BRUNO PONTES COSTANZO

INNOVATION IN IMPACT ASSESSMENT: A BIBLIOMETRIC REVIEW AND A PRACTICAL TEST

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Área de Concentração: Engenharia Mineral

Orientador: Prof. Dr. Luis Enrique Sánchez

São Paulo
2017

Este exemplar foi revisado e corrigido em relação à versão original, sob responsabilidade única do autor e com a anuência de seu orientador.

São Paulo, _____ de _____ de _____

Assinatura do autor: _____

Assinatura do orientador: _____

Catalogação-na-publicação

Costanzo, Bruno
Innovation in Impact Assessment: A Bibliometric Review and a Pratical Test / B. Costanzo -- versão corr. -- São Paulo, 2017.
111 p.

Tese (Doutorado) - Escola Politécnica da Universidade de São Paulo. .

1.Innovation 2.Impact Assessment 3.Evolution 4.Bibliometric I.Universidade de São Paulo. Escola Politécnica. II.t.

DEDICATÓRIA

Aos meus amores: filhos, esposa, irmãos e pais.

AGRADECIMENTOS

Agradeço novamente ao professor Luís Enrique Sánchez por ter me aceitado mais uma vez como orientando, sempre com muita generosidade e dedicação.

Aos meus companheiros de trabalho da Walm Engenharia e Tecnologia Ambiental, que me ensinam sobre avalição de impactos ambientais cotidianamente. Agradecimento especial à Laura Rocha de Castro, que me ajudou muito nos projetos em que eu estava envolvido, permitindo meu engajamento pleno no doutorado na reta final do mesmo.

Às minhas filhas Lívia e Beatriz pelo carinho santo que tanto me ajuda. Ao meu filho Luiz pela dose de sorriso diário. À minha esposa Luciele pelo companheirismo e pelas revisões do texto. Ao meu irmão Caetano e pai Jacinto, meus ídolos e eternos companheiros. À minha mãe Evanisa e irmã Iara pelo amor incondicional de sempre, e por me ajudar com as crianças em alguns finais de semana, permitindo meu foco no projeto de doutorado.

EPÍGRAFE

Sou um tupi tangendo um alaúde!
(Mário de Andrade)

RESUMO

Um estudo bibliométrico foi desenvolvido para identificar as principais inovações e lacunas apontadas pela pesquisa científica em avaliação de impactos (AI). Dos 1.547 artigos publicados entre 1990 e 2015 nos dois periódicos de maior relevância na área, o IAPA e o EIAR, 381 artigos tiveram seus conteúdos analisados em relação a novas abordagens metodológicas ou propostas para melhoria da prática.

Verificou-se que as inovações e lacunas são tratadas predominantemente desconsiderando a base teórica de AI. Sugerimos que os valores fundamentais da avaliação de impactos devem sempre orientar a inovação. Propõe-se que as fronteiras teóricas de um Sistema AI sejam estabelecidas previamente ao se discutir a inovação. A informação sistematizada através de uma abordagem bibliométrica permitiu propor uma estrutura que correlaciona os fundamentos teóricos da avaliação de impactos com as opções de inovação.

Palavras chaves: Eficácia; avaliação de impactos ambientais; sistemas; inovação; bases teóricas; mineração.

ABSTRACT

A bibliometric study was carried out to identify the main innovations and shortcomings pointed out by scientific research on impact assessment (IA). Out of 1,547 articles published between 1990 and 2015 in two leading journals, IAPA and EIAR, 381 were reviewed for their contents related to new methodological approaches or proposals for improving practice.

It was found that innovations and gaps are predominantly treated disregarding IA's theoretical basis. We suggest that IA core values shall always guide innovation. It is proposed that the theoretical boundaries of an IA System shall be previously stablished when discussing innovation. The information systematized through a bibliometric approach allowed to propose a framework that correlates IA theoretical foundations with innovation options in a vertical integration way.

Keywords: Effectiveness; environmental impact assessment; systems; innovation; theoretical basis; mining.

LISTA DE ILUSTRAÇÕES

LISTA DE QUADROS

LISTA DE ABREVIATURAS E SIGLAS

ARA	Arquivo de Regularização Ambiental
CBA	Cost benefit analysis
CE	choice experiments
CEA	Cumulative effect assessment
CIA	Cumulative impact assessment
CV	Valuation approach
DNPM	Departamento Nacional de Produção Mineral
EA	Environmental assessment
EF	Ecological Footprint
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statements
ES	Ecosystem Services
FEAM	Fundação Estadual do Meio Ambiente - FEAM
GIS	Geographic information system
IA	Impact Assessment
IO	Input-output model
VEC	Valued ecosystem components

SUMÁRIO

1. Introduction

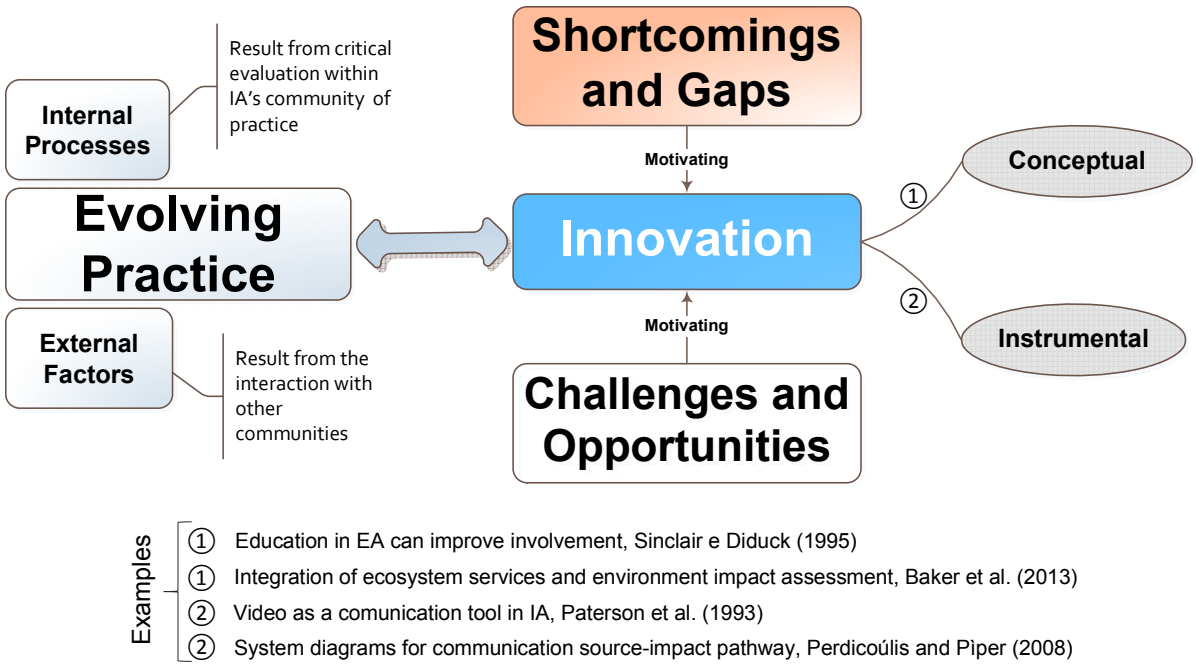
In most professional fields, the state-of-the-art evolves over time, driven by both internal processes (such as critical evaluation within a community of practice) and external factors (such as availability of new tools and interaction with other communities of practice). The evolutionary path can be seen as a process of overcoming problems, challenges and shortcomings and taking advantages of opportunities through innovation. Although some authors understand that there is no academic consensus on the definition of innovation (COOPER, 1998; GOSWAMI; MATHEW, 2005), for the purpose of studying innovation in Impact Assessment (IA), the concept advanced by Crossan and Apaydin (2010) is useful: “production or adoption, assimilation, and exploitation of a value-added novelty in economic and social spheres. It is both a process and an outcome.”

Innovations in impact assessment can take different forms, such as new technical tools to improve a certain task or new concepts aimed at integrating information obtained from biophysical and socioeconomic surveys. Examples of the former are methods to appraise landscape and scenic values (PALMER et al., 1990) and system diagrams for communications source-impact pathways (PERDICOÚLIS; PÌPER, 2008), while the latter include ecosystem services (ROSA; SÁNCHEZ, 2016).

The above definition of innovation captures important aspects of IA, as it considers both internal development (within the field) and adoption of concepts, approaches or tools developed externally, i.e. both “production” and “adoption”. Innovation is more than a creative process and includes application (“exploitation”) and is expected to be capable of providing benefits (“value-added”). It also should be pointed out that Impact Assessment is generally described in the literature as a process, but it also result in products, including physical deliverables such as the environmental impact studies, as well as decisions on approvals, mitigation, choice of alternatives and others. Hence, innovation in IA could be initially conceived as novelties, motivated by shortcomings/ gaps and/or challenges/ opportunities, bearing a potential to improve the process and/or its products. Figure 1.1 illustrates some innovation’s aspects

already described and emphasizes the direct relationship between evolving practice and innovation.

Figure 1.1 – Motivators and types of innovation in impact assessment



It is worthwhile noting that the concept of innovation bears two different magnitude dimensions, incremental and disruptive (or radical) (FREEMAN, 1988). Incremental innovation is understood as continuous improvement initiatives while disruptive innovation is related to essential changes in current concepts and practices (DEWAR; DUTTON, 1986). In IA context, incremental innovation can be exemplified as photo simulations and simple editing for making EISs accessible to general public (SULLIVAN et al., 1997), or GIS approach in order to integrate biological, physical and landscape indicators (GENELETTI, 2008). Disruptive innovation can be illustrated by "stage 4" of environment assessment evolution proposed by Gibson (2002), where IA should be devoted to empowering the public.

In the impact assessment literature, learning and evolution have been acknowledged by several authors (HAQUE, 1996; DANIELS; WALKER, 1996; MULVIHILL; BAKER, 2001; LAWRENCE, 2003; WOOD, 2003; LANDIM; SÁNCHEZ, 2012; POPE et al.,

2013, SÁNCHEZ; MITCHELL, 2017). Even though many practical achievements may go unnoticed in the academic literature, several papers describe some kind of evolution, improvement or change in IA practice. On the other hand, concepts emerging from other disciplines can be seen by scholars and practitioners as relevant to IA and be incorporated in conceptual frameworks or adopted in practice. Recent examples are the concept of ecosystem services (ROSA; SÁNCHEZ, 2015) and the emphasis on the relevance of human rights for assessing the impacts of projects (KEMP; VANCLAY, 2013).

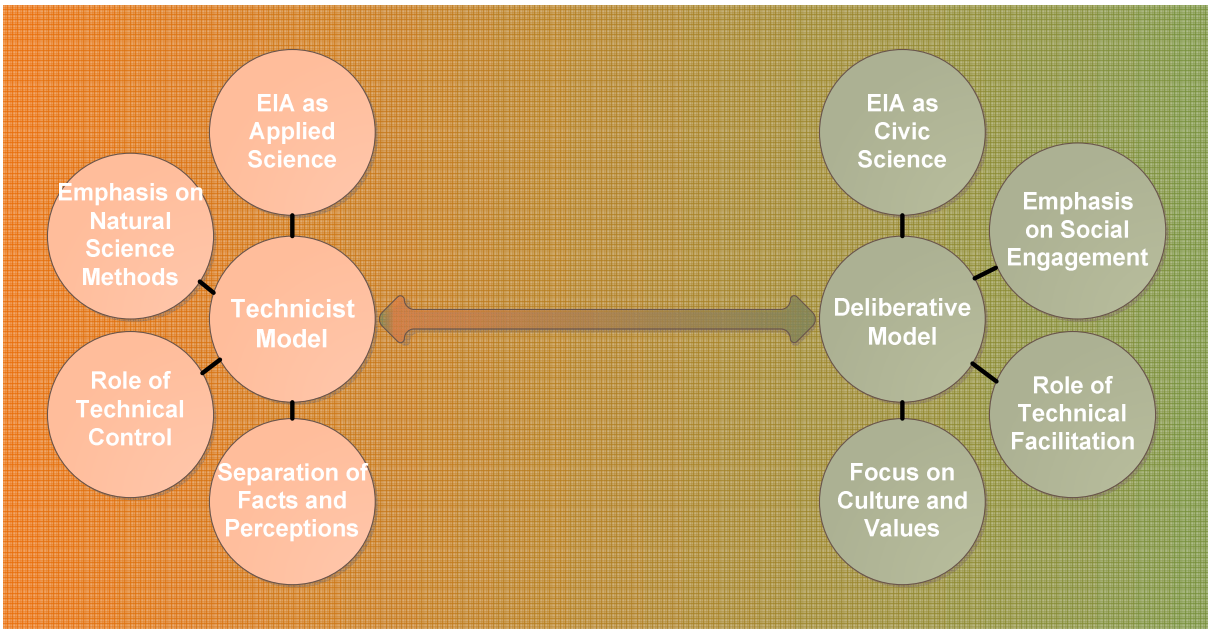
However, no significant efforts were observed to analyze the state-of-the-art of IA through a bibliometric approach. A few exceptions are Li and Zhao (2015) for environmental assessment literature analysis in terms of trends of growth, Fischer and Onyango (2012) and Caschili et al. (2014) for strategic environmental assessment, and Duarte et al. (2017) for a systematic review of IA research in Brazil. Such approach allows a particular reading of the state-of-the-art of impact assessment, making it possible to analyze the transitions in the history of the field, the most active areas, the turning points and literature trends (CHEN, 2006).

The present work intends to contribute to fill this gap - using both qualitative and bibliometric analysis – to identify which themes are most explored by the academic community and discuss how they evolved, in order to detect the main innovations and shortcomings highlighted in research works.

The appearance of novelties is framed by identifying innovations - and shortcomings/ gaps and/or challenges/ opportunities that could motivate those innovations - found in a systematic review of articles published between 1990 and 2015 in two journals considered the main platforms for academic production in this field - Environmental Impact Assessment Review (EIAR) and Impact Assessment and Project Appraisal (IAPA). We posit that it is important to understand the context underlying innovations. Therefore, we enquiry if the theoretical foundations of IA were taken into account in the literature, following Pope et al. (2013) on the necessity to associate theory with the effectiveness of IA being as strong now as it has ever been.

The theoretical foundations are interpreted as the core values that condition IA practice. Those values can be represented as a spectrum between two poles (Figure 1.2). On one side, a technicist model conceives IA essentially as a kind of applied science to inform decision-makers and stakeholders. On the other end, a deliberative model conceives IA as civic science (ORTOLANO; SHEPHERD, 1995; SINCLAIR; DIDUCK, 2001; CASHMORE, 2004). As described by Morgan (2012), environmental impact assessment (EIA) was originally implemented as a technicist tool, but critical reflections on its practice suggested that a predominantly technocratic rationality is ill-equipped to treat values, perceptions and complex social situations with active stakeholders' participation, revealing the necessity for the flowering of other theoretical approaches (LOCKIE, 2001). Beattie (1995), for instance, proposes that IA have more in common with urban planning, economic forecasting, and corporate planning than to applied science. Fischer (2000) and Nooteboom (2007) call the latter end of the spectrum as post-rationalistic, for its emphasis on dialogue and social learning. This end of the spectrum can also be compared with the pluralist model of Bartlett and Kurian (1999), which interprets EIA as a way to ensure democratic processes and practices through citizen involvement, or with the "stage 4" of the evolution of environment assessment (EA) as a concept and practice proposed by Gibson (2002).

Figure 1.2 – A theoretical spectrum of impact assessment



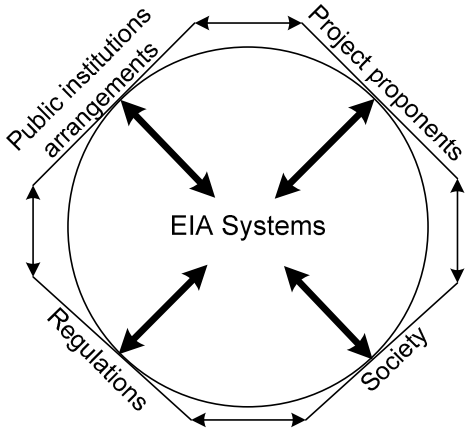
It should be emphasized that the present work does not aim to discuss an “ideal” positioning of an IA system in the theoretical spectrum, because it is believed that neither theoretical perspective (opposite poles) can decisively resolve the most fundamental questions of IA practice (RICHARDSON, 2005), and the boundaries in the spectrum shall be discussed for each specific context combining both perspectives (OWENS et al. 2004).

The information systematized through the bibliometric approach sought to investigate a possible correlation between IA theoretical foundations and innovation options in a vertical integration way. It is suggested that the theoretical boundaries of an IA system shall be previously established when discussing innovation, considering theoretical boundaries as the limits that an IA system occupies within the spectrum existing between the two poles. It is assumed that the positioning of an IA system in the theoretical spectrum helps with the identification of the appropriated novelties for that context.

IA systems are considered as the milieu in which IA processes take place, constituted by public institutions arrangements, regulations (legislation, norms,

technical guidelines and tacit rules) and interactions among major agents (project proponents, regulators and stakeholders). Some country IA systems are very leaning towards the technicist pole, such as China's (REN, 2013) while others may be better represented as fulfilling the spectrum towards the deliberative model, such as in Canada before the 2012 reform.

Figure 1.3 – Representation of IA System



In this sense, it can be noted that IA process depends on its milieu (BEATTIE, 1995; ROSS, 1994; WOOD; AILEY, 1994); therefore, structural evolution depends on changes on the four elements of IA system.

Impact assessment is generally understood as an approach applied in a broad range of decision-making contexts (ANDRÉ et al., 2003; CASHMORE et al., 2009; KIRKPATRICK; GEORGE, 2006) covering three distinct levels: (i) strategic (policies, plans and programs); (ii) intermediate (projects); (iii) operational (monitoring and auditing). The present study focus on the intermediate and operational levels.

Once the levels of IA have been defined, it is necessary to delimit which forms of IA will be addressed. Bond and Pope (2012), among others, mention forms of IA at the intermediate level, such as: environmental impact assessment (EIA); social impact assessment (SIA); health impact assessment (HIA); human rights impact assessment and others. The present study considered all forms of the intermediate level for analyzing innovation in the field.

In the remaining of this thesis, we present the research objectives (section 2) methodology (section 3), the results (section 4), depicting seven innovation clusters and related papers; we further discuss our findings and present conclusions (sections 5 and 6). In order to reach a better document organization, supporting materials are featured as appendices.

2. Objectives

The present work intends to identify the main innovations and shortcomings highlighted in the Impact Assessment literature, seeking to understand which themes are most explored by the academic community and how they evolved in the period 1990-2015. The research also aims to investigate a possible correlation between IA theoretical foundations and innovation options and to propose a conceptual framework to help the alignment between the characteristics of an EIA systems and innovation options.

As a secondary objective, the research aims to verify a possible correlation between the IA international literature evolution and national practice evolution in the iron ore mining sector. For this purpose, ten Environmental Impact Statements (EIS) prepared in the same period of time were examined through content analysis in order to investigate if the innovations pointed out by academic literature were considered by Brazilian EISs.

Table 2.1 summarizes the research questions, objectives and methods of data collection and analysis.

Table 2.1 – Number of articles and citations per cluster

Research Questions	Objectives	Data Collection Methods	Data Analysis Methods
Which are the innovations identified in IA literature?	Identify the main innovations highlighted in Impact Assessment literature.	Access to the scientific databases and journals.	Content analysis and bibliometric analysis.
Which are the shortcomings/ gaps and challenges/ opportunities (innovation's motivators), identified in IA literature?	Identify the main innovation's motivators highlighted in Impact Assessment literature.	Access to the scientific databases and journals.	Content analysis and bibliometric analysis.
Innovations and it's motivators are treated in the literature disregarding IA's theoretical basis?	Identify correlations between IA theoretical foundations and innovation options.	Access to the selected articles.	Content analysis.
Brazilian iron ore EIS are influenced by innovations pointed out by international academic literature?	Verify a possible correlation between the IA international literature evolution and national practice evolution.	Access to ten Brazilian iron ore EIS through contact to physical documents at FEAM.	Content analysis.

3. Methodology

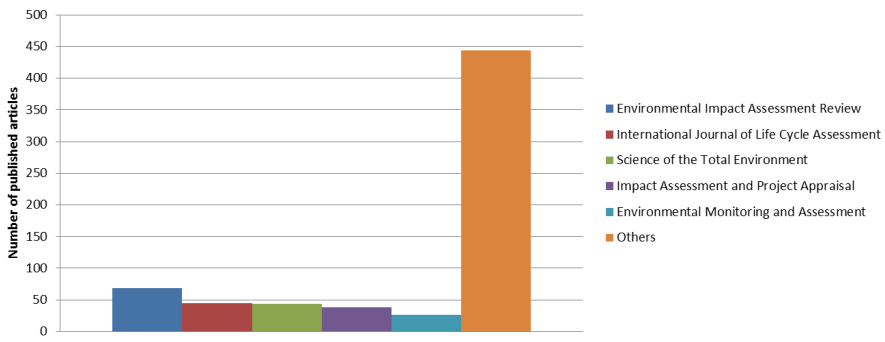
Both qualitative and bibliometric analysis were used to undertake a systematic literature review. A bibliometric analysis consists of the quantitative evaluation of the literature in a particular field, supporting organization and analysis of publications information, and allowing the identification of possible patterns (SPINAK, 1996; PRASAD; TATA, 2005). A systematic bibliographic review also allows a higher

degree of transparency, optimizing the replicability of the study in question (CROWTHER; COOK, 2007).

This literature review was carried out in stages. Initially, the search term "environmental impact assessment" was used in the *Scopus*, *Elsevier* database. The search was performed with data filtering criteria - between 1990 and 2015 -, obtaining 22,847 results. According to de Battisti and Salini (2013), Scopus is the second most extensive database, behind only *Google Scholar*, however, with more reliable data due to the greater rigor of indexing.

The next step was to refine the search through more specific search criteria. First, the type of document was restricted for articles, obtaining 16,314 results. Then, the area of interest for environmental science was restricted, obtaining 12,576 results. However, the volume of articles was still very large, making a systematic analysis of this sample an impracticable task. Therefore, another stage of refinement was applied, selecting the articles that presented in their title, summary or key words the term "state of art", resulting in 666 articles, distributed in 153 journals (Figure 3.1).

Figure 3.1 – Journals with high number of articles - Scopus

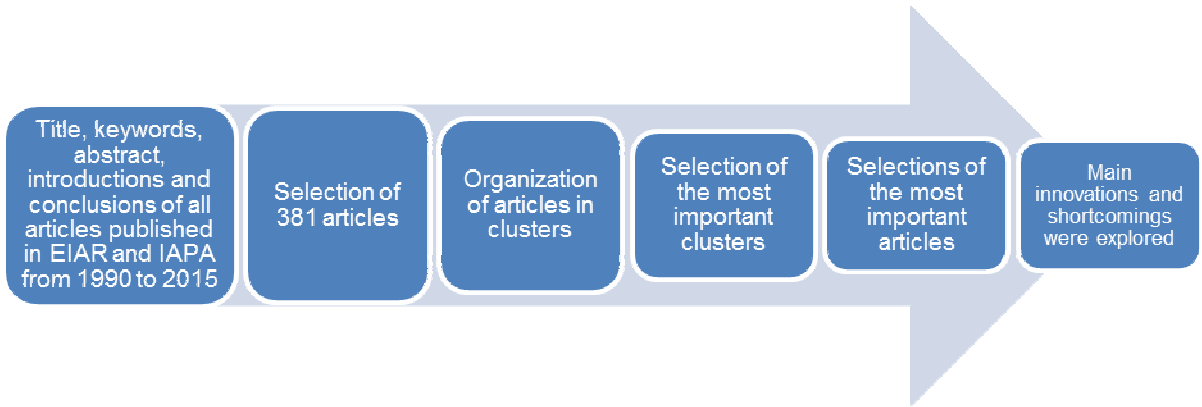


Analyzing the titles and abstracts of the articles presented in the five journals with the greatest number of articles, it is noted that three - *International Journal of Life Cycle Assessment*, *Science of the Total Environment* and *Environmental Monitoring and Assessment* - publish mainly papers related to environmental impacts of products or production processes, such as life cycle analysis, and technologies and practices

related to eco-efficiency. Thus, the search using the Scopus base proved to be ineffective for the purposes of the research and a new strategy was necessary. The new approach was to analyze title, keywords, abstract, introduction and conclusions of all articles published in the two other top journals, namely *Environmental Impact Assessment Review* (EIAR) and *Impact Assessment and Project Appraisal* (IAPA) in that period. The need to go beyond title, key words and abstracts emerged after noticing that articles dealing with innovation in IA can be developed without explicit mention to key terms such as state of art, innovation, progress, enhancement, evolution, weaknesses, shortcoming or gaps. Fischer and Onyango (2012) proposed a similar approach when studying the literature of strategic environmental assessment published in the past 20 years.

Among the 1,547 articles published between 1990 and 2015 in IAPA and EIAR, 381 were selected using this approach. The next step was to organize the articles in clusters in order to identify the main themes in which innovations, shortcomings/ gaps and challenges/ opportunities were explored. The clusters were recognized according to the amount of production and citations. Finally, the most influential articles, considering the number of citations, were sorted and the main innovations and shortcomings were explored by content analysis. The steps of the methodological approach are illustrated in Figure 3.2.

Figure 3.2 – Steps of the methodological approach



It is worth noting that two complementary approaches were taken to define the clusters, the first and most important one was to analyze qualitatively the content of

the articles in order to identify groups of the same or similar elements. Complementarily, a citation and co-citation technique was performed by a bibliometric analysis tool called *CiteSpace*[1] (CHEN, 2006), employing the basic idea that two publications are interconnected if one cites the other.

For the Environmental Impact Statements analysis, ten EISs were examined through content analysis in the same period of time (1990 – 2015) in order to investigate if the innovations pointed out by academic literature were considered in Brazilian practice.

The EISs selection focused on projects located in the state of Minas Gerais, where Brazil's largest iron production history is found. Thus, the study consultation was carried out within the Environmental Regularization File (Arquivo de Regularização Ambiental - ARA) of the State Environmental Foundation (FEAM).

First, a list of all mining licensing processes indexed to the ARA's filing system by the word "iron" was requested to FEAM, this first step resulted in a set of 173 processes. The second step consisted in selecting, from the 173 processes, those which were submitted to the Environmental Impact Study, resulting in a set of 30 processes. The third and final stage consisted in accessing the FEAM file in person in order to select and copy the 10 EISs.

The criteria for the EISs selection were: (i) to privilege licensing processes involving as many mining structures as possible (mining pits, waste piles, tailings/ waste dams, treatment plants, pipelines, conveyor belts , etc.); (ii) select studies arranged sequentially in the timeline, so that sampling is well distributed in the period between 1990 and 2015. Table 3.1 presents the selected EISs.

After the Environmental Impact Statements selection the content analysis was performed to verify if innovations, shortcomings and challenges/ opportunities raised on the literature (innovation timeline - Figure A1), before the EIS development year, were considered in practice. Figure 3.3 illustrates this demarche.

[1] The CiteSpace version utilized was 5.0.R4 SE, released in Mar 7, 2017.

Figure 3.3 – EIS content analysis process

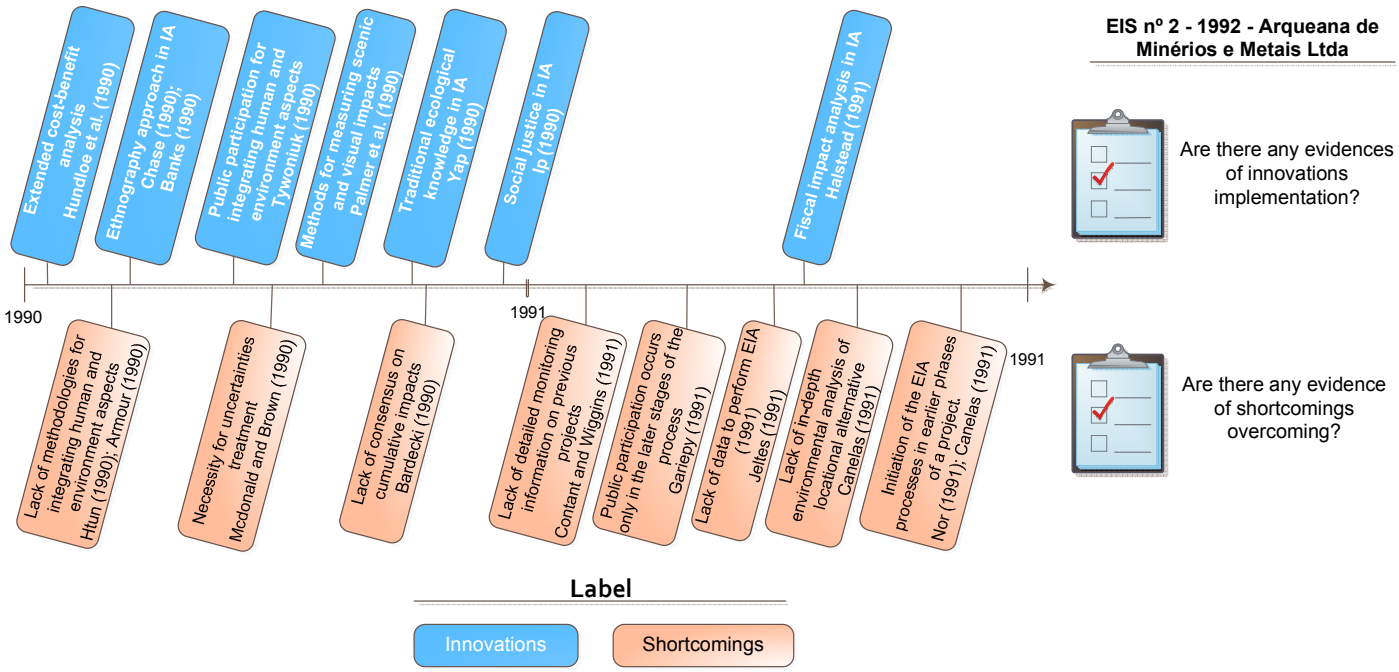


Table 3.1 – Selected Environmental Impact Statements

ID	Year	Process	Proponent	DNPM	Municipality	Status
1	1990	00311/1990/001/1990	Mineração Costa Araújo Ltda.(former-Sociedade Braccini de Mineracao Ltda.-Sobram)	1986830476	Brumadinho	License dismissed
2	1992	00180/1988/002/1992	Arqueana de Minérios e Metais Ltda	1975804088	Araçuaí	License granted
3	1997	00364/1990/006/1997	Vale S.A	1961001719	Barão De Cocais	License granted
4	1998	00122/1987/004/1998	Mineração Socoimex Ltda	1985830370	São Gonçalo Do Rio Abaixo	Technical analysis completed
5	2000	00015/1984/020/2000	Samarco Mineração SA	1982930193	Ouro Preto	License granted
6	2003	00103/1981/026/2003	Companhia Siderúrgica Nacional - CSN	1956043306	Congonhas	License granted
7	2007	00472/2007/001/2007	Anglo American Minério de Ferro Brasil S/A	832978/2002	Conceição Do Mato Dentro	License granted
8	2008	00095/1986/014/2008	Empresa de Mineração Esperança S.A - Emesa	4212/1940	Brumadinho	License granted
9	2011	01261/2006/005/2011	Ferrous Resources do Brasil S/A	2771/1935	Congonhas	License granted
10	2012	00095/1986/022/2012	Empresa de Mineração Esperança S.A - Emesa	4212/1940	Brumadinho	License granted

4. Results

4.1 Clusters Organization and Selection

From the 381 selected articles, seven clusters of greater relevance according to the number of citations and frequency of publication were identified: (I) Public Participation, Social and Community Engagement; (II) IA Systems; (III) Effectiveness, Quality and Improvement; (IV) Economic Impacts, Cost Benefit Analysis, Environmental Valuation; (V) Cumulative and Synergistic Impacts; (VI) Biodiversity, Ecology and Ecosystem Services; (VII) Integration (Table 4.1). The relevance is here considered on the basis of the numbers of citations and the number publications greater than the average, excluding the category “others”. It is worth noting that although the cluster called IA Theoretical foundation is quite cited, only 4 articles were found within this group.

Table 4.1 – Number of articles and citations per cluster

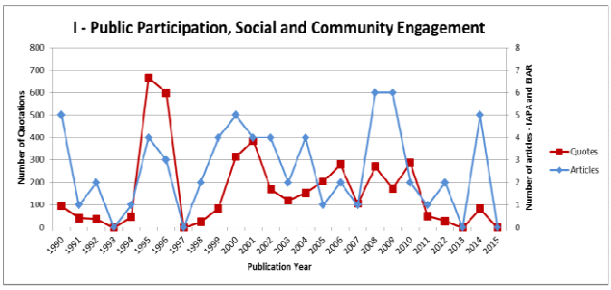
Clusters	Number of articles	Number of citations*	Average citations per article	Number of years with selected articles
Public Participation, Social and Community Engagement**	67	4,234	63.2	23
IA Systems**	48	1,704	35.5	21
Effectiveness, Quality and Improvement**	45	1,668	37.1	18
Economic Impacts, Cost Benefit Analysis, Environmental Valuation**	17	1,042	61.3	11
Cumulative and Synergistic Impacts**	23	1,032	44.9	14
Biodiversity, Ecology and Ecosystem Services**	33	924	28.0	13
IA’s Theoretical Foundation	4	807	201.8	4
Integration*	26	711	27.3	13
Management and Monitoring of Impacts	18	644	35.8	11
Geographic Information Systems (GIS)	8	389	48.6	6
Impact Analysis	10	308	30.8	5
Treatment of uncertainties	12	259	21.6	9
Project Alternatives	7	230	32.9	6
Scoping	5	226	45.2	3
Human Health Risks	10	222	22.2	8

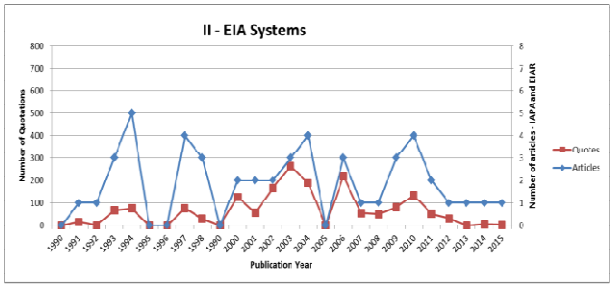
Clusters	Number of articles	Number of citations*	Average citations per article	Number of years with selected articles
Landscape Analysis	7	115	16.4	6
Cultural Heritage	2	59	29.5	2
Ethnography in impact assessment	2	58	29.0	1
Climate Changes	2	33	16.5	2
Human Rights	1	31	31.0	1
Fiscal Impacts	2	12	6.0	2
Others	32	628	19.6	23
Mean (Excluding Others)	16.6	700.4	42.1	-
Total	381	15,336	-	-

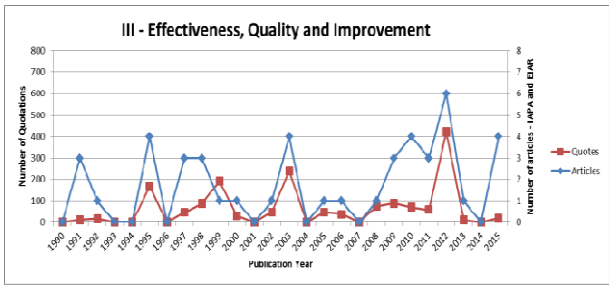
Note:*Google Scholar / More than 50% of production and citations are concentrated in 4 countries, Canada, USA, Australia and the Netherlands. Google Scholar was used to identify the citation number because IAPA was indexed in Scopus only on 1998.
** Clusters with number of articles and academic quotes greater than the average.

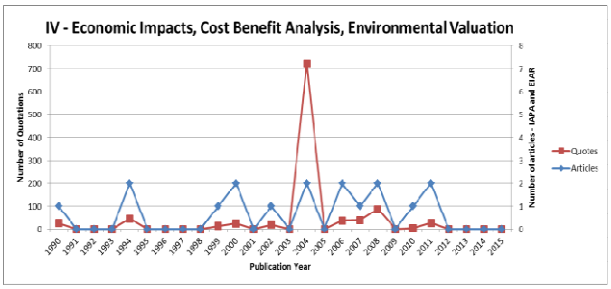
Figure 4.1 illustrates the time distribution of publications for the clusters of major relevance. The vertical axis shows the same scale to allow for quick visual comparison. It can be observed that the three themes that obtained the greatest number of publications and citations (clusters I, II and III) are distributed throughout the study range (26 years). Even though they feature a peak period, they have never left the focus of the IA research community, presenting lasting opportunities to be explored and developed.

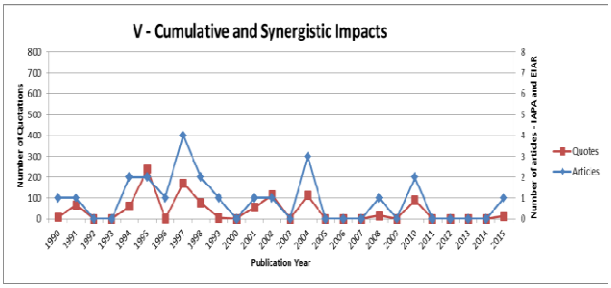
Figure 4.1 – Clusters Timeline

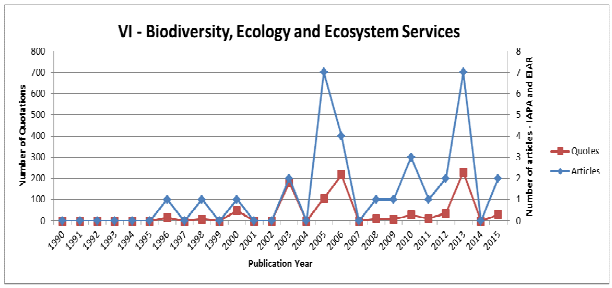


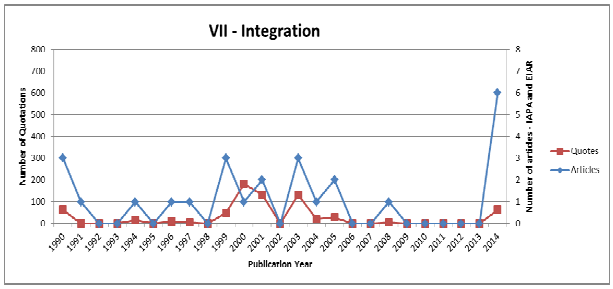












Cluster IV features papers published in only 11 or the 25 years reviewed and a very homogenous production and citation behavior, excluding its peak of citations in 2004. This theme also presents a high average of citations per article (61.3), there are few selected articles (17), but very influential.

Publications of papers classified in cluster V is also irregular (in 14 years of the time series), with three articles standing out over citations number, two published in 1995 and one in 1997. This cluster has also few selected articles (23), with a relatively high citation per article (44.9).

The two peaks presented in the timeline of cluster VI represent two different approaches. The first peak in 2006 addresses impacts and threats to biodiversity, whilst the second one, in 2013, addresses mostly ecosystem services. This cluster has the second lowest citation per article average; the citations are well distributed

among the articles, with just two articles with more than one hundred quotes, both published in 2006.

For cluster VII, the selection of articles comprehended three different levels of integration: (i) biophysical and social integration within IA processes; (ii) professional integration and its areas of action due to the proliferation of IA tools; (iii) external integration with other theories planning and management tools (ARMOUR, 1990; SLOOTWEG et al., 1991; MORRISON-SAUNDERS et al., 2014). The peak observed in 2000 represents an influential article treating the interaction and integration between IA and planning theory. This cluster has the lowest citation per article average, with also just two articles with more than one hundred quotes, published in 2000 and 2001.

According to the planned methodology, in order to complement the clustering proposed by content analysis the bibliometric analysis tool called *CiteSpace* was performed.

As presented by figures 4.2, 4.3 and 4.4, the application of a citation and co-citation grouping technique through *CiteSpace* resulted in twelve clusters, being the cluster number zero (#0) the strongest one, considering number of articles and citations, and cluster number eleven (#11) the less significant one.

The first aspect that shall be emphasized is that the automatic clusters' labelling, based on terms repetition and relevance of articles, was performed by three different criteria; by abstract terms (figure 4.2), by title terms (figure 4.3) and by keywords terms (figure 4.4), showing that the only cluster with the same label during the three distinct labeling approaches was cluster number zero (#0), environmental impact assessment, which represents a broad concept.

The labeling alterations when performing CiteSpace using different criteria (abstract terms, title terms and keywords terms) indicates that the articles inside a specific cluster, even though they are correlated considering citation and co-citation, they

could focus in different themes inside impact assessment umbrella. Cluster number seven (#7), for instance, is labeled “social license” by abstract terms, “mitigation” by title terms and “biodiversity” by keywords terms.

Taking a closer look to cluster number zero (#0) it is noted that even if the articles in this cluster are correlated by citation and co-citation, they address different themes inside environmental impact assessment. As an example, in this cluster it can be found articles such as Bond et al. (2004), classified by content analysis in the cluster I - Public Participation, Social and Community Engagement; Nadeem and Hameed (2008), classified by content analysis in the cluster II - IA Systems; João et al. (2011), classified by content analysis in the cluster III - Effectiveness, Quality and Improvement.

Investigating the others clusters proposed by CiteSpace, it is possible to verify the same pattern presented by cluster number zero (#0), i.e., the clustering by citation and co-citation technique does not capture the specificities of the themes, which can be captured only by content analysis.

Considering the context above mentioned, the present work focused on the clusters defined by content analysis.

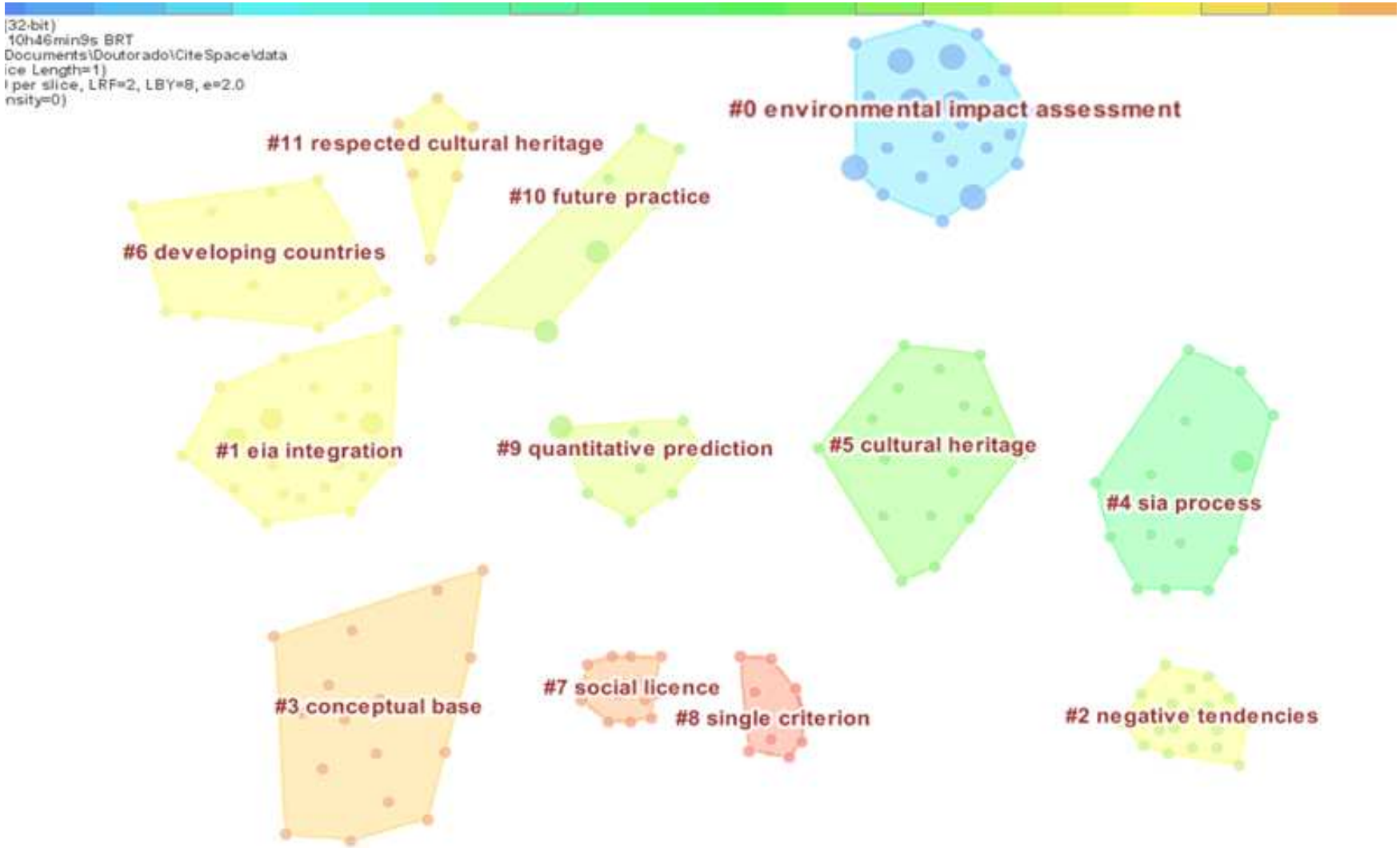


Figure 4.2 - Clusters proposed by CiteSpace labeled by abstract terms

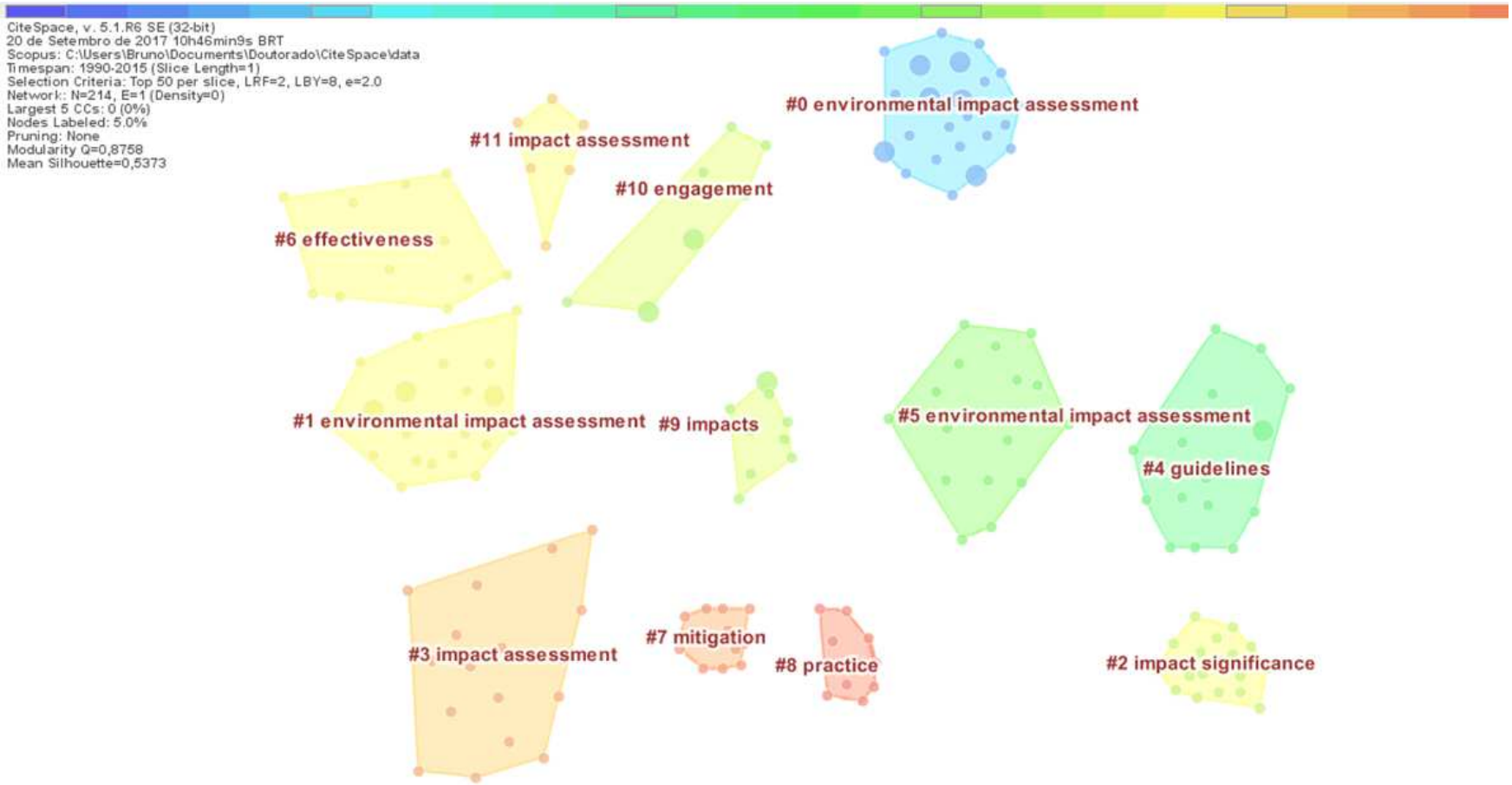


Figure 4.3 - Clusters proposed by CiteSpace labeled by title terms

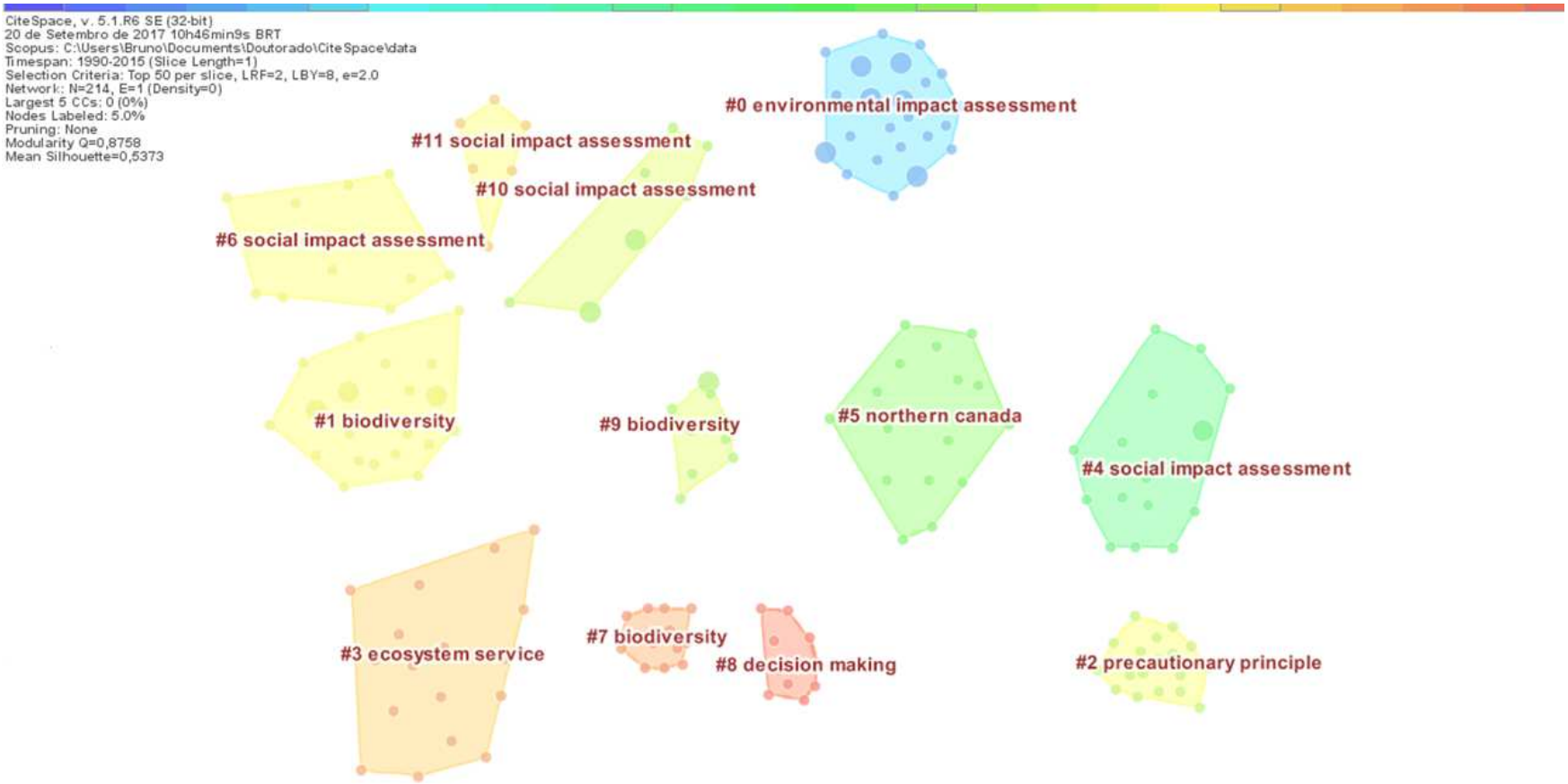


Figure 4.4 - Clusters proposed by CiteSpace labeled by keywords

4.2 Articles Selection and Exploration of Innovations and its Motivators

Within the clusters, the prominent articles were sorted following the same logic of the clusters selection. In other words, the articles with more citations than the average citation per cluster were chosen. Table 4.2 summarizes the selection result. This process resulted in 89 articles, whose contents were reviewed. Diagrams were prepared for each cluster.

Table 4.2 - Articles selection results

Years	Clusters													
	Public Participation, Social and Community Engagement		EIA Systems		Effectiveness, Quality and Improvement		Economic Impacts, Cost Benefit Analysis, Environmental Valuation*		Cumulative and Synergistic Impacts		Biodiversity, Ecology and Ecosystem Services		Integration	
	Articles	Quotes	Articles	Quotes	Articles	Quotes	Articles	Quotes	Articles	Quotes	Articles	Quotes	Articles	Quotes
1990							Hundloe et al.	25					Armour	52
1991									Contant; Wiggins	67				
1992														
1993														
1994							Leistritz	36						
1995	Sinclair; Diduck	98			Mcdonald; Brown	63			Smit; Spaling	158				
	Webler et al.	535			Ortolano; Shepherd	86			Canter; Kamath	83				
1996	Daniels; Walker	453												
	Burdge; Vanclay	133												
1997					Canter; Clark	38			Burris; Canter	95				
1998			Bojórquez-Tapia; García	39	Hickie; Wade,	42			Ross	73				
1999					Barker; Wood	192							Kirkpatrick; Lee	33
2000	Del Furia; Wallace-Jones	76	Glasson; Salvador	101							Atkinson	48	Lawrence	182
	Saarikoski	119												
2001	Appiah-Opoku	79	Cherp	52					Baxter et al.	57			Slootweg et al.	125
	Sinclair; Diduck	157												
	Lockie	105												
2002			Momtaz	67	Gibson	48			Cooper; Sheate	115				
			Ahmad; Wood	98										
2003	Becker et al.	89	Purnama	38	Lenzen et	114					Geneletti	118	Alton;	31

Years	Clusters													
	Public Participation, Social and Community Engagement		EIA Systems		Effectiveness, Quality and Improvement		Economic Impacts, Cost Benefit Analysis, Environmental Valuation*		Cumulative and Synergistic Impacts		Biodiversity, Ecology and Ecosystem Services		Integration	
	Articles	Quotes	Articles	Quotes	Articles	Quotes	Articles	Quotes	Articles	Quotes	Articles	Quotes	Articles	Quotes
					al.								Underwood	
			Wang et al.	127	Buchan	38					Slootweg; Kolhoff	62	Burdge	72
			Baker; Mclelland	100	Benson	72							Birley	29
2004	Bond et al.	72	Ramjeaw; Beedassy	51			Venkatachalam	700	Brismar	61				
			Almer; Koontz	43										
			El-Fadl; El-Fadel	70			Morimoto; Hope	23						
2005	Hartley; Wood	205			Canelas et al.	47					Wegner et al.	31		
2006	Vanclay	125	Androulidakis; Karakassis	44	Ross et al.	38	Knaus et al.	31			Gontier et al.	121		
	Doelle; Sinclair	156	Paliwal	139							Geneletti	55		
			Polonen	36							Soderman	30		
2007	O'Faircheallaigh	106	Pinho et al.	55			Lindhjem et al.	39						
2008	Tang et al.	92	Nadeem; Hameed	51	Sandham; Pretorius	75	Erikstad et al.	35						
							Han et al.	52						
2009					Elling	47								
2010	O'Faircheallaigh	279	Toro et al.	68					Canter; Ross	63				
			Haydar; Pediaditi	51										
2011					João et al.	41	Ivanova; Rolfe	22						
2012					Bond; Pope	56					Scolozzi; Geneletti	32		
					Esteves et al.	183								
					Morgan	165								

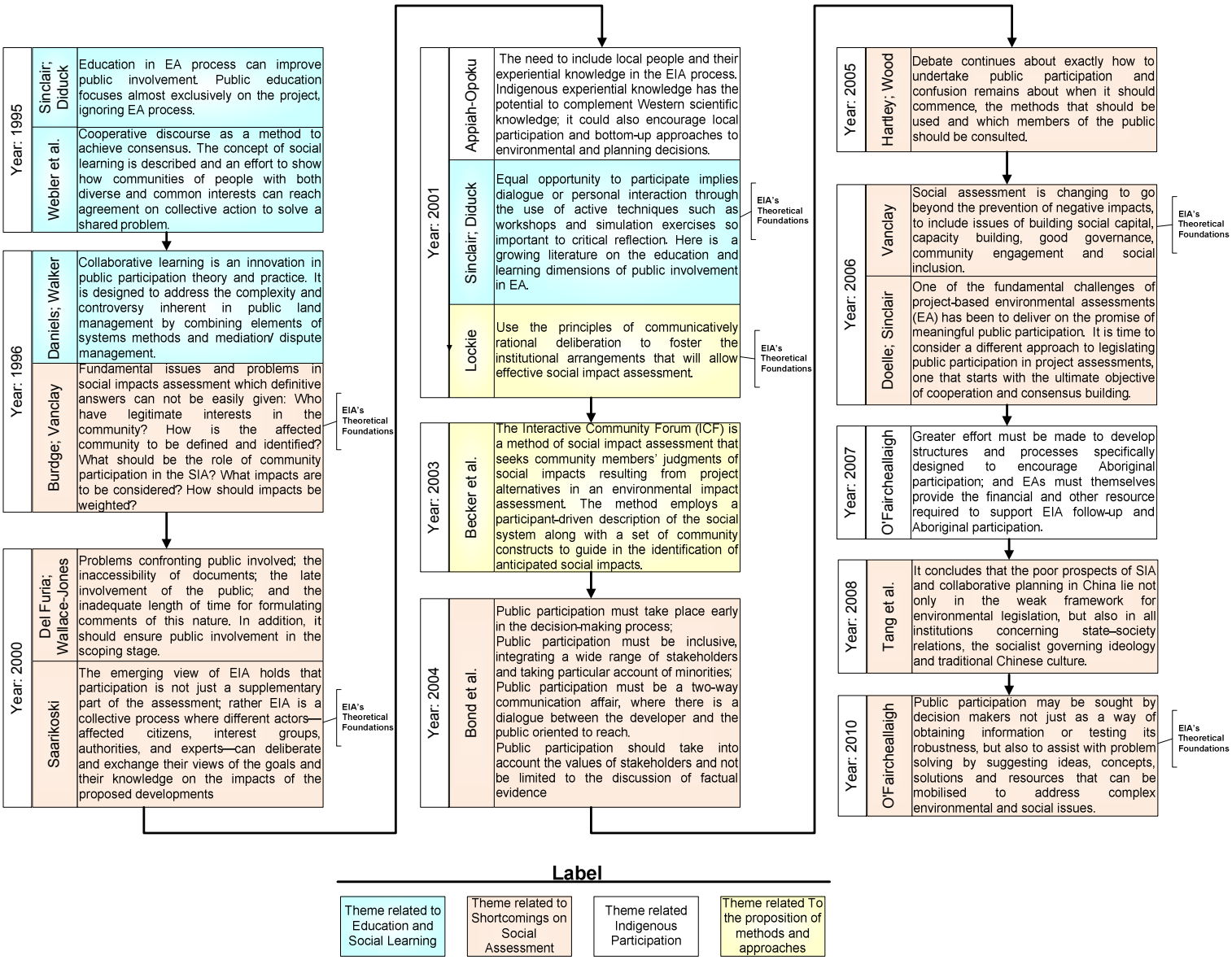
Years	Clusters													
	Public Participation, Social and Community Engagement		EIA Systems		Effectiveness, Quality and Improvement		Economic Impacts, Cost Benefit Analysis, Environmental Valuation*		Cumulative and Synergistic Impacts		Biodiversity, Ecology and Ecosystem Services		Integration	
	Articles	Quotes	Articles	Quotes	Articles	Quotes	Articles	Quotes	Articles	Quotes	Articles	Quotes	Articles	Quotes
2013											Briggs; Hudson	30		
											Baker et al.	67		
											Karjalainen et al.	43		
2014													Morrison-Saunders et al.	41
2015														
Total	17	2,879	18	1,230	17	1,345	9	963	9	772	11	637	8	565

Notes:*The articles selection was made based on the average excluding the work of Venkatachalam (2004) considered an outlier. Therefore the articles with more than 21 quotes were selected.

- ✓ Public Participation, Social and Community Engagement

Four themes were identified within cluster I (Figure 4.2): (i) education and social learning; (ii) shortcomings of social assessment; (iii) indigenous participation; (iv) new methods and approaches.

Figure 4.2 – Public Participation, Social and Community Engagement Timeline [Cluster I: 17 papers]



The four articles related to the first theme recognize that education and social learning has the potential to improve public participation and, therefore, the IA process. Although this theme did not appear in a relevant way after Sinclair and Diduck (2001) work, it has the two most quoted articles within this cluster: Webler et al. (1995) with 535 quotes and Daniels and Walker (1996) with 453 quotes. The former suggests a model aiming to highlight stakeholder's interaction and integrative

thinking, emphasizing their intentions, values and beliefs; authors propose that social learning processes can alter individuals' interests into shared collective interests. The latter observes that social learning is not intended to eliminate conflict, it is to explore conflictual and complex issues; authors propose that collaborative learning is an innovation in public participation that can assist to mediate conflicts between technical view and stakeholders' perceptions.

The second theme contains 9 out of 17 papers. The most relevant shortcomings pointed out: (i) public participation must take place early (DEL FURIA; WALLACE-JONES, 2000; BOND et al., 2004; HARTLEY; WOOD, 2005); (ii) public participation data are often poorly collected (BURDGE; VANCLAY, 1996): (iii) communication should happen in two-ways (SAARIKOSKI, 2000; BOND et al., 2004); (iv) stakeholders should have real access to key information (DEL FURIA; WALLACE-JONES, 2000; BOND et al., 2004); (v) participation should empower stakeholders (SAARIKOSKI, 2000; BOND et al., 2004); (vi) it should take into account culture, values and perceptions of stakeholders (SAARIKOSKI, 2000; BOND et al., 2004; TANG et al., 2008); (vii) it must be inclusive (BOND et al., 2004); and (viii) it must be focused in cooperation and consensus building (DOELLE; SINCLAIR, 2006).

Burdge and Vanclay (1996), in addition to the identification of the difficulties confronting public participation, present fundamental questions, such as: What should be the role of community participation in the impact assessment? Who has legitimate interests in the community participation? O'Faircheallaigh (2010), the work most quoted within this theme, distinguishes different purposes for public participation in IA and suggests three broad purposes for public participation: obtain public input into decisions taken elsewhere; share decision making with public; alter distribution of power and structures of decision making; and recommend specific practices in accordance with the broad purposes. He argues that general literature tends to adopt rigid positions in favor of specific forms of public participation, making propositions without contextualizing the broad objectives of public participation. The present work confirms O'Faircheallaigh (2010) position: considering the17 articles in this cluster, only 6 consider the theoretical foundations.

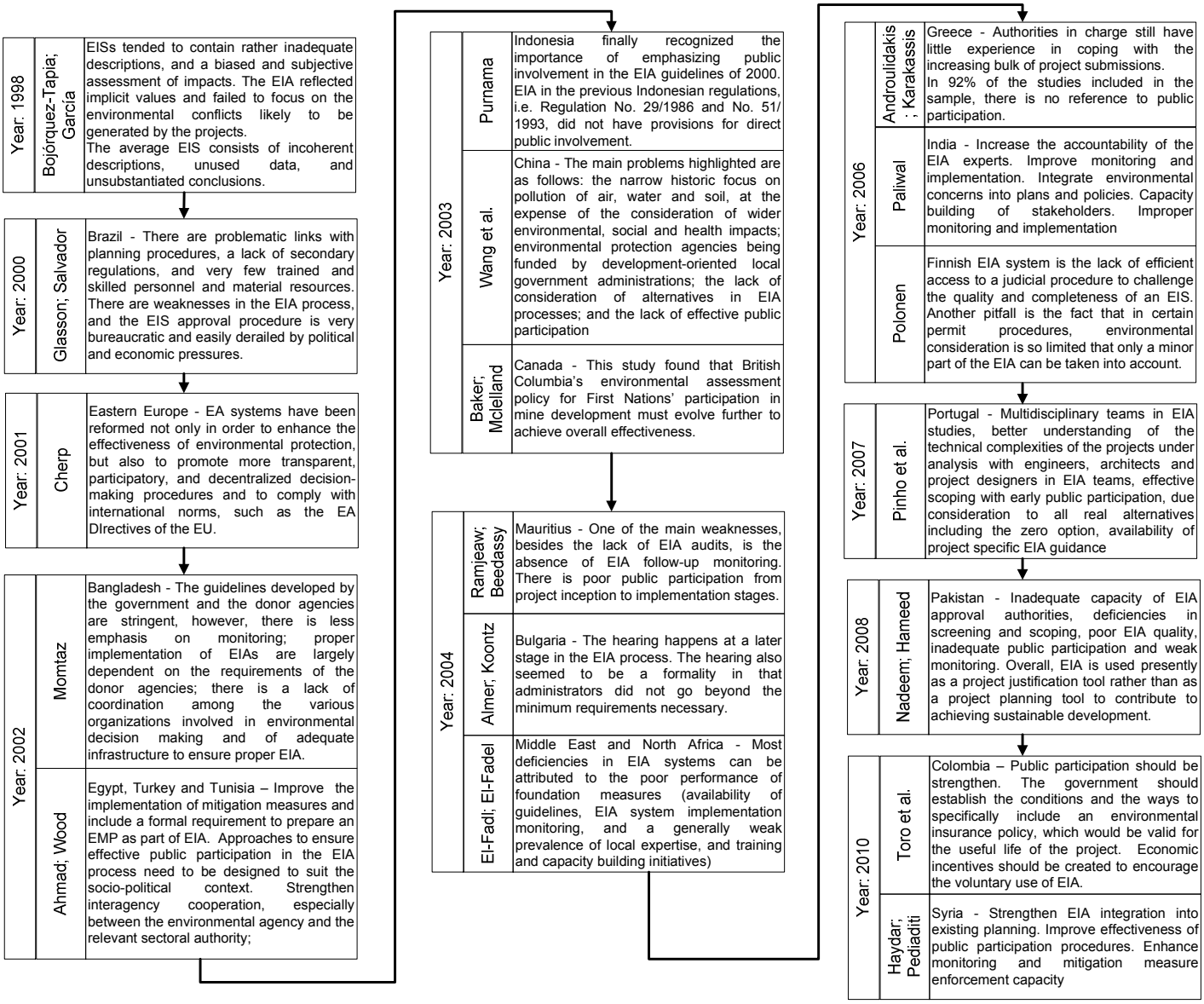
In the third theme, Appiah-Opoku (2001) argues that Indigenous experiential knowledge shall be included in impact assessments, complementing scientific knowledge and encouraging local participation. O'Faircheallaigh (2007), based on Canadian experience, explores the potential of environmental agreements to address indigenous participation and monitoring and emphasizes the use of traditional ecological knowledge to environmental planning and management, direct involvement in follow-up and membership on monitoring boards.

Lockie (2001) presents the concept of communicative rational deliberation, which aims to foster mutual learning with proponents, impacted communities and other stakeholders in order to arrive at decisions that participants believe fair and reasonable. However, dialogue, deliberation and learning among stakeholders depend on appropriate institutional arrangements (DANIELS; WALKER, 1996). Becker et al. (2003) present a participatory approach as method of social impact assessment called Interactive Community Forum (ICF), based on group discussion aiming to assess how the communities will be affected through the interaction of people.

- ✓ IA System

The most relevant articles in this cluster focus preponderantly on the performance of IA systems of countries and specific regions. The timeline (Figure 4.3) shows that on a 10 years period there are some recurrent problems around the world pointed mostly for developing countries.

Figure 4.3 – IA System Timeline



The issues most mentioned in this cluster are: weak or nonexistent public participation, cited in 17 out of 18 articles and weak or nonexistent monitoring and follow-up, cited in 11 articles out of 18.

A variety of weaknesses concerning public participation are mentioned, including late participation in the process (MOMTAZ, 2002; ALMER; KOONTZ, 2004; PALIWAL,

2006; PINHO et al., 2007), limited to public hearings (GLASSON; SALVADOR, 2000; PALIWAL, 2006); lack of representability (PURNAMA, 2003; ALMER; KOONTZ, 2004), difficult accessibility of EIA reports to the public (HAYDAR; PEDIADITI, 2010) and questionable capacity to identify major stakeholders (PALIWAL, 2006).

On monitoring and follow-up, Glasson and Salvador (2000) mention that when monitoring take place, it is not audited by environmental agencies, raising the question of credibility. Ahmad and Wood (2002) report that there is a lack of clear jurisdiction requiring environmental management plans in Egypt, Turkey and Tunisia cases. In Bangladesh, Momtaz (2002) inform that there is no mechanism in place to ensure monitoring of project impacts. In any case it was observed the presence of a feedback model to utilize monitoring data in new environmental assessments.

Other important issues indicated in the most relevant articles of this cluster are: Integration problems with development plans (GLASSON; SALVADOR, 2000; PALIWAL, 2006); deficiencies in screening and scoping (TORO et al., 2010); lack of multidisciplinary teams in EIA studies (PINHO et al., 2007); weak accountability of the EIA experts (EL-FADL; EL-FADEL, 2004; PALIWAL, 2006); lack of reliable and accurate data (GLASSON; SALVADOR, 2000; PALIWAL, 2006); few availability of guidelines (AHMAD; WOOD, 2002; MOMTAZ, 2002; EL-FADL; EL-FADEL, 2004); weak institutional structures (GLASSON; SALVADOR, 2000; ANDROULIDAKIS; KARAKASSIS, 2006).

It is important to point out that conventional issues such as weaknesses in public participation and post-IA monitoring are still discussed in the literature, e.g. Panigrahi and Amirapu (2012) for India, Kengne et al., (2013) for Cameroon and Nzeadibe et al., (2015) for Niger.

Although environmental agencies transform over time as organizational knowledge accumulates (SÁNCHEZ; MORRISON-SAUNDERS, 2011), the analyzed publications barely show any positive evolution in IA systems. Among the 48 articles of this cluster only one was identified as showing significant improvements in IA

system, Clausen et al. (2011), on Vietnam, but still pointing out meaningful gaps. Therefore, it is observed that the literature analyzed doesn't reflect IA systems evolution, showing recurrent shortcomings and few examples of practical solutions. It is also noticeable that these articles don't consider the theoretical foundations in depth when discussing IA systems.

- ✓ Effectiveness, Quality and Improvement

Effectiveness is broadly understood in this work as what IA is reaching or failing to achieve or the ability of the EIA process to meet its objectives (ELLING, 2009). According to Retief (2010), it is closely related to quality (how to conduct IA), improvement (quality over time) and theoretical grounding (core values). Pope et al. (2013) also mention about the necessity to associate theory with the effectiveness of IA.

Analyzing the articles selected, in Ortolano and Shepherd (1995) and Morgan (2012), it is noted that there is still no universal methodology for IA, while practice features several problems, including limited public participation, inadequately assessed cumulative impacts, problematic post-project monitoring and difficulties in dealing with global socio-environmental concerns (climate change, human rights and biodiversity). Another important interpretation from these articles is that the effectiveness and quality of IA are conditioned by their paradigms, or theoretical foundations, in accordance to Elling (2009), Retief (2010) and Pope et al. (2013).

Barker and Wood (1999), the most quoted article in this cluster, also discuss the necessity to strengthen public participation and EIA monitoring and auditing to ensure that mitigations are implemented. Additionally, they make complementary recommendations such as strengthening the treatment of alternatives as well as screening and scoping. The need to strengthening the treatment of alternatives is also present in the work of Hickie and Wade (1998); Barker and Wood (1999); Gibson (2002); Benson (2003); Sandham and Pretorius (2008); Bond and Pope (2012).

Gibson (2002) calls the attention to the necessity to recognize and address uncertainties, applying precaution while Benson (2003) argues that EIA does not deal satisfactorily with uncertainty and the precautionary principle. Ross et al. (2006) also address uncertainty mentioning that practitioners need to cultivate humility to acknowledge the inherent uncertainties of EIA work.

Explicit mention on innovation can be found in this cluster. João et al. (2011) and Mcdonald and Brown (1995) argue that EIA should focus on the enhancement of the positive impacts, being creative and seizing the opportunity to improve project design, rather than being reactive and focus predominantly on negative impacts and legal compliance. Once again, it is important to note that those influential articles published 16 years apart still have similar concerns and propositions, indicating issues that have not yet been overcome. Ross et al. (2006) propose that EIA community should cultivate some virtues, including creativity (producing new ideas and insights to address established or emerging challenges) and innovation (making positive changes that resolve problems).

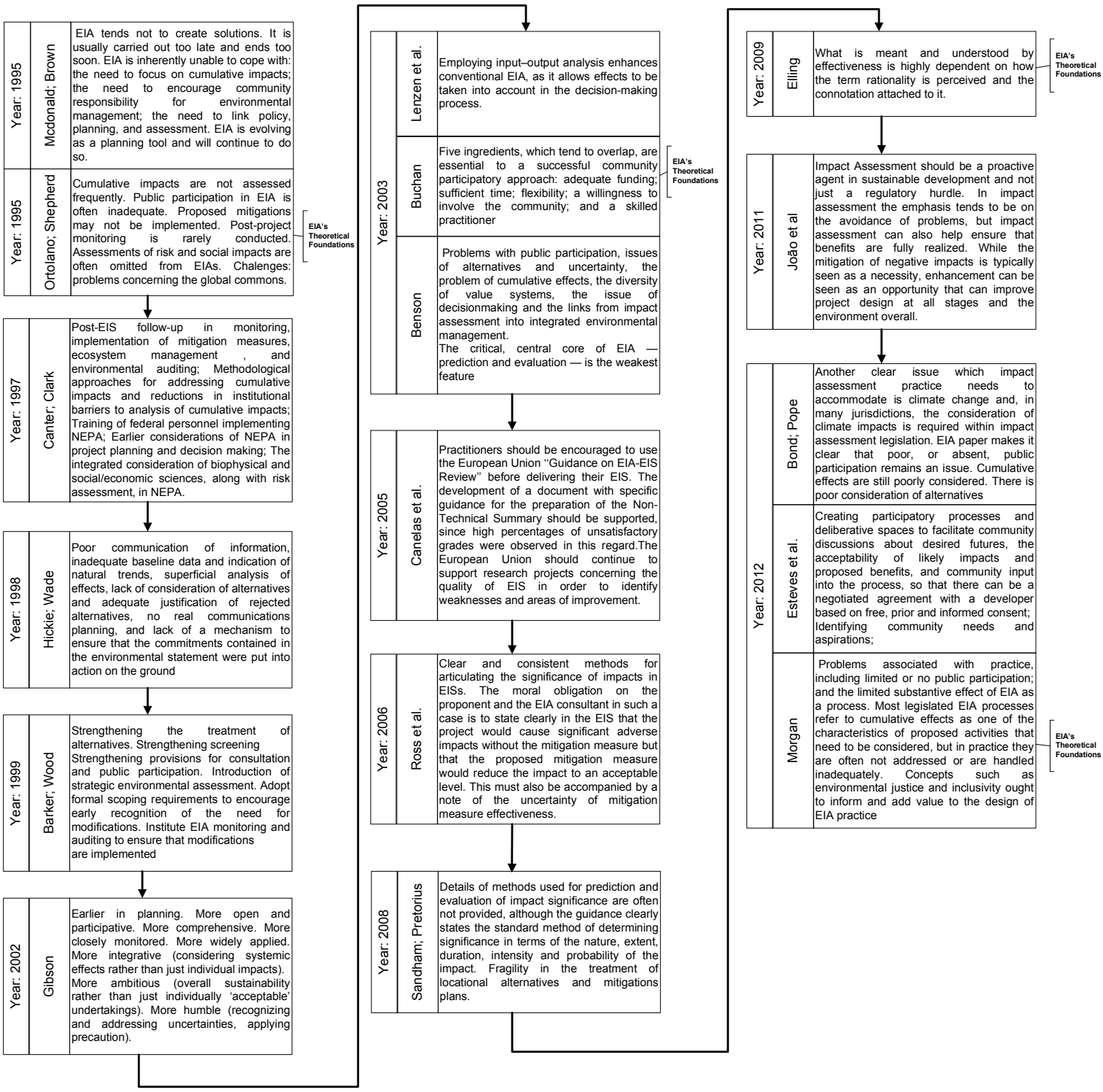
Mcdonald and Brown (1995) also warn about the need to focus on cumulative impacts, to encourage community involvement in EIA process and to align policy, planning and environmental assessment. João et al. (2011) suggest that cumulative impacts should also be concerned about cumulative positive impacts. Other authors also highlights that cumulative effects are still poorly considered (CANTER; CLARK, 1997; BENSON, 2003; BOND; POPE, 2012).

Within the 17 articles there is one that proposes a specific approach to enhance impact analysis, Lenzen et al. (2003) apply an input–output analysis in a case study and conclude that it allows for national and international effects to be taken into account in the decision-making process. Even though Lenzen et al. (2003) is a well quoted article (114), the input–output analysis was only observed twice again in the platform of articles, in the works of Leistritz (1994) and Ivanova and Rolfe (2011)

belonging to the cluster “Economic Impacts, Cost Benefit Analysis, Environmental Valuation”.

Talking about the articles which consider the theoretical foundations it is noted in Figure 4.4 that 4 articles among 17 linked effectiveness with IA paradigms.

Figure 4.4 – Effectiveness, Quality and Improvement Timeline



- ✓ Economic Impacts, Cost Benefit Analysis and Environmental Valuation

As presented in Figure 4.5, two themes were identified in this cluster: (i) Valuation Methods; (ii) Economics and Fiscal Impact.

Within the first theme, starting with the article that stands out in relation to citations' number, Venkatachalam (2004) makes a review on measures to address the validity and reliability issues concerning contingent valuation approach (CV). According to this work, CV is a nonmarket valuation method that is widely used in cost benefit analysis (CBA); it includes the estimation of economic values on elements out of market, such as, for instance, quality of air, social values, and landscapes, surveying individuals' willingness to pay for these elements. Venkatachalam (2004) mentions that CV is already an integral part of environmental assessment and has a lot of potential when applied with rigor.

Erikstad et al. (2008) points out that the willingness to pay approach to value socioenvironmental elements into monetary terms has the advantage of being easily comparable over a wider field. However, natural and cultural heritage are not in the market and linear comparison with market goods can be misleading. Erikstad et al. (2008) argue that valuation assessment for socioenvironmental elements shall be reflected more like levels for consideration and conservation. Erikstad et al. also ponder that value has a dynamic nature; therefore, the value assessment system should evolve over time with the utilization of database modelling and digital analysis of map data (GIS).

Within the selected works, Hundloe et al. (1990), Morimoto and Hope (2004), Lindhjem et al. (2007) and Han et al. (2008) also address the utilization of CBA in impact assessment. According to Hundloe et al. (1990), cost benefit analysis is an effective method to compare biophysical and socioeconomics elements in similar basis. Morimoto and Hope (2004) propose a probabilistic model to CBA in order to take into account project uncertainty, resulting in more robust and justifiable results. Lindhjem et al. (2007) mention that valuation methods can assist a more objective

analysis of tradeoff, this work also identify gaps and challenges to use valuation methods in China context, such as limited availability of data and statistics, lack of guidelines, unclear regulations, among others.

Han et al. (2008) utilize a choice experiments (CE) approach as a valuation method in detriment to contingent valuation approach (CV). Based on the ideas of Kwak and Russell (1994), Han et al. (2008) argue that CV is more appropriated when project scenario is limited to one option and the status quo. For a project scenario with a diversity of options, CE approach offers a better solution.

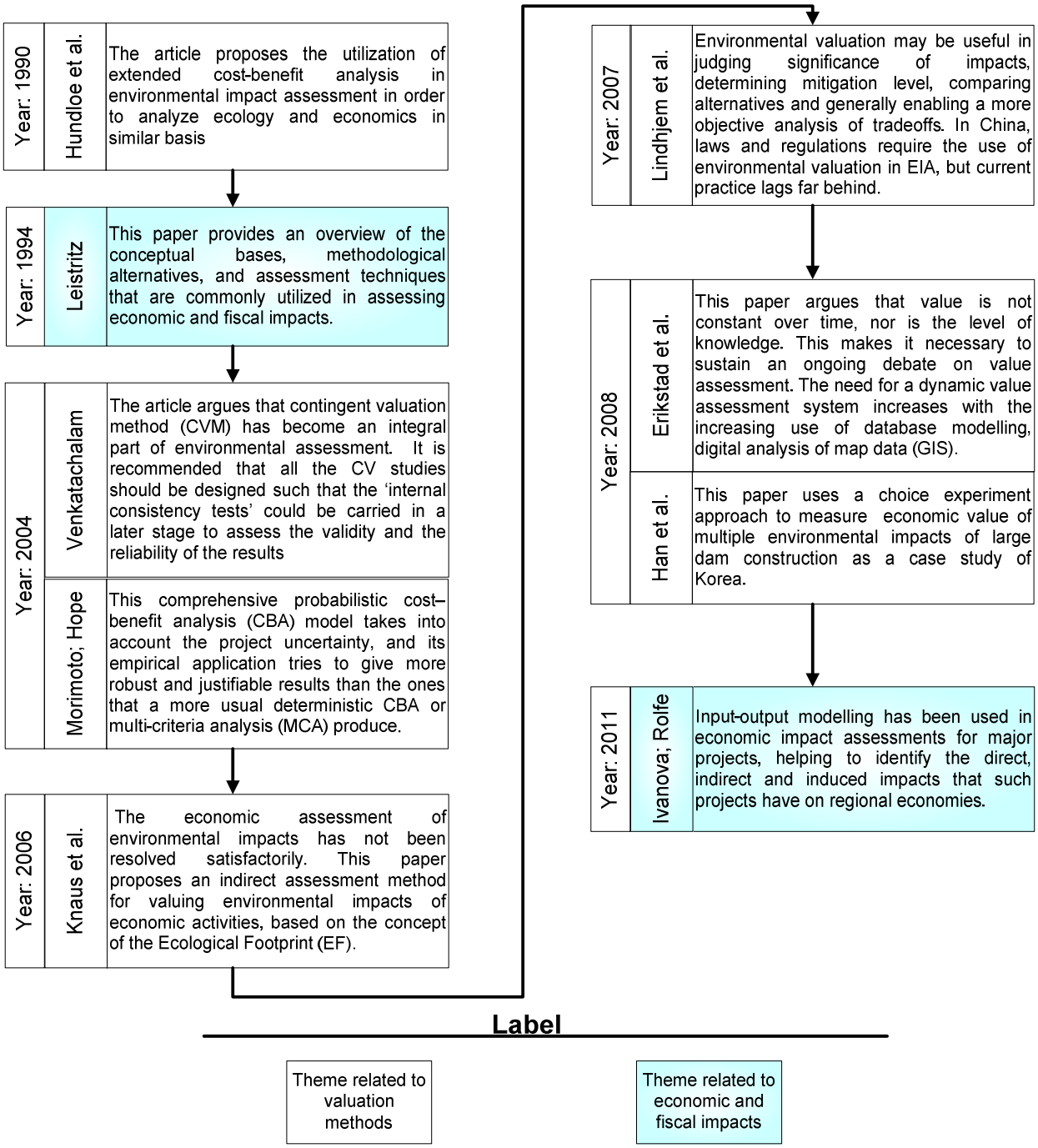
Knaus et al. (2006), based on the idea that the economic assessment of environmental impacts has not been resolved satisfactorily (Spangenberg, 2002), proposes a method for valuing environmental impacts, based on the concept of the Ecological Footprint (EF). In a simplified way, the idea is to correlate negative impacts with offset areas needed to compensate the impacts by applying EF concept, than the offset areas are valued according to local land market.

Concerning the second theme, Leistritz (1994) mention two methods for assessment of economic impacts, export base model and input-output (IO) model, for the author, the main challenge to assess economic impacts, regardless the method, is to gather reliable information of work force requirements, capital investment, local input purchase patterns, project outputs and resource requirements.

Ivanova and Rolfe (2011) demonstrate how input-output model can be adapted to be applied into smaller cases, where non-resident work forces are involved. They argue that IO model can be functional in regions of any size; however, truthful results will depend on the quality of the data about the level of economic activity and interrelationships between economic sectors.

As a final point it shall be mentioned that the articles sample analyzed didn’t consider the theoretical foundations when discussing Economic Impacts, Cost Benefit Analysis and Environmental Valuation.

Figure 4.5 – Economic Impacts, Cost Benefit Analysis and Environmental Valuation Timeline



- ✓ Cumulative Impacts or Cumulative Effects Assessment

The analysis of this cluster shows that even though cumulative impact assessment (CIA) or cumulative effects assessment (CEA) has been part of IA since its genesis and its practice is growing out of its infancy (CANTER; ROSS, 2010), a variety of interpretations and treatments of cumulative effects issue still occurs and continue to be a persistent challenge (CONTANT; WIGGINS, 1991; SMIT; SPALING, 1995; CANTER; KAMATH, 1995; BURRIS; CANTER, 1997; ROSS, 1998; COOPER; SHEATE, 2002; BRISMAR, 2007; CANTER et al., 2010).

Starting with an overview of the existing methods for cumulative impact assessment (CIA), Smit and Spaling (1995) present a variety of methodological tools to assess cumulative effects and evaluate them. They argue that there are basically two CIA approaches: (i) Analytical approaches (comprising spatial analysis, network analysis, biogeographic analysis, interactive matrices, ecological modeling and expert opinion); (ii) Planning approaches (comprising multi-criteria evaluation, programming models, land suitability evaluation and process guidelines). According to their analysis based on the ability to consider multiple perturbations, additive and interactive pathways of accumulation, and different types of cumulative effects, they propose that geographic information systems, landscape analysis, and simulation modeling are appropriate methods for CIA.

Canter and Kamath (1995), reviewing eight EIA case studies, reach similar assumptions and observe that methods for cumulative impact assessment need to deal with both qualitative and quantitative information.

Talking about cumulative impacts at project level, Contant and Wiggins (1991) emphasize that major limitation in CIA is the lack of detailed monitoring information on previous development and propose that improving monitoring, aided by GIS and remote sensing techniques, associated with enhanced modeling, can lead to a better cumulative impact analysis.

Also in the project level, Burris and Canter (1997) verified that systematic analysis of cumulative impacts was not found in a 30 environmental impact statements review in the United States. Among the raised shortcomings, the authors emphasize the weakness in defining spatial and temporal boundaries as well as lack of attention in identifying other projects which contribute to the cumulative impacts and lack of access to information on other relevant developments. Cooper and Sheate (2002), five years later, reviewing 50 UK environmental impact statements arrive in very similar conclusions. It is argued that inconsistent treatment of cumulative effects reflects the limitations at EIAs in project level to deal properly with cumulative effects.

Even though Brismar (2007) highlights the increasingly importance of addressing cumulative environmental impacts in EISs of large development projects, her work, based on an in-depth analysis of six EISs in different countries, finds important shortcomings as limited attention to the identification and analysis of cumulative impact root causes and their pathways.

Ross (1998), in order to help professional practitioners to develop good cumulative impact assessment, outlie an approach based in four main steps: determine valued ecosystem components (VECs); identify what other human activities will affect these VECs; predict cumulative impacts of project; suggest how to manage the cumulative impacts. Ross also emphasize that CIA needs substantial improvements to really subsidize with EIA. Baxter et al. (2001), converging to Ross contributions, point out important shortcoming on professional practice, such as inadequacy of scooping and weakness concerning cumulative effects analysis and follow-up.

Canter et al., 2010 propose a six step process to conduct CIA which complements Ross (1998) contribution, simplified here as: identify the incremental direct and indirect effects of the proposed project on selected VECs; identify other past, present, and reasonably foreseeable future actions within the space and time set boundaries; for the selected VECs, assemble appropriate information on their indicators; connect the proposed project and other actions in the CIA study area to

the selected VECs and their indicators; assess the significance of the cumulative effects on each VEC over the time horizon; develop appropriate action or activity-specific mitigation measures for such impacts.

Aligned with Contant and Wiggins (1991) idea, that detailed monitoring information is essential to CIA, Baxter et al. (2001) argues that CIA enhancement depends on the commitment to implement follow-up.

Figure 4.6 – Cumulative and Synergistic Impacts Timeline

Year: 1991	Contant; Wiggins	A new, comprehensive analysis approach is proposed. Critical elements of this approach include: an increased emphasis on improved monitoring of both environmental conditions and past development activities, and enhanced modeling of both development patterns and natural systems' responses. Finally, techniques to accomplish these tasks are discussed.
Year: 1995	Smit; Spaling	Geographic information systems, landscape analysis, and simulation modeling are shown to be useful methods of CEA.Loop analysis and cause-effect diagramming serve mainly as heuristic devices. A challenge for future methodological development is the design and testing of methods that incorporate processes of cumulative environmental change.
	Canter; Kamath	A structured questionnaire checklist is proposed for usage in scoping cumulative impacts.The items in the proposed checklist will not all be applicable to all projects and impact studies. However, usage of this approach would provide a consistent beginning for systematically addressing cumulative impacts.
Year: 1997	Burris; Canter	This study included a systematic review of CI considerations in 30 EAs prepared on a variety of project types in the United States. In general, it was determined that CIs are neither normally mentioned nor thoroughly addressed; in fact, only 14 EAs even mentioned the term. When CIs were mentioned, they were typically addressed in a qualitative manner without clear delineations of spatial and temporal study boundaries and utilized guidelines or methodologies.
Year: 1998	Ross	There is confusion concerning exactly what CEA involves. This clarifies the requirements of CEA and illustrates its use in a number of case studies. Practitioners must: identify valued ecosystem components (VECs) affected by the proposed project; determine what other past, present and future human activities have affected or will affect these VECs; predict the impacts on the VECs of the combined activities; and suggest how to manage these cumulative effects
Year: 2001	Baxter et al.	CEA is inadequately distinguished from EIA; scoping is inadequate; and cumulative effects analysis and follow-up are weak. Based on the results of the evaluation, four actions are recommended to improve the professional practice of CEA: include CEA considerations in terms of reference; use context scoping; use more follow-up studies; and link project and regional CEA.
Year: 2002	Cooper; Sheate	The results of the review suggest that cumulative effects are far from thoroughly addressed. Only 24 EISs (48%) mentioned the term 'cumulative effects/impacts' and only 9 EISs (18%) provided a discussion, which were mostly qualitative. The problems in addressing these issues are explored, and the main findings include the various interpretations of the concept of cumulative effects and the varied treatment of cumulative effects issues.
Year: 2004	Brismar	The importance of addressing cumulative environmental impacts in Environmental Impact Statements (EISs) of large development projects is increasingly underlined. However, cumulative impacts are generated through complex impact pathways, involving multiple root causes and lower and higher order effects, interlinked by cause–effect relationships. Consideration to potential impact pathways may thus be difficult without appropriate analytical methods, expertise, and supportive Environmental Impact Assessment guidelines and terms-of-references (TOR).
Year: 2010	Canter; Ross	EIA documents include minimal attention to CEAM, with the included information being very brief and reflective of assertions without analyses (cumulative effects assessment and manegement - CEAM CEA, CIA). A six-step generic process for carrying out CEAM is provided.

- ✓ Biodiversity, Ecology and Ecosystem Services;

Figures 4.1 and 4.7 show that this cluster is the most recent, with significant papers, according to their citations, appear on the stage only in 2000, when biodiversity and ecology assessment are addressed. The second positive trend of production and citation appears recently, when ecosystem services comes into play, having its peak in 2013. Therefore, this cluster was subdivided in two themes: (i) biodiversity and ecology assessment; (ii) ecosystem services.

Starting with the first theme, Geneletti (2003) proposes an approach to address direct loss of ecosystems and habitats in road projects. The methodological approach is divided into three main steps: ecosystem mapping, ecosystem evaluation, and ecosystem loss impact assessment. The approach proposed is based on the evaluation of the significance of the different ecosystem types concerning rarity and biodiversity conservation. Gontier et al. (2006), also with the focus on habitat loss and fragmentation, discuss prediction tools in biodiversity assessment based on GIS ecological models.

Gontier et al. (2006), aligned with Atkinson et al. (2000), witness that the term biodiversity is rarely used in EIS and its practice shows important shortcomings as descriptive nature of assessments, the absence of quantifications and methods for impact predictions, and lack of spatial and temporal scales of ecological processes. Similar gaps are also highlighted in the work of Geneletti (2006). Gontier et al. (2006) argue that GIS-based ecological models have potential to address these shortcomings.

Scolozzi and Geneletti (2012) discuss that simple application of GIS indicators may be not enough to assist appropriate biodiversity impact assessment. The authors propose a methodology to address habitat loss and fragmentation caused by land-use changes that integrates three different approaches, landscape graphs, object-oriented rule-based habitat assessment and expert knowledge.

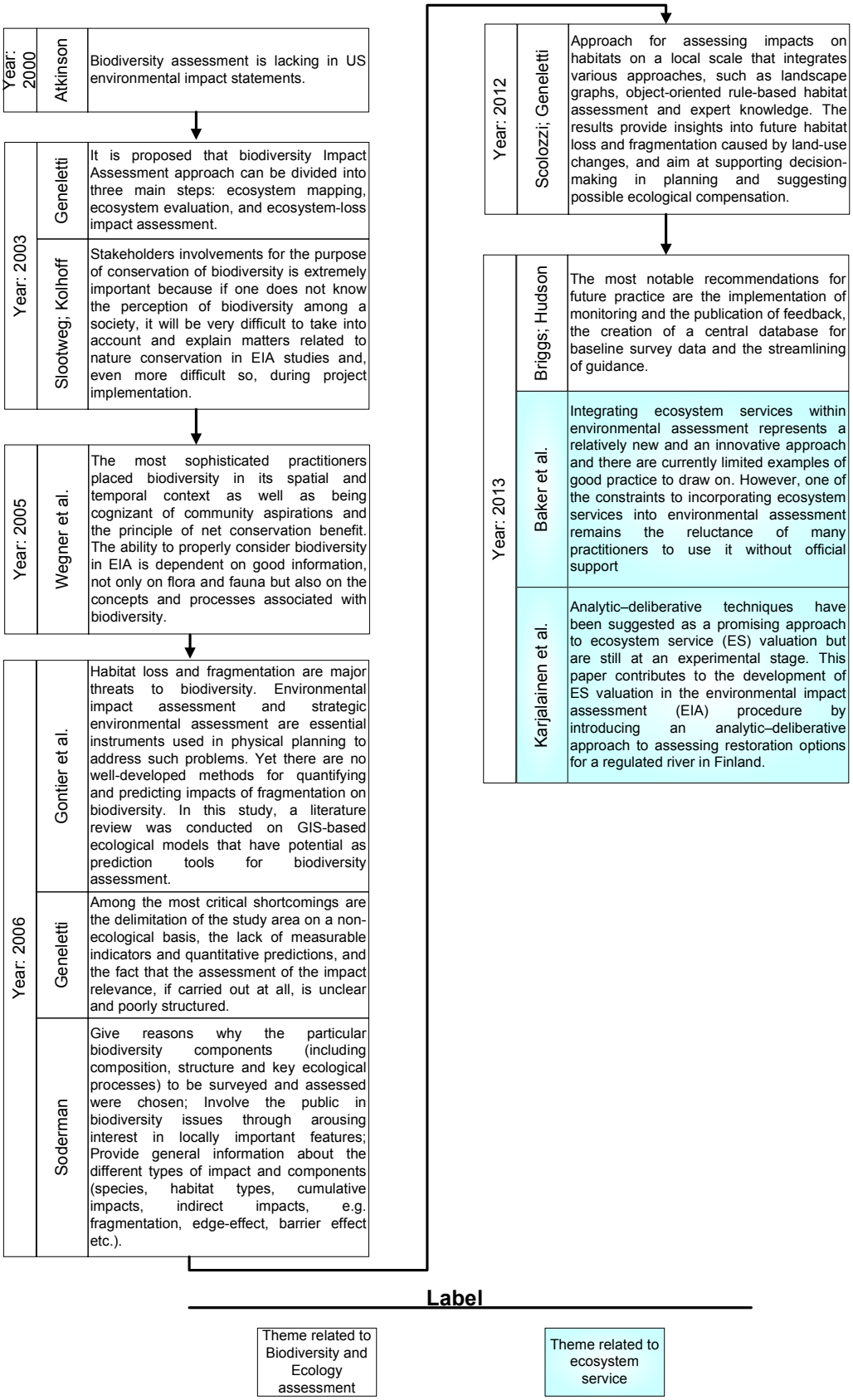
Briggs and Hudson (2013) show that the determination of significance in ecological impact assessment has improved, however, there are still limitations concerning the accuracy of the studies due to the quality of baseline survey data, scientific understanding of ecological processes and the lack of monitoring and feedback of results. The authors emphasize important recommendations for future practice such as implementation of monitoring and the publication of feedback and creation of a central database for baseline survey.

Still in the first theme, Slootweg and Kolhoff (2003) introduce an important idea arguing that biodiversity impacts shall not be determined by external experts only, emphasizing that public participation is essential to understand how to address biodiversity in a specific context. Wegner et al. (2005), argues that the most sophisticated practitioners placed biodiversity in its spatial and temporal context as well as being cognizant of community aspirations. Soderman (2006), proposing suggestions to improve the effectiveness on the conduction of biodiversity issues in project level, also highlights the importance to involve the public in biodiversity issues. He argues that the scoping phase should address baseline survey and assessment methods in order to encourage interaction between all stakeholders early in the process.

Speaking of the second theme, Baker et al. (2013) reinforce that the integration of ecosystem services and environment impact assessment is an innovative approach and there are few examples of good practice at that time. The authors state that integrating ecosystem services within environmental assessment has potential value, and discuss strengths and weaknesses of using ecosystem services. Within the strengths it should be highlighted, for the purpose of the present work, that ecosystem services is an integrating concept that enable the approximation of ecosystems elements to socioeconomic ones. Karjalainen et al. (2013) ratifies this idea stating that ecosystems services in an EIA process may help to develop more rigid links between ecosystem characteristics and benefits for people.

Karjalainen et al. (2013), based on previous experience concerning application of Multi-criteria decision analysis methods (MCDA) in EIA, test the application of MCDA in ecosystem services analysis. They argue that the proposed approach has potential to integrate ecosystem services into EIA.

Figure 4.7 – Biodiversity, Ecology and Ecosystem Services Timeline



- ✓ Integration

Based on all selected papers in this cluster, with greater emphasis on Armour (1990), Slootweg et al. (1991), Kirkpatrick and Lee (1999) and Morrison-Saunders et al. (2014), it is noted that there are at least three dimensions of integration under discussion: biophysical and social integration within EIA processes; professional integration and its areas of action due to the proliferation of IA types; external integration with other planning and management tools. The importance of integration is underlined by Kirkpatrick and Lee (1999), stating that integration enhancement is a way to increase effectiveness in EIA process; Armour (1990) claims that integration is the raison d'etre of impact assessment.

Starting with biophysical and social integration within EIA, Armour (1990) mentions that the theme of integration has been always relevant since EIA origins. He argues that there is a need to integrate disparate social, ecological and economic elements into a unified holistic perspective. However, the attempts for an integrative framework have frequently the appearance of being subjective and arbitrary. Slootweg et al. (2001) state that even though biophysical impacts also have social impacts and vice versa, there is not yet an adequate framework for integrating biophysical and social impact assessment. Burdge (2003) is also concerned about the integration of EIA elements and states that social impact has not been as widely adopted in the assessment process as biophysical components, additionally, he argues that there is a necessity for better models to comprehend the casual linkages between biophysical, land-use, financial and subsequent social impacts .

Slootweg et al. (2001) propose a method for integration using function evaluation as a conceptual framework. The function evaluation concept presented is correlated to ecosystem services concept in the sense that function evaluation is defined as the characterization and classification of the functions provided by the biophysical environment and the assessment of their value for supporting human activities. Alton and Underwood (2003) present a method to couple biophysical and social

environments to move toward effective decision making. To implement the proposed method, it is argued that EIA professionals must change the focus on the traditional physical environment to softer aspects of the environment, getting closer to the public where the decisions are implemented.

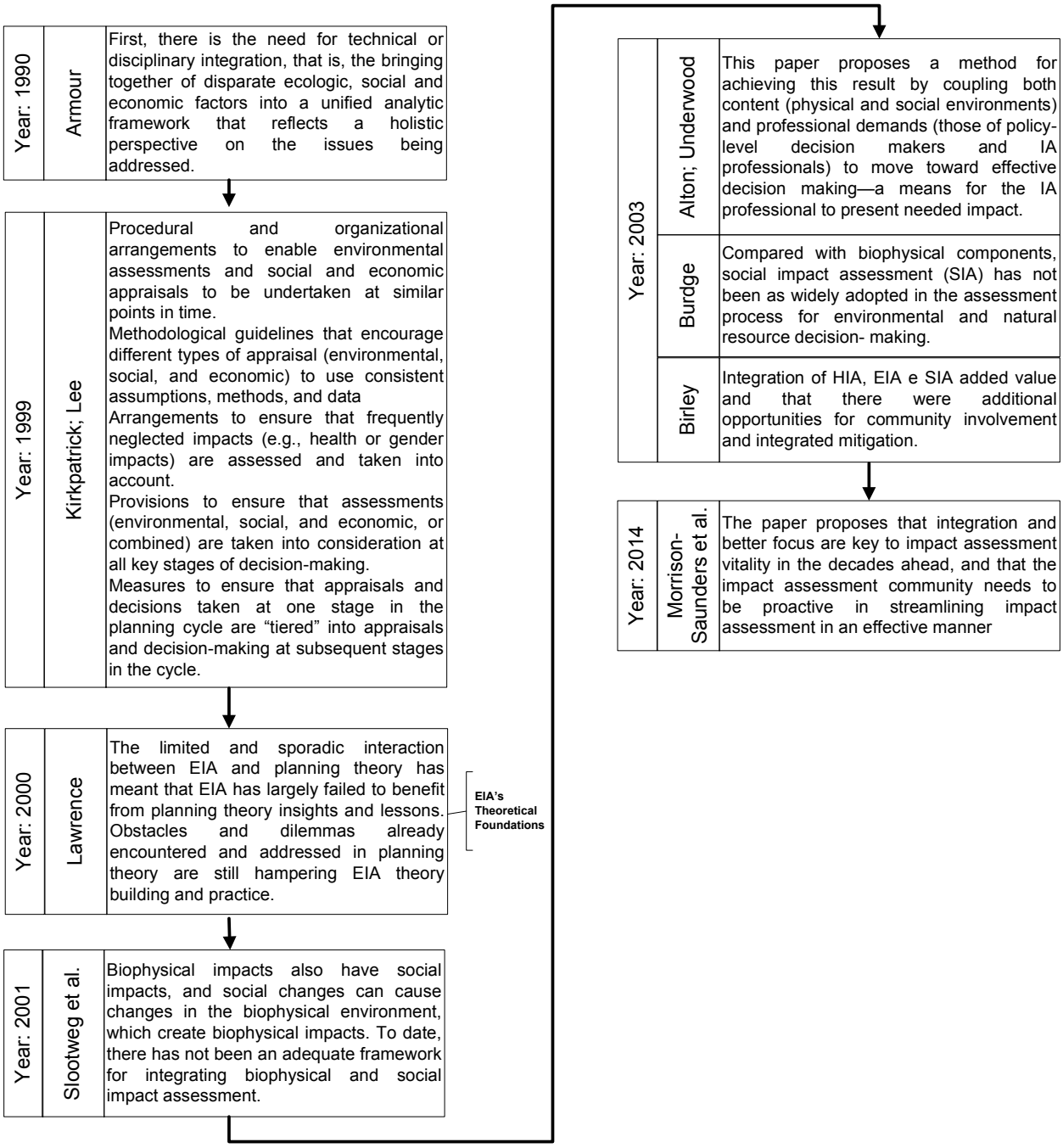
Concerning professional integration and its areas of action, Armour (1990) alerts that disciplinary chauvinism is one of the main barriers to integration. Morrison-Saunders et al. (2014) argue that the excessive specialization has the potential to difficult interdisciplinary practice and, therefore, the effectiveness of EIA processes. The authors present arguments to criticize the proliferation of different types of impact assessment and the appearance of separate silos of expertise. They propose that integration and better focus are essential to impact assessment vitality. Birley (2003) declares that there is a strong relationship among environmental, social and health impact assessment, and, through a case study, he shows evidences that integration adds value to the assessment process.

Talking about external integration with other planning and management tools, Armour (1990) argues that the effectiveness of EIA depends on its point of intersection with the planning and decision-making process. Even though Ortolano and Shepherd (1995) claim that EIA is often not carefully integrated into planning, Mcdonald and Brown (1995) states that EIA is evolving as a planning tool and will continue to do so. Kirkpatrick and Lee (1999), Paliwal (2006) and Haydar and Pediaditi (2010) discuss the need to integrate project level assessments with strategic level assessment. Lawrence (2000) states that EIA has not been learning from planning theory, thus EIA in facing obstacles already addressed in the planning theory path, without beneficiating from lessons previously conquered.

As noted in Figure 4.8, Lawrence (2000) is the only work that put in the stage the theoretical foundations discussion. He makes a valuable contribution presenting the evolution of planning theories, emphasizing the major features of theory reorientation. For the purpose of the present work, it is highlighted here two major features: (i) rationalism is no longer the center of planning theory; (ii) Planning is

generally recognized as a collective activity. Lawrence (2000) also observes that EIA has only partially and tentatively explored these themes. Concerning the most recent planning theory views, he argues that new approaches understand planning as a collective exercise stressing the importance of dialogue and integrating personal experiential and processed knowledge.

Figure 4.8 – Integration Timeline



4.3 Environmental Impact Statements Analysis

Within 148 innovation issues raised in the literature (89 innovations, 44 shortcomings and 15 challenges/ opportunities), as presented in the innovation timeline (Figure A1), considering that 119 could be verified in IA process through EIS content analysis, only five were possible to be identified in the statements (less than 5%), showing evidences of a lack of correlation between international literature innovations remarks and IA practice concerning Minas Gerais iron ore developments.

The five innovation issues verified through content analysis are: (i) GIS is improving environmental assessment effectiveness (JOÃO; FONSECA, 1996); (ii) lack of Biodiversity assessment (ATKINSON et al., 2000); (iii) EIS preparation should be structured around the activity–aspect–impact model (SÁNCHEZ; HACKING, 2002); (iv) weak connection between baseline studies and impact prediction (SODERMAN, 2005); (v) seek opportunities to add to the value chain of products associated with the proposed development; stimulate and enhance local entrepreneurships (WEAVER et al., 2008).

Table 4.3 shows that in only three EISs, out of ten, it was possible to identify some of the five innovation issues, corroborating with the hypothesis of low correlation between literature and practice, with two EISs contemplating the five issues (EISs nº 7 and 9) and one contemplating just three (EISs nº 10).

It shall be emphasized that the EISs content analysis did not aim to assess the quality of the statements; however during the analysis focused on innovation, it was possible to verify some quality problems (e.g. lack of seasonality for fauna survey and water quality, weak project description, lack of primary data for anthropic environment, lack of interdisciplinary team, generic impacts, low detailing level for socio and environmental programs, among others).

This analysis also illustrates that it took in average 5 years to a literature innovation issue be considered into practice. Within our sample, in just one case the innovation

appeared in practice before it appeared in the IA literature, when EIS number 7 (Anglo American Minério de Ferro Brasil S/A, developed in 2007) proposed activities to diversify local economy and stimulate/ enhance local entrepreneurships.

Table 4.3 – EIS content analysis

Issues observed in EIS content analysis	EIS Identification number										Observations*
	1	2	3	4	5	6	7	8	9	10	
	EIS Year										
	1990	1992	1997	1998	2000	2003	2007	2008	2011	2012	
GIS is improving environmental assessment effectiveness. João and Fonseca (1996)							*				Maps with better quality presenting scale and datum. Utilization of GIS tools.
Lack of Biodiversity assessment. Atkinson et al. (2000)											Biodiversity treatment with primary data by specialists.
EIS preparation should be structured around the activity–aspect–impact model. Sánchez and Hacking (2002)											Greater clarity in the definition of environmental aspects and impacts.
Weak connection between baseline studies and impact prediction. Soderman (2005)											Greater connection between baseline studies and impact prediction. Less generic impacts descriptions.
Seek opportunities to add to the value chain of products associated with the proposed development. Stimulate and enhance local entrepreneurships. Weaver et al. (2008)											Activities to stimulate entrepreneurship and strengthening of micro, small and medium local enterprises. Prioritization of local services.

Note: The observations are related to the table cells in green. EIS 7 = Anglo American Minério de Ferro Brasil S/A; EIS 9 = Ferrous Resources do Brasil S/A; EIS10 = Empresa de Mineração Esperança S.A - Emesa

Considering that the positive correlation between literature and practice revealed to be ephemeral in the study sample, it is worth to emphasize some of the important issues raised only by the most quoted articles which are apparently missing in practice, as presented below.

- Public participation must take place early (DEL FURIA; WALLACE-JONES, 2000; BOND et al., 2004; HARTLEY; WOOD, 2005);
- Public participation data are often poorly collected (BURDGE; VANCLAY, 1996);
- IA should take into account culture, values and perceptions of stakeholders (SAARIKOSKI, 2000; BOND et al., 2004; TANG et al., 2008);
- Necessity to recognize and address uncertainties (GIBSON, 2002; BENSON, 2003; ROSS et al., 2006);
- Use of valuation methods in IA (HUNDLOE et al., 1990; MORIMOTO; HOPE, 2004; VENKATACHALAM, 2004; LINDHJEM et al., 2007; HAN et al., 2008; ERIKSTAD et al., 2008);
- Systematic treatments of cumulative effects (CONTANT; WIGGINS, 1991; SMIT; SPALING, 1995; CANTER; KAMATH, 1995; BURRIS; CANTER, 1997; ROSS, 1998; COOPER; SHEATE, 2002; BRISMAR, 2007; CANTER et al., 2010);
- Use of integrated landscape analysis (SMIT; SPALING, 1995)
- GIS-based ecological models to deal with biodiversity assessment (GENELETTI, 2006; GONTIER et al., 2006);
- Public participation is essential to understand how to address biodiversity (SLOOTWEG; KOLHOFF, 2003; WEGNER et al., 2005; SODERMAN, 2006);
- Method to integrate biophysical and social environments (SLOOTWEG et al., 2001; UNDERWOOD, 2003);
- EIS integration to environmental planning (ARMOUR, 1990; ORTOLANO; SHEPHERD, 1995).

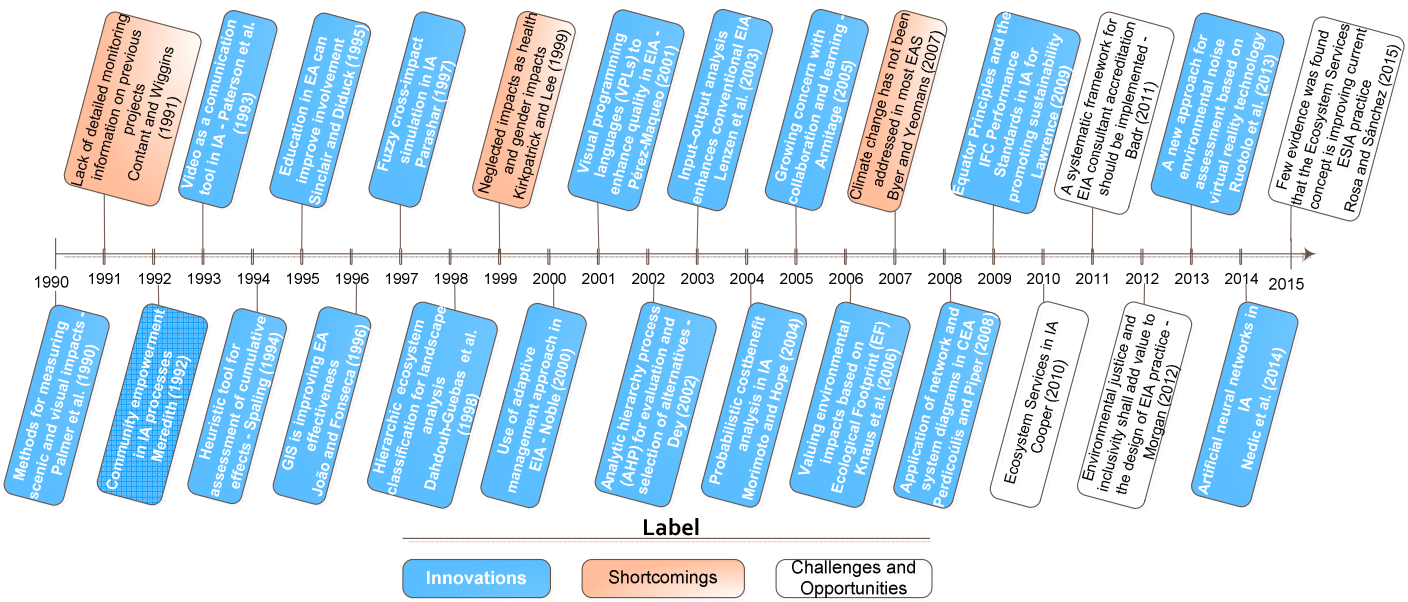
5. Discussion

The research showed that the most studied themes - “Public Participation, Social and Community Engagement”, “IA Systems” and “Effectiveness, Quality and Improvement” have been on board for a long time, offering lasting opportunities to be explored and developed, while a number of issues emerged throughout the review period.

The innovations and shortcomings highlighted in the previous section represent only the selected 89 most quoted articles (Table A1). Taking a wider look at the 381 screened articles, other innovations and shortcomings appear (148 innovation issues represented by 89 innovations, 44 shortcomings and 15 challenges/ opportunities). Figure 5.1 represents a timeline showing the first appearance of selected identified innovations and shortcomings, considering the whole set of articles (Figure A1 on the Appendix features the complete version).

It is worth recalling that the innovation timeline constituted the basis for EIS content analysis, which showed a lack of correlation between international literature innovations remarks and IA practice concerning Minas Gerais iron ore developments.

Figure 5.1 – Abbreviated version of the innovation timeline



Figures 5.1 and A1 ratify what was observed in the clusters timelines: research tended to concentrate on practical and procedural aspects, rather than on theory development. Additionally, the literature review didn't show significant efforts in correlating practical innovations and shortcomings with the existing theoretical frames, as if the signification of an innovation or shortcoming didn't depend on the core values that condition IA practice.

For analytical purposes, we grouped the most cited papers in clusters, but they are essentially interconnected, being sometimes difficult to place an article unequivocally in a cluster. Therefore, it is important to explore clusters' relations through content analysis (Table A1 I the Appendix).

Figure 5.2 illustrates graphically the correlations between clusters, showing that clusters I, II and III are still the most connected. Among the 89 articles: 49 consider Public Participation, Social and Community Engagement (17 articles belonging to the clusters and 32 from other clusters); 30 consider IA Systems (18 articles in the clusters and 12 from other clusters); 40 consider Effectiveness, Quality and Improvement (17 articles in this cluster and 23 from others). Among the 18 articles belonging to the cluster II, 14 are correlated to cluster I and 14 to cluster III (considering that 10 articles are correlated to both clusters at the same time). Among the 17 articles belonging to cluster III, 12 are correlated to cluster I and 4 to cluster II.

Considering that we found that innovation is mainly presented in the literature within these three mutually correlated clusters, elements of these clusters were chosen as building blocks in an attempt to connect theory and innovation, as synthesized in Figure 5.3.

Starting with the IA theoretical spectrum (Figure 1), we propose that any innovation should be contextualized by positioning it in this spectrum. An IA system is represented by a zone with blur boundaries somewhere between the technicist and the deliberative poles. Some national systems may be very narrow, possibly closer to the technicist pole, while others are broader, spanning the spectrum. Changes in IA

systems (e.g. due to legislation) can move its boundaries towards one or another pole or enlarge the boundaries towards both sides. Gibson (2002) proposes that the evolution of environmental assessment is towards a participative model and Morgan (2012) states that more recent theoretical debates are pointing to a more participatory and collaborative way of operating. The transition from a technicist to a deliberative implies a gradual enhancement of citizens involvement, represented by the four blue boxes inspired by the spectrum of public participation of the IAP2 (2017).

Considering effectiveness as the ability of the IA process to meet its objectives (Elling, 2009), and innovations as novelties that would contribute to overcome gaps and enhance effectiveness, we propose that an alignment between the theoretical basis and innovations shall always be sought. In other words, the selection of opportunities to overcome problems, challenges and shortcomings should be made after acknowledging and in accordance with the boundaries of a given IA system, i.e. its positioning in the theoretical spectrum. The approach to develop innovations should always go from the macro level (theoretical boundaries) to the micro level (plausible innovations to put efforts on). The approach from macro to micro level is compatible with the IA literature, when Pope et al. (2013) defend that IA theoretical perspective conditions practice and Nykvist and Nilsson (2009), using a macro to micro level reasoning in the Swedish IA context, propose that strengthening institutional arenas for social learning is more relevant for sustainable development than the improvement of more advanced and complex assessment models.

Figure 5.2 – Clusters Correlation

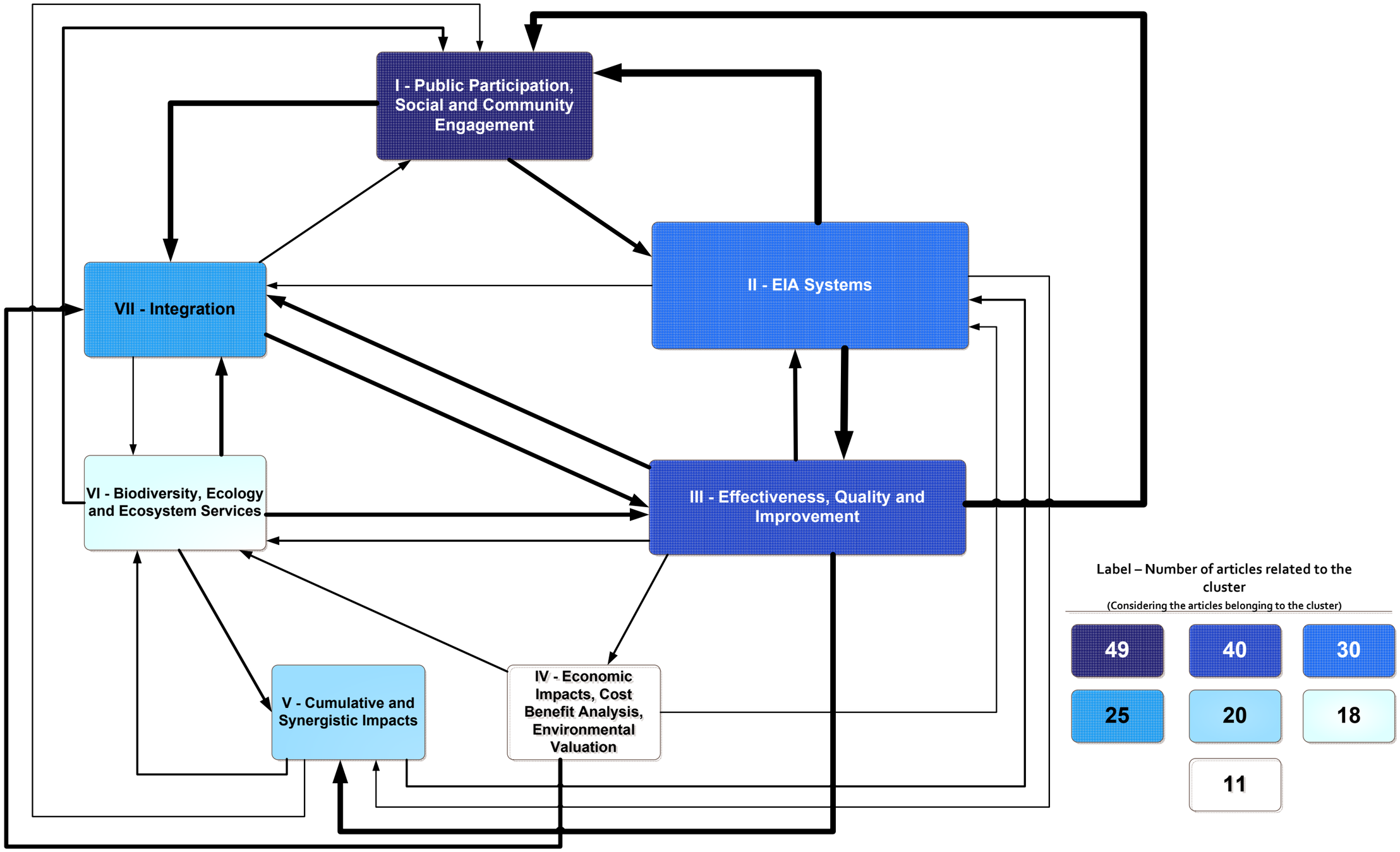
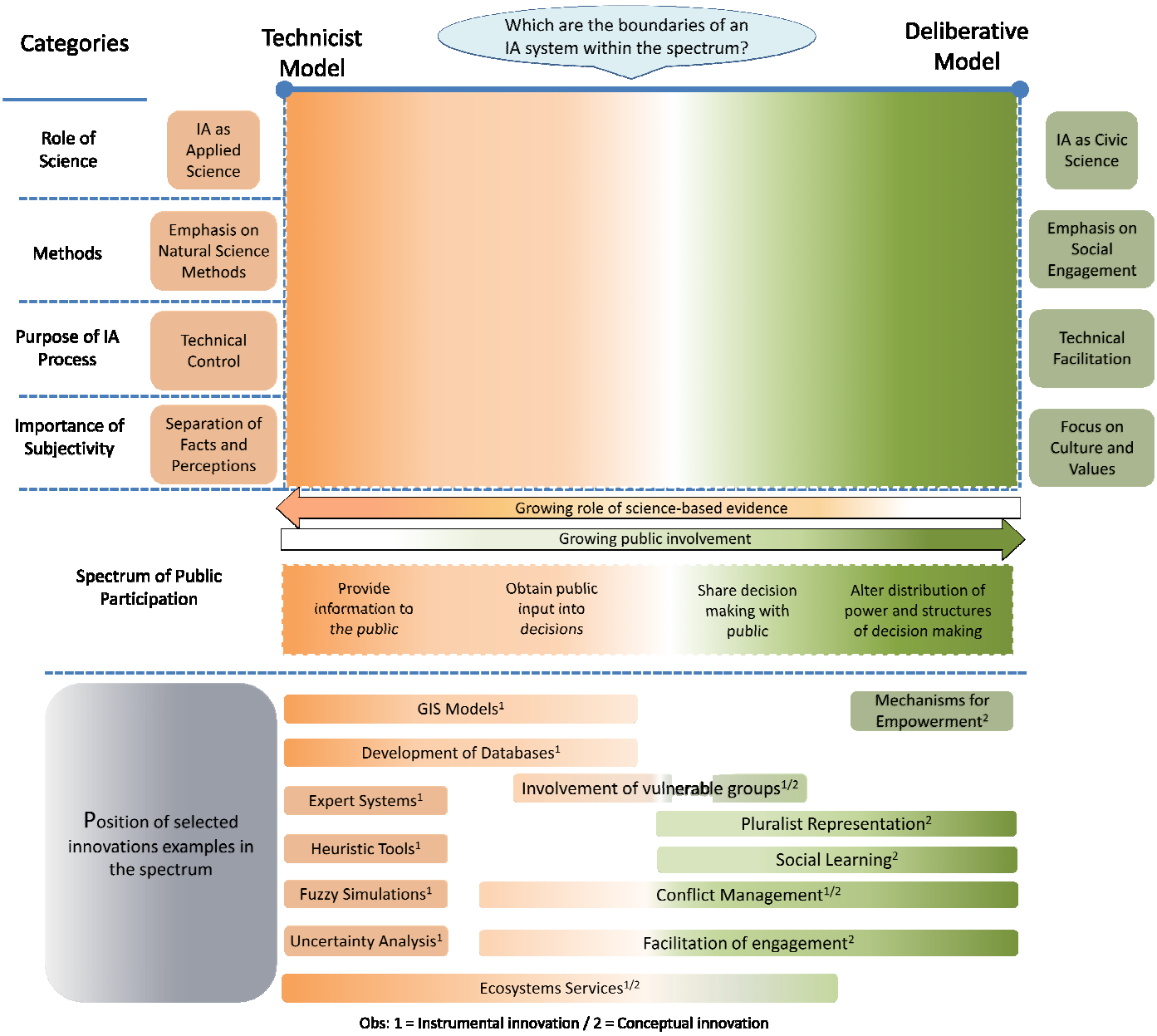


Figure 5.3 – Positioning innovations in the impact assessment spectrum



6. Conclusion

Papers published in two major journals in the field of impact assessment in the period 1990-2015 do identify several shortcomings of practice, as well as evaluate adopted novelties and propose other innovations. However, most innovations are not contextualized or related to any theoretical perspective of IA and there is little effort in correlating innovations with the existing theoretical frames. We interpret this finding as a critical flaw in IA research.

Information systematized through the bibliometric approach undertook made it possible to propose a framework that integrates theoretical perspectives of impact assessment with innovation options. Innovation should be discussed from a macro level (core values and *raison d'être*) to a micro level (tools, models and practice) approach. In the proposed framework, the theoretical boundaries of an IA system shall be previously established when discussing innovation, considering theoretical boundaries as the limits that an IA system occupies within the spectrum existing between two poles of IA - technicist and deliberative. It is assumed that the positioning of an IA system in the theoretical spectrum helps with the identification of the appropriated tools and approaches for that specific context, supporting the development of fit-for-purpose innovations that potentially conduce to better practice.

The research also supported the construction of an innovation timeline based on literature review, which assisted the content analysis of ten EIS of iron ore developments in the state of Minas Gerais, indicating a lack of correlation between international literature innovations issues and IA practice.

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APÊNDICE A – Clusters Correlation

Table A1 – Clusters Correlation

ID	Article	Correlation points	Clusters Correlated	
1	Armour (1990)	The effectiveness of EIA depends on its point of intersection with the planning and decision-making process	Integration	Effectiveness, Quality and Improvement
1	Kirkpatrick and Lee (1999)	Integration enhancement is a way to increase effectiveness	Integration	Effectiveness, Quality and Improvement
1	Lawrence (2000)	The most recent planning theory views planning as a collective exercise stressing the importance of dialogue and integrating personal experiential and processed knowledge.	Integration	Public Participation, Social and Community Engagement
2	Lawrence (2000)	Within pragmatic planning theory, Implementation, impact management, and EIA quality and effectiveness receive much more attention.	Integration	Effectiveness, Quality and Improvement
1	Slootweg et al. (2001)	The natural system comprises many environmental functions that provide goods and services that can be utilized by humanity.	Integration	Biodiversity, Ecology and Ecosystem Services
1	Alton and Underwood (2003)	By providing a simple but accurate way to see trade-offs, EIA will have created a means to engage the interested parties in meaningful dialogue.	Integration	Public Participation, Social and Community Engagement
1	Birley (2003)	A critical appraisal process is proposed to discuss the quality of health impact assessment or the quality of the integration of health with environmental and social assessment.	Integration	Effectiveness, Quality and Improvement
1	Morrison-Saunders et al.	Proliferation of different impact Assessment feeds	Integration	Effectiveness, Quality and

ID	Article	Correlation points	Clusters Correlated	
	(2014)	arguments for lack of effectiveness		Improvement
1	Atkinson et al. (2000)	Cumulative impacts on biodiversity are partially addressed	Biodiversity, Ecology and Ecosystem Services	Cumulative and Synergistic Impacts
1	Slootweg and Kolhoff (2003)	Development of a conceptual framework to integrate biodiversity considerations in EIA.	Biodiversity, Ecology and Ecosystem Services	Integration
2	Slootweg and Kolhoff (2003)	Public participation is essential to understand how to address biodiversity in a specific context.	Biodiversity, Ecology and Ecosystem Services	Public Participation, Social and Community Engagement
1	Wegner et al. (2005)	The most sophisticated practitioners placed biodiversity in its spatial and temporal context as well as being cognizant of community aspirations.	Biodiversity, Ecology and Ecosystem Services	Public Participation, Social and Community Engagement
1	Gontier et al. (2006)	The integration of biodiversity in the scope of the EIA process is rather recent, and a few years of inertia in the implementation of new practices concerning biodiversity can be expected.	Biodiversity, Ecology and Ecosystem Services	Integration
2	Gontier et al. (2006)	Lack of consistent quality in biodiversity assessment.	Biodiversity, Ecology and Ecosystem Services	Effectiveness, Quality and Improvement
3	Gontier et al. (2006)	The approach proposed could also facilitate the consideration and integration of widespread, long-term or cumulative impacts in the assessment.	Biodiversity, Ecology and Ecosystem Services	Cumulative and Synergistic Impacts
1	Geneletti (2006)	The identification of the study area is done on a non-ecological basis, undermining the effectiveness of the subsequent impact analysis.	Biodiversity, Ecology and Ecosystem Services	Effectiveness, Quality and Improvement

ID	Article	Correlation points	Clusters Correlated	
1	Soderman (2006)	Use EIA reports as genuine planning tools to promote interaction between the developer, the public and the EIA authority.	Biodiversity, Ecology and Ecosystem Services	Public Participation, Social and Community Engagement
2	Soderman (2006)	Makes several suggestions to improve the effectiveness of the treatment of biodiversity issues in EIA.	Biodiversity, Ecology and Ecosystem Services	Effectiveness, Quality and Improvement
3	Soderman (2006)	Cumulative impacts on biodiversity are not adequately treated in project EIAs at present.	Biodiversity, Ecology and Ecosystem Services	Cumulative and Synergistic Impacts
1	Briggs and Hudson (2013)	A collective source for consultants' data would improve the effectiveness of scoping (thereby reducing costs) and preliminary studies, improve research and inform policy making.	Biodiversity, Ecology and Ecosystem Services	Effectiveness, Quality and Improvement
1	Baker et al. (2013)	Ecosystem services is an integrating concept that enable the approximation of ecosystems elements to socioeconomic ones.	Biodiversity, Ecology and Ecosystem Services	Integration
1	Karjalainen et al. (2013)	They argue that the proposed approach has potential to integrate ecosystem services into EIA.	Biodiversity, Ecology and Ecosystem Services	Integration
1	Smit and Spaling (1995)	Landscape analysis is based on principles of biogeography and landscape ecology. Loop analysis has been used in marine ecology to model plankton communities.	Cumulative and Synergistic Impacts	Biodiversity, Ecology and Ecosystem Services
1	Baxter et al. (2001)	Public participation is one of the strengths of Canadian EIA and it is through public consultation that key values and issues are	Cumulative and Synergistic Impacts	Public Participation, Social and Community Engagement

ID	Article	Correlation points	Clusters Correlated	
		identified, providing pertinent contextual information		
2	Baxter et al. (2001)	Demystifying CEA will require that the Canadian Environmental Assessment Agency works with universities and other educational institutions, community groups and government departments to disseminate and solicit information that is easily understood and accessible.	Cumulative and Synergistic Impacts	EIA Systems
1	Cooper and Sheate (2002)	The consideration of cumulative effects in environmental impact assessment (EIA) has been required in the UK, though somewhat ambiguously, since the EC Directive (85/337/EEC) was implemented in 1988.	Cumulative and Synergistic Impacts	EIA Systems
1	Brismar (2004)	To assess river ecological effects is generally difficult, particularly in quantitative terms, due to the inherent spatial heterogeneity, temporal dynamics, and complex ecological behavior of large river systems.	Cumulative and Synergistic Impacts	Biodiversity, Ecology and Ecosystem Services
1	Hundloe et al. (1990)	Environmental assessment requires that all impacts, ecological, economic, and sociological, be integrated. Economic evaluation permits this.	Economic Impacts, Cost Benefit Analysis, Environmental Valuation	Integration
1	Leistritz (1994)	Another trend in the development of economic impact assessment methods and models has been the development of integrated assessment models that incorporate multiple impact	Economic Impacts, Cost Benefit Analysis, Environmental Valuation	Integration

ID	Article	Correlation points	Clusters Correlated	
		dimensions.		
1	Knaus et al. (2006)	On a project level, there is a strong need to integrate environmental impacts into economic analysis in order to holistically compare different project alternatives.	Economic Impacts, Cost Benefit Analysis, Environmental Valuation	Integration
2	Knaus et al. (2006)	The ecosystem services valuation technique is based on assessing indirect economic values when market valuation does not adequately capture the social costs.	Economic Impacts, Cost Benefit Analysis, Environmental Valuation	Biodiversity, Ecology and Ecosystem Services
1	Lindhjem et al. (2007)	The details of the Chinese EIA system and institutional setup has been thoroughly evaluated and criticized in previous studies.	Economic Impacts, Cost Benefit Analysis, Environmental Valuation	EIA Systems
2	Lindhjem et al. (2007)	Many of the challenges of integrating Economical Valuation into EIA identified here are likely not to be specific to China, and a comparative cross-country study would be an interesting topic for further research.	Economic Impacts, Cost Benefit Analysis, Environmental Valuation	Integration
1	Erikstad et al. (2008)	This paper focuses on two main subjects, natural environment (including both geodiversity and biodiversity) and cultural heritage. In ecology, structure can be understood as a combination of physical properties of the landscape (barriers, corridors, etc.). Landscape ecology has developed these concepts as useful tools describing ecological processes within a geographical framework.	Economic Impacts, Cost Benefit Analysis, Environmental Valuation	Biodiversity, Ecology and Ecosystem Services
1	Mcdonald and	The article indicates the	Effectiveness,	Integration

ID	Article	Correlation points	Clusters Correlated	
	Brown (1995)	requirements for its eventual absorption into project planning and design, and the concomitant need to fully incorporate environmental issues in land use planning to address those matters that cannot be addressed on a project-by project basis.	Quality and Improvement	
1	Ortolano and Shepherd (1995)	EIA is not well integrated into decision making; and EIA occurs at the project level, but not generally at the policy or program level.	Effectiveness, Quality and Improvement	Integration
2	Ortolano and Shepherd (1995)	Cumulative Impacts Are Not Assessed Frequently.	Effectiveness, Quality and Improvement	Cumulative and Synergistic Impacts
3	Ortolano and Shepherd (1995)	Cumulative Impacts Are Not Assessed Frequently.	Effectiveness, Quality and Improvement	Public Participation, Social and Community Engagement
1	Canter and Clark (1997)	This paper summarizes results of a survey of an interdisciplinary group of 31 academics about NEPA's strengths and issues of concern.	Effectiveness, Quality and Improvement	EIA Systems
2	Canter and Clark (1997)	NEPA should encourages agencies and decision makers to acknowledge potential environmental consequences to the public, thus opening up the decision process;	Effectiveness, Quality and Improvement	Public Participation, Social and Community Engagement
3	Canter and Clark (1997)	Ecosystem management should be used for large-scale projects or programs, including the incorporation of biodiversity considerations in NEPA documentation.	Effectiveness, Quality and Improvement	Biodiversity, Ecology and Ecosystem Services
4	Canter and Clark (1997)	Clarification of requirements for cumulative impacts	Effectiveness, Quality and Improvement	Cumulative and Synergistic Impacts

ID	Article	Correlation points	Clusters Correlated	
		documentation in EAs and EISs is needed. In addition, connected actions and how they should be addressed in the NEPA process should be addressed.		
5	Canter and Clark (1997)	A task force should be formed from pertinent federal agencies to study the issues associated with integrating biophysical and social/ economic considerations in the NEPA process; one expected outcome would be a series of actions which could be taken to encourage more timely and greater integration of these environmental components in the NEPA process.	Effectiveness, Quality and Improvement	Integration
6	Canter and Clark (1997)	The results suggest it may be concluded that these academics support the contention that NEPA is accomplishing its fundamental goal, requiring agencies to include environmental considerations in project planning and decision making along with the more traditional engineering (or technical) analyses and economic evaluations (as reflected by cost-benefit analyses).	Effectiveness, Quality and Improvement	Economic Impacts, Cost Benefit Analysis, Environmental Valuation
1	Hickie and Wade (1998)	A 4-year research program undertaken in the Midlands Region of the Environment Agency has studied the EA process related to projects in the water environment. It has explored past deficiencies and undertaken the	Effectiveness, Quality and Improvement	EIA Systems

ID	Article	Correlation points	Clusters Correlated	
		development of new ideas. This research builds on previous studies undertaken by the NRA on the role of EA in the water industry.		
1	Barker and Wood (1999)	Strengthening provisions for consultation and public participation (to increase the number of proposed modifications).	Effectiveness, Quality and Improvement	Public Participation, Social and Community Engagement
1	Gibson (2002)	Canadian environmental assessment has evolved significantly from the embarrassing Wreck Cove hydroelectric project experience in the mid-1970s to the more exemplary case of the Voisey's Bay Mine and Mill project, approved in 2002. Over this period, policy and law reforms have slowly made federal assessment requirements more demanding, open and mandatory.	Effectiveness, Quality and Improvement	EIA Systems
2	Gibson (2002)	EIA has moved towards being more open and participative (not just proponents, government officials and technical experts).	Effectiveness, Quality and Improvement	Public Participation, Social and Community Engagement
3	Gibson (2002)	A shift to sustainability assessment would be demanding. It would entail, among other things, more direct integration of social, economic, biophysical and other considerations.	Effectiveness, Quality and Improvement	Integration
4	Gibson (2002)	While the current forms of environmental assessment do give concentrated, public attention to ecological issues, they frequently play a marginal	Effectiveness, Quality and Improvement	Biodiversity, Ecology and Ecosystem Services

ID	Article	Correlation points	Clusters Correlated	
		end role, making recommendations to closed, economically-dominated approvals processes.		
5	Gibson (2002)	Stage 4 of EIA development: integrated planning and decision making for sustainability, addressing policies and programs as well as projects, cumulative and global effects.	Effectiveness, Quality and Improvement	Cumulative and Synergistic Impacts
1	Lenzen et al. (2003)	The paper describes a method that uses input–output analysis to calculate the indirect effects of a development proposal in terms of several indicator variables.	Effectiveness, Quality and Improvement	Economic Impacts, Cost Benefit Analysis, Environmental Valuation
1	Buchan (2003)	Involving communities in a participatory manner facilitates skill transfer, fosters buy-in and creates local social capital.	Effectiveness, Quality and Improvement	Public Participation, Social and Community Engagement
1	Benson (2003)	Of the many shortcomings and criticisms levelled at impact assessment, the paper concentrates on those elements considered crucial to a move towards sustainable planning, in particular the role of public participation.	Effectiveness, Quality and Improvement	Public Participation, Social and Community Engagement
2	Benson (2003)	Although reference to cumulative effects is made in Directive 97/11/EC (and acknowledged elsewhere as an 'emerging challenge' for EIA systems), it is too early to say if this gesture in the revised Directive will be effective.	Effectiveness, Quality and Improvement	Cumulative and Synergistic Impacts
1	Ross et al. (2006)	Active participation of the public is an important principle for best practice	Effectiveness, Quality and Improvement	Public Participation, Social and

ID	Article	Correlation points	Clusters Correlated	
		EIA (IAIA & IEA 1999). However, there is a tendency for participants in a review process to view their concerns as most important, even when they may not be perceived as terribly important by others, especially by decision-makers.		Community Engagement
1	Sandham and Pretorius (2008)	EIA process in South Africa requires a full suite of public participation and authority consultation in both the scoping and EIA phases.	Effectiveness, Quality and Improvement	Public Participation, Social and Community Engagement
2	Sandham and Pretorius (2008)	EIA regulations were promulgated in South Africa in terms of Sections 21, 22 and 26 of the Environment Conservation Act (73 of 1989). The EIA system was characterized by a strong emphasis on public participation and on scoping.	Effectiveness, Quality and Improvement	EIA Systems
1	Elling (2009)	The right for everybody to participate is guaranteed because significant impacts on the environment concern everybody's life-situation.	Effectiveness, Quality and Improvement	Public Participation, Social and Community Engagement
1	João et al. (2011)	Cumulative impacts can leverage and coordinate actions for enhancement	Effectiveness, Quality and Improvement	Cumulative and Synergistic Impacts
1	Bond and Pope (2012)	EIA paper makes it clear that poor, or absent, public participation remains an issue.	Effectiveness, Quality and Improvement	Public Participation, Social and Community Engagement
2	Bond and Pope (2012)	Cumulative effects are still poorly considered.	Effectiveness, Quality and Improvement	Cumulative and Synergistic Impacts
1	Esteves et al. (2012)	Creating participatory processes and deliberative spaces to facilitate community discussions	Effectiveness, Quality and Improvement	Public Participation, Social and Community

ID	Article	Correlation points	Clusters Correlated	
		about desired futures, the acceptability of likely impacts and proposed benefits		Engagement
1	Morgan (2012)	Problems associated with practice, including limited or no public participation; and the limited substantive effect of EIA as a process.	Effectiveness, Quality and Improvement	Public Participation, Social and Community Engagement
2	Morgan (2012)	Most legislated EIA processes refer to cumulative effects as one of the characteristics of proposed activities that need to be considered, but in practice they are often not addressed or are handled inadequately.	Effectiveness, Quality and Improvement	Cumulative and Synergistic Impacts
1	Bojórquez-Tapia and García (1998)	The average EIS consists of incoherent descriptions, unused data, and unsubstantiated conclusions.	EIA Systems	Effectiveness, Quality and Improvement
1	Glasson and Salvador (2000)	There are some concerns about EIA quality. A recent study [27] showed that, although EIS quality has improved over time, up to 40% of post-1991 EISs were not of satisfactory quality.	EIA Systems	Effectiveness, Quality and Improvement
2	Glasson and Salvador (2000)	Public participation in EIA leaves much to be desired in many systems, and Brazil is no exception. There is a strong case for including a formal requirement to provide the opportunity for public consideration of an EIS, and for mandatory publicizing of EIA cases in the local press. Formal channels for public participation are very rare and weak in Brazil.	EIA Systems	Public Participation, Social and Community Engagement
3	Glasson and	Secondary, indirect, and	EIA Systems	Cumulative and

ID	Article	Correlation points	Clusters Correlated	
	Salvador (2000)	cumulative impacts are also not well identified or properly assessed. Although the legislation provides for EIA monitoring, this procedure is rarely carried out in practice.		Synergistic Impacts
1	Cherp (2001)	EA systems have been reformed not only in order to enhance the effectiveness of environmental protection, but also to promote more transparent, participatory, and decentralized decision-making procedures and to comply with international norms, such as the EA Directives of the EU.	EIA Systems	Effectiveness, Quality and Improvement
2	Cherp (2001)	EA systems have been reformed not only in order to enhance the effectiveness of environmental protection, but also to promote more transparent, participatory, and decentralized decision-making procedures and to comply with international norms, such as the EA Directives of the EU.	EIA Systems	Public Participation, Social and Community Engagement
1	Momtaz (2002)	Community participation and consultation should be incorporated at every stage of project development. Consultation with local people and their representation in project development process will ensure better decision making.	EIA Systems	Public Participation, Social and Community Engagement
1	Ahmad and Wood (2002)	Preparing user-specific guidelines on EIA. These guidelines could be	EIA Systems	Effectiveness, Quality and Improvement

ID	Article	Correlation points	Clusters Correlated	
		targeted to those responsible for preparing EIA reports, to those consulted, to those reviewing EIA reports and to those making decisions.		
2	Ahmad and Wood (2002)	Strengthening public participation in the EIA process, especially in Egypt and Tunisia. Approaches to ensure effective public participation in the EIA process need to be designed to suit the socio-political context in which EIA is applied.	EIA Systems	Public Participation, Social and Community Engagement
1	Purnama (2003)	After developing the EIA system for 14 years, Indonesia finally recognized the importance of emphasizing public involvement in the EIA guidelines of 2000	EIA Systems	Public Participation, Social and Community Engagement
1	Wang et al. (2003)	There are problems with the current EIA system which limit its effectiveness as a tool for protecting the wider environment. The strong emphasis on environmental protection, and especially pollution control, has tended to limit the attention given to other aspects of the biophysical and socio-cultural environment.	EIA Systems	Effectiveness, Quality and Improvement
2	Wang et al. (2003)	The main problems highlighted includes the lack of effective public participation.	EIA Systems	Public Participation, Social and Community Engagement
1	Baker and Mclelland (2003)	Effectiveness is reviewed as a means to measure policy implementation and an expanded framework is proposed to measure	EIA Systems	Effectiveness, Quality and Improvement

ID	Article	Correlation points	Clusters Correlated	
		effectiveness. The framework is applied to three case studies in north-central British Columbia to measure the effectiveness of First Nations' participation in the EA process for mining development.		
2	Baker and Mclelland (2003)	First Nations must be asked what participation techniques they prefer, rather than what techniques are acceptable. Just because meetings and presentations take place in First Nations' communities and are accepted by First Nations, does not mean that these techniques are the preferred choice for First Nations.	EIA Systems	Public Participation, Social and Community Engagement
1	Ramjeawon and Beedassy (2004)	One of the main weaknesses, besides the lack of EIA audits, is the absence of EIA follow-up monitoring. It is necessary to distinguish between monitoring done for regulatory purposes (compliance monitoring) and environmental monitoring related to the EIA.	EIA Systems	Effectiveness, Quality and Improvement
1	Almer and Koontz (2004)	The hearing happened at a later stage in the EIA process, as opposed to what occurs in the United States. The hearing also seemed to be a formality in that administrators did not go beyond the minimum requirements necessary.	EIA Systems	Public Participation, Social and Community Engagement
1	El-Fadl and El-Fadel (2004)	Most deficiencies in EIA systems can be attributed to the poor performance of	EIA Systems	Effectiveness, Quality and Improvement

ID	Article	Correlation points	Clusters Correlated	
		foundation measures (availability of guidelines, EIA system implementation monitoring, and a generally weak prevalence of local expertise, and training and capacity building initiatives).		
1	Androulidakis and Karakassis (2006)	In 92% of the studies included in the sample, there is no reference to public participation	EIA Systems	Public Participation, Social and Community Engagement
1	Paliwal (2006)	Increase the accountability of the EIA experts. Certification of consultants is deemed necessary so that only licensed agencies should accomplish EIA. Manage baseline data properly. One of uncertainties in the EIA prediction is due to lack of reliable and accurate data.	EIA Systems	Effectiveness, Quality and Improvement
2	Paliwal (2006)	Effective public involvement in the process brings forth wide range of social, cultural and emotional concerns, to establish terms of reference of scoping, which may be deemed outside the scope of EIA. It would make decision socially acceptable.	EIA Systems	Public Participation, Social and Community Engagement
3	Paliwal (2006)	Integrate environmental concerns into plans and policies.	EIA Systems	Integration
1	Polonen (2006)	The quality of the statement has consequences in the decision-making process and it is one of the key elements of an effective EIA. Another challenge facing the effectiveness of the EIA system concerns	EIA Systems	Effectiveness, Quality and Improvement

ID	Article	Correlation points	Clusters Correlated	
		the linkage between environmental impact assessment and decision making. In today's situation it is not guaranteed that the assessment results filter widely into decision-making.		
1	Pinho et al. (2007)	Multidisciplinary teams in EIA studies, better understanding of the technical complexities of the projects under analysis with engineers, architects and project designers in EIA teams, effective scoping with early public participation, due consideration to all real alternatives including the zero option, availability of project specific EIA guidance, are all aspects that may prove decisive if an effective improvement of the quality of EIA reports is envisaged.	EIA Systems	Effectiveness, Quality and Improvement
2	Pinho et al. (2007)	The incorporation of public suggestions in the EIA report (criterion 10) is not common in Portugal, unless a social survey or a series of interviews is conducted prior to the public participation phase, by the EIA team and as part of their work to prepare the EIA report.	EIA Systems	Public Participation, Social and Community Engagement
1	Nadeem and Hameed (2008)	Inadequate capacity of EIA approval authorities, deficiencies in screening and scoping, poor EIA quality, inadequate public participation and weak monitoring. Overall, EIA is used presently as a project justification tool rather than	EIA Systems	Effectiveness, Quality and Improvement

ID	Article	Correlation points	Clusters Correlated	
		as a project planning tool to contribute to achieving sustainable development.		
2	Nadeem and Hameed (2008)	There is no compulsion on the proponents in case of Pakistan to involve the concerned public during EIA preparation. Some proponents (particularly of foreign funded public sector projects) however, consult affected mainly for collecting socio-economic baseline data and occasionally for obtaining their views on project.	EIA Systems	Public Participation, Social and Community Engagement
1	Toro et al. (2010)	Given this state of affairs, and in compliance with international treaties, the Political Constitution, and current legislation, the Environmental Impact Assessment System in Colombia must be made more effective in order to effectively protect the environment and conserve Colombian biological and cultural diversity.	EIA Systems	Effectiveness, Quality and Improvement
2	Toro et al. (2010)	Public participation should be increased by open consultation of all population groups.	EIA Systems	Public Participation, Social and Community Engagement
1	Haydar and Pediaditi (2010)	The quality of EIA reports was perceived by interviewees to be of poor quality and public participation to be problematic in practice. The EIA's influence on decision making was considered weak, attributed to a number of reasons, such	EIA Systems	Effectiveness, Quality and Improvement

ID	Article	Correlation points	Clusters Correlated	
		as poor institutional integration within existing licensing procedures, persisting exclusion of government projects from the process, as well as inadequate technical and financial resources. The absence of technical background and necessary guidance in EIA, as well as baseline environmental information, was underlined as a key issue.		
2	Haydar and Pediaditi (2010)	Improve effectiveness of public participation procedures by: • Increasing accessibility of EIA reports to the public; • Extending the two-week consultation review period; • Providing facilitation training to environmental departments; • Public awareness raising programs.	EIA Systems	Public Participation, Social and Community Engagement
1	Daniels and Walker (1996)	Collaborative Learning is a framework that can be adapted to a particular situation to generate integration of scientific and public knowledge about the problem situation.	Public Participation, Social and Community Engagement	Integration
1	Burdge and Vanclay (1996)	All types of assessment face the problem of integration. How do EIA and SIA fit together in providing a comprehensive picture of likely project impacts? At present, most SIA statements are stapled to an EIA, and the total recommendations are the sum of the parts. No attempt is made to integrate and interpret the collective findings. This	Public Participation, Social and Community Engagement	Integration

ID	Article	Correlation points	Clusters Correlated	
		needs to be improved.		
1	Del Furia and Wallace-Jones (2000)	It should also be noted that some regions of Italy and autonomous provinces have special constitutional rights, and have promulgated specific EIA laws, some of which are considered far more advanced than the decrees from the Ministry of Environment.	Public Participation, Social and Community Engagement	EIA Systems
1	Appiah-Opoku (2001)	In 1973, Ghana created the Environmental Protection Council (EPC), which became the first governing body in Africa to focus on issues of environmental management. The EPC soon recognized the need to introduce formally a systematic procedure for evaluating environmental impacts of major development projects in the country.	Public Participation, Social and Community Engagement	EIA Systems
1	Sinclair and Diduck (2001)	All Canadian jurisdictions have notice provisions in their EA statutes, supporting regulations or policies. These provisions include specific notice (ranging from 30 to 45 days) if public hearings are to be held. There is less consistency, however, in how notice is provided, and by whom, for other milestones in the EA process, such as filing of the proposal and completion of the environmental impact statement (EIS).	Public Participation, Social and Community Engagement	EIA Systems
1	Lockie (2001)	Some authors collapse social and economic	Public Participation,	Integration

ID	Article	Correlation points	Clusters Correlated	
		assessment into 'socio-economic impact assessment' which, despite the obvious relationships between the two, belies the very different methodological and theoretical expertise necessary to evaluate social and economic change.	Social and Community Engagement	
1	Becker et al. (2003)	The practical tools employed in the Interactive Community Forum provide an innovative way to inform citizens' judgments offering a valuable supplement to traditional SIA and a way to integrate social considerations into the EIS process.	Public Participation, Social and Community Engagement	Integration
1	Bond et al. (2004)	Public participation should take place from the very earliest stages and should be integrated into the EIA (thereby going beyond the Directive requirements).	Public Participation, Social and Community Engagement	Integration
1	Hartley and Wood (2005)	The article explores the nature of public participation in the environmental impact assessment (EIA) process in the context of the potential integration of the Aarhus Convention principles into the UK EIA system.	Public Participation, Social and Community Engagement	EIA Systems
1	O'Faircheallaigh (2007)	These require that the Aboriginal groups be involved in all phases of the development of a comprehensive monitoring program for the Project, the integration of traditional knowledge into the monitoring program, Inuit/Innu participation in all	Public Participation, Social and Community Engagement	Integration

ID	Article	Correlation points	Clusters Correlated	
		biophysical monitoring activities of interest to them, and an annual review of the Company's management plans related to the monitoring program and of its emergency response and contingency plans.		
1	Tang et al. (2008)	From the late 1990s, the contents of EIA in China began to gradually shift from being physically-oriented to being more socially-focused (Chen, 1995). International funding agents were the principal driving force behind this shift.	Public Participation, Social and Community Engagement	EIA Systems

APÊNDICE B – Complete version of the innovation timeline

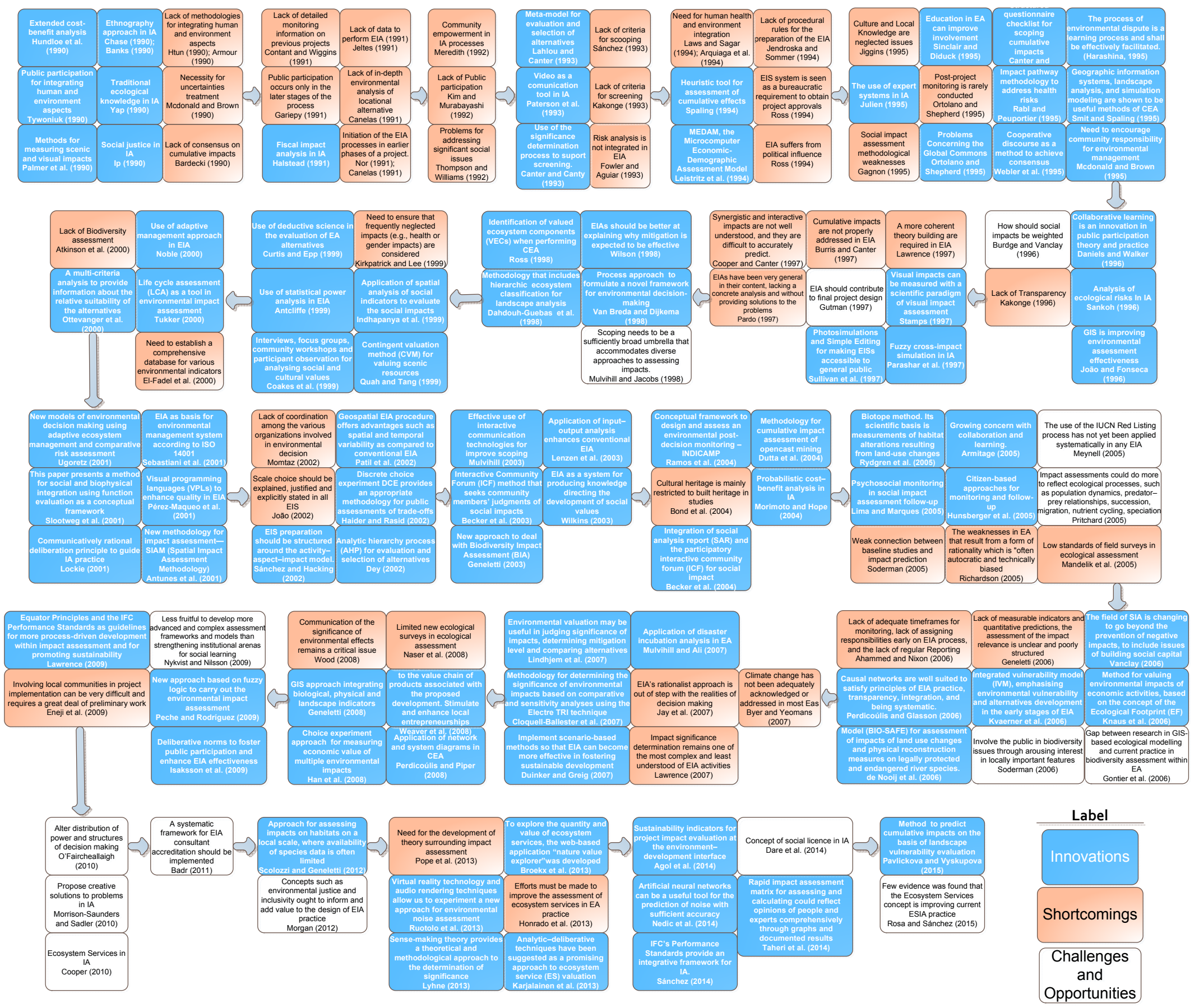

Figure A1 – Innovation Timeline