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## Can bibliometrics help in assessing societal contributions of agricultural research? Exploring societal interactions across research areas

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### Introduction

Research assessment has become increasingly influenced by performance indicators such as journal impact factor, h-index or citation-counts, which are based on scientometric analysis (DORA, 2013; Wilsdon, 2015). While some of these indicators properly used and defined (e.g. in citation percentiles) can be informative in specific contexts, they are less useful for the assessment of organisations or programmes with specific societal missions such as the improvement of health, agriculture, sustainability, or other engineering related fields (Hicks et al., 2015; Bianco et al., 2016).

When the main mission of an organisation or programme is about development in some sector of society (e.g. in technical universities or research technology organisations, as mapped in Noyons and Ferreira, 2018), the use of conventional indicators can be problematic for two reasons. First, because they may be misleading, since better performance in academic terms does not mean better performance in terms of societal contribution. Indeed, there is no evidence that the academic values of research contributions are correlated with the societal values of the same contribution, as shown by Woolley and Robinson-Garcia (2017) using the UK’s REF data.

Second, because the use of bibliometric based assessment in mission-oriented contexts, seems to be leading to ‘goal displacement’, possibly driving researchers away from what are supposed to be their main activities and objectives (Rijcke et al., 2016). The focus on bibliometric criteria such as journal ranking or journal indexing may shape research towards topics that are less interdisciplinary (Ràfols et al., 2012) and less attuned to societal needs, particularly those that are related to local development (Vessuri et al., 2014; Bianco et al., 2016; Chavarro et al., 2017).

Therefore, instead of indicators based on traditional bibliometrics, there is a growing demand for indicators of societal contributions (or “impact”) based on a whole variety of data sources beyond bibliographic databases (Molas-Gallart et al., 2002). In recent years, the controversy on whether and how could metrics based on social-media data (“almetrics”) could help in mapping societal contributions (Bornmann, 2014; Robinson-Garcia et al., 2018) has been particularly prominent.

In this paper, we explore whether and how mapping bibliometric methods combined with other data sources (e.g., mentions in news and policy) can also be useful for mapping potential societal engagement of research fields. We use as a case study of agricultural research, broadly defined, since this is a field that has long been recognised as problematic for conventional bibliometric assessment, particularly in developing contexts (Velho and Krige, 1984; Arvanitis and Chatelin, 1988; Rafols, Ciarli and Chavarro, 2015).

On the one hand, we use conventional bibliometric data such as internal coverage, non-English publications (Van Leeuwen et al., 2001), co-word mapping and the fine-grained classification of science provided by article-level clustering (Waltman and Eck, 2012; Klavans and Boyack, 2017). On the other hand, we explore relative frequency of mentions in policy documents and news items (Noyons and Ferreira, 2018). The comparison of patterns across research areas suggests those areas that may be more directly engaged with societal actors.

This study is one of the research efforts that was instigated in the framework of the informal "Metrics and Indicators in Agricultural Sciences" group of the Research Data Alliance."

## **Methods**

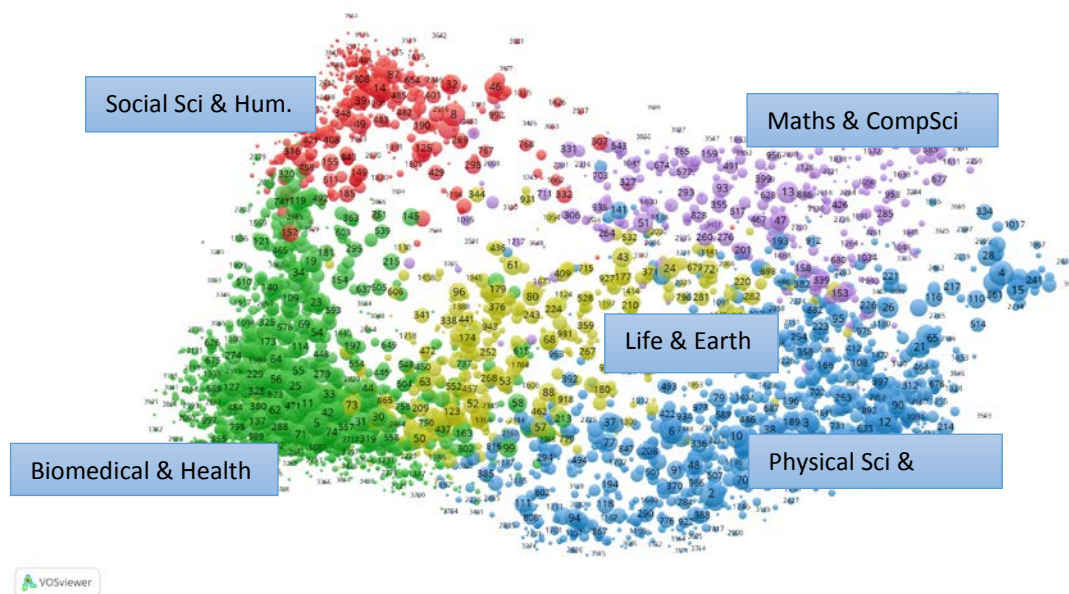
### *Global Map of Sciences*

For this study we used a multi-disciplinary publication and citation database, Web of Science (WoS). It should be noted that this database covers primarily output in journals and hence to a lesser extent fields in which research output is primarily published in non-journals sources, e.g. books, conference proceedings.

We will focus on *agriculture & food science*, positioning it within the broader context of all sciences. This broader context is portrayed with a map of publication-level clusters. These clusters are groups of publications created algorithmically, using direct citations (Waltman & van Eck, 2012). These clusters represent 'research areas' with a consistent epistemic content, and which are sometimes referred to micro-fields. For each cluster we can calculate a variety of statistics (number of publications, growth, citation average, etcetera) and gather relevant information regarding content, actors etc.

A network of citation traffic among these clusters can be rendered as a 2-dimensional representation that provides a map of all sciences (e.g., using the software tool VOSviewer). In this map clusters sharing dense citation traffic are placed in each other's vicinity while clusters with hardly any citation from one to the other are placed in distant positions. This network of around 4,000 clusters represents a structure of the entire landscape, with patterns that have been shown to be robust, even when using various classifications schemes (Klavans and Boyack, 2009; Rafols et al., 2010). The overall structure of sciences is shown in Figure 1.

**Figure 1 Global map of sciences 2000-2016. 4000 micro-fields clustered in 5 main fields**



### *Characterizing individual research areas (micro-fields)*

We can characterize each area in the map on the basis of statistics and other information. In the global map above, we used the number of publications (in 2000-2016) to size the circles. The size varies between less than one thousand to tens of thousands.

The characterizations we use in this study regard:

- Internal coverage. This is a proxy of how well Web of Science covers the area. This indicator is based on the average percentage of references in a paper being covered by Web of Science. The higher this percentage, the better WoS covers this area.
- Coverage of agriculture and food science publications. This regards the absolute number and percentage of publications collected by journals in the field of agriculture and food science.
- Percentage of papers published in a non-English language. This indicator is proxy for research with a local geographical focus.

In the next sections, we will introduce some other indicators to characterize areas.

### *Visualization*

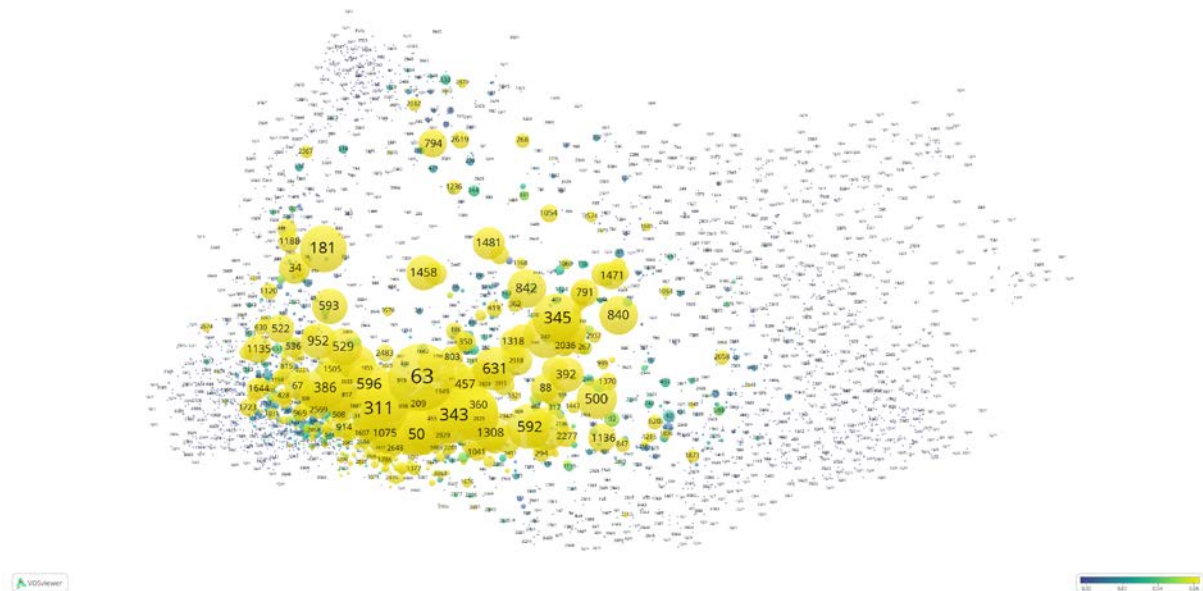
In this paper, the global map of sciences is used as a fixed framework to visualize a variety of properties and thus allowing to compare properties of research areas. This is known as the overlay map technique (Rafols et al, 2010). Each research area is kept in the same position, while in the visualization we vary the size of areas and/or color to characterize them and hence to study distributions. The higher an absolute or relative number of publications (proportion or percentage), the bigger a circle. The color-coding ranges from blue (low) to yellow (high) to indicate a relative measure (percentage or proportion) of a certain property (e.g. non-English language, mentions in policy, etc.)

### **Results (1). Characteristics of agriculture within WoS: database coverage and non-English publications**

First of all, we position and distribute the publications as retrieved by fixed set of journals in the WoS category of agriculture and food science over the global map of sciences (a list of used journal categories used is available at CWTS). The delineation of the fields is shown by

the areas (circles) represented in yellow in Figure 2. Most of it is in life and earth sciences and medical and health sciences. We also see some areas of interest in the social sciences, though.

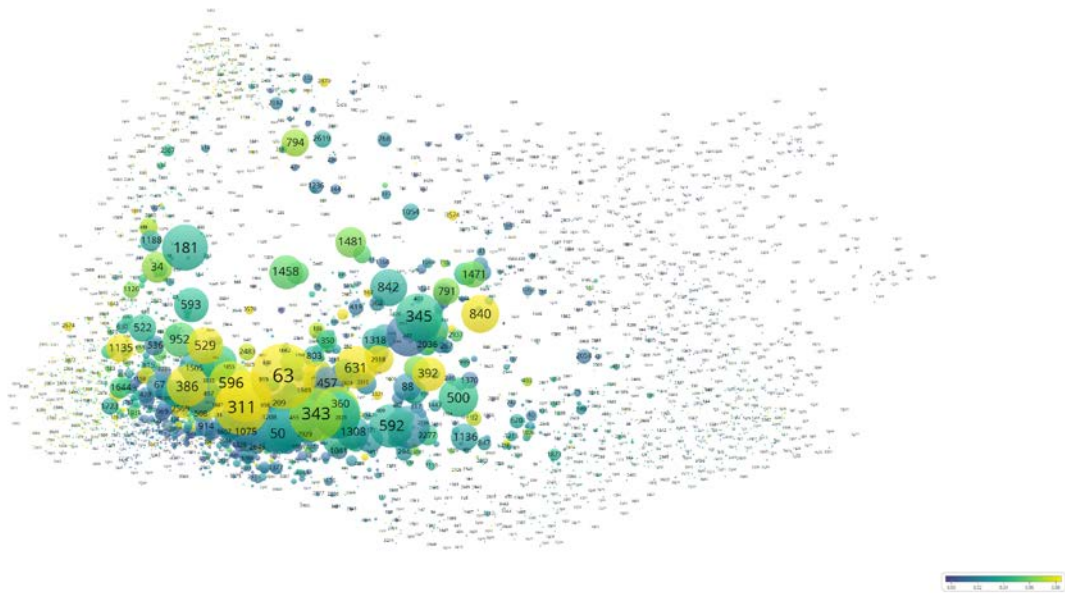
**Figure 2 Global map of science (top), position and distribution of journal-based agriculture-related research in global map. Circle size: absolute number of publications. Color: proportion of publications in a given cluster. The number in the circle indicates the cluster-ID.**



If we now use color coding to investigate the distribution of non-English publications (as shown in Figure 3), we see high proportions in a substantial amount of areas in the core of the field of agriculture. This way of defining a field will pick up all relevant research output, not only publications in agriculture & food science journals. The percentage is not always very high (all yellow areas have values of 10% or above). Nevertheless, the message is clear if we look at the distribution: since non-English publications are associated with communication with local readers, this result indicates that a lot of research in agriculture also has a local emphasis. It is often stated that local focus is mostly found in social science but Figure 3 suggests that some fields in agriculture and food are also related to issues of local concern.

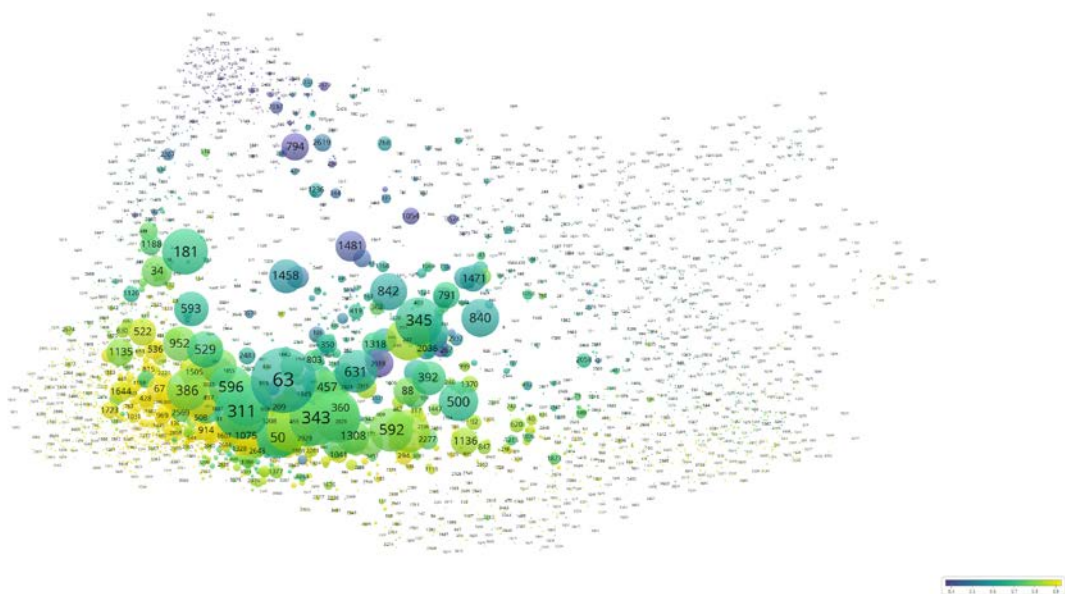
We plan to further investigate the specific issues where non-English particularly high so as to understand the particular drivers, whether crops present in specific countries (e.g. passion fruit in Colombia, Chavarro et al., 2017), agronomic techniques or wider socio-economic issues (e.g. Thailand's focus on rice export, Ciarli and Rafols, 2018).

**Figure 3 Non-English publications (color-coding) and distribution of agriculture (size) over the global map of science.**



The next distribution, in Figure 4, regards internal coverage, a proxy for WoS coverage of a research field or area. In this same map we now color-coded the average percentage of reference in a paper in an area covered by WoS. The distribution shows that the coverage decreases moving from the bottom left (biomedical mainly yellow), towards centre-right (core agriculture mainly in green) the top of the map (social sciences turning towards blue). This demonstrates that within agriculture there are large differences in coverage that are associated with distinctive disciplinary and topic focus. These differences will have an effect on reliability of comparisons of indicators of conventional academic performance such as number of publications or citations. Corrections of the indicators to account for these differences might be explored (e.g. dividing number of publications by coverage estimate).

**Figure 4 Approximate coverage by WoS (color-coding) and distribution of agriculture (size) on the global map of science.**

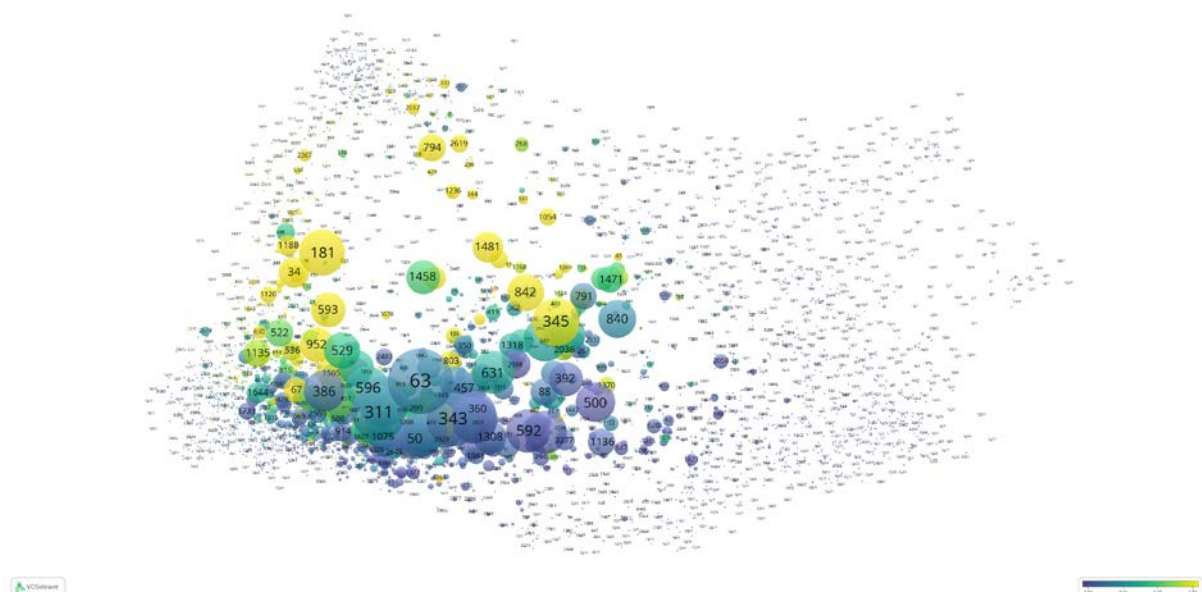


## Results (2). Mapping of policy mentions and news interest

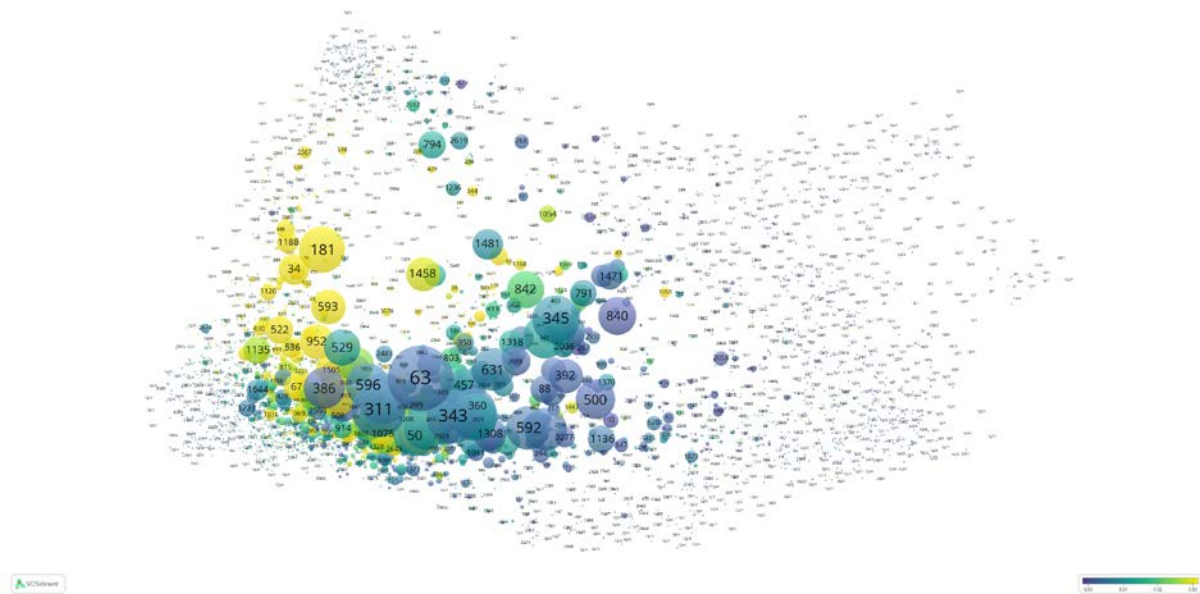
Using Altmetrics.com data on publications covered by WoS, we are also able to investigate distributions of regarding other properties of research (Costas, 2018). Using again the global map of science as a base, we overlay the proportion of publications mentioned in policy documents (Figure 5) and news items (Figure 6). The distributions we can characterize some aspects of policy engagement and of news interest of agriculture research. These two measures refer to different dimensions of science-society interactions, as demonstrated by their different distributions.

While hopefully useful, one should be very cautious about the interpretation of these measures because they are based on explicit mentions to the article – while in fact, studies on social contribution of research emphasize that most policy engagement happens through training or direct personal interaction between academics and policy-makers rather than through formal codified articles (Salter and Martin, 2001; Spaapen and Van Drooge, 2011; Robinson-Garcia et al., 2018).

**Figure 5** Proportion of papers mentioned in policy documents (color-coding) and distribution of agriculture (size) on the global map of science.



**Figure 6 Proportion of papers mentioned in news items (color-coding) and distribution of agriculture (size) on the global map of science.**



Policy engagement is primarily observed in the social and behavioural sciences and health areas of agriculture, but also in soil and climate related areas (middle part of the map). News interest mainly is focused on (mental) health research and food within agriculture research. We plan to test the hypothesis that news coverage reflects consumers' interest in food science in relation to health effects, and lack of interest in issues more related to production and agronomy. A more detailed analysis of policy mentions may reveal which socio-economic issues are more relevant in policy discussions (in countries covered).

### Conclusions

This proceeding paper suggests that although conventional bibliometric performance indicators are not appropriate for assessing mission-oriented research in sectors such as agriculture or health, bibliometric data combined with social media data can be helpful to highlight patterns of interest or engagement of societal actors in research areas.

We should highlight that while the data we build on is patchy and not comprehensive (e.g. in terms of policy mentions), we believe that the patterns observed may be somehow reliable since they are based: i) on research areas (aggregating typically a few hundred papers); and ii) relative (and not absolute) frequency of mentions between research areas.

The overlay mapping of various characteristics of agricultural research shows that there are important differences in the communication and interaction patterns of diverse areas. First, we observe that local issues are relevant in some core-agriculture research areas, as suggested by presence of non-English publications. Second, we find that, within agricultural research, coverage decreases from areas related to biomedical sciences to areas related to social science. Third, the policy mentions show a gradient of increase in the direction from natural to social sciences. However, mentions in the news show a gradient of increase in the direction from earth sciences to biomedical sciences. These general patterns have to be studied in a more fine-grained manner, since there is significant variation between research areas in the same position.

We propose that this type of analyses can be helpful in research assessment but allowing to contextualise the type of contribution of given research areas – e.g. in terms of some research being locally-oriented, with potential policy implications, whereas other research has a global orientation and potential journalistic interest. Also, the analyses can provide a point of departure, for example pointing to topics or formulating hypothesis, to carry out qualitative studies on the science-society interactions

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