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Best management practices from agricultural economics: Mitigating air, soil and water pollution

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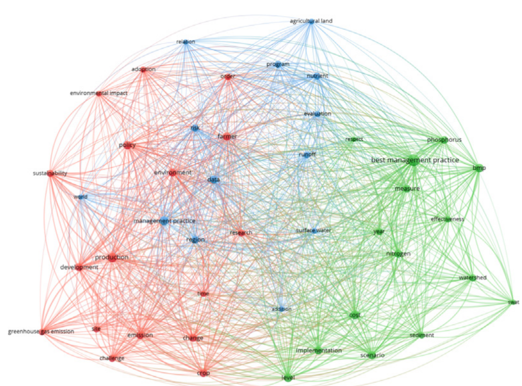
HIGHLIGHTS

- It was stressed the best management practices from the farming sector.
- It was made a literature review considering mainly the Web of Science.
- The crucial role of farmers and of agricultural policies were highlighted.

GRAPHICAL ABSTRACT



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ABSTRACT

Often the several stakeholders involved in the agricultural sector place a greater emphasis on the negative externalities from farming production rather than on the solutions and approaches to mitigate, namely impacts from pollution. The scientific literature, in certain circumstances, follows this tendency leaving a vast chasm of enormous potential left to be explored. It is important to contribute towards the reduction of this gap, highlighting the best management practices implemented across the agricultural sector around the world, specifically to make them more visible and give incentive to the several agents in adopting and spreading their use. In this way, the main objective is to stress the best management practices presented by the global scientific literature from the farming sector. To achieve this objective methodology based on bibliometric analysis-factor-analysis-literature survey approach was considered, applied to 150 documents obtained from the Web of Science (core collection) related with the following topics: best management practice; agricultural economics; air, soil and water pollution. As main insights, it is worth referring the best management practices to deal with problems from agricultural production, such as, for example, the use of agricultural residues as feedstock for renewable energies. With regard to sustainable development in the agricultural sector, concepts such as "sustainable remediation" have their place. On the other hand, the agricultural and environmental policies and the agricultural costs associated with the several farming practices also play a determinant role here. Finally, only fraction of the scientific documents analysed (16 papers) belong to the group of studies related to policies, showing that there are potential subjects to be addressed here in future studies related with these topics. The same happens for cost-benefit analyses (24 documents).

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1. Introduction

Negative externalities from the agricultural sector are a reality and need effective approaches to be mitigated. In fact, farming activities, namely those from conventional agriculture, have relevant contributions for the problems related with air, soil and water pollution. In addition, more attention is frequently focussed on the negative impacts and less so on good practices that may contribute towards a proactive mitigation, stressing the problems further rather than the solutions (Xian et al., 2019).

Sometimes, the great problems related with the several approaches in mitigating the negative externalities from the agricultural sector are the farming costs associated with alternative farming activities such as, for example, the conversion of runoff-prone surfaces to buffers and the installation of good barnyard practices (Rao et al., 2012), specifically those related with the labour inputs as found in organic farming (Jansen, 2000). The agricultural innovation associated with new technologies and nanotechnology, for example, may provide an interesting contribution towards reducing costs and improving agricultural sustainability (D. Wang et al., 2018).

In general, environmental problems from the agricultural sector have their sources, for example, the waste from animal production and the use of fertilizers and plant protection products in crop production (Mourao and Martinho, 2017), as well as, the land use capacity, variation of soil carbon content and loss of fertility. To change these frameworks it is necessary, also, to change the farmers' attitudes and perceptions. One of the most important approaches to mitigating pollution impacts from agricultural economics is to do some work to raise farmers' awareness (Lin et al., 2018).

Another important question will be the consumers' preferences in the future. In fact, due to concerns for human health, consumers will increase, in the next years, their preferences for healthier food. These contexts will force farmers to make significant adjustments in the production systems to meet these new tendencies (Timsina, 2018).

Considering the context described before, it seems that there is, in some frameworks, a gap in the scientific literature to greater stress these good practices in farming activities. In this framework, to contribute to an increase in the outcomes within these issues, the main objective of this study is to highlight the best management practices (practices to promote environmental, social and economic sustainability) from the agricultural sector to mitigate the air, soil and water pollution in a sustainable way. In any case, it is worth mentioning that there are many studies where problem identification is complemented with the very presentation of solutions such as studies explored here as well as others (Bacenetti et al., 2016; Pires, 2019). The principal focus in this research is to stress more upon the solutions and less on the problems. For that purpose 150 documents obtained from all the databases of the Web of Science (2019) were analysed and related with the following topics: best management practice; agricultural economics; air, soil and water pollution. These documents were first explored through the VOSviewer (2019) and Atlas.ti (2019) software tools, grouped with factor analysis and subsequently analysed individually through literature survey. The approaches provided by the VOSviewer and the Atlas.ti allow to better explore and group the 150 documents related with the topics considered. With the factor analysis four indexes (factors) that explain 96.2% of the total variance, related with "Upstream approaches", "Sustainable development", "Policy adjustments" and "Constraints", were found and the several studies were gathered into these groups, in a proportion of 46, 47, 16 and 24 documents associated, respectively, with each index (for the remaining studies it was not possible to associate with an index or it was not possible to import information).

After this introduction, the remaining structure of this study is organized into a second part for the VOSviewer and Atlas.ti analysis, a third part for the literature review, a fourth part for discussions and implications and a final part for the main findings and insights.

2. Data collection and data analysis

This section will explore the scientific documents through VOSviewer and Atlas.ti. The VOSviewer software allows to explore, for example, bibliometric network visualization maps, where the number of times each term appears in the documents and the number of co-occurrences is accounted for. The number of times each term appears is symbolized by the dimension of the respective circle in the map and the number of co-occurrences is represented by the proximity between the terms. This software groups the several terms in clusters considering the number and the strength of the links between terms (van Eck and Waltman, 2018).

In turn, the Atlas.ti software allows for other kinds of analysis, namely because of its exploitation of the entire parts of the documents (the VOSviewer explores namely the titles and the abstracts fields within the documents). However, for some documents it is not possible to obtain more than the title and the abstract. In any case, each software has its specificities and advantages, the option for one or the other depends on the objectives intended. The Atlas.ti allows, also, to export documents in excel format with several statistics for each item, which for example, in some cases, brings about interesting outcomes (Friese, 2018).

2.1. Network visualization map obtained through VOSviewer

The network visualization map presented in Fig. 1 (obtained considering 10 as the minimum number of occurrences of a term) shows that the terms with more occurrences are, namely, the following: bmp; best management practice; production; nitrogen; development; cost; policy; change; management practice; crop; data; environment; level.

Fig. 1 also reveals that the several terms were grouped in three clusters where the terms with more occurrences, in each one, are "best management practice", "production" and "management practice".

The cluster where the term "best management practice" appears shows that phosphorus and nitrogen are the main concerns for the stakeholders, as well as sediments and water pollution. Another question is about the costs associated with these best management practices.

Relative to the cluster associated with the term "production", here the questions related with the environment, sustainability, emissions and crops assume a special relevance. The relationships between development and policies also have their importance in this cluster.

In the cluster related with the terms "management practice" the relevance was given, namely, for aspects related with the agricultural land, evaluation, risks, programs, data and world, where the regional dimension seems to be important.

2.2. Analysing the scientific documents with the Atlas.ti

Considering the terms identified before by the VOSviewer with more occurrences, indexes through factor analysis were created, following, for example, the procedures of Stata (2019) and Torres-Reyna (n.d.). With these indexes the several documents were grouped considering the relative number of occurrences of the respective terms related with each index. In other words, after the indexes' identification, each term was associated with an index and the percentage between the respective number of occurrences was calculated, by document, and the total. Subsequently, each document was associated with the index where it presented the term with higher percentage. Finally, the documents belonging to the same index were grouped together. The number of occurrence for each term, by document, was obtained with the Atlas.ti through a word list (considering the information available for each study and exported from the Web of Science). Whereas the Atlas.ti for the word list, usually, only considers terms individually (not expressions), the following specific terms for the factor analysis were considered: best; production; nitrogen; development; cost; policy; change; management; practice; crop; data; environment; level. For this word

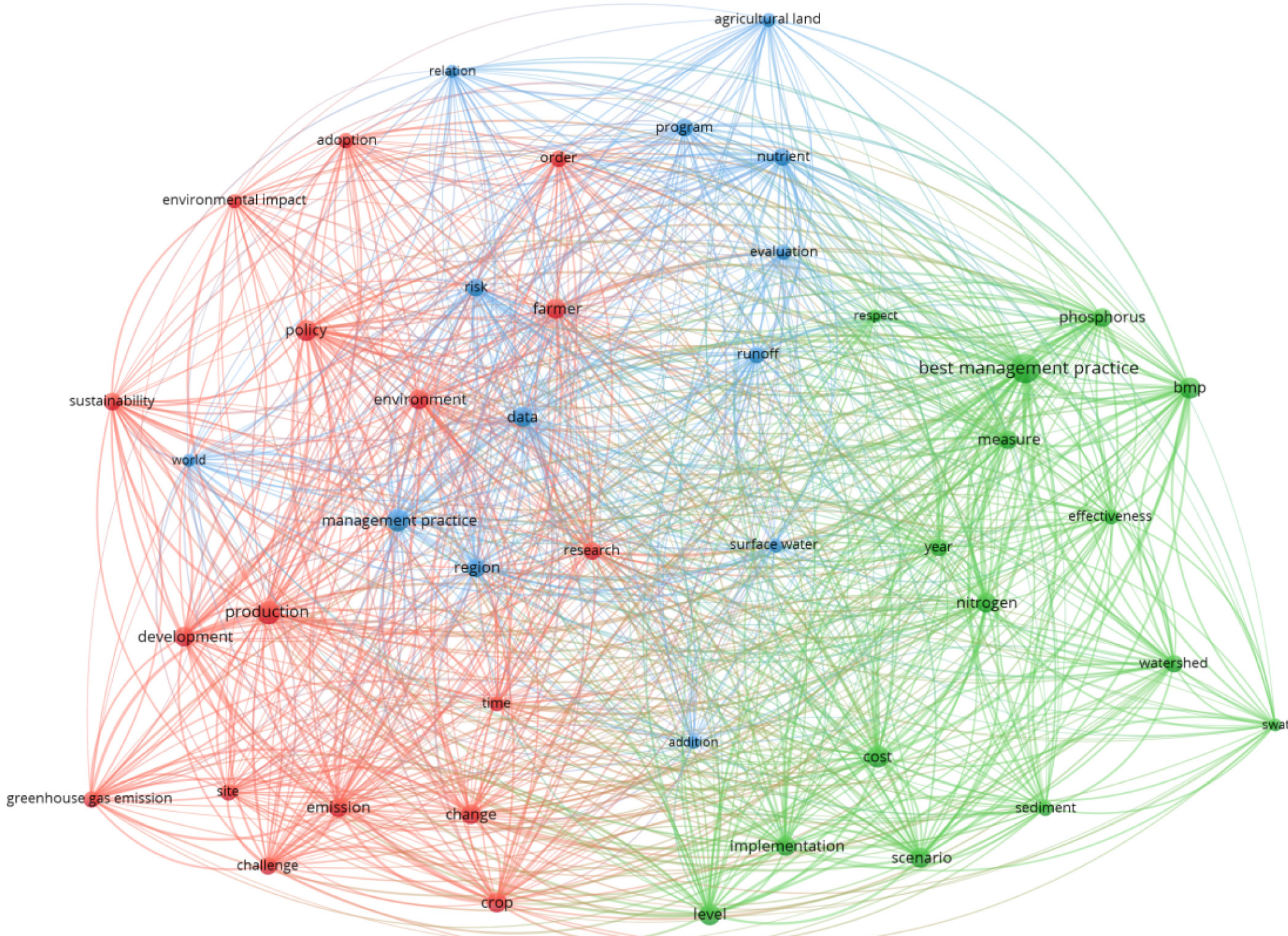

Fig. 1. Network visualization map for topics related with the pollution mitigation from agricultural sector.

list the Atlas.ti considered only 139 (from the 150) documents, because for 11 documents the software was unable to import information (Matthews, 1985; Edwards, 1989; Bode, 1990; Laskowski et al., 1990; Spooner et al., 1990, 1992; Waskom and Walker, 1994; Willis et al., 1994; Castelnuovo, 1995; Line et al., 1997, 1999).

The results in Table 1 show that the first 4 factors with variances greater than 1, explain around 96% of the total variances (cumulative values). On the other hand, Table 2 reveals that in total the variables (terms) have a uniqueness lower than 0.5, as expected (Torres-Reyna, n.d.), with the exception for the term "production" that presents a high value. Table 2 reveals, also, that factor1 is defined by the terms (variables) best, crop, data and nitrogen (considering the higher values for each variable). Factor2 is defined by development, environment, management and practice, factor3 by change and policy and, finally, factor4 by cost and level. Table 3 confirms the adequacy of the sample, taking into account the Kaiser-Meyer-Olkin results.

Table 4 presents the percentages (calculated from the word list produced by the Atlas.ti) considered to associate each document to the several indexes obtained. The index "Upstream approaches" was obtained from factor1. This factor is defined by terms that suggest the need of some planning and data analysis to implement best practices and to avoid problems, namely that with nitrogen from crops. The index "Sustainable development", from factor2, proposes a balanced development, where management practices have their importance. From factor3 the index "Policy adjustments" was created, and from factor4 the index "Constraints", as a result of the problems related to costs in implementing best management practices.

3. Literature survey

This section will further explore the documents inside each index found in the previous sections. For this one subsection for the following four indexes will be considered: upstream approaches; sustainable development; policy adjustments; and constraints. The studies not included in these indexes (the last six documents presented in Table 4) will be distributed across these four subsections.

3.1. Upstream approaches

Nitrogen which is often used as a component in several agricultural activities appears as a determinant contaminant of the air, soil and water (Cerro et al., 2014). However, the big challenge to mitigate its

Table 1
Factor analysis through principal factors with rotation (orthogonal varimax).

Factor	Variance	Difference	Proportion	Cumulative
Factor1	3.419	1.320	0.378	0.378
Factor2	2.099	0.341	0.232	0.611
Factor3	1.758	0.337	0.195	0.805
Factor4	1.421	1.041	0.157	0.962
Factor5	0.381	0.097	0.042	1.005
Factor6	0.283	0.085	0.031	1.036
Factor7	0.198	0.191	0.022	1.058
Factor8	0.007	.	0.001	1.059

Table 2
Relevance of the several terms in each factor.

Variable	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7	Factor8	Uniqueness
Best	0.680	0.465	0.191	0.018	−0.013	0.396	0.019	0.017	0.127
Change	0.108	0.293	0.737	0.056	0.112	−0.037	−0.030	−0.029	0.341
Cost	0.111	0.258	0.125	0.766	0.009	−0.036	0.007	−0.003	0.317
Crop	0.959	0.099	0.044	0.102	0.148	0.056	−0.042	−0.012	0.032
Data	0.736	0.237	0.165	−0.006	−0.063	0.043	0.322	0.012	0.265
Development	0.523	0.645	0.283	0.156	0.015	−0.075	0.065	−0.005	0.196
Environment	0.242	0.533	0.378	0.272	−0.091	0.019	0.276	−0.021	0.355
Level	0.342	0.192	0.429	0.580	0.244	0.114	0.024	0.021	0.253
Management	0.163	0.630	0.291	0.412	0.162	0.292	0.034	−0.048	0.207
Nitrogen	0.948	0.108	0.026	0.156	−0.020	−0.067	−0.009	0.004	0.060
Policy	0.055	0.160	0.771	0.237	−0.026	0.098	0.068	0.024	0.305
Practice	0.232	0.685	0.162	0.231	0.072	−0.006	−0.052	0.044	0.388
Production	0.204	0.154	0.144	0.288	0.491	0.010	−0.043	−0.002	0.588

impact is to find balanced approaches that allow to reduce nitrogen use without compromising the farmers' income (Gutierrez et al., 2018). The drip fertigation seems to be an interesting good practice towards mitigating the impacts from the application of nitrogen and to promote sustainable agricultural production, namely when well managed (Abalos et al., 2014). In fact, best practices in irrigation management are a remarkable strategy for the mitigation of soil salinity and drainage problems (Levers and Schwabe, 2017) and of nitrogen pollution, namely that from off-site contaminations (Cavero et al., 2012). The best management practices seem to be the more adjusted approaches in some contexts (Cai et al., 2018) such as, for example, poultry manure and litter utilization, namely as fertilizer/corrective for crop production (Bolan et al., 2010). Better management practices have their importance in fertilizer application, as well as for the crop protection products use (De Geronimo et al., 2014). This shows that it is important to understand the importance of good management practices across the entire agricultural sector (Furtula et al., 2012), recreational/sports activities (Rice and Horgan, 2013) and other activities outside of agriculture (Gulbaz and Kazezyilmaz-Alhan, 2017). The air, soil and water pollution in last instance pose serious risks to human health (Kostyla et al., 2015). It is worth highlighting, that the soil quality, for example, also, depends on natural conditions (winds, storms, etc) (Pi and Sharratt, 2017).

In some cases, it seems that a rational management of fertilizers and plant protection products is not enough. Organic farming and a demitarian diet for humans appear as a more plausible approach for some frameworks (Billen et al., 2018). However, for an effective and expected feedback from organic farming its principles should be effectively applied (da Silva et al., 2015). The use of agricultural residues such as feedstock for renewable energy production seems to be an interesting approach to mitigation (Brentner et al., 2011), specifically using waste from poultry production (Octavio Rico-Contreras et al., 2017), under specific conditions. Conservation tillage is another relevant way to improve the soil structure, reduce the risks of runoff, energy consumption and improve biodiversity (Holland, 2004). The tillage practices significantly impact environmental quality (Neogi et al., 2014). Needless to mention, grass filter strips as approaches towards reducing the presence of herbicides present in bodies of water (Lafrance et al., 2013), or the conservation buffers for agricultural nonpoint source contamination (Qiu, 2003), or vegetation ditch (Xu et al., 2013), or integrated nutrient-crop management for mitigation in plastic-greenhouses (X. Wang et al., 2018). Some results revealed, also, the unused African terrestrial snail shell as an interesting sorbent to reduce the levels of phosphate in the aqueous systems (Oladoja et al., 2012). In any case, for an effective mitigation it is important to analyse the several combinations of different tillage, cropping, fertilization practices and farmers' incomes and subsequently choose the best, because each context has its specific reality (Naramngam and Tong, 2013). The economic aspects have a determinant contribution towards the adoption of adjusted management practices (Rao et al., 2012), but should be compared with the environmental dimensions (Rodriguez et al., 2011) and social and ecological dimensions (Duguma and Hager, 2011), in a sustainable way (Sterrett et al., 2005).

Table 3
Kaiser-Meyer-Olkin results.

Variable	kmo
Best	0.755
Change	0.727
Cost	0.664
Crop	0.708
Data	0.873
Development	0.888
Environment	0.902
Level	0.865
Management	0.795
Nitrogen	0.770
Policy	0.704
Practice	0.842
Production	0.709
Overall	0.791

To conveniently address the mitigation of air, soil and water pollution it is important to understand the farmers' perceptions, options (Frost et al., 2004) and motivations (Greiner et al., 2009) and how to deal with them (Brock et al., 2018). Extension services to support and inform (Monteny, 2001) the farmers and to give them more vocational training are fundamental (Klove et al., 2017) to effectively mitigate the contamination from the farming sector (Centner, 2004), specifically for a more efficient water use (Goyne and McIntyre, 2003). The extension approaches have their utilities for farmers but, also, for other stakeholders (Monaghan et al., 2016).

There are several approaches to assess the different air, soil and water contamination from agricultural activities such as, for example, the Soil and Water Assessment Tool (SWAT) (Dechmi et al., 2012), or DeNitrification and DeComposition (DNDC) model (Dutta et al., 2018), or Source Load Apportionment Model (SLAM) (Mockler et al., 2017), or dynamic model to predict pesticide water impacts (DynAPlus) (Morselli et al., 2018), although the permanent update of these approaches is fundamental. Other methodologies, in some circumstances considering the previous tools, have as a main intention to join together economic and environmental aspects (Ghebremichael et al., 2013), or cost-benefit framework (Jang et al., 2015), or consider multi-criteria assessments to analyse agronomic, economic, social and environmental dimensions (Giuliano et al., 2016), in a permanent concern for the risk assessment of agricultural contamination. In other cases, the studies compare the performance of different approaches such as ARMOSA, COUPMODEL, DAISY, EPIC, SIMWASER/STOTRASIM and SWAP/ANIMO models (Groenendijk et al., 2014). Other studies suggest strategies for monitoring the irrigation water (Lothrop et al., 2018), or infiltration basin–nitrogen removal (IBNR) models (Xuan et al., 2013), or create indices to assess the soil quality (Yu et al., 2018). New technologies bring about interesting contributions to the rigorous assessments in all societal fields (Zhang et al., 2010).

Table 4
Groups by index, considering the percentage of each term in the total.

	Upstream approaches				Sustainable development				Policy adjustments		Constraints	
	best	crop	data	nitrogen	development	environment	management	practice	change	policy	cost	level
Wang (2018) - Environmental costs and mitigation potential in plastic-greenhouse pepper production system in China: A life cycle assessment	0.599	0.215	0.000	0.000	0.000	0.000	0.364	0.000	0.000	0.000	0.000	0.000
Billen (2018) - Two contrasted future scenarios for the French agro-food system	0.000	0.429	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gutierrez (2018) - An overview of nitrate sources and operating processes in arid and semiarid aquifer systems	0.599	0.429	0.000	0.660	0.000	0.000	0.243	0.000	0.000	0.000	0.000	0.000
Brock (2018) - Bridging the Divide: Challenges and Opportunities for Public Sector Agricultural Professionals Working with Amish and Mennonite Producers on Conservation	0.000	0.000	0.257	0.000	0.000	0.000	0.243	0.000	0.000	0.000	0.000	0.000
Dutta (2018) - Characterising effects of management practices, snow cover, and soil texture on soil temperature: Model development in DNDC	0.000	0.429	0.257	0.000	0.000	0.000	0.364	0.000	0.000	0.000	0.000	0.000
Yu (2018) - Selecting the minimum data set and quantitative soil quality indexing of alkaline soils under different land uses in northeastern China	0.599	0.000	0.514	0.000	0.000	0.000	0.121	0.000	0.000	0.000	0.000	0.000
Morselli (2018) - Predicting pesticide fate in small cultivated mountain watersheds using the DynAPlus model: Toward improved assessment of peak exposure	0.000	0.000	0.257	0.000	0.000	0.000	0.121	0.000	0.000	0.000	0.000	0.000
Cai (2018) - An export coefficient based inexact fuzzy bi-level multi-objective programming model for the management of agricultural nonpoint source pollution under uncertainty	0.599	0.000	0.000	0.000	0.000	0.000	0.485	0.000	0.000	0.000	0.000	0.000
Lothrop (2018) - Optimal strategies for monitoring irrigation water quality	0.599	0.215	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Gulbaz (2017) - An evaluation of hydrologic modeling performance of EPA SWMM for bioretention	0.000	0.000	0.514	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Mockler (2017) - Sources of nitrogen and phosphorus emissions to Irish rivers and coastal waters: Estimates from a nutrient load apportionment framework	2.395	0.000	13.882	4.620	2.959	2.597	2.063	1.724	0.000	3.650	0.714	4.545
Octavio Rico-Contreras (2017) - Moisture content prediction in poultry litter using artificial intelligence techniques and Monte Carlo simulation to determine the economic yield from energy use	0.599	0.000	0.000	0.000	0.000	0.000	0.121	0.000	0.000	0.000	0.000	0.000
Pi (2017) - Evaluation of the RWEQ and SWEEP in simulating soil and PM10 loss from a portable wind tunnel	0.000	0.215	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Levers (2017) - Biofuel as an Integrated Farm Drainage Management crop: A bioeconomic analysis	0.000	1.073	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.730	0.000	0.000
Klove (2017) - Future options for cultivated Nordic peat soils: Can land management and rewetting control greenhouse gas emissions?	1.198	0.215	0.000	0.000	0.000	0.000	0.607	0.000	0.000	0.000	0.000	0.000
Monaghan (2016) - Balancing the Ecological Function of Residential Stormwater Ponds with Homeowner Landscaping Practices	2.395	0.000	0.000	0.000	0.000	0.000	0.485	0.000	0.000	0.000	0.000	0.000
Giuliano (2016) - Low-input cropping systems to reduce input dependency and environmental impacts in maize production: A multi-criteria assessment	0.000	0.429	0.000	0.330	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Kostyla (2015) - Seasonal variation of fecal contamination in drinking water sources in developing countries: A systematic review	0.599	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
da Silva (2015) - Organic farm does not improve neither soil, or water quality in rural watersheds from southeastern Brazil	0.000	0.000	0.514	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Groenendijk (2014) - Performance assessment of nitrate leaching models for highly vulnerable soils used in low-input farming based on lysimeter data	13.174	35.193	21.337	43.894	14.793	6.494	1.699	6.897	5.637	1.460	0.000	5.455
Abalos (2014) - Management of irrigation frequency and nitrogen fertilization to mitigate GHG and NO emissions from drip-fertigated crops	1.198	0.215	0.000	0.330	0.000	0.000	0.364	0.862	0.245	0.000	0.000	0.000
De Geronimo (2014) - Presence of pesticides in surface water from four sub-basins in Argentina	0.000	0.000	0.257	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Cerro (2014) - Simulating Land Management Options to Reduce Nitrate Pollution in an Agricultural Watershed Dominated by an Alluvial Aquifer	0.599	0.000	0.000	0.000	0.000	0.000	0.364	0.000	0.000	0.000	0.000	0.000
Xuan (2013) - System Dynamics Modeling of Nitrogen Removal in a Stormwater Infiltration Basin with Biosorption-Activated Media	0.599	0.000	0.000	0.990	0.000	0.000	0.121	0.000	0.000	0.000	0.000	0.000
Rice (2013) - Evaluation of nitrogen and phosphorus transport with runoff from fairway turf managed with hollow tine core cultivation and verticutting	0.599	0.000	0.257	0.990	0.000	0.000	0.364	0.000	0.000	0.000	0.000	0.000
Xu (2013) - [Estimation of nonpoint source pollutant loads and optimization of the best management practices (BMPs) in the Zhangweinan River basin].	0.000	0.000	0.000	0.330	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

(continued on next page)

Table 4 (*continued*)

Naramngam (2013) - Environmental and economic implications of various conservative agricultural practices in the Upper Little Miami River basin	0.599	0.000	0.000	0.330	0.000	0.000	0.121	0.000	0.000	0.000	0.000	0.000
Lafrance (2013) - Impact of grass filter strips length on exported dissolved masses of metolachlor, atrazine and deethylatrazine: a four-season study under natural rain conditions	0.599	0.000	0.000	0.000	0.000	0.000	0.121	0.000	0.000	0.000	0.000	0.000
Ghebremichael (2013) - Integrated watershed- and farm-scale modeling framework for targeting critical source areas while maintaining farm economic viability	0.599	0.215	0.771	0.000	0.000	0.000	0.243	0.000	0.000	0.000	0.000	0.000
Dechmi (2012) - SWAT application in intensive irrigation systems: Model modification, calibration and validation	4.192	5.150	10.797	0.990	1.775	0.000	1.942	0.000	1.471	0.000	0.000	0.000
Oladoja (2012) - Low-cost biogenic waste for phosphate capture from aqueous system	1.198	0.000	0.257	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rao (2012) - Economic Analysis of Best Management Practices to Reduce Watershed Phosphorus Losses	0.599	0.000	0.000	0.000	0.000	0.000	0.121	0.000	0.000	0.000	0.000	0.000
Furtula (2012) - Inorganic nitrogen, sterols and bacterial source tracking as tools to characterize water quality and possible contamination sources in surface water	0.000	0.000	0.000	0.330	0.000	0.000	0.121	0.000	0.000	0.000	0.000	0.000
Cavero (2012) - APEX simulation of best irrigation and N management strategies for off-site N pollution control in three Mediterranean irrigated watersheds	7.784	8.798	1.542	4.290	1.183	1.299	5.825	0.862	0.980	0.000	0.714	3.636
Rodriguez (2011) - Environmental and economic impacts of reducing total phosphorous runoff in an agricultural watershed	1.796	0.000	0.000	0.000	0.000	0.000	0.607	0.862	0.000	0.000	0.000	0.000
Brentner (2011) - Combinatorial Life Cycle Assessment to Inform Process Design of Industrial Production of Algal Biodiesel	1.198	0.000	0.000	0.000	0.592	0.000	0.121	0.000	0.000	0.000	0.000	0.000
Bolan (2010) - Uses and management of poultry litter	0.599	0.215	0.000	0.330	0.000	0.000	0.243	0.000	0.000	0.000	0.000	0.000
Jiayan (2010) - Robust Transmission of Progressive Images in the Deep Space Communication	0.000	0.000	0.514	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Greiner (2009) - Motivations, risk perceptions and adoption of conservation practices by farmers	0.000	0.000	0.257	0.000	0.000	0.000	0.121	0.000	0.000	0.000	0.000	0.000
Sterrett (2005) - Alternative management strategies for tomato affect cultural and economic sustainability	0.000	0.858	0.000	0.000	0.592	0.000	0.485	0.000	0.000	0.000	0.000	0.000
Holland (2004) - The environmental consequences of adopting conservation tillage in Europe: reviewing the evidence	0.000	0.429	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Centner (2004) - New regulations to minimize water impairment from animals rely on management practices	1.198	0.000	0.000	0.000	0.000	0.000	0.485	0.000	0.000	0.000	0.000	0.000
Frost (2004) - Agricultural environmental management; case studies from theory to practice	0.000	0.000	0.257	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Qiu (2003) - A VSA-based strategy for placing conservation buffers in agricultural watersheds	0.599	0.000	0.000	0.000	0.000	0.000	0.121	0.000	0.000	0.000	0.000	0.000
Goyne (2003) - Stretching water - Queensland's water use efficiency cotton and grains adoption program	0.599	0.000	0.000	0.000	0.000	0.000	0.364	0.000	0.000	0.000	0.000	0.000
Monteny (2001) - The EU Nitrates Directive: a European approach to combat water pollution from agriculture.	0.000	0.000	0.000	0.330	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Amin (2018) - Conservation dairy farming impact on water quality in a karst watershed in northeastern US	0.599	0.644	0.000	0.000	0.000	0.000	0.607	0.862	0.000	0.000	0.000	0.000
Kuppusamy (2017) - Risk-based remediation of polluted sites: A critical perspective	0.000	0.000	0.000	0.000	0.592	0.000	0.243	0.000	0.000	0.000	0.000	0.000
Singh (2017) - Estimating Sediment Delivery Ratios for Grassed Waterways Using Wepp	0.000	0.215	0.000	0.000	0.000	0.000	0.485	0.000	0.000	0.000	0.000	0.000
Primost (2017) - Glyphosate and AMPA, "pseudo-persistent" pollutants under real world agricultural management practices in the Mesopotamic Pampas agroecosystem, Argentina	0.000	0.000	0.000	0.000	0.000	0.000	0.243	0.000	0.000	0.000	0.000	0.000
Blair (2017) - US News Media Coverage of Pharmaceutical Pollution in the Aquatic Environment: A Content Analysis of the Problems and Solutions Presented by Actors	0.000	0.000	0.000	0.000	0.000	2.597	0.243	0.000	0.000	0.000	0.000	0.000
Haas (2017) - Assessing the impacts of Best Management Practices on nitrate pollution in an agricultural dominated lowland catchment considering environmental protection versus economic development	0.000	0.000	0.000	0.000	1.183	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hashemi (2016) - Review of scenario analyses to reduce agricultural nitrogen and phosphorus loading to the aquatic environment	0.000	0.000	0.000	0.330	0.000	0.000	0.364	0.862	0.000	0.000	0.000	0.000
Solazzo (2016) - How effective is greening policy in reducing GHG emissions from agriculture? Evidence from Italy	0.000	0.000	0.000	0.000	0.000	1.299	0.000	0.000	0.245	0.000	0.000	0.000
Rossel (2016) - Soil sensing: A new paradigm for agriculture	0.599	0.000	0.257	0.000	0.592	1.299	0.121	0.000	0.245	0.730	0.000	0.000

Table 4 (*continued*)

Bardos (2016) - The rationale for simple approaches for sustainability assessment and management in contaminated land practice	5.988	0.000	2.057	0.000	12.426	12.987	7.282	13.793	0.000	4.380	13.571	4.545
Hewett (2016) - The decision support matrix (DSM) approach to reducing environmental risk in farmed landscapes	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.862	0.000	0.000	0.000	0.000
Holmes (2016) - Effects of Best Management Practice on Ecological Condition: Does Location Matter?	0.000	0.000	0.000	0.000	0.000	0.000	0.243	0.000	0.000	0.000	0.000	0.000
Antille (2016) - Soil compaction and controlled traffic considerations in Australian cotton-farming systems	0.599	0.429	0.000	0.000	0.592	1.299	0.364	0.862	0.000	0.000	0.714	0.000
An (2015) - Exploiting Co-Benefits of Increased Rice Production and Reduced Greenhouse Gas Emission through Optimized Crop and Soil Management	6.587	6.438	2.828	4.950	2.959	1.299	8.010	10.345	0.980	0.730	0.000	3.636
Viswanathan (2015) - Water quality deterioration as a driver for river restoration: a review of case studies from Asia, Europe and North America	0.599	0.000	0.000	0.000	1.183	0.000	0.243	0.000	0.000	0.000	0.000	0.000
Mullendore (2015) - US farmers' sense of place and its relation to conservation behavior	0.000	0.000	0.000	0.000	0.000	0.000	0.121	0.000	0.000	0.000	0.000	0.000
Sage (2015) - Stormwater Management Criteria for On-Site Pollution Control: A Comparative Assessment of International Practices	3.593	0.000	0.000	0.330	2.367	5.195	9.587	0.862	0.245	0.730	2.143	4.545
Dick (2015) - Life cycle assessment of beef cattle production in two typical grassland systems of southern Brazil	0.599	0.000	1.285	0.990	2.367	2.597	0.971	2.586	0.490	0.000	0.714	0.909
Xu (2015) - An integrated environmental risk assessment and management framework for enhancing the sustainability of marine protected areas: The Cape d'Aguilar Marine Reserve case study in Hong Kong	0.000	0.000	0.000	0.000	0.000	1.299	0.728	0.000	0.000	0.000	0.000	0.000
Blundell (2015) - Using palaeoecology to support blanket peatland management	0.000	0.000	2.314	0.990	11.243	0.000	2.427	6.897	5.147	0.000	0.000	2.727
Jianchang (2015) - Trade-off between water pollution prevention, agriculture profit, and farmer practice-an optimization methodology for discussion on land-use adjustment in China	0.000	0.000	0.000	0.000	0.000	0.000	0.121	13.793	0.000	0.000	0.000	0.000
Aouissi (2014) - Modeling Water Quality to Improve Agricultural Practices and Land Management in a Tunisian Catchment Using the Soil and Water Assessment Tool	0.599	0.000	0.000	0.000	0.000	0.000	0.121	0.862	0.000	0.000	0.000	0.000
Li (2013) - Fine-Particle Emission Potential From Overflowing Areas of the Tarim River	0.000	0.000	0.000	0.000	0.592	0.000	0.121	0.000	0.000	0.000	0.000	0.000
Serpa (2013) - A coupled biogeochemical-Dynamic Energy Budget model as a tool for managing fish production ponds	0.599	0.000	0.257	0.000	0.000	2.597	0.485	0.000	0.000	0.000	0.000	0.000
De Marchis (2013) - Modelling of E. coli distribution in coastal areas subjected to combined sewer overflows	0.000	0.000	0.514	0.000	0.000	1.299	0.000	0.862	0.000	0.000	0.000	0.000
Fu (2013) - Watershed Agricultural Non-Point Source Pollution Management	0.000	0.000	0.000	0.000	0.000	1.299	0.850	1.724	0.000	1.460	0.000	0.000
Pandey (2012) - Greenhouse gas emissions from rice crop with different tillage permutations in rice-wheat system	0.599	0.215	0.000	0.000	0.000	0.000	0.000	0.862	0.245	0.000	0.000	0.000
Panagopoulos (2011) - Reducing surface water pollution through the assessment of the cost-effectiveness of BMPs at different spatial scales	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.862	0.000	0.000	0.714	0.000
Smith (2011) - Nitrate Loading and Isotopic Signatures in Subsurface Agricultural Drainage Systems	0.599	0.215	0.000	0.000	0.000	0.000	0.000	0.862	0.000	0.000	0.000	0.000
Shen (2011) - A framework for priority non-point source area identification and load estimation integrated with APPI and PLOAD model in Fujiang Watershed, China	0.000	0.000	0.000	0.000	0.000	0.000	0.364	0.000	0.000	0.000	0.000	0.000
Li (2011) - Research and Implementation in RFID Authentication Protocol Based on Bloom Filter	0.000	0.000	0.514	0.000	0.000	1.299	0.000	0.000	0.000	0.000	0.000	0.000
Nash (2010) - A Bayesian Network for Comparing Dissolved Nitrogen Exports from High Rainfall Cropping in Southeastern Australia	1.796	6.438	6.427	1.980	7.692	1.299	3.641	0.862	2.206	0.730	0.000	0.909
Britz (2009) - Development of marginal emission factors for N losses from agricultural soils with the DNDC-CAPRI meta-model	0.000	0.215	10.283	0.000	0.592	11.688	0.850	0.000	1.225	1.460	0.714	0.909
Chen (2008) - Agricultural phosphorus flow and its environmental impacts in China	0.599	0.000	0.257	0.000	0.000	1.299	0.121	0.000	0.000	0.730	0.000	0.000
Piehler (2008) - Chapter 12: Watershed management strategies to prevent and control cyanobacterial harmful algal blooms	0.599	0.000	0.000	0.000	0.592	0.000	0.850	0.000	0.000	0.000	0.000	0.000
Han (2007) - Making carbon sequestration a paying proposition	0.599	0.000	0.000	0.000	0.000	1.299	0.121	0.000	0.000	0.000	0.714	0.000
Merrilees (2005) - Review of attitudes and awareness in the agricultural industry to diffuse pollution issues	1.198	0.000	0.000	0.000	0.000	2.597	0.121	0.000	0.000	0.000	0.000	0.000
Reith (2003) - Eco-efficiency analysis of an agricultural research complex	0.000	0.215	0.000	0.000	0.000	0.000	0.364	0.000	0.000	0.000	0.000	0.000
Mantau (2003) - Co-operation between agriculture and water management in the Stever reservoir catchment area - advice and its results	0.000	0.215	0.000	0.000	0.000	1.299	0.243	0.862	0.000	0.000	0.000	0.000
Kao (2003) - A multiobjective model for non-point source pollution control for an off-stream reservoir catchment	0.000	0.000	0.000	0.000	0.592	0.000	0.000	0.000	0.000	0.000	0.000	0.000

(*continued on next page*)

Table 4 (*continued*)

Withers (2002) - Agricultural nutrient inputs to rivers and groundwaters in the UK: policy, environmental management and research needs	0.599	0.000	0.000	0.330	0.000	1.299	0.607	0.000	0.000	0.000	0.000	0.000
Holas (2002) - Integrated watershed approach in controlling point and non-point source pollution within Zelivka drinking water reservoir	0.599	0.000	0.000	0.000	0.592	1.299	0.243	0.000	0.000	0.730	0.000	0.000
Kremser (1997) - Agriculture within the context of HELCOM's - Mandate and activities	0.000	0.000	0.000	0.000	0.000	1.299	0.000	0.000	0.000	0.000	0.000	0.909
Gren (1997) - Nutrient reductions to the Baltic Sea: Ecology, costs and benefits	0.000	0.000	0.000	0.660	0.000	0.000	0.000	0.862	0.000	0.000	0.000	0.000
Egdell (1996) - How can EU livestock policies meet environmental objectives?	0.000	0.000	0.000	0.000	0.000	1.299	0.000	0.000	0.000	0.730	0.000	0.000
Ross (1992) - Risk Characterization and Management of Sewage-Sludge on Agricultural Land - Implications for the Environment and the Food-Chain	0.000	0.000	0.257	0.000	0.000	1.299	0.000	0.862	0.000	0.000	0.000	0.000
Stenholm (1991) - Developing Future-Minded Strategies for Sustainable Poultry Production	0.599	0.000	0.000	0.000	0.000	0.000	0.243	0.862	0.000	0.000	0.000	0.000
Koutsos (2018) - A new framework proposal, towards a common EU agricultural policy, with the best sustainable practices for the re-use of olive mill wastewater	0.000	0.215	0.000	0.000	0.000	0.000	0.364	0.000	0.000	0.730	0.000	0.000
Gomiero (2018) - Large-scale biofuels production: A possible threat to soil conservation and environmental services	0.000	0.000	0.000	0.000	0.592	0.000	0.000	0.000	0.000	0.730	0.000	0.000
Scherer (2017) - Mapping and linking supply- and demand-side measures in climate-smart agriculture. A review	1.198	4.077	1.028	1.320	4.734	5.195	3.398	3.448	26.961	1.460	0.000	1.818
McDowell (2016) - A review of the policies and implementation of practices to decrease water quality impairment by phosphorus in New Zealand, the UK, and the US	0.000	0.000	0.000	0.000	0.000	0.000	0.121	0.000	0.245	2.920	0.000	0.000
Collins (2016) - Tackling agricultural diffuse pollution: What might uptake of farmer-preferred measures deliver for emissions to water and air?	2.395	0.858	5.398	4.290	1.183	3.896	3.519	1.724	4.412	17.518	4.286	1.818
Sieverding (2015) - Meta-Analysis of Soybean-based Biodiesel	0.000	0.000	0.257	0.000	0.000	0.000	0.121	0.000	0.490	0.730	0.000	0.000
Abler (2015) - Economic evaluation of agricultural pollution control options for China	0.599	0.000	0.000	0.000	0.000	0.000	0.121	0.000	0.000	0.730	0.000	0.000
Short (2012) - Reforming Agricultural Nonpoint Pollution Policy in an Increasingly Budget-Constrained Environment	0.599	0.000	0.000	0.000	0.000	0.000	0.121	0.000	0.000	1.460	0.000	0.000
Esteban (2011) - Pigouvian taxation to induce technological change and abate nonpoint pollution in the Ebro Basin, Spain	2.395	6.009	0.771	0.000	0.000	1.299	0.121	0.862	2.941	10.949	7.143	10.909
Bumbudsanpharoke (2009) - Exploring perspectives of environmental best management practices in Thai agriculture: an application of Q-methodology	0.599	0.000	0.000	0.000	0.000	0.000	0.121	0.000	0.000	0.730	0.000	0.000
Dowd (2008) - Agricultural nonpoint source water pollution policy: The case of California's Central Coast	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.460	0.000	0.000
Orr (2008) - Climate change in the uplands: a UK perspective on safeguarding regulatory ecosystem services	5.389	0.644	3.599	1.980	9.467	9.091	8.131	7.759	37.745	24.088	6.429	9.091
Gang (2005) - Nonpoint sources	0.599	0.000	0.000	0.330	0.000	0.000	0.243	0.000	0.000	0.730	0.000	0.000
Weaver (1996) - Efficacy of standards vs incentives for managing the environmental impacts of agriculture	0.000	0.215	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.730	0.000	0.000
Lakshminarayan (1995) - A Multiobjective Approach to Integrating Agricultural Economic and Environmental Policies	0.000	0.215	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.650	0.000	0.000
Petersen (1993) - Soil Conservation Policy and Law in United-States Agriculture	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.920	0.000	0.000
Balafoutis (2017) - Precision Agriculture Technologies Positively Contributing to GHG Emissions Mitigation, Farm Productivity and Economics	0.000	10.730	2.828	16.832	4.142	3.896	6.068	4.310	3.186	1.460	27.857	10.000
Durand (2017) - Agroecological transition: A viability model to assess soil restoration	0.599	0.000	0.257	0.000	0.000	0.000	0.121	0.000	0.000	0.000	2.857	0.000
Romshoo (2017) - Hydrochemical characterization and pollution assessment of groundwater in Jammu Siwaliks, India	0.599	0.000	0.000	0.000	0.592	0.000	0.121	0.000	0.000	0.000	0.000	0.909
Cundy (2016) - Brownfields to green fields: Realising wider benefits from practical contaminant phytomanagement strategies	2.994	0.000	2.571	0.000	1.775	0.000	3.762	5.172	0.000	0.000	7.857	0.000
Mahjoobi (2016) - Management of unregulated agricultural nonpoint sources through water quality trading market	0.599	0.000	0.000	0.000	0.592	0.000	0.121	0.000	0.000	0.730	1.429	0.909
Bichsel (2016) - Water quality of rural ponds in the extensive agricultural landscape of the Cerrado (Brazil)	0.000	0.000	0.000	0.000	0.000	0.000	0.243	0.000	0.000	0.000	0.000	2.727
Makkar (2016) - Smart livestock feeding strategies for harvesting triple gain - the desired outcomes in planet, people and profit dimensions: a developing country perspective	0.000	0.000	0.514	0.000	1.183	0.000	0.000	0.000	0.245	0.730	0.000	1.818

Table 4 (*continued*)

Talberth (2015) - Pay for Performance: Optimizing public investments in agricultural best management practices in the Chesapeake Bay Watershed	0.599	0.000	0.000	0.000	0.000	0.000	0.121	0.000	0.000	0.730	1.429	1.818
Yang (2015) - Spatial optimization of watershed management practices for nitrogen load reduction using a modeling-optimization framework	0.000	0.000	0.000	0.330	0.000	0.000	0.243	0.000	0.000	0.000	0.714	0.000
Sohngen (2015) - Nutrient prices and concentrations in Midwestern agricultural watersheds	0.599	0.000	0.000	0.660	0.000	0.000	0.121	0.000	0.000	0.000	0.714	0.000
Martinez-Martinez (2015) - Assessing the significance of wetland restoration scenarios on sediment mitigation plan	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.245	0.000	0.714	5.455
Wang (2015) - Greenhouse gas intensity of three main crops and implications for low-carbon agriculture in China	0.599	6.652	1.799	2.640	2.367	0.000	3.277	0.000	2.941	4.380	2.143	7.273
Liu (2014) - Cost-effectiveness and cost-benefit analysis of BMPs in controlling agricultural nonpoint source pollution in China based on the SWAT model	0.000	0.000	0.000	0.330	0.000	0.000	0.607	0.862	0.000	0.000	0.000	3.636
Abdalla (2014) - Simulation of CO2 and Attribution Analysis at Six European Peatland Sites Using the ECOSSE Model	0.599	0.000	0.000	0.000	0.000	0.000	0.485	0.862	0.000	0.000	0.000	0.909
Giri (2014) - Application of analytical hierarchy process for effective selection of agricultural best management practices	0.599	0.000	0.000	0.330	0.000	1.299	0.364	0.000	0.000	0.000	1.429	3.636
Sommerlot (2013) - Evaluating the impact of field-scale management strategies on sediment transport to the watershed outlet	0.599	0.000	0.000	0.000	0.000	0.000	0.364	0.000	0.000	0.000	1.429	0.000
Panagopoulos (2013) - Multi-objective optimization for diffuse pollution control at zero cost	0.599	0.215	0.000	0.000	0.000	0.000	0.850	0.000	0.000	0.000	2.143	0.000
Maringanti (2011) - Application of a Multi-Objective Optimization Method to Provide Least Cost Alternatives for NPS Pollution Control	0.000	0.000	0.000	0.660	0.000	0.000	0.607	0.000	0.000	0.000	1.429	0.000
Keipert (2008) - Guiding BMP adoption to improve water quality in various estuarine ecosystems in Western Australia	0.599	0.000	1.285	0.330	4.734	2.597	4.612	1.724	0.490	0.730	5.714	0.909
Boadi (2004) - Mitigation strategies to reduce enteric methane emissions from dairy cows: Update review	0.000	0.000	0.000	0.000	0.000	0.000	0.121	0.000	0.000	0.000	0.714	0.000
Pacini (2003) - Evaluation of sustainability of organic, integrated and conventional farming systems: a farm and field-scale analysis	0.000	0.215	0.000	0.660	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.727
Sandor (2002) - Greenhouse-gas-trading markets	0.000	0.000	0.000	0.000	0.592	0.000	0.243	0.000	0.735	1.460	2.143	0.000
McIntosh (2000) - The potential impact of imposing best management practices for nutrient management on the US broiler industry	0.000	0.000	0.000	0.000	0.000	0.000	0.121	0.000	0.000	0.000	0.714	0.000
Logan (1993) - Agricultural Best Management-Practices for Water-Pollution Control - Current Issues	0.599	0.000	0.000	0.000	0.000	0.000	0.121	0.000	0.000	0.000	0.000	0.909
Guyader (2016) - PRODUCTION, MANAGEMENT, AND ENVIRONMENT SYMPOSIUM: Forage use to improve environmental sustainability of ruminant production	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Jang (2015) - Prioritizing Watersheds for Conservation Actions in the Southeastern Coastal Plain Ecoregion	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Neogi (2014) - Soil respiration, labile carbon pools, and enzyme activities as affected by tillage practices in a tropical rice-maize-cowpea cropping system	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Duguma (2011) - Farmers' Assessment of the Social and Ecological Values of Land Uses in Central Highland Ethiopia	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Dadfar (2010) - Development of a method for estimating the likelihood of crack flow in Canadian agricultural soils at the landscape scale	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Centner (2001) - Evolving policies to regulate pollution from animal feeding operations	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

3.2. Sustainable development

The great challenge is to improve agricultural production, as a supplier of public goods (Solazzo et al., 2016), to achieve the demand for food from the population without compromising environmental quality (Amin et al., 2018) and be socially accepted (Stenholm and Waggoner, 1991). The same happens in other sectors (Serpa et al., 2013). One of the main concerns will be the conservation of water quality (Aouissi et al., 2014). The concerns with sustainability brought about expressions such as "sustainable remediation" and conducted the international community to create concepts about this topic and to include them in the ISO rules (Bardos et al., 2016). In fact, land contamination with chemical products and its remediation are relevant topics for the international stakeholders (Kuppusamy et al., 2017), as well as for the restoration of ecosystems (Viswanathan and Schirmer, 2015).

In these discussions about sustainable practices it is important to listen to the several stakeholders (Blair et al., 2017), because the contamination source has several origins (De Marchis et al., 2013). The involvement of the several stakeholders is fundamental for the success of any strategy (Haas et al., 2017) and reducing environmental risks (Hewett et al., 2016). With regards to sustainable development there are several approaches (Li and Sui, 2011). In some cases, sustainable development depends on natural conditions (Li et al., 2013) for example, soil type, slope, drainage class (Nash et al., 2010), which brings about additional difficulties. For an effective sustainable development it is crucial to provide advisor services (Merrilees and Duncan, 2005), where strategic plans may bring providential support (Mullendore et al., 2015), as well as the development of indicators of pollution and risks (Dadfar et al., 2010).

This commitment, between the economic and the environmental, requires adjusted management practices, namely by simultaneously controlling the agricultural productivity and the environmental impacts (An et al., 2015). In these frameworks, It is important to make the several dimensions of the farming sector compatible, namely those related with the economic, social and environmental fields (Dick et al., 2015). To address all these dimensions multidisciplinary approaches are required (Gren et al., 1997), international commitments (Kremser, 1997), co-operation between the several actors (Mantau, 2003) and involving researchers (Piehler, 2008). The agricultural sector has relevant contributions for environmental contamination (Fu et al., 2013), but has, also, several activities and systems that significantly support pollution mitigation (Egdell and Dixon, 1996), specifically contributing to carbon sequestration (Han et al., 2007). The concept of efficiency may have a relevant contribution here for an optimized and sustainable use of resources (Antille et al., 2016), or more specifically the concept of eco-efficiency (Reith and Guidry, 2003). Indeed, in some cases, a significant part of the agricultural resources used, namely fertilizers, may go into the environment (Britz and Leip, 2009). The historic archives may give relevant insights for sustainability restoration in some ecological and agricultural systems (Blundell and Holden, 2015). In certain contexts, adjusted changes in the agricultural systems bring interesting outcomes in terms of pollution mitigation (Guyader et al., 2016).

The understanding of nutrient flow, linkages and impacts (Withers and Lord, 2002) in agricultural systems (Holas and Hrncir, 2002), or in waterways (Singh et al., 2017), is crucial for the implementation of adjusted management practices and strategies, namely when coming from nonpoint sources (Kao and Chen, 2003). Because, in some circumstances, it may be possible to harmonise the flows between systems (Chen et al., 2008). The nonpoint sources of pollution are, in general, difficult to manage and control (Shen et al., 2011).

Concerning adjusted management practices, it is important to be aware that the specific conditions change spatially (Hashemi et al., 2016) with the local environment and specificities (Holmes et al., 2016), it depends on the objectives intended (Panagopoulos et al., 2011) and sometimes land use adjustments are needed (Jianchang et al., 2015). In the processes of implementation of adjusted management practices, monitoring plans are required to understand the many factors that may influence the results intended (Pandey et al., 2012), the adequacy of which should be permanently revised and assessed (Primost et al., 2017). These questions are particularly pertinent when new management practices are implemented (Ross et al., 1992), to deal with new realities that call for innovative strategies (Sage et al., 2015), sometimes combining different approaches (Smith and Kellman, 2011). The new technologies of information and communications provide new tools for these assessments (Rossel and Bouma, 2016), namely for the communication between stakeholders and information exchange (Xu et al., 2015).

3.3. Policy adjustments

The several policies play a determinant role for sustainable development and to promote adjusted management practices (Abler, 2015). The agricultural policies and regulations if well designed may bring interesting contributions to the mitigation of pollution, namely those implemented through positive stimuli (subsidies). In some cases, the adoption of punitive approaches (taxes) drive for better results (Esteban et al., 2011). However, the success of any plan to introduce new strategies in the agricultural sector should consider the involvement of several stakeholders (Bumbudsanpharoke et al., 2009), namely the farmers in order to understand which policy instruments should be more readily available to implement (Collins et al., 2016). Because, sometimes, the several stakeholders have effective obstacles in place against adjusted implementation of new policies and regulations, namely those from context and technical conditions (Dowd et al., 2008), or from trade-offs between environmental and economic objectives (Lakshminarayan et al., 1995). These barriers, frequently, appear in the policy design process, specifically in cases of nonpoint sources of pollution, where it is more difficult to find useful information (Gang et al., 2005). The mitigation of nonpoint pollution is a great task for the policymakers (Shortle et al., 2012). In any case, it is important to continuously assess, monitor and rethink the strategies adopted for agricultural and rural development (Gomiero, 2018), because the contexts and the tendencies change over time (Sieverding et al., 2015).

The Common Agricultural Policy, from the European Union, is a specific case, where common instruments may support broader and more uniform intended adjustments (Koutsos et al., 2018), however these frameworks make it more difficult to take into account specific and local realities.

The success of policy and regulation implementation depends, indeed, on the design of adjusted instruments, where, in specific contexts, it is relevant to consider land use changes (McDowell et al., 2016), and the farmers' options (Weaver et al., 1996), but, also, it is crucial to be aware of the local and specific conditions (Orr et al., 2008). Realities around the world are diverse and have changed significantly over the last decades (Petersen, 1993). The policy approaches across several countries to deal with these contexts are, also, diverse (Centner, 2001). Global warming and secure food provision are some of the main future challenges for the agricultural policymakers (Scherer and Verburg, 2017).

3.4. Constraints

One of the main constraints towards better management practices are, indeed, the costs associated with the pollution mitigation approaches relative to conventional activities (McIntosh et al., 2000), nonetheless the cost-effectiveness of any measures depends on each local characteristics (Panagopoulos et al., 2013), on the policies designed (Talberth et al., 2015) and on the combination; policies-local conditions (Wang et al., 2015). The implications in terms of costs are always a concern in any new proposal to reduce the environmental impact from farming production (Boadi et al., 2004). Another question raised is that concerning the trade-off between management practices (Abdalla et al., 2014). Precision agriculture, new technologies and new advances in biotechnology may bring relevant contributions to help in these trade-offs (Balafoutis et al., 2017) and support in order to find new solutions (Yang and Best, 2015). The pollutants markets may, also, bring interesting contributions for these frameworks (Sandor et al., 2002).

The international context around the world promoted, over the last decades, the intensification of agriculture and with this, changes in agricultural systems (Bichsel et al., 2016) and in the ecosystems (Martinez-Martinez et al., 2015). However, in recent years, albeit not all with the same level of commitment, the several stakeholders became more concerned with the need of changing farming systems into more sustainable approaches (Durand et al., 2017). In any case, there are no perfect systems. In fact, for example, organic farming has its virtues, including in some cases higher gross margins (because of the higher prices and lower costs with fertilizers), but may promote more soil erosion in certain specific conditions (Pacini et al., 2003).

In any case, there are sustainable management practices for different implicit costs (Keipert et al., 2008), some with lower negative impacts on the relation costs-benefits (Cundy et al., 2016), depending on the specific context (Sohngen et al., 2015) and the approach considered (Sommerlot et al., 2013), or others with farming profit (Mahjoobi et al., 2016). In general, the costs associated with best management practices are those related to investments, maintenance and opportunity costs (Giri and Nejadhashemi, 2014). The best management practices are usually related with land use, tillage and fertilizers application (Liu et al., 2014) and plant protection products (Maringanti et al., 2011). More specifically, in the livestock sector the contributions for sustainability may come more from the use of feed resources and feeding strategies (Makkar, 2016). Sometimes there is a need for greater awareness regarding the consequences of pollution

(Logan, 1993), to better understand medium, long-term plans of mitigation and the respective costs, because poor environmental quality compromises economic development (Romshoo et al., 2017).

4. Discussions and implications

The approach considered in this study deserves some discussion in the beginning of this section. In fact, bibliometric analysis was considered, through the VOSviewer and Atlas.ti software and approaches, complemented with factor analysis and literature survey. Several studies (150 documents) were considered for this analysis and were obtained from the platform Web of Science for the following topics: best management practices; agricultural economics; air, soil and water pollution. This approach of bibliometric analysis-factor analysis-literature survey has its degree of innovation and follows studies such as, for example, that developed by Martinho (2018). In the bibliometric analysis, the VOSviewer software allowed to obtain an initial picture about the main terms related with the topics considered and the Atlas.ti proved useful to produce a word list used for the factor analysis. From the factor approach, considering the number of times each term appeared in each study, it was found that the several documents (139 studies, because for 11 studies the Atlas.ti was unable to import any information) could be associated with the following four factors (indexes): "Upstream approaches"; "Sustainable development"; "Policy adjustments"; and "Constraints". Furthermore, this factor analysis made it possible to relate each index with the respective terms. The upstream approaches (first index) are related with words such as "best", "crop", "data" and "nitrogen", showing the importance of analysis upstream to support best management practices to deal with the pollutants (nitrogen) impacts. The second index related with terms such as "environment", "development", "management" and "practice" reveals the importance of adjusted management practices for sustainability. The third index is related with the items "change" and "policy" and the fourth associated with words such as "level" and "cost". This factor analysis was crucial to support and better organize the literature survey and to cluster the several scientific documents.

The literature survey also raises a specific discussion. Farming production ("Upstream approaches") shows that nitrogen, along with other pollutants, do in fact bring about, great challenges for agricultural sustainability around the world. Nonetheless, there are interesting best management practices to mitigate these problems such as, for example, the drip fertigation (Abalos et al., 2014), use of agricultural residues as feedstock for renewable energies (Brentner et al., 2011), conservation tillage (Holland, 2004), grass filter strips (Lafrance et al., 2013), conservation buffers (Qiu, 2003), vegetation ditch (Xu et al., 2013), integrated crop-nutrient management (X. Wang et al., 2018) and unused African terrestrial snail shell (Oladoja et al., 2012). Another way is to consider alternative/complementary approaches such as organic farming and the demitarian human diet (Billen et al., 2018). In any case, the farmers' involvement and extension/advisor services play a determinant role, here. Finally, there are many methodologies for environmental quality assessment, where the Soil and Water Assessment Tool (SWAT) seems to be one of the most considered (Dechmi et al., 2012). To spread and implement these best management practices in agricultural production, institutions and agricultural policies have a relevant role, here. On the subject of "Sustainable development" the literature reveals that the main topic of discussion for sustainability is and will be the trade-off between farming profitability and the environment protection. In these contexts concepts such as "sustainable remediation" will be the order of the day (Bardos et al., 2016). For the commitment between the economic and environmental dimensions, it is important to find continuously adjusted management practices, where the multidisciplinary approaches, international co-operation and involvement of the several stakeholders may bring interesting insights and outcomes (Mantau, 2003). The new technologies of information and communication, also, provide a crucial contribution here, namely for a better context in understanding and for a better information exchange between the several stakeholders.

In these frameworks, in terms of practical implications, the policy instruments and the regulations ("Policy adjustments") have their contributions for sustainable evolution (Abler, 2015), which may be implemented through positive stimuli or punitive taxes. It is important to design adjusted strategic plans considering the specific characteristics of each reality and, again, involve the several stakeholders, namely the farmers in the processes of policy creation. The several costs associated with the best management practices implementation are and will be ("Constraints") always a constraint for the measures of mitigation. However, the concepts of efficiency and precision agriculture may support to solve these trade-offs (Balafoutis et al., 2017). In general, the costs related with better management practices are those associated with the investments, maintenance and opportunity costs. Finally, it will be important to raise awareness amongst the several stakeholders that sustainable development is a medium, long-term plan, where costs today may be revenues tomorrow.

5. Main insights

The approach here explored for these topics combining the bibliometric analysis (considering outputs from the VOSviewer and Atlas.ti software)-factor analysis-literature survey proved to be adjusted and brought interesting insights to the discussion about the best management practices in the agricultural sector to mitigate soil, air and water pollution. This model may be easily applied to other topics and in other contexts around the world.

The outcomes obtained with this study show that any discussion about best management practices in the agriculture sector should consider, at least, the following four dimensions: agricultural practices; sustainable development; agricultural policies; and relations benefits-costs. In agricultural practices the main attention must be paid to fertilizers and crop protection products, but, also, to alternative farming and social practices such as, for example, organic farming and the demitarian human diet. For a sustainable development the multidisciplinary approaches, the networks and the co-operation between the several stakeholders will be crucial. The agricultural and environmental policies may have here, in these contexts, a determinant contribution towards promoting best management practices in agriculture and to share the best sustainable practices with farmers. Finally, the relations benefits-costs may be in some cases a constraint towards implementing best practices, however, there are several examples where the adoption of sustainable approaches is more profitable. In any case, concepts such as productivity, efficiency and innovation may bring relevant insights to this discussion. Innovation will provide the future for all dimensions of socioeconomic frameworks and, indeed, may contribute significantly to improvements in the agricultural sector.

The study developed here can be an interesting contribution for the several stakeholders related with agricultural economics, namely for public institutions (at a national and international level) and for the policymakers. The outcomes obtained in this study may be considered as a basis for designing policies that further promote good practice in farms and to inform/train farmers about these approaches and about the new challenges for the future in the related sectors both upstream and downstream from agriculture.

In any case, to promote, implement and spread agricultural good practices in order to mitigate multilevel pollution it is fundamental to understand the perceptions and involve the several stakeholders, namely the farmers. Without this involvement there is the risk of the farmers' failure to understand or a risk of them formulating the wrong perceptions about the importance of each policy instrument and this may compromise the compliance of these strategies.

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