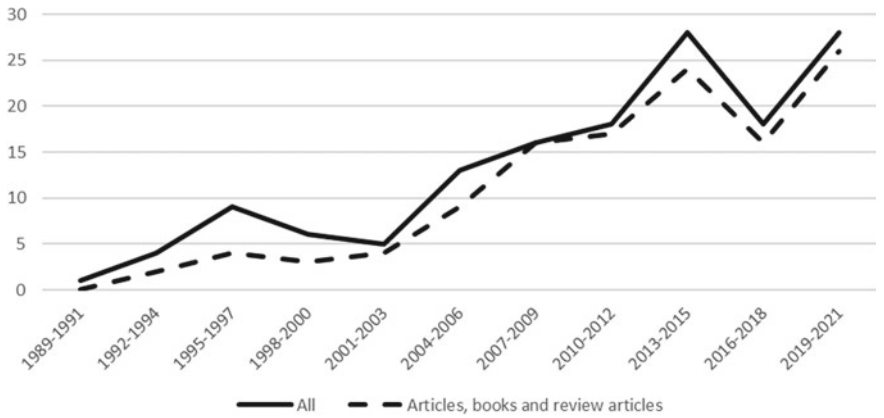


**Fig. 2** Number of publications available in the WoS with the word "CORINE" in the title by time period. The total includes meeting abstracts and other unspecified documents. Drawn up by the authors. Data from the WOS Core Collection

has grown, especially from 2004 and 2013, reaching 26 publications between 2019 and 2021 (28 if we include meeting abstracts and unspecified documents).

The period analysed in this research runs from 2011 to 2021 in which 77 articles, books and review articles were published. This positive trend, with a slight fall between 2016 and 2018, is related with advances in the development of the CLC cartography, which made more data available and made it easier, for example, to make comparisons over time.

As regards the 77 publications analysed in this research, most of these studies were papers published in scientific journals. There were only two book chapters and three proceedings, all of which were indexed in the WoS. Table 2 shows the first ten journals in which most articles were published. At the top of this list is the journal Remote Sensing, which in 2020 published a special issue entitled "CORINE Land Cover System: Limits and challenges for territorial studies and planning". Forty-three journals published just one article.

As regards the individual words that were most frequently used in the abstracts for these publications, we should highlight "land", "cover", "CORINE" and "data" (Fig. 3), but there were also many others related with the sources (satellite, Sentinel, Landsat), the methods (mapping, model, aggregation, comparison, simulation, accuracy), their applicability (erosion, soil, species), land covers/uses (forest, urban, agricultural, water, natural), places (watershed, habitat) or consequences (diversity, richness, conservation, management).

**Table 2** Journals and number of publications

| Journal | Publisher | Impact factor (JCR) | Publications |
|---|---|---|---|
| Remote Sensing | MDPI | 4.848 | 14 |
| International Journal of Applied Earth Observation and Geoinformation | Elsevier | 5.933 | 6 |
| Atmospheric Research | Elsevier | 5.369 | 2 |
| Carpathian Journal of Earth and Environmental Sciences | Carpathian Association of Environment and Earth Sciences | 0.162 | 2 |
| International Journal of Remote Sensing | Taylor & Francis | 3.151 | 2 |
| Journal of Maps | Taylor & Francis | 2.709 | 2 |
| Land | MDPI | 3.398 | 2 |
| Present Environment and Sustainable Development | PESD | ESCI | 2 |
| Urbanism Architecture Constructions | Nird Urban-Incerc | ESCI | 2 |
| Other | – | – | 43 |

It also shows the publisher of the journal and its impact factor in the Journal Citation Report in 2020
The authors

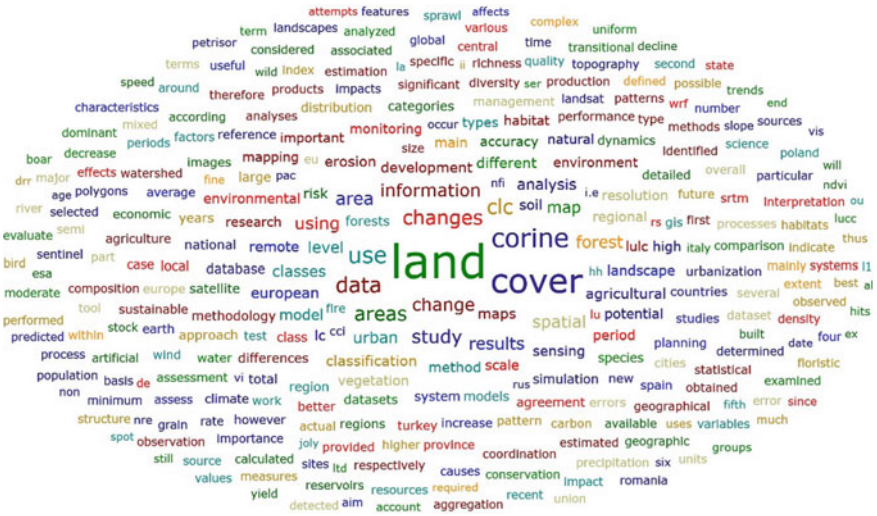


**Fig. 3** Word cloud of the words found in the abstracts of the publications. Drawn up by the authors

## *The Authors*

There were weak relations between the authors of the different publications. There were 8 sole-authored publications, representing 10% of the total. Most of the publications had either two or three authors (42%), while 26% had four or five authors. About 22% had more than five authors. As regards the number of affiliations, the largest groups were the manuscripts with just one affiliation (38%) and those with two or three affiliations (49%), while the manuscripts with four or five different affiliations represented just 10% of the total and those with more than five affiliations just 3%. Geographically speaking, their affiliation was very local in that 70% of the manuscripts were written by authors belonging to institutions from the same country, and the remaining 30% were by authors located in two or three different countries.

As regards the relations between their places of affiliation, if we analyse the 43 documents selected in VOSViewer using a minimum of one publication per author, we observed that there were 20 institutions and that the largest network was made up of just five of them (Fig. 4): the Department of Ecology of the University of Alicante (Spain), the INIA (Spain), the Department of Biology and Geology, Physics and Inorganic Chemistry of the University Rey Juan Carlos (Spain), the Group on Ecology and Forest Restoration of the University of Alcalá (Spain) and the Department of Geography and the Environment of the University of Aberdeen (United Kingdom). There were also two other smaller clusters each made up of three institutions: the first contained the Faculty of Science of the University of Zagreb (Croatia), the Croatian Natural History Museum and the National Centre for External Evaluation of Education (Croatia); the second was made up of the Department of Biology of the University of Aveiro (Portugal), the Department of Zoology of the University of Salamanca (Spain) and the INIA (Spain).

The next stage was to analyse the relations between authors and co-authors. In total, there were 150 authors, who together formed 35 different clusters. The largest network was made up of 9 interconnected people: six researchers from the University of Warsaw, Poland (Ahmed H Al-Sulttani, Anca Dabija, Marcin Kluczek, Marlena Kycko, Edwin Raczko and Bogdan Zagajewski) and three employees from the Cartographic and Geological Institute of Catalonia, Spain (Jordi Corbera, Lydia Pineda and Anna Tarda). When the search was restricted to authors who had published at least two articles, we obtained 4 clusters (Fig. 5), made up of: (a) D. Băltenau, I. Grigorescu, G. Kucsicsa B. Mitrică and E. Popovici, all of whom belong to the Institute of Geography, Romanian Academy, Romania; (b) A. de Meij and J.F. Vinuesa, from Noveltis, France; (c) I. Cieślak and K. Szuniewicz, from the Faculty of Geodesy, Geospatial and Civil Engineering of the University of Warmia and Mazury (Poland); (d) and P. Śleszyński, from the Institute of Geography and Spatial Organization of the Polish Academy of Sciences (Poland).

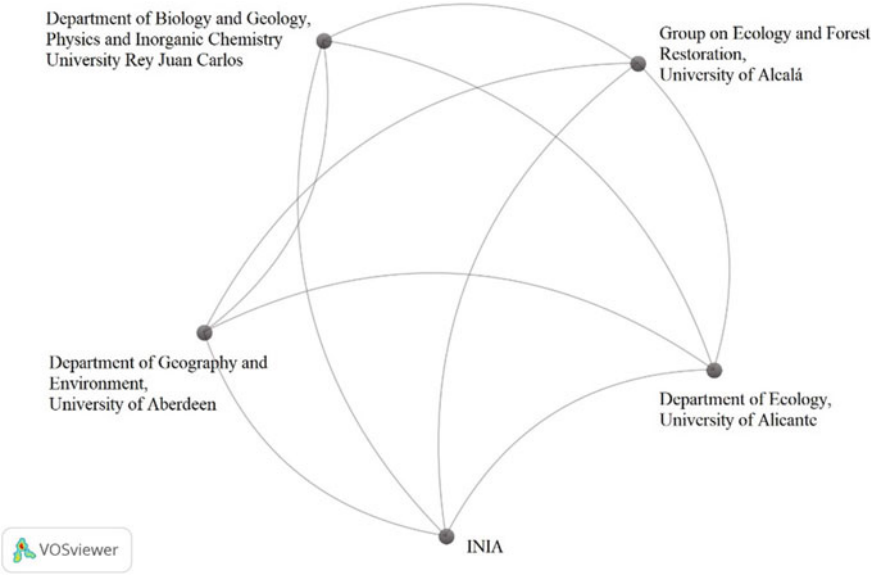


**Fig. 4** Biggest cluster between organizations and co-authorship. Drawn up by the authors

## *Analysis of the Citations*

As regards citations, these articles, book chapters and proceedings have so far been cited on 1152 occasions (1052 not including self-citations). Eight of the publications have never been cited. This gives an average per publication of 14.05 citations. The most cited publication is the book chapter by Büttner (2014) with a total of 89 citations, detailing the main characteristics of CLC, and how it has evolved over time with the production of the first three databases and their accuracies. This is followed by the article by Baltzer et al. (2015) with 87 citations, in which they demonstrate the validity of Sentinel-1A images for discriminating several CLC classes and monitoring cloud-covered regions. Perez-Hoyos et al. (2012) received 54 citations for an article that provides a methodology for comparing global land cover maps that allows for differences in the legend definitions, using CLC, GLC2000, MODIS land cover and GlobCover. The paper by Gallego et al. (2011) also received 54 citations, in which they compare the disaggregation methods used to produce a dasymetric population density grid of the EU, using CLC as ancillary information. Lastly, the fifth most cited publication (with 51 citations) was a paper by Díaz-Pacheco and Gutierrez (2014), in which the authors analysed the limitations of CLC for monitoring urban land use dynamics. Figure 6 shows the publications and citations on an annual basis over the period analysed. The maximum was achieved in 2021 in which 13 articles were published and 260 citations were received.

We then looked at the co-citations, in other words the citations within each article of any of the other articles analysed. If from the total of 803 authors (those who wrote

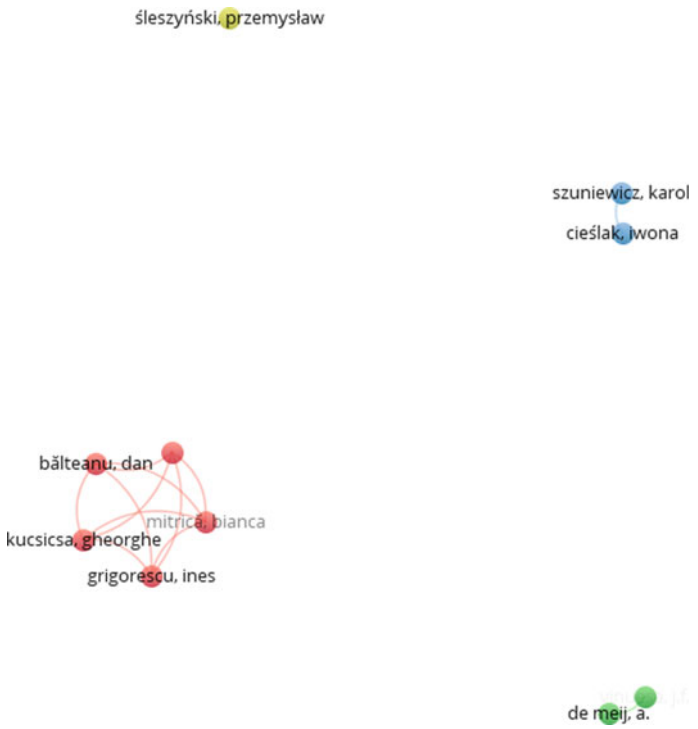


**Fig. 5** Relation between authors and co-authors with a minimum of two documents per author. Drawn up by the authors

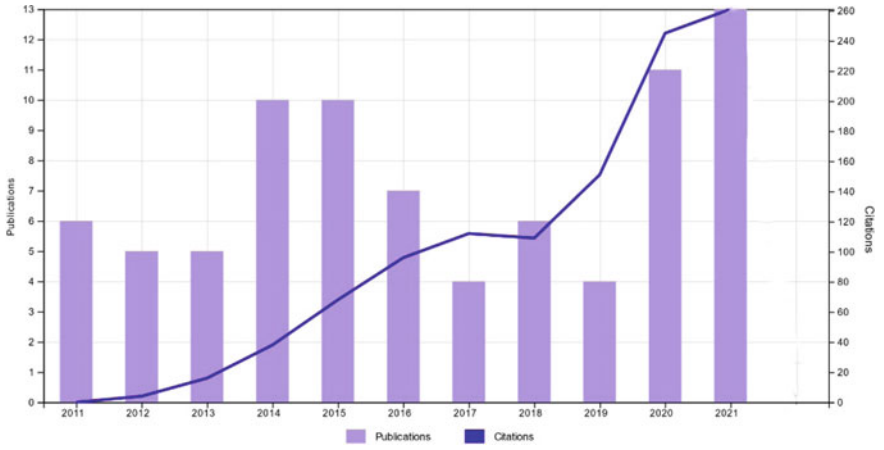


**Fig. 6** Annual number of publications that contain CORINE in their title and the citations thereof over the period 2011–2021 WOS Core Collection

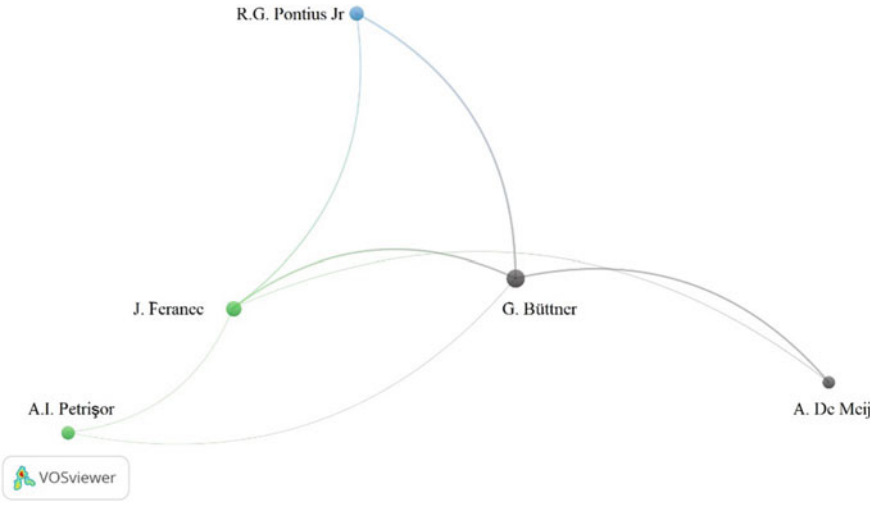


**Fig. 7** Cluster between cited authors and co-citations. Drawn up by the authors

the articles plus those cited in the bibliography), we select those with 10 or more citations, we obtain a single cluster made up of three subclusters, as can be seen in Fig. 7.

This cluster is made up of R.G. Pontius Jr. (Clark University, USA), in blue; A. De Meij (Noveltis, France) and G. Büttner (European Environment Agency), in black; and J. Feranec (Slovak Academy of Sciences, Slovakia) and A.I. Petrişor (Ion Mincu University of Architecture and Urbanism, Romania), in green.

## *The Use of the CLC Database*

A very wide range of topics are explored in these articles. These range from a detailed study of the characteristics of the CLC database to the production of its cartography or of more detailed maps based on this cartography. Figure 8 shows the topics analysed in these research studies. Many authors use the CLC database for LULCC and environmental changes. The second most frequently used topic focused on the accuracy of the database itself (including its thematic quality) or in comparison with other data sources on land use change at a global or local level (third topic). Lastly, a few publications centred on the production of its cartographic base and one article made a systematic review of the different applications of CLC.

More specially, the authors use the CLC to identify LULC changes, their patterns and causes, or to draw up predictive scenarios. They also use them to analyse deforestation, urban development and sprawl, green infrastructure, the dynamics in agricultural lands, pressures on Natura 2000 sites or to analyse the urban-rural gradient. They also examine CLC's potential for observing dynamics at a micro-scale or in

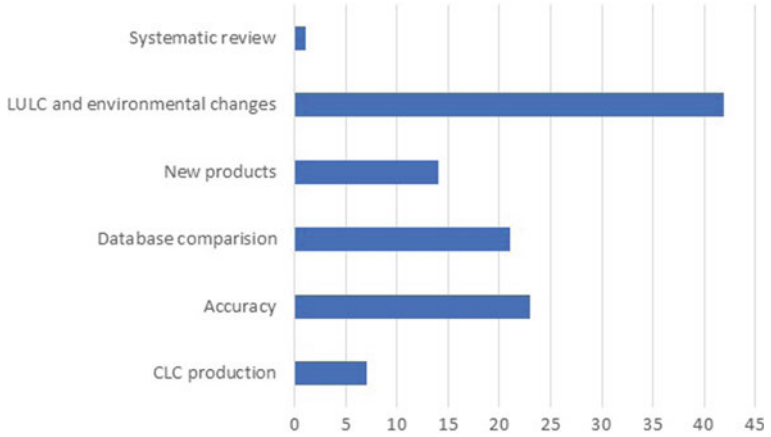


**Fig. 8** Topics analysed by the authors. Drawn up by the authors

watersheds or for assessing soil erosion risk, the floristic composition, water quality or the capacity of CLC to separate vascular plant assemblages or to estimate and predict the richness of fauna communities. CLC has also been used to estimate soil organic carbon stocks, wildfire occurrence, potential vehicle speed and to predict food production. The authors were also interested in proposing new vegetation or fragmentation indices and new urban indicators and in assessing the applicability of CLC as a basis for climate simulations, population densities or for the Water Research and Forecasting (WRF) model. Monitoring of all these processes provides us indicators to analyse the progress made towards the achievement of the SDG 15, which aims to protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forest, combat desertification, halt and reverse land degradation and halt biodiversity loss.

Other authors assess the accuracy of CLC via the aggregation of its thematic legend or by making comparisons with other cartographic databases or with products derived from satellite images, in order to evaluate their potential, their misclassifications, their limitations for monitoring certain land uses and covers or their discrepancies. These include Urban Atlas, GLG2000, Global Land Cover Characterization database (GLCC), LUCAS survey, ESA Climate Change Initiative on Land Cover (CCI-LC), ESA GlobCover and SIOSE or data from Sentinel, MODIS or Landsat images. They also made comparisons with LiDAR, Shuttle Radar Topography (STRM) sources and with national statistical databases and even field data photographs from platforms such as Flickr and Panoramio.

As regards the use of CLC maps, 56% of these studies used the maps for 2006 and 47% used those for the year 2000. These percentages were slightly lower when we looked at the maps for 1990 (26%), 2012 (25%) and the most recent one, 2018 (23%). It is important to bear in mind that 46% of the studies used more than one map; in other words, they made comparisons between the maps and observed the evolution of certain land covers/uses over time. In addition, the most frequently used hierarchal

**Table 3** Number of publications according to the different thematic legends of CLC and the different versions of the database (years) used

| Legend level | Number | Year | Number |
|---|---|---|---|
| CLC 1 | 14 | 1990 | 20 |
| CLC 2 | 15 | 2000 | 36 |
| CLC 3 | 51 | 2006 | 43 |
| CLC 4 or 5 | 3 | 2015 | 19 |
| Reclassification | 30 | 2018 | 18 |

The authors

level was Level 3, which was used by 66% of the articles. This was followed by Level 2 and Level 1 with 19% and 18%, respectively, and lastly by Level 4, which was used in 4% of the articles. Once again, it is important to bear in mind that a single study may use various different thematic scales. Furthermore, in 30% of the studies, the authors carried out a reclassification of the categories, normally on the basis of CLC Level 3, so as to adjust them to the subject they were researching (Table 3).

In this sense, it is important to remember that 57% of the studies were made at a local scale, 29% at national and 10% regional. The countries which concentrated most of these studies were Poland and Romania with nine and eight studies, respectively, and Italy, Spain and Turkey with six studies each.

## Discussion and Conclusions

Bearing in mind that three-quarters of the ice-free land surface is used or managed by humans and that many land systems have constrained future options, due to land use changes that crossed critical thresholds and created path dependence (Meyfroidt et al. 2022), the knowledge of LULCC and its drivers, impacts and responses are essential for achieving sustainable development and the SDGs, and in particular SDG 15. In this sense, cartographic databases developed according to standardized methods at different points in time, such as CLC, play an essential role in expanding our knowledge of these issues and monitoring past and future trajectories. To this end, there are various studies (Hinz et al. 2020; Cao et al. 2022) that focus on constructing future LULCC scenarios in relation with the SDGs in order to assess the trade-offs and their implications.

Our review focused on a Europe-centred cartography (CORINE). The bibliometric analysis of the 77 publications obtained in our search highlights the growing interest in the use of CLC in order to gain a clearer picture of land use and land cover change in different parts of Europe and its impact on different environmental issues. Most of the studies we analysed dealt with subjects such as urban growth and the reduction in agricultural land, while also displaying interest in the relation between these LULCC and soil erosion, their effects on flora and fauna dynamics and their

impact on protected natural spaces. The accuracy and disagreement of CLC have also been assessed, as has its applicability with other LULC sources and databases or with climate models.

Most of these studies use the cartography for 2000 and 2006 and almost half of them used more than one time point. Over 60% of the studies used Level 3 of the thematic legend, and a third of them reclassified this legend in order to be able to carry out their analyses. Over half used CLC to make a local study, while almost a third worked at a national scale and only 10% at a regional scale.

As regards the journals in which they were published, we should highlight a special issue of Remote Sensing Journal. The second most popular journal was the Journal of Applied Earth Observation and Geoinformation. In most cases, the publications were written by two or three authors who work in one, two or three institutions in the same country. The relationship between the authors of these publications was in general quite weak.

The results obtained coincide with the bibliometric analyses and the systematic analyses conducted by other scholars (Gomes et al. 2021; He et al. 2022), who highlighted an upwards trend in publications in relation with LULCC studies. This is also evident in the review of CLC by Bielecka and Jenerowicz (2019) in which they highlight this trend. They also found similar results in terms of the main topics analysed (forest fragmentation, soil erosion and loss, agriculture, urbanization or accuracy), although differences can be observed in relation to the authors and their publications, as their article had a broader time spectrum (1989–2019) and analysed more publications than ours.

Our study has an obvious limitation in that we only selected articles with the word "CORINE" in the title. It also has a limited timeframe in that we selected the papers published in the last 11 years. Lastly, there is a limitation in the use of databases, as the search was restricted to the Web of Science Core Collection. If we were to widen the search to other databases such as Scopus or Google Scholar or if we were to extend the timeframe, different results might be obtained. We believe that a broader systematic review which encompasses other bibliographic databases and a longer timeframe is necessary in order to verify the interest and the use made by scientists of the CLC database. As we have previously stated, it is also important to make clear that the results of the analyses carried out with the VOSViewer should be interpreted with caution, in that as they were introduced with crossref the authors' names and sources may not have a consistent format and may not have been harmonized.

Finally, we want to point out that in our selection, there is lack of papers that focus on the use of CLC for policy development or land use, urban or environmental planning in order to offer ways to respond to these changes and challenges. The Sustainable Development Goals for 2030 can only be realized with effective policies, developed according to the specific assets, the cultural background, the resources and criticalities of each country (Bellantuono et al. 2022), and as De Wit and Verheye (2009) make clear, sustainable development approaches may only be put into practice if there is a political will to do so. Therefore, for the achievement of SDG 15, it is also necessary to strengthen the means of implementation and revitalize the multistakeholder and voluntary commitments specified in SDG 17.

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