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Review

The science and politics of co-benefits in climate policy

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ABSTRACT

The co-benefits concept implies a 'win–win' strategy to address two or more goals with a single policy measure. There is much scholarly and policy attention paid to this concept as a way to avoid making trade-offs between developmental and environmental issues. However, there is no review paper that reviews the nature, evolution, strengths and limits of the co-benefits concept in relation to climate change. Hence, this review article addresses the question: What does the literature tell us about the definition, application and use of the co-benefits concept? Using a literature review approach, this article explains the evolution of the co-benefits concept and its strengths and weaknesses. We conclude that while the concept has tremendous advocacy potential in dealing with the problem that the costs and benefits of climate policy are temporally and spatially not aligned, its de facto potential is limited as mostly economists have engaged with this concept, and there is little trans-disciplinary work undertaken that also looks at the politics and institutional aspects of co-benefits. The article thus provides an impetus to rethink current approaches to studying co-benefits and points to the need for inter- and trans-disciplinary research drawing on economic, political and social sciences.

1. Introduction

Since the 1990s, the term 'co-benefits' has been used in both academia and official policy documents. The use of the term has exploded in the last decade and 'co-benefits' has become a predominant concept in scientific writing that focuses on reconciling environmental and developmental goals. The influential Intergovernmental Panel on Climate Change reports now feature 'co-benefits' as a central concept (IPCC, 2007; IPCC, 2014a; IPCC, 2014b). Here, co-benefits refer to 'the positive effects that a policy or measure aimed at one objective might have on other objectives, irrespective of the net effect on overall social welfare' (IPCC, 2014b, p. 14). The concept appears to be very promising for developed economies and emerging economies, as it offers them a way of not compromising on economic growth while still allowing them to take environmental aspects into account. For example, countries like India have adopted the co-benefits approach as a dominant strategy to deal with the twin goals of climate change mitigation and economic and social development. The National Action Plan on Climate Change released by the Indian government in 2008 identifies 'measures that promote [India's] development objectives while also yielding co-benefits for addressing climate change effectively' (PMCCC, 2008, p. 2). In both its scientific and political usage, 'co-benefits' has outpaced related concepts such as 'no-regrets' and 'double dividends' and is seen as significantly easier than concepts such as coherence, integration and mainstreaming.

Despite its prevalence in the scientific literature, there is no common definition of what 'co-benefits' means or what counts as a co-benefit. While a review of co-benefits studies can be found in, for instance, Pearce (2000), Rübbelke (2002), Pittel and Rübbelke (2008) and Bollen et al. (2009), these reviews have been conducted on the basis of articles that use macroeconomic models to estimate the co-benefits of a particular policy or in a particular country. Conversely, the meaning of the term 'co-benefits' and its political usage has attracted comparatively little attention. Of the short-listed 138 articles on co-benefits, not one focused on the meaning, contestations and usage of 'co-benefits' in practice. This can be ascribed to the dominant scholarly focus on seeing co-benefits as primarily a subject for the economic discipline as opposed to the necessary multi-disciplinary approach needed to analyse

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co-benefits. In the former approach, co-benefits are equated with positive externalities. As we shall argue, the concept of co-benefits is not an economic concept or a prescriptive policy approach but should be understood as an idea, and it carries political weight in its definition, application and use. If the latter is not understood, no amount of potential opportunities derived from the co-benefits approach will ever be realized in practice.

This article poses the question: What does a review of the literature tell us about the definition, application and use of the co-benefits concept? The article first outlines the steps taken in the literature review (Section 2). Section 3 analyses the meaning of 'co-benefits'. Section 4 reviews the application of the concept. The conclusion reflects on our findings.

2. Key elements of the literature review

To select journal articles for our literature review, we conducted a search in the ScienceDirect database in the spring of 2014. Four steps were applied to find suitable articles for analysis. First, a search for the key terms 'co-benefits* OR ancillary benefits*' in the database revealed 2273 articles. 'Ancillary benefits' is here and elsewhere used interchangeably with the term 'co-benefits' (see, e.g., IPCC, 2007). Second, articles were selected if they had one of these key terms in their title, abstract or keywords. Third, we applied three criteria to judge the suitability of the articles' content for our analysis: 'co-benefits' is the central part of the analysis; the article studies climate change mitigation or adaptation measures; and the article makes conclusions regarding 'co-benefits' as a result of these measures. Only articles that met all the three criteria were selected for further analysis. Fourth, the resulting sample of 138 articles was subjected to both quantitative and qualitative analyses. In practice, this meant that we focused on articles on climate change, but very often, the co-benefits issue meant that we also looked at co-benefits in the fields of economics, environment, social and institutional studies (see Fig. 1).

In the qualitative analysis, all articles were scrutinized in relation to their definition and application of the concept of 'co-benefits' as well as their applied methodology in order to get a deeper understanding of the concept as well as to develop categories for the subsequent quantitative analysis. To assemble a database for quantitative analysis, each article was coded on seven variables with multiple categories (Table 1) to allow for a more objective evaluation and the recognition of patterns in the application of the concept.

3. Diversification in the meaning of 'co-benefits'

This section analyses the meaning of 'co-benefits' in the academic literature. First, we identify three strands of common understandings of the concept and provide associated definitions. Second, we review the scope of the concept by providing an overview of possible co-benefits from our sample. Third, we explain why the concept of co-benefits has replaced the earlier concepts.

3.1. The use of 'co-benefits' in the academic literature

The qualitative analysis of how scholars define the term revealed that there is no univocal definition of what 'co-benefits' actually means. We find, first, that authors frequently fail to provide an explicit definition. Second, the common ground in all approaches is the elaboration of a 'win–win' strategy through which at least more than one objective is achieved through a single policy. Third, since our search focused on climate change, we found that in this field the term has been used to describe synergies between climate change mitigation/adaptation and other goals. Fourth, the analysis shows that the co-benefits terminology has been used in different ways throughout our sample. We argue that there are three strands of usage in empirical research that can be distinguished along various lines (Table 2).

A first cluster of articles refer to co-benefits as '*climate co-benefits*'. The policies studied in these articles are not specifically designed to address climate change. Conversely, co-benefits refer to the impact that development plans or sectoral policies might have on global climate change in line with the 'development first' approach (see, e.g., Bradley et al., 2005). The primary goal of such policies might thus be energy security (Mondal et al., 2010), health benefits (De Nazelle et al., 2011) or

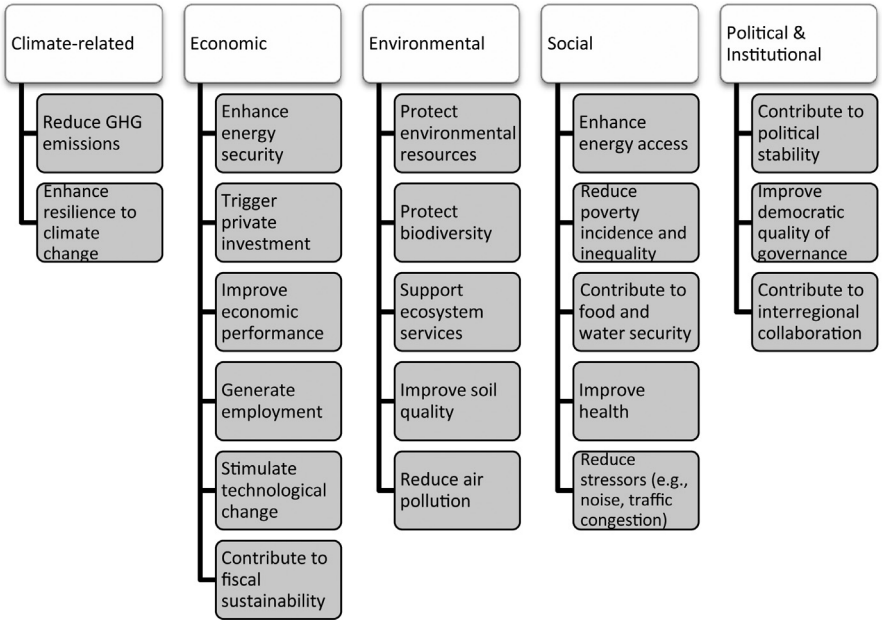

Fig. 1. Types of co-benefits.

Table 1
Coding for quantitative analysis.

Variable	Date of publication	Country studied	Scale	Definition of Co-benefits	Co-benefits	(Scientific) nature of article	Measurement
Categories	(Year)	Developed country Emerging economy Developing country	International Country Regional (e.g., state) Local (e.g., city) Multiple	Climate co-benefits Development co-benefits Co-impact	Economic Environmental Social Political and institutional Climate related	Case study Meta-analysis Literature review Theory	Quantitative Qualitative Monetary

better waste management (Kurniawan et al., 2013), but the policy is recognized to yield co-benefits for climate change. An exemplary definition is the 'advantages for climate change mitigation and adaptation brought by enhancing [..] policies in inter-related environmental sectors' (Lee and van de Meene, 2013, p. 16). The idea entailed in this strand of applications is that policy measures can contribute to a development pathway that is also sensitive to climate change and, hence, applied mainly (but not exclusively) to developing countries and emerging economies.

A second grouping of articles refer to '*development co-benefits*'. Here, authors take on co-benefits as the largely local impacts that are the result of specific climate change policies. While policies thus have the primary goal of climate mitigation or adaptation through, for instance, low carbon electricity generation, spillover effects on other policy goals such as employment (Cai et al., 2011) or the improvement of public health (Haines et al., 2010) are recognized. Accordingly, a typical definition is the 'potential benefits of climate change mitigation actions in other fields or areas not covered by climate change' (Kapshe et al., 2013, p. 53).

A third strand of articles is characterized by the non-prioritization of either goals and hence speaks of '*climate and [other goal] co-impacts/co-benefits*'. The policy measures studied here are thus a priori designed to achieve two goals simultaneously. The most prominent example is 'climate and pollution co-benefits' (see, e.g., Bollen et al., 2009). Because CO_2 is not emitted in isolation but often emitted along with other gases like the N-gases (N_2O, NO_x, NH_3) that are either other greenhouse gases (GHG) or cause local air pollution, policy measures can achieve both goals simultaneously (Winiwarter and Klimont, 2011). The underlying principle is that of 'co-control of atmospheric emissions to yield simultaneous benefits for climate change and air quality' (Thambiran and Diab, 2011, p. 2683). While co-benefits occur automatically and thus do not necessitate particular attention in the policy design process, the literature foregrounds the advocacy potential. The idea has been coined in, but is not limited to, developed countries where most studies were conducted.

While 'co-benefits' entails the same basic idea in each strand, the definitional components that have been added to the concept result in an important distinction in the valuation of goals. Depending on the usage of the concept, scholars and policy makers take different perspectives on the 'window of opportunity' (Kingdon, 1984) that opens up through a certain policy. 'Climate co-benefits' (22% of articles) denotes a primacy of other goals with the 'window of opportunity' opening up for climate action. Conversely, 'development co-benefits' (49%) gives primacy to climate goals, opening up a window for action in relation to economic or social development. In its third usage (29%), the question of primacy does not arise because goals are achieved even-handedly through an integrated approach and the 'window of opportunity' arises merely from the recognition of multiple benefits. In each of these cases, the co-benefits idea is perceived as an opportunity to push a certain agenda—the specifics of the agenda makes the difference between these three strands of usage.

3.2. The many types of co-benefits

Authors using the co-benefits terminology have applied it to a wide range of climate-related, economic, environmental, social and political goals (Fig. 1). The scope for potential co-benefits studied in our sample is enormous. The following gives an ideal-typical classification of policy goals in the co-benefits approach. In practice, studied policies often cut across multiple sectors.

Economic co-benefits can take the form of energy security or energy independence through the promotion of renewable energy sources and the consequent reduced dependence on imported fossil fuels like oil, gas and coal (Mondal et al., 2010). This can also reduce import bills and enhance the fiscal stability of a country (Dowling and Russ, 2012). Moreover, renewable energy technologies are usually also more labour intensive, resulting in the creation of so-called green jobs (Kammen et al., 2004; Cai et al., 2011). Finally, climate mitigation in developing countries can entail technology transfer and spur technological change in other sectors, hence impacting the overall economic performance (Barker et al., 2010).

While adapting to and mitigating global warming are certainly the most prominent environmental goals, co-benefits also apply to other environmental goals. Co-benefits can relate to the improvement of air, water and soil quality (Rive, 2010; Thambiran and Diab, 2011; Winiwarter and Klimont, 2011) or the protection of environmental resources (Liang and Zhang, 2011). Policy measures related to land use and forest management have been shown to yield co-benefits in the form of biodiversity protection

Table 2
Three strands of co-benefits.

Term	Valuation of goals	Paradigm	Window of opportunity	Dominant geography	Examples in the literature
Climate co-benefits	Subordination of climate change	'Development first'	Climate change window	Mostly developing countries	Jack and Kinney (2010); Menikpura et al. (2012)
Development co-benefits	Primacy of climate change	'Climate first'	Non-climate change/ development window	Developing countries	Haines et al. (2010); Dowling and Russ (2012)
Climate and [..] co-impacts/co-benefits	Equal treatment of goals	'Seeking synergies'	Integration window	Mostly developed countries	Winiwarter and Klimont (2011); Thambiran and Diab (2011)

(Díaz et al., 2009) and conservation of ecosystems (Locke and Rissman, 2012).

Environmental benefits such as a reduction in air pollution, in turn, have beneficial effects on public health such as a reduction in cardiovascular and respiratory diseases both on a larger scale (Jack and Kinney, 2010) and in relation to indoor pollution through the deployment of clean cooking stoves (Simon et al., 2012). The expansion of public transport is said to yield health co-benefits as it entails fewer fatal and non-fatal injuries (Creutzig and He, 2009) and improved mental health through a reduction in stressors like noise and traffic congestion (Younger et al., 2008). Other social benefits include energy access through the local deployment of clean energy technologies (Ürge-Vorsatz and Tirado Herrero, 2012) and food and water security through forest conservation (McAlpine et al., 2010) and nutrient recycling (Haq and Cambridge, 2012). Finally, equity effects can be yielded through the asymmetric impact a policy might have on the local population (Garg, 2011). An example includes the payment for environmental services within policies for Reducing Emissions from Deforestation and Forest Degradation (REDD+) schemes (Pagiola, 2011).

Political and institutional co-benefits relate to participation, cooperation and political stability. This perspective has only recently gained attention in the literature. Nordaas and Gleditsch (2007) maintain that both intra- and international trouble spots in relation to water, food and energy can be defused through co-benefits policies, hence contributing to political stability. Participation is a co-benefit that has been observed in relation to the local benefits of REDD+ programmes that offer the possibility of a democratic deepening of concurrent forest management and climate mitigation (Chhatre et al., 2012). Another strand of articles studies opportunities for interregional collaboration on climate change mitigation through the exploitation of co-benefits on a local level (Nakamura and Kato, 2011; Puppim de Oliveira et al., 2013b).

3.3. The evolution of 'co-benefits'

An analysis of the definitions of co-benefits used in the influential IPCC reports reveals that the co-benefits concept evolved out of the term 'ancillary benefits'. The latter term was first introduced in the second IPCC report that did not mention co-benefits yet (IPCC, 1995). The third IPCC assessment report (2001) distinguishes the two terms as referring to side benefits specific to climate change policy (ancillary benefits) and the side benefits of any policy (co-benefits). This distinction collapses in the subsequent IPCC report (2007), and the most recent assessment (2014b) uses the same definition for both terms (see Section 1).

The roots of this idea can be traced even further back. Preceding the coining of the term co-benefits, climate change policy makers were advocating stricter GHG controls using the arguments of 'no-regrets' policies and 'double dividends' to carbon taxation. Becoming popular in the early 1990s, the double-dividend hypothesis postulates that the taxation of carbon-intensive activities yields both climate-related benefits and reduces distortions in, for example, the labour market through the creation of revenues that substitute for income taxes (Goulder, 1995). Policy options that can be classified as 'no-regrets' are those emission reduction policies that have net negative costs because indirect benefits outweigh their implementation costs (IPCC, 2007). 'No-regrets' was a concept that was primarily used by policy makers to shape policy to counter the uncertainty inherent in the science of climate change. They argued that some policies made sense in any case even if climate change did not turn out to be a serious challenge and this argument could be used to promote energy efficiency or address deforestation. Both these concepts preceding the 'co-benefits' concept were contested on the ground that economic agents would have already pursued no-regrets options in the market if they truly existed (see, e.g., Sutherland, 1991) and that the double dividends hypothesis does not hold (see, e.g., Fullerton and Metcalf, 1998). Both these concepts had their publication peak in the 1990s and have since then lost popularity or become subsumed as part of the co-benefits discourse which emerged in the late 1990s (Fig. 2).

We argue that this evolution can be explained by the different ways in which each of these concepts frames the underlying idea of a 'win–win' strategy/policy (Table 3). Four differences can be identified. First, the definitions of these concepts reveal that the 'co-benefits' concept frames the issue in positive terms, whereas the other two concepts speak of 'potential welfare losses' and 'costs to society'. Second, 'double dividends' are by definition only applicable to revenue generating policy measures, whereas the other two concepts embrace a wider range of policy options. Third, whereas options are only classified as 'no-regrets' if the side effects outweigh their costs, the other two concepts do not set a yardstick on the effect size. In line with this, the most recent IPCC assessment report (2014b) replaces the term '*no*-regrets' with the term '*low* regrets'. Fourth, co-benefits may refer to a wide range of co-benefits in various sectors (see Section 3.2), whereas the other two concepts are limited to economic goals, i.e., cost reduction (no-regrets) and revenue generation (double dividends). In a nutshell, 'co-benefits' can be distinguished from its predecessors because it has a positive valance, is non-instrument specific and embraces a wider range of policy goals and effect sizes.

The hypothesis that these differences have caused the contrasting developments in the popularity of these concepts in the scientific literature is further supported by the ways in which the politics of climate change and its underlying discourses have changed in the studied period. First, the 1980s were characterized by *uncertainty* about the existence of dangerous anthropogenic climate change. Nowadays, although there is uncertainty in the specifics of climate impacts, there is near *consensus* that climate change exists, is anthropogenic and negatively effects socio-economic systems (Doran and Zimmerman, 2009). Therefore, in general, it becomes less important that additional benefits are greater than implementation costs (no-regrets).

Second, there is evidence that climate change has been reframed from a *technocratic* to a *development* issue. In the 1990s, climate change was seen largely as an abstract technological challenge for industrialized countries, whereas the new millennium witnessed the rise of climate change as an urgent development issues (Gupta and Van der Grijp, 2010). The integration of climate change and development and the focus on the social component of both these issues have caused the co-benefits concept to be given the edge over cost-saving double-dividends and no-regrets options. The sustainable development

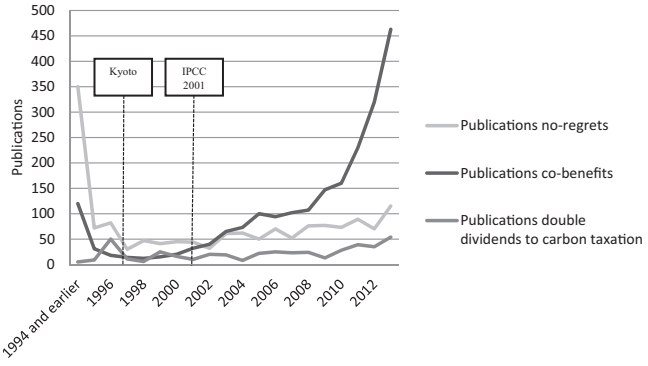

Fig. 2. Publications using co-benefits and related concept in the ScienceDirect database.

Table 3
Comparison of co-benefits and related concepts.

	Double dividends	No-regrets	Co-benefits
Definition	'The extent to which revenue-generating instruments [..] (1) limit or reduce GHG emissions and (2) offset at least part of the potential welfare losses of climate policies through recycling the revenue in the economy to reduce other taxes likely to cause distortions' (IPCC, 2007,p. 813)	'Options whose benefits (such as reduced energy costs and reduced emissions of local/regional pollutants) equal or exceed their costs to society, excluding the benefits of avoided climate change' (IPCC, 2007,p. 818)	'The positive effects that a policy or measure aimed at one objective might have on other objectives, irrespective of the net effect on overall social welfare. Co-benefits are often subject to uncertainty and depend on local circumstances and implementation practices. Co-benefits are also called ancillary benefits' (IPCC, 2014b,p. 14)
Origins and usage	Economic argument	Political argument	Economic argument
Framing	Negative	Negative	Positive
Instrument-specificity	Specific	Generic	Generic
Magnitude of effects necessary	All magnitudes	Equal/greater than costs	All magnitudes
Potential benefits	Limited to economic benefits (tax revenue)	Limited to economic benefits (cost reduction)	Generic
Publication peak	1996	1996 and 2013	2013
Trend co-efficient[a]	+1.2	−2.2	+15.0

[a] The coefficient here can be interpreted as the increase/decrease in the number of articles per year on average.

approach that has gained popularity through the paradigm shift neatly aligns with the multidimensional potential of co-benefits.

Third, while climate change has historically been appraised in the *negative* terms of risk, there is some evidence that climate change is increasingly also perceived in *positive* terms, i.e., as an opportunity. The United Nations Environment Programme argues that 'the greening of economies is not generally a drag on growth but rather a new engine for growth' (UNEP, 2011, p. 2). Parallel developments such as the transformation of international policy concepts are emblematic for this development. For instance, burden sharing under a 'targets-and-timetables approach' (UNFCCC, 1997) has been replaced by emission allowances under an 'aggregate-global-emissions approach' (England et al., 2009). The positive framing entailed in 'co-benefits' can thus be seen as timely adjustments to the negative connotations inherent in definitions and applications of 'no-regrets' and 'double dividends'.

Finally, the preference for policy instruments for climate mitigation has shifted from *command-and-control* instruments to *market-based* instruments like carbon trading (Stavins, 2003). While, in principle, all three approaches are compatible with market-based policy options, the co-benefits approach provides additional leeway with respect to the choice of policy instruments vis-à-vis the double dividends approach that is by definition limited to environmental taxation.

4. Specialization in the approaches to study 'co-benefits'

This section first discusses how the literature studies co-benefits. It then explains both the appeal and the shortcomings of the co-benefits concept in its scientific and political usage.

4.1. The study of 'co-benefits' in the academic literature

The earliest studies on the idea of co-benefits argue that GHG control generates additional societal benefits (see, e.g., Schneider, 1989). Most of these papers in the 1980s were written by natural scientists. In the early 1990s, economists increasingly became involved. Several authors incorporated 'indirect' or 'secondary' benefits of air pollution control into cost–benefit analyses albeit not using the co-benefits terminology (see, e.g., Ayres and Walter, 1991; Pearce, 1992). These studies used the co-benefits concept in line with the 'co-impact' category (see Section 3.1) and studied air pollution benefits in Europe. Since around 2000, there is both a steep increase in the concept's use and there has been a shift in its geographical distribution. Nowadays, most studies are conducted in the global South and the total volume of our reviewed sample favours non-industrialized countries (47% vs. 22%) and particularly emerging economies (32%).

However, as the concept is mostly used by economists, it tends to be rooted in a positivist epistemology. The majority of articles use a single case study design (61%) or a comparative case study design (7%) to evaluate co-benefits in an ex-post fashion. Eight percent of the reviewed sample use modelling software for an ex-ante evaluation of hypothetical or planned programmes. Literature reviews, mostly in the form of meta-analyses, account for 19% of articles. The distribution in the nature of scientific approaches clearly shows that the co-benefits literature is dominated by a technocratic paradigm that is directed at problem solving through predefined means-ends calculations. Merely 5% of articles in our sample concern the theory behind the co-benefits concept.

Accordingly, most articles apply a quantitative measurement of co-benefits. These articles can be further categorized in articles that seek to quantify co-benefits such as air pollution reduced, jobs created, etc. (49%) and studies that evaluate co-benefits in monetary terms (19%). In contrast, merely 20% of the papers approach co-benefits in a qualitative way. This can again be related to the dominance of quantitative economic approaches using cost-effectiveness analysis (quantitative outcome measure) or cost–benefit analysis (monetary outcome measure) to study co-benefits. Few articles are rooted in the social or political science (for exceptions, see, e.g., Brown et al., 2008; Dubash et al., 2013).

Conversely, there is considerable diversity with respect to the sector and scale at which studies are conducted. While most studies concern country-wide co-benefits programmes (30%), local co-benefits initiatives also figure prominently (24%). The international level (8%) and the regional level (6%) find less attention. An emerging area is the discussion of co-benefits in a multi-level governance context (9%) that focus on more than a single level (see, e.g., Nakamura and Kato, 2011; Visseren-Hamakers et al., 2012). Research is also dispersed with respect to the studied sector. Traditionally, the focus has been on air pollution reduction and health benefits in relation to transport (12%), land use change (10%) and sanitation and recycling (4%). A growing field is the study of co-benefits in relation to energy such as the economic and environmental benefits of alternative sources of power generation (17%) and co-benefits of energy efficiency measures in buildings

(7%) and industry (4%). Another trend is the evaluation or comparison of co-benefits across sectors (28%).

4.2. Appeals of 'co-benefits'

Apart from its specific characteristics (see Section 3.3), the successful consolidation of the co-benefits approach can be explained through its advocacy potential in relation to climate change. A key problem of climate change policy is that it is a 'wicked' problem in that the benefits of climate policy are visible only much later in time, cannot be causally related and may be more prominent in other parts of the world, while the costs of action are immediate, large and fall on specific actors. The concept of co-benefits has advocacy potential in that a co-benefits strategy helps to align the temporal and scalar difference between climate policy costs and climate policy benefits/impacts by compensation with other co-benefits that are often local, take effect immediately and are easier to measure and hence more politically feasible (Table 4).

In more general terms, the recognition of co-benefits opens up a 'window of opportunity' for certain policy goals to be achieved as side effects of another goal that might be higher on the current political agenda (see Section 3.1). The literature entails plenty of examples for the appeal of co-benefits that we have grouped into economic, political and social arguments. First, in economic terms, co-benefits are said to diminish the costs of climate change for society. In an early meta-analysis, Pearce finds that co-benefits are in the range of 0.07 and 6.93 measured against the size of primary benefits for climate mitigation leaving him with 'the impression [..] that ancillary benefits could be comparable in size to the "primary" (global warming) benefits' (Pearce, 2000, p. 41). He argues that policy evaluation should include cost–benefit analysis to justify policy action. The argument of the bulk of authors is that taking co-benefits into account shifts the financial viability mark to include a larger number of policy options.

Second, the decreased costs of policy options with co-benefits yield advantages from a political point of view. Rübbelke (2002) argues that the recognition of co-benefits privately motivates players to adopt stricter GHG controls, thus playing an important part in overcoming the collective action problem of building a global climate regime. Indeed, a study conducted in the UK found that emphasizing co-benefits increased the willingness to pay (MacKerron et al., 2009). John and Rübbelke (2009) maintain that because co-benefits are generally easier to assess than the primary benefits of climate policy, it is easier to 'sell' policies and overcome political economy obstacles.

Third, co-benefits can take the form of social benefits and hence legitimize governmental policy action to the wider public. The reviewed literature determines societal benefits to be particularly large in less developed countries. Rübbelke (2002) argues that lower marginal costs in places where, for instance, rigorous pollution controls are not in place, render co-benefits more efficient. Furthermore, co-benefits are easier to achieve because energy systems may be less 'locked-in' in comparison to industrialized countries and technologies less advanced, hence providing tremendous benefits if leapfrogging takes place (Jochem and Madlener, 2003). Therefore, the recognition of co-benefits can provide leverage for mainstreaming or integrating climate change and development objectives for both large-scale development plans (see, e.g., Romero et al., 2011) and on a local level (see, e.g., Sharma and Tomar, 2010). Taking this perspective to an extreme, several scholars perceive the concept of co-benefits as instrumentalization of the more abstract sustainable development paradigm (see, e.g., Jochem and Madlener, 2003; Kurniawan et al., 2013). In sum, whether economic, political or social, all arguments relate to the advocacy potential entailed in the co-benefits approach.

Table 4
Costs and benefits of climate mitigation with co-benefits.

	Spatial	Temporal	Certainty
Climate change mitigation benefits	Global	Delayed	(Uncertain)
Climate mitigation costs	Local	Immediate	Certain
Co-benefits	Local	Immediate	Certain

4.3. Shortcomings of 'co-benefits'

It is perhaps ascribable to the positive valence naturally entailed in the term co-*benefits* and the approaches through which the concept is studied that there is considerably less criticism of the concept in the reviewed sample of articles. Nevertheless, the co-benefits concept has not been immune to criticism, often directly responding to the appeals identified in the previous section. First, the methodology underlying cost–benefit and cost-effectiveness analysis has been subject to criticism. A lack of available data on co-benefits, faulty baselines and intervening variables are said to impede reliable estimates (see, e.g., Paladino, 2011). Voices within the epistemic community also maintain that 'methodological complications remain, including establishing causality between programmes and co-benefits, monetising different types of co-benefits, accounting for different beneficiaries, and avoiding double-counting' (Heffner and Campbell, 2011,p. 9). This holds true especially for co-benefits that are difficult to quantify such as those related to poverty or health and whose economic benefits may be visible over longer-term trajectories (Williams, 2014). Moreover, the a priori choice of variables to include in the models leaves little leeway for non-anticipated effects. Another argument centres on the opportunity costs of co-benefits policies, i.e., other policy options might achieve co-benefits in a more cost-effective, but less climate-sensitive way.

Second, the co-benefits concept has been criticized from a political point of view. Co-benefits, even when acknowledged, are often ignored in policy design (Nemet et al., 2010), partly due to the difficulties of monetizing social costs/benefits that often guide policy decisions (Creutzig and He, 2009) and a lack of communication between epistemic communities dealing with climate change and other areas (Norgaard, 2004). These barriers extend to the policy level where fragmented international regimes or a multitude of isolated ministries on a national level exist to deal with particular problems (Keohane and Victor, 2011). Zusman (2008) observes that institutional arrangements and incentive structures for a co-benefits approach that call for integration of issue domains and cooperation between institutions and individuals are underdeveloped. Even if co-benefits are incorporated in policy design, they often face implementation challenges due to a lack of awareness, a guiding framework and common understanding among policy makers and bureaucrats (Puppim de Oliveira et al., 2013a; Mayrhofer and Gupta, in press).

Third, others point to the shortcomings of co-benefits as a policy strategy. Several scholars caution that a search for 'win–win' options in line with the co-benefits approach obscures trade-offs (Visseren-Hamakers et al., 2012). Dubash et al. (2013) note that there is a risk that the co-benefits concept is used to 'sell' particular policies in an opportunistic manner if there is no clear specification of what is meant by co-benefits. Yet another criticism points to the discourse in which co-benefits is embedded. Co-benefits, these authors maintain, is a symptomatic approach that does not address the underlying causes of climate change such as 'over

development' and 'incremental improvements in energy efficiency will be meaningless if the prevailing mindset is one of ever increasing consumption' (Puppim de Oliveira et al., 2013a, p. 44). From this perspective, the incremental co-benefits approach is insufficient to effectively respond to the climate problem.

Fourth, in response to the argument that the co-benefits are particularly large for developing countries, the co-benefits approach has been perceived as environmental imperialism. Scholars have argued that the focus on developing countries is misplaced because conventional measures (with no or negative climate benefits) are oftentimes far cheaper than co-benefits policies. Dowlatabadi (2003, p. 466) takes up this line of reasoning by enunciating that 'those who emphasize CO_2 controls for its ancillary benefits in less industrialized countries are [..] putting the cart of GHG controls before the horse of human welfare maximization'. While the social benefits resulting from co-benefits policies are hardly questioned in the literature, the critique revolves around the opportunity costs of such policies.

5. Conclusion

This review article has examined the literature on co-benefits. Section 3 discussed the meaning of the term in the academic literature and leads us to the conclusion that 'co-benefits' is essentially an 'umbrella' concept that is contestable in its meaning due to its definitional ambivalence, multidimensional nature, normative character, and modification in due course of its evolution.

First, the concept is not rigid with clearly identifiable boundaries or a fixed definition. Conversely, there are three strands of usage of the term made up of distinct definitional components, the ordering and weighting of which produces different meanings, all falling within the broad 'umbrella' of multiple benefits (see Section 3.1). The co-benefits literature in climate can be interpreted as climate first, development first or optimize two areas simultaneously. Moreover, the co-benefits concept is inherently complex and multidimensional as shown by the various goals that might count as a co-benefit in diverse policy areas such as economic, environmental and social policy (see Section 3.2).

Second, the idea entailed in the co-benefits concept has changed in parallel to the needs of politics and its meaning has also changed from its earlier focus to justify climate policies in Europe to the recent focus on justifying such policies in emerging economies (see Section 3.3 and Section 4.1). The analysis has shown how this concept has evolved from a primarily negative framing (e.g., no-regrets) or limited framing (e.g., double dividends; climate-energy) to a more positive framing (i.e., co-benefits) that can be globally applicable (e.g., climate–development, a concern of the developing world).

Third, the very nature of 'co-benefits' implies a positive normative valence that can be contrasted with more neutral terms such as co-impact. The term conveys the idea that there is always a 'win–win' and hence accredits some valued achievement in the combination of multiple goals. The co-benefits approach is a positive and constructive 'win–win' way to operationalize how economic, social, ecological and political aspects can be integrated within the concept of sustainable development and thereby prevents framing issues in terms of trade-offs.

Section 4 discussed the application of the concept in the literature and finds that although the co-benefits concept is an 'umbrella' concept, it has tended to attract initially natural science scholars and subsequently mostly economic scholars (see Section 4.1). As the concept is mostly used by economists, it tends to be rooted in a positivist epistemology. This reflects not only the nature of the concept, which attracts economic analysis, but also the lack of engagement by other academic scholars who find it more difficult to develop theory on this concept because of their own specific epistemologies. This has led it to be defined primarily based on the epistemological foundations of economic scholars, leading to a highly specialized theoretical and empirical approach. The strength of the co-benefits concept lies in its positive framing and its advocacy potential because it can help to align the temporal and spatial costs and benefits of climate policy and support by providing strong empirical evidence with a convincing financial price tag (see Section 4.2).

As a result, however, the dominant economic approaches tend to depoliticize the political argument of 'no-regrets' into an optimization approach that fails to include political realities. The bulk of articles in our sample is based on cost–benefit or cost-effectiveness analysis and follows a relatively simple model to study co-benefits: identify, model, estimate, (monetize), leading to promoting technocratic, context-neutral and managerial co-benefits policies. In this way, the co-benefits approach is not a monolith, but 'much of the theory, debate, evidence-gathering and implementation linking climate change and development assume a largely apolitical and linear policy process' (Tanner and Allouche, 2011, p. 1). In other words, the politics of co-benefits are inadequately explored in the literature, not least because the political science scholars have scarcely engaged with this concept. Therefore, co-benefits ends up being a 'business-as-usual' incremental approach which does not adequately call for the structural change needed to address climate change, and may even have neo-colonial trends in that the price tag of co-benefit policy may be significantly higher than that of alternative policy thereby entailing larger opportunity costs (see Section 4.3).

We argue that it is time for a broader engagement with this concept in order to take also the political, policy and 'north–south' aspects into account. Sociologists, anthropologists, geographers, lawyers and political scientists have yet to engage productively with this concept and give it the multi-disciplinary treatment it needs if it is to rise above incrementalism and sterile policy recommendations. All of these challenges are resolvable within the context of the co-benefits concept. As it is an 'umbrella' concept, there is no reason why scholars from other disciplines cannot more productively engage with this concept and help it evolve further from a sterile, managerial, technocratic instrument, into a more dynamic and political instrument that can actually help to bring the much needed triple loop learning, i.e. re-examining and challenging the value systems and norms underpinning the co-benefits idea. Such engagement by other scholars could help to question and redefine its incremental implications, could confront and diffuse the neo-colonial character, and could incorporate other elements to make it much more politically attractive and viable in specific institutional architectures and contexts.

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