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Methods for land use impact assessment: A review

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ABSTRACT

Many types of methods to assess land use impact have been developed. Nevertheless a systematic synthesis of all these approaches is necessary to highlight the most commonly used and most effective methods. Given the growing interest in this area of research, a review of the different methods of assessing land use impact (LUI) was performed using bibliometric analysis. One hundred eighty seven articles of agricultural and biological science, and environmental sciences were examined. According to our results, the most frequently used land use assessment methods are Life-Cycle Assessment, Material Flow Analysis/Input–Output Analysis, Environmental Impact Assessment and Ecological Footprint. Comparison of the methods allowed their specific features to be identified and to arrive at the conclusion that a combination of several methods is the best basis for a comprehensive analysis of land use impact assessment.

Contents

1. Introduction

The current stage of development of the world economy is characterized by the increasing level of land use and the environmental impact associated with it (Foley et al., 2005; Lambin and Meyfroid, 2011). The complexity and intensity of the interactions, both natural and man-made lead to a degradation of the land quality, biodiversity reduction,

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food security concerns and lack of environmental sustainability (Reid et al., 2000) at different scales. Since land is one of the most essential resources needed for humans, not only as a living or economic activity space, but also for the ecosystems, it is vitally important to preserve it and prevent possible irreversible effects associated with human activities.

Talking about environmental impacts on land use, two basic land use activities should be considered: land use change and land occupation (Koellner and Scholz, 2007). Land use change (transformation) is a man-made change of the land use from one type to another (e.g. from forests to agricultural crop). On the one hand, such changes could be dramatic and lead to environmental damage (biodiversity decreases, etc.); on the other hand, they can have a positive influence, for example, transformation of built-up areas to gardens or secondary forests. Land occupation is continuous use of some area for a certain period of time for specified land use type. The environmental impact from land occupation could be different (negative or positive). Thus, all human impacts on soil, water, plant and animal life, etc. caused by the land use activities are referred to land use impact (Doka et al., 2002). Such impact not has only ecological consequences, but in so far as land use is part of a worldwide research agenda, sustainable land management is also a political, economic and social issue (Meshesha et al., 2014). Therefore land use impact assessment could be understood in this broad sense. But we should note that in our study we use the term "land use impact assessment" specifically in the context of environmental impact assessment.

Nowadays there are many types of methods, tools and methodologies to assess the environmental impact of land use. Each of them has their own particularities, depending on the specific research purposes. To identify the existing methods used, their scope and scale of application, understand which ones are the most commonly used, for what purposes, and finally highlight the most promising ones for supporting different levels of decision-making, we performed a bibliometric analysis of the state of the art in land use impact assessment. A comparison of the methods is presented in two tables, which offer a view of the essential elements of the issues studied depending on the objectives of each case study.

Since there are no generally accepted definitions of "method", "tool" and "methodology" (see section on *Limits*), we used the following definitions for our research. *Methodology* is a way to solve a research problem that includes collection of rules, practices and procedures and explains why we use specific methods and tools (McGregor and Murname, 2010). *Method* is a technique including a systematic and planned procedure for performing research (McGregor and Murname, 2010). *Tool* is a specific instrument or device that can be used within different methods to carry out a particular task (for example, SimaPro or GaBi in LCA).

Several criteria summarized in Table 1 were chosen to compare the methods and to understand their importance within different contexts of land use.

Table 1
List of criteria chosen to compare the methods with several examples provided in brackets.

"First" group	"Second" group
Criteria (*example*)	
Method type (*analytical or procedure oriented*)	Driving forces *(incentives or regulation)*
Method strategy (*bottom up or top down*)	Application areas (e.g. *territory, product*)
Necessity of use (*voluntary or compulsory*)	Target audiences (e.g. *policy makers*)
Main principle (e.g. *mass balance*)	Indicator levels (e.g. *impact*)
	Input data type (*primary or secondary*)
	Scale (e.g. *global*)
	Combination(s) of methods (e.g. *MFA and LCA*)
	Land use type (e.g. *agricultural*)
	GIS and RS application (e.g. *GIS*)
	Subject division (e.g. *production*)

Our so-called "first" group of criteria was based on the general assumptions typical of each method that were explicit in the definition and generic existing description.

The "second" group of criteria took into account the use of non-evident characteristics of the methods, and this is the basis of our analysis, bringing out the state of the art and usefulness of the methods. These criteria were chosen for different reasons. For instance, knowing that compulsory procedures enforced by policy regulation and markets, could be driving forces favoring the use of some methods more than others, we decided to include the mechanisms promoting their use in our analysis. The application of the methods, and the target audience for whom the study is made, could influence the choice of method depending on the goal of the assessment, hence it was important for it to be included in the study. The next important criteria seemed to be an indicator level showing a qualitative or quantitative measure of the land use impact. Quite often the quality of the outcome depends on the way the data is collected (e.g. sampling) or the accessibility challenge if it is necessary to use external databases. Even though we could assume the data type used in each method, it was very interesting to see how it was developed, knowing that, for example, LCA is very often criticized for using mainly secondary data thus generating considerable uncertainty in results. So, the input data type was another chosen criterion. The geographical scale of the assessment is also of importance, as it shows how the information is represented and generalized spatially and temporally. It was included as a criterion. A comparison of methods could show potential interrelations and possibilities of combining them to obtain a more explicit assessment, so this criterion was also included. Most studied land use type shows the priority of such types in the current state of the knowledge, so appeared to be important. Since land use has spatial and temporal aspects, geographical information system (GIS) and remote sensing (RS) are quite important to be applied to land use assessment studies. Thus, the use of these two tools within the methods was chosen as a criterion. The subject division allows the identification of the fields where land use is most studied.

Comparison according these criteria summarized in two comparative tables (Tables 2 and 3) shows the current state of the art in this area and opens the discussion of their use.

2. Methodology

To achieve the main goal of our study we carried out a bibliometric analysis (BA). We examined several articles discussing different approaches to perform a bibliometric analysis (Coroama and Hilty, 2014; Loiseau et al., 2012; Russell et al., 2011) and decided to use a strategy represented by Russell et al. (2011). Basing on this approach that included two steps: the first is the choice of journals based on scientific journal ranking (SJR) (SCmago Journal & Country Ran) and the second is the choice of key words within those chosen journals we run our study. Among the four possible options for key word search, Publish or Perish software seemed more user-friendly and thus was chosen despite some disadvantages, for example, inaccuracy of results using search by author (Baneyx, 2008). This drawback was avoided by using the key-word search.

Choosing scientific journals that could be relevant to the ecological issue, among the various subject categories proposed by the SJR platform (SCmago Journal & Country Ran), only two categories were retained as being of interest: "*Agricultural and biological sciences*" and "*Environmental Science*". Since the ranking of journals is more or less consistent over time, we chose a default year of 2013 for our study. To take into account the journals of all possible countries in these categories, we did not exclude a journal based on country of origin. Furthermore, we selected the top 100 journals in each category and verified their listing to exclude duplication. In our case the studied categories included several numbers of the same journals. We finally retained just 187.