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Cumulative Effects Assessment (CEA), A Review

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Most development activities have individually minor impact, but collectively over time their impact on the environment is more substantial. The available environmental circumstances in different locations show the important position of cumulative effects (CEs) in environmental studies. Many sources notified the complexity of cumulative effects assessment (CEA) in practice and identification of CEs in assessments. Maybe it is because the essence of impact assessments have to focus on future consequences, and this situation is complex substantive. Also, a lack of knowledge with respect to how to include CEs and lack of clear regulations concerning how this should be done are the most complex criteria of CEA which have been mentioned by CEA practitioners. Most guides and regulations are considered in the performance of CEA during environmental impact assessment (EIA) of projects. Also, there is an important consideration regarding performance of CEA in strategic environmental assessments (SEAs) process, and some reasons present it. In the section of methods and tools used for CEA, risk assessment approaches and modeling are the most used innovative methodologies for the improvement of CEA in recent times. Generally, improvement in performance and knowledge of CEA is noticeable in recent years.

Keywords: Environmental impact/effect; cumulative effects; assessment; review.

Introduction

Cumulative effects assessment (CEA) has obtained an important place in environmental assessments over the years. Sustainable development requires that the full range of human-generated stresses are understood and acted upon in their environmental, economic, and social context. Most development activities have individually minor impacts, but collectively over time their impact on the environment is more substantial. The combined incremental effects of human activity pose a serious threat to environmental quality (Eccleston and Doub, 2016). The central idea behind the assessment and management of cumulative impacts (CIs) is lack of sufficient individual impacts consideration of isolation (Vanclay and Esteves, 2011). While such impacts may be non-significant by themselves, over time they can compound, from one or more sources, up to the point where they significantly degrade environmental resources.

The assessment of CIs reflects a broadened perspective on the nature of human–environment interactions (James *et al.*, 2003). This perspective acknowledges that the environmental change originates not only from single projects but also from interactions of multiple projects (sometimes contained within a plan or program). These interactions need to be considered in planning to ensure that environmental limits are not breached. The impact of two actions on the environment can be complex and may result in environmental degradation that is worse than initially thought because of interactions between projects. These can be chemical, biological, or physical interactions (James *et al.*, 2003). It has been recognized worldwide that consideration of CIs should be an integral part of the environmental impact assessment (EIA) process and sector-specific methodologies should be evolved to address these impacts (Dutta *et al.*, 2004).

The available environmental circumstances in different geographical points show the important position of cumulative effects (CEs) in environmental studies. Ehrlich reported the role of cultural CEs in rejection of four proposed uranium exploration projects in the Upper Thelon Basin (Northwest Territories, Canada) (Canter *et al.*, 2010). Also, drying Uremia Lake in Iran shows signs of CIs. There are some dams at the water basin of the lake so that most of them have Environmental Impact Statement (EIS), and are accepted by Department of Environment. But, the dams together, have important role in drying the Uremia Lake.

CEA promises to improve EIA by considering how a given “receptor is affected by the totality of plans, projects and activities, rather than the effects of a particular plan or project” (Therivel and Ross, 2007). CEA is considered to be a subdiscipline of EIA, because it derives from EIA’s principles, methods, and tools, and is broadly applicable across the diversity of EIA practice (Jones, 2016). CEA has been a key element of good-practice impact assessment for more than 40 years in countries such as the US and Canada. It is now implemented widely in many countries in a variety of project-based, regional, and strategic contexts (Jones, 2016).

Based on importance of CEA in environmental studies, this article has been prepared to indicate the different aspects of CEA. The aim of the paper is to present the status, challenges, and latest findings and opinions in relation to CEA.

Concept and Definition of Cumulative Effects

CI and cumulative effect (CE) are terms which are often used interchangeably, for example, in the US Council on Environmental Quality (CEQ) regulations. (Center for Environmental Excellence by AASHTO, 2016; James *et al.*, 2003), and this circumstance is respected in this article. Also, there are different opinions in this regard, for example, Gillingham *et al.* (2016) have mentioned which effects and impacts are different, and they believe that an impact can include more environmental changes than an effect. They define an effect as a direct and observable change in the current circumstance, whereas an impact represents the longer-term consequences that flow from that change. Impacts are much wider and more nebulous, and oftentimes they are much more difficult to discern.

In the practice of EIA in the US, the term "cumulative effects" was first mentioned in the 1973 guidelines of the CEQ (Canter and Ross, 2010). Then, the concept of CE had been first defined by the CEQ (1978) and later detailed by other scholars (Bragagnolo and Geneletti, 2012). CIs may result from the aggregation and interaction of direct or indirect impacts. Depending on the context and the location in time and space, different receiving environments (such as a social group, river, or geographic region) may experience the same impacts differently (Franks *et al.*, 2010). Cumulative environmental effects are defined as the results of actions that are individually minor but collectively significant when added to other past, present, and reasonably foreseeable future actions (Seitz *et al.*, 2011). For example, several developments with insignificant impacts individually but together have a CE which is considered a significant effect. CIs are not necessarily generated as part of a simple causal pathway; that is, a CI may result from the aggregation or interaction of impacts from multiple unrelated sources (Franks *et al.*, 2010). An example of this may be the cumulative social impact experienced from the aggregation of different amenity impacts of mining (such as noise, dust, vibration, and scenic amenity).

The concept of cumulative change is based on the premise that the impacts of individual independent actions are not mutually exclusive to each other, rather they may accumulate, interactively or additively to bring about significant environmental change (James *et al.*, 2003).

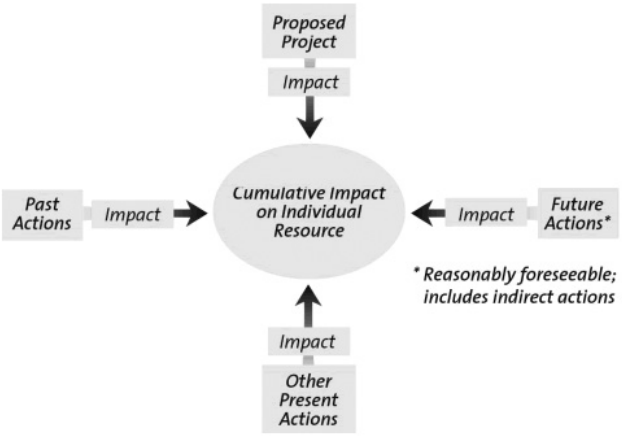

Fig. 1. Cumulative impact diagram.

CIs cannot be understood if our attention is limited to single stages of projects or is constrained to inappropriately small spatial or temporal scales (Halseth, 2016). Figure 1 shows CI concept.

CIs can be both positive and negative and can vary in intensity as well as spatial and temporal extent (Franks *et al.*, 2010). CIs may interact such that they trigger or are associated with other impacts. They may aggregate linearly, exponentially or reach "tipping points" after which major changes in environmental, social, and economic systems may follow (Franks *et al.*, 2010). CIs often extend well beyond the geographic location of an operation and may contribute to systems already impacted by other operations, industries, and activities.

Eccleston (2011) has mentioned that the CIs can generally be divided into broad classes: additive and synergic (or interactive). Additive effects occur when the magnitude of combined effects is equal to the sum of individual effects. When effects are combined, the results may be substantially greater or less than that expected based on additivity, and greater than expected result which can be described as synergistic. James *et al.* (2003) have mentioned that additive effects are those where the impacts may be combined in a straightforward manner, while interactive or synergistic effects lead to a net decrease in environmental quality that differs from the simple summation of the impacts, i.e. the result may be greater than the sum of the parts.

Indeed, specialists are still not united in the question of classification of CE. So that Crain *et al.* (2008) classified CEs as additive, synergistic, and antagonistic in their research. For the most common case where each stressor (action) has a negative effect when applied individually, e.g. stressor A reduces the response by "a" and stressor B by "b", then the CE under A + B conditions is a reduction of the response from control levels that is additive (= a + b), antagonistic (< a + b) or synergistic (> a + b) (Crain *et al.*, 2008).

Some references strictly have distinguished between cumulative and synergic impacts such as Short *et al.* (2013), The Scottish Government (2006) and Schmidt *et al.* (2005). Also, CEAA (2014) has presented two other types of CEs as compensatory and mask CEs. Compensatory CEs are effects from two or more physical activities that "offset" each other. In mask CEs, the effects of one project might mask the effects of another in the field.

In landscape and visual assessment, CEs are considered. Knight (2009) has mentioned that cumulative landscape and visual assessment (CLVIA) should identify significant effects which are the result of introducing the development into the landscape in combination with other existing developments and the developments which are not present yet. CEs on visual amenity can be experienced either from static viewpoints, where two or more developments can be seen from a single location (combined visibility); or sequentially, where in the process of moving along a route, two or more proposals are visible.

Different organizations and scientists have presented some definitions for CEs and CIs, as follows: The US CEQ (1997, Executive Summary page v) defines CI as "the impact on the environment which results from the incremental impact of the action when added to their past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other action". CIs are the aggregate result of the incremental direct and indirect effects of a project or plan, the effects of past and present actions, and effects of reasonably foreseeable future actions by others on resources of concern (Elvin and Fraser, 2012; Center for Environmental Excellence by AASHTO, 2016). The Canadian Environmental Assessment Agency (CEAA) defined CEs as changes to the environment that are caused by an action in combination with other past, present, and future human actions (James *et al.*, 2003). European Union guidance on CEA defines CIs as the accumulation of human-induced changes in valued ecosystem (or environmental) components (VECs) across space and over time; such impacts occur in an additive or interactive manner.

Social CEs

CEA is rarely done, and when they are done they tend to focus on biophysical impacts rather than social impacts (Vanclay and Esteves, 2011), and social impact assessment (SIA) has probably not given sufficient attention to CIs as well (Lockie *et al.*, 2008; Canter and Ross, 2010). The topical attention in most "Cumulative

Effects Assessment and Management" (CEAM) studies is related to air quality, water quality and quantity, ecological components, and natural resources (Canter and Ross, 2010). Social impacts resulting from policy changes and other interventions that interact and aggregate are influenced by additional interventions and exogenous factors, leading to cumulative social impacts (Loxton *et al.*, 2013). These interactions mean that social impacts caused by disparate factors are experienced cumulatively, encouraging increased assessment of cumulative social impacts within SIA.

Social impacts differ from other types of impacts, such as those on the environment, owing to the role of human interpretation in determining how individuals experience interventions (Loxton *et al.*, 2013). Understanding the complex pathways that lead to cumulative social impacts is challenging, but essential to designing effective mitigation strategies that reduce the negative, and enhance the positive, social impacts that arise from an intervention while assisting the proponent to meet their goals. Empirical evidence is needed to better inform the consideration of social impacts in the practice of CEAM; in particular, improved understanding is needed of the processes involved in the interaction and aggregation of social impacts, and the development of strategies to address cumulative social impacts (Franks *et al.*, 2010).

Attention should also be given to developing processes, methods, and tools for addressing cumulative social and economic impacts (Canter and Ross, 2010).

CEA in Different Countries

Increased recognition of the cumulative nature of impacts has led to the practice of "Cumulative Effects Assessment and Management" (CEAM) within the field of impact assessment (Canter and Ross, 2010). In many countries, cumulative impact assessment (CIA) is undertaken as part of the EIA process (Zhao *et al.*, 2012). The most of developed countries have started the study of environmental CIs some decades ago. At first, CEs were considered as other types of effects such as indirect and direct effects in EIA guides and manuals. But, since then, CEA have achieved more independent and important position.

In the US, CEA began in the early 1970s when it was realized that proposed projects needed to be analyzed in relation to their location and surrounding land uses (IAIA, 2018). Throughout most of Canada, the Canadian Environmental Assessment Act (CEAA) describes the requirements for CEAs (Ehrlich, 2010). The CEAA requires CEAs to consider future projects only in terms of projects that will occur. It states that assessments shall include a consideration of "any cumulative environmental effects which are likely to result from the project in combination with other projects or activities that have been or will be carried out" (Ehrlich, 2010).

EU and UK legislation require a CIA as part of EIA (Masden *et al.*, 2010). The requirement to asses CEs was originally set out in the European EIA Directive 85/337/EEC (since amended by further Directives) and by the European Community (EC) Habitats Directive 92/43/EEC (Masden *et al.*, 2010). Also, the necessity to consider CEs in the recent EU directive is mentioned (Directive 2011/92/EU of the European Parliament on the assessment of the effects of certain public and private projects on the environment (in ANNEX IV) which amended by Directive 2014/52/EU). The changes introduced by these directives maintain and enforce this requirement by establishing that evaluation of selecting projects criteria should include CEs with other projects. Also, the European Directive on strategic environmental assessment (SEA) requires the evaluation of cumulative and synergistic impacts (Therivel and Ross, 2007).

In 1991, provisions for EIA in New Zealand changed significantly with the enactment of the Resource Management Act. Among other provisions, this act requires consideration of CIs in environmental assessment activities undertaken by planners in newly created regional authorities and district and city councils (Dixon and Montz, 1998).

The consideration of CEs is mostly absent in the developing world (Li, 2008). In Iran, the analysis of CIs was considered during performance of SEAs for strategies of regional developments based on Law for the Fifth Development Plan of Iran (Year of Version: 2011).

Cumulative Effects Assessment

CEA, CIA and Cumulative Effects Assessment and Management (CEAM) are terms which are used in the analysis and management of CEs or impacts. Early practice focused on CEA; however, with current attention to management and mitigation of CEs, an M has been added to CEA (Canter and Ross, 2010).

The origins of CEA began in the early 1970s when it was realized that proposed projects needed to be analyzed in relation to their location and surrounding land uses (Canter *et al.*, 2010). Further, agencies that processed multiple concurrent permit approvals for similar types of projects also realized that such approvals needed to incorporate consideration of all applications in close spatial and temporal proximity to each other; as such actions often contribute to CEs. Increased recognition of the cumulative nature of impacts has led to the practice of CEAM within the field of impact assessment. The first decade in the 21st century has experienced continuing improvements in CEAM practice, particularly as related to proposed projects. SEAs, also referred to as Programmatic EISs in the US, have also given greater attention to CEs (Canter and Rieger, 2005; Therivel and Ross, 2007).

An assessment of CIs focuses on the combined effects of the proposed action and other actions on specific resources. A CIs analysis typically focuses on a subset of the resources considered in the analysis of direct and indirect effects. For each resource considered, the CIs analysis should provide information on the current health of the resource and historical trends; summarize the direct and indirect impacts of the proposed action; describe the reasonably foreseeable effects of other actions; and consider mitigation (Center for Environmental Excellence by AASHTO, 2016). CEA will also require historical data, showing how the condition of a resource has changed over time. CEA is (or should be) an integral part of environmental assessment at both the project and the more strategic level (Therivel and Ross, 2007). CIA helps to link the different scales of environmental assessment in which it focuses on how a given receptor is affected by the totality of plans, projects, and activities, rather than on the effects of a particular plan or project.

Johnson *et al.* (2011), based on Canadian regulations for CEA, said that a key component of this effort is regional planning, which will lay the primary foundation for CEs management into the future. Alberta Environment has considered the information needs of regional planning and has concluded that Regional Strategic Assessment may offer significant advantages if integrated into the planning process, including the overall improvement of cumulative environmental effects assessment in the province.

Authors and organizations have presented some definitions for CIA or CEA. Judd *et al.* (2015) have defined CEA as a systematic procedure for identifying and evaluating the significance of effects from multiple sources/activities and for providing an estimate on the overall expected impact to inform management measures. The analysis of the causes (source of pressures and effects), pathways and consequences of these effects on receptors is an essential and integral part of the process (Judd *et al.*, 2015).

Different studies show some challenges and problems related to the analysis of CI. CIA is particularly challenging when several projects from different proponents are presented simultaneously for a region (Neri *et al.*, 2016). The transition from single-media, single-location, and single point-in-time analysis to a cumulative approach represents a profound challenge for policy makers, planners, advocates, and researchers (Huang and London, 2016). The main reasons are the difficulty of CI identification caused by lack of data, inability to measure the intensity and spatial effect of all types of impacts and the uncertainty of their future evolution (Pavlickova and Vyskupova, 2015). Gunn and Noble (2011) demonstrate that definitions and conceptualizations of CEA are typically weak in practice; approaches to effects aggregation vary widely; and a systems perspective lacks in both SEA and CEA. Also, Stelzenmüller *et al.* (2018) have mentioned that yet CEA is inherently complex and seldom linked to real-world management processes for protection of environment.

Another important aspect of assessment of CEs is that some scientists have emphasized performance of CEA in SEA process. Dovers and Marsden (2002) have mentioned EIA misses regional impacts, CIs of multiple projects over time, and may allow environmental death by a thousand small cuts. Masden *et al.* (2010) propose that benefits would be gained from elevating CIA to a strategic level, as a component of spatially explicit planning because CIs are currently considered on restricted scales (spatial and temporal) relating to individual development EIAs. SEA can cope better with CEs, alternatives and mitigation measures than project assessment because CEs have been formed beyond one project (Glasson *et al.*, 2013). Bragagnolo and Geneletti (2012) have mentioned the assessment of CI should go beyond the evaluation of site-specific and direct project impacts, and this consideration has moved forward the EA legal frameworks from EIA to regional CEA–SEA. Gunn and Noble (2011) have mentioned the constraints to assessing and managing cumulative environmental effects in the context of project-based environmental assessments that are well documented, and the potential benefits of a more strategic approach to CEA are well argued; however, such benefits have still to be clearly demonstrated in practice. Also, it has been argued that the SEA provides a suitable Impact Assessment (IA) framework for addressing CE because it is applied to developments with broad boundaries, but few have tested this claim (Bidstrup *et al.*, 2016).

Conducting CEA

Conducting CEA has been mentioned as a challenging topic by different sources. The difficulty and complexity of implementation of CEA, the lack of systematic approaches for the implementation of CEA, identifying CEA boundaries clearly, lack of trained and capable CEA practitioners and managers, and uncertainty in the results of CEA are some of the challenges for conducting CEA. Uncertainty in CEA can be rooted in inadequate knowledge, low predictive ability of ecosystem behavior, natural variability, measurement error, or changing policies (Stelzenmüller *et al.*, 2018). However, there were many attempts to solve these problems, and different organizations and scholars have presented different methods, ideas, guides, and so on to solve them over the years.

In recent years, assessment of the VECs has been considered as an important and essential step in the CIA. The VECs are determined on the basis of perceived public concerns related to social, cultural, economic, or esthetic values. Generally, VECs are defined as those aspects of ecosystem or associated socioeconomic systems that are important to humans (Kominkova, 2008). VECs need not be necessarily biophysical in nature; rather they may encompass aspects with social or economical values such as recreational areas, local communities, sensitive categories of people, etc. (Bragagnolo and Geneletti, 2012).

In most of the CEAs, VECs selection is a core component and gives direction to impact analysis, mitigation, and monitoring (Olagunju and Gunn, 2015). CEAs are complex, and cost time and money. For a CEA to be effective in supporting good overall environmental and social risk management, its scope must be properly defined. It is unrealistic to think that every environmental and social aspect that can be subject to CIs can be appropriately factored into a CEA; it is good practice to focus the assessment and management strategies on VECs (International Finance Corporation, 2013). While VECs may be directly or indirectly affected by a specific development, they often are also affected by the CEs of several developments. VECs are the ultimate recipient of impacts because they tend to be at the ends of ecological pathways (International Finance Corporation, 2013).

CEA conducting frameworks have been promulgated in the US and Canada. Further, such frameworks (step-wise processes or procedures) have also been developed for usage in the European Union countries, Australia, New Zealand, and elsewhere. The conducting frameworks can generally be condensed into the following six steps (IAIA, 2018; Glasson *et al.*, 2013; Canter and Ross, 2010): (1) Initiating the CEA process by identifying the incremental effects of the proposed project (or policy, plan, or program) on selected VECs within the environs of the project location. (2) Identifying other past, present, and reasonably foreseeable future actions within the space and time boundaries that have been, are, or could contribute to CEs (stresses) on the VECs or their indicators. Based on this knowledge, identifying appropriate spatial and temporal study boundaries for each VEC. (3) For the selected VECs, assembling appropriate information on their indicators, and describing and assessing their historical to current conditions. (4) Connecting the proposed project (or plan, program or policy) and other actions in the CEA study area to the selected VECs and their indicators and consider aggregation of effects (prediction of CEs). Many tools could be used to establish either descriptive or quantitative connections (Table 1). (5) Assessment of the significance of the CEs on each VEC over the time horizon for the study. Such significance determinations should begin with the incremental effects (the direct

Table 1. Presentation of CEA methods and tools.

Used and introduced methods or tools (references)	Description
Questionnaires and Interviews (Walker and Johnston, 1999)	Interviews and questionnaires can be used to assist in the collection of baseline data and increase understanding of the environmental effects of other physical activities, the VECs affected, and possible mitigation measures.
Checklists and Matrices (Dutta *et al.*, 2004; Canter and Ross, 2010)	In Checklists, potential cumulative impacts can be identified by using a list of common or likely effects. Matrices can be used in the analysis of the additive and interactive effects of various configurations of multiple projects.
Network and Systems Analysis/Diagrams (CEAA, 2014)	Networks and system diagrams are useful for mapping and identifying cause-and-effect relationships, which result in cumulative effects.
Indicators and Indices (Canter and Atkinson, 2011; Sutherland *et al.*, 2016; Neri *et al.*, 2016)	Describing baseline conditions of VECs. Predicting the cumulative consequences of multiple actions. Identifying and evaluating incremental and cumulative effects of VECs against threshold. Developing effective mitigation measures for incremental effects.
Ecological modeling (DEAT, 2004; Haverson *et al.*, 2017)	Computer modeling of ecosystems for which the structure and processes are fairly well understood.
Trends Analysis (CEAA, 2014)	Trends can help practitioners identify cumulative effects issues, establish appropriate environmental baselines, or project future cumulative effects.
Spatial Analysis (CEAA, 2014; Depellegrin, 2016)	Identifying where cumulative effects may occur as a result of the geographic location of the project in relation to other physical activities. Also, spatial analysis system such as geographic information system (GIS) is suitable for cumulative visual impact assessment.
Risk-based approach (Battista *et al.*, 2017; Stelzenmüller *et al.*, 2018)	Entrenching CEAs in a risk management process, comprising the steps of risk identification, risk analysis, and risk evaluation.

Table 1. (*Continued*)

Used and introduced methods or tools (references)	Description
	Comprehensive ecosystem risk assessment model allows analysts to consider the cumulative impact of multiple threats, interactions among threats that may result in synergistic or antagonistic impacts, and the impacts of a suite of threats on whole-ecosystem productivity and functioning, as well as on ecosystem services (Battista *et al.*, 2017).
Habitat suitability modeling (Bragagnolo and Geneletti, 2012)	Quantifying cause-effect relationships leading to CE (e.g. air, hydrological, water quality, noise, transport).
Scenarios Analysis (Bragagnolo and Geneletti, 2012; Weber *et al.*, 2012)	Scenario analysis is a process of analyzing possible future events by considering alternative possible outcomes. It is used to predict CE of future scenarios and to assess likely effectiveness of CE mitigation measures.
Environmental Management Systems (Canter and Ross, 2010)	For VECs or their indicators that are expected to be subject to negative incremental impacts from the proposed project and for which the cumulative effects are significant, develop appropriate action-specific "mitigation measures" for such impacts.
Carrying Capacity Analysis (DEAT, 2004; Walker and Johnston, 1999)	In the ecological context, carrying capacity is defined as the threshold below which ecosystem functions can be sustained. By identifying these limits, projects can be systematically assessed in terms of their additional environmental impacts in relation to carrying capacity. The threshold approach is therefore highly applicable to the evaluation of cumulative impacts.
Expert Opinion (Walker and Johnston, 1999)	Expert Panels can be formed to facilitate exchange of information of different aspects of the impacts of a project.

and indirect effects) of the proposed action on specific VECs. The focus is on the VEC, not on the action. (6) For VECs or their indicators that are expected to be subject to negative incremental impacts from the proposed project and for which the CEs are significant, developing appropriate action-specific "mitigation measures" for such impacts. Uncertainty can also be factored in by including monitoring and applying adaptive management (follow-up activities).

To perform CEA, some methods and tools are required (Table 1). These methods and tools are used based on different performance steps of CEA and aims of studies. Based upon the review of various CEA informational sources, it can be concluded that many of the current and developing methods and tools are similar to those used for EIA practice. Mahatha and Dutta (2003) have explained how different activities should be performed to address CIs within the basic EIA framework (Dutta *et al.*, 2004). According to this, an essential difference between the project-specific EIA and CIA is the consideration of larger geographical and temporal boundaries to include other past, present, and reasonably future actions during both the scoping and analysis phases of the process (Dutta *et al.*, 2004) CEAA (1999). Therefore, any methodology for CIA should essentially demonstrate how the other actions could be considered during these two phases. When any overlap between the impact zones of the project under study and that of the other projects occurs, it is concluded that the area under the overlap zones could be subjected to CIs.

Discussion

It is obvious CEA has grown more in the recent decade than earlier decades generally. But, some authors have mentioned insufficient attention to CEA in impacts' assessment of projects and plans, with the included information being very brief and reflective of "assertions without analyses" (Canter and Ross, 2010). The CEA information is very brief and does not demonstrate that any efforts were made to follow systematic CEA processes such as the six steps noted above. Apart from technical and scientific issues, these points can be focused on the fact that practitioners of EISs and CEAs just follow the adoption of them with minimal cost and in shorter time.

Many papers have notified complexity of CEA in practice and identification of CIs in assessments. It can be returned to essence of environmental assessments that have to focus on future consequences, and this situation is complex substantive. Also, a lack of knowledge with respect to how to include CEs and lack of clear regulations concerning how this should be done are the most complex criteria of CEA that have been mentioned by authors.

There are important discussions, in the papers and texts, regarding the determination of CEAs place in environmental assessments. The most of guides and regulations consider performance of CEA during EIA of projects. Also, there is an important consideration regarding performance of CEA in SEAs process, and some reasons have been presented for this consideration.

Based on the review of references, the preparation and implementation of applicable guides and frameworks for the development and improvement of CEA are important and necessary. It should be noted that CEA is a professional study, and it is under conditions of launching the developmental, industrial, and so on projects or plans, it is not a study in academic conditions. Therefore, introducing guides and approaches that consider feasibility of execution, financial constraints, time constraints, and achievement of efficient findings is important for the development and improvement of the CEA. Of course, there have been some advances in the feasibility and effectiveness of CEA implementation over the past years such as considering the VECs for CEA conducting and presenting practical guides such as "Good Practice Handbook: Cumulative Impact Assessment and Management (International Finance Corporation, 2013)" and "ASSESSING INDIRECT EFFECTS AND CUMULATIVE IMPACTS UNDER NEPA (Center for Environmental Excellence by AASHTO, 2016)".

Investigation on the methods and tools application for CEA is an active part in terms of introducing new approaches and problem solving. There are some references for CEA's empowerment based on the introduction of new methods and tools. Many researchers have been researching for operations and eliminating complexities and ambiguities in CEA. Risk assessment approaches and modeling are the most used innovative methodologies for the improvement of CEA recently. The researchers have tried to place CEA in the form of risk assessment methodology.

For preparation of this paper, many resources have been reviewed since 1970, based on which the improvement in performance and knowledge of CEA is obvious. Experts have worked to expand CEA in environmental studies. Because, it is known to them that CEs have an important role in environmental changes and problems. It is also worth to mention that most CEA practitioners have reached more or less identical views about CEAs different aspects and performance steps.

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