Title

How does stakeholder involvement affect environmental impact assessment?

Authors

Ulibarri, Nicola
Scott, Tyler A
Perez-Figueroa, Omar

Publication Date

2019-11-01

DOI

10.1016/j.eiar.2019.106309

Peer reviewed

How Does Stakeholder Involvement Affect Environmental Impact Assessment?

Nicola Ulibarri[a,*], Tyler A. Scott[b], and Omar Pérez Figueroa[c]

[a]Department of Urban Planning and Public Policy, University of California, Irvine, 300 Social Ecology I, Irvine, CA 92697, USA; ulibarri@uci.edu

[b]Department of Environmental Science and Policy, University of California, Davis, 1023 Wickson Hall, 1 Shields Ave, Davis, CA 95616, USA; tascott@ucdavis.edu

[c]Department of Urban Planning and Public Policy, University of California, Irvine, 300 Social Ecology I, CA 92697, USA; operezfi@uci.edu

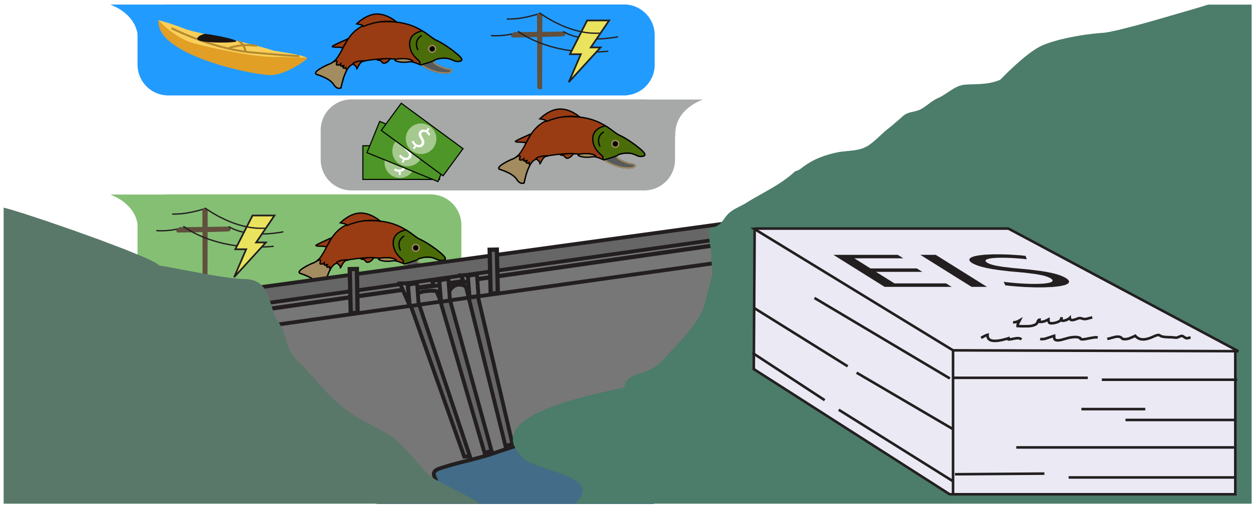
*Corresponding author

This is the accepted version of a manuscript published on September 7, 2019 in *Environmental Impact Assessment Review*. The full citation is Ulibarri, N, Scott, TA, & Perez-Figueroa, O. How Does Stakeholder Involvement Affect Environmental Impact Assessment? *Environmental Impact Assessment Review,* 79: 106309, https://doi.org/10.1016/j.eiar.2019.106309.

Abstract

Environmental impact assessment (EIA) processes are grounded on the assumption that producing information about environmental impacts will yield better environmental decisions. Despite the ubiquity of EIA as a policy tool, there is scant evidence of its environmental, social, or economic impacts. Focusing on Environmental Impact Statements (EIS) prepared for water and energy-related projects under the US National Environmental Policy Act, this analysis addresses two questions: (1) What is the balance of environmental impacts associated with infrastructure decisions?; and (2) How does the content of stakeholder feedback received during the review phase differ from draft EIS content, and does this correspond to any changes in the final EIS? We demonstrate the use of automated text mining approaches to identify the distribution of impacts, measure the content of public comments, and observe whether values reflected in comments are associated with a shift in emphases between the draft and final EIS. EISs are shown to convey evenly distributed focus across multiple impact areas. However, we observe no substantive change in focal emphasis between draft and final issuances. This calls

into question assumptions about the role that public participation plays in bringing new information to light or changing the course of action.



Keywords: Environmental Impact Assessment, National Environmental Policy Act (NEPA), water infrastructure, energy infrastructure, public participation, text mining

1. Introduction

First codified in the United States with the passage of the National Environmental Policy Act (NEPA) in 1969 (Caldwell, 1988), environmental impact assessment (EIA) has since been adopted worldwide. As of 2011, 191 countries had EIA regulations or were signatories to an international EIA process (Morgan, 2012). The intent of EIA processes is to enable planners, regulators, and resource managers to make better decisions about managing the environment by aggregating information and data inputs into a comprehensive assessment. EIA intends to "provide for a full and fair discussion of the significant environmental impacts and shall inform decision makers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment" (Evans, 2013, p. 4).

Despite the global reach of EIA as a policy tool, we have scarce evidence of its environmental, social, or economic impacts (Cashmore et al., 2004; Loomis and Dziedzic, 2018). In the US, NEPA is a procedural regulation--there is no requirement that an agency choose a particular alternative. The assessment and review process is thus grounded on the assumption that making information available about impacts will yield better decisions (Bazerman et al., 2003). An important and outstanding question on the usefulness of EIA as a policy tool is thus whether the process shifts the types of projects that are built or where they are built.

In absence of that information, understanding whether the EIA process changes how decision-makers account for cross-resource, distributional, or cumulative impacts can yield insights into its long term effects. Substantively, few studies have assessed whether EIA actually affects decision-making, let alone a project's impact on the environment (Loomis and Dziedzic, 2018). Existing studies on the content of EIAs find that structure and quality varies substantially, across agencies, sectors, and countries (Badr et al., 2011; Kabir and Momtaz, 2013; Peterson, 2010). For instance, in a cross-sectoral assessment of EIS documents in Bangladesh, Kabir and Momtaz (2013) found that almost 100% of EISs in the infrastructure and water sectors met author-defined criteria regarding treatment of impacts and alternatives, compared to 20% in the industry sector. Others have observed an emphasis on purely environmental rather than social impacts (Evans, 2014; Gregory et al., 1992) and a bias toward short-term benefits over longer term costs in the relative ranking of impacts (Evans, 2013). Finally, in the sole piece assessing the impact of EISs on decisions made by regulatory agencies, Hansen and colleagues (2013) find that the EIS document itself had little impact on final decisions, but that decisions were influenced by the working group that formed around preparing the EIS.

Besides creating information about environmental impacts, the second key tenet of EIA regulations like NEPA is creating opportunities for members of the public to provide input into decisions (Eckerd, 2014; Eckerd and Heidelberg, 2019; Glucker et al., 2013; O'Faircheallaigh, 2010). Although EIA itself is highly technical, project siting and management decisions ultimately reflect social and political values regarding acceptable environmental tradeoffs (Bartlett, 1997). As such, stakeholders are invited to provide input on proposed policies, projects, and management plans. NEPA, for instance, requires that "the Responsible Official will make diligent efforts to involve the public... in the preparation of ... EISs", including publishing notices of intent, holding public scoping meetings, and providing opportunities to comment on draft documents (40 CFR § 6.203). This reflects a broader push toward stakeholder participation in environmental governance that has occurred over the last several decades (Newig et al., 2018; Newig and Fritsch, 2009) given its presumed normative and substantive benefits for environmental decision-making (Glucker et al., 2013; Reed, 2008).

Normatively, providing opportunities for stakeholder involvement should enhance the democratic nature of policy processes, by providing people with opportunities to learn about government decisions (O'Faircheallaigh, 2010), giving people a voice in decisions that affect their lives (Karjalainen and Järvikoski, 2010), and helping to empower marginalized groups (Buckwalter, 2014; Martin and Sherington, 1997). Substantively, public input should help decision-makers identify impacts they might have missed, thereby developing more ecologically effective decisions and minimizing unintended side-effects (Newig and Fritsch, 2009; Rega and Baldizzone, 2015). In the case of EIA, this means that stakeholder involvement should shape what trade-offs are deemed acceptable in the approved version of the project.

However, in evaluating the role of public participation in administrative processes such as EIA, Eckerd and Heidelberg (2019) observe a tension: if public participation is not formalized it is unlikely to occur, but when formalized participation is likely to become just another bureaucratic hurdle which managers must navigate and a vector for discretionary administrative behavior. This likely helps to explain why in practice the benefits of participation are highly variable (Glucker et al., 2013). On the normative side, having some opportunities for participation is certainly more democratic than having none. However, empirical research on the types of organizations that choose to submit comments finds a skew toward business interests and away from individual citizens (Golden, 1998). There are also marked disparities between who attends meetings or submits comments and who actively shapes a decision, with the latter often being larger, wealthier organizations (Hui et al., 2018; Koski et al., 2016). And in the case of NEPA, the comments of organized interest groups are more likely to receive a substantive response relative to those of an individual resident (Eckerd, 2014). These studies suggest that there is a bias toward more organized or powerful groups in public participation, limiting its ability to empower marginalized groups and/or ensure that affected stakeholders have a voice.

Evidence for the substantive benefits of participation is more promising. Plans and policies that are made with stakeholder engagement are more comprehensive, less likely to overlook important environmental concerns, and more implementable (Beierle, 2002; Ulibarri, 2015). And public participation can increase compliance with the new policy or plan (Sultana and Abeyasekera, 2008), enhancing plan implementation (Koontz and Newig, 2014). However, a general conclusion on the benefit of public participation is that the quality of its outcomes depends substantially on the process that was used to reach them (National Research Council et al., 2008; Reed, 2008). In other words, participation should "not [be] merely a formal procedural requirement" (National Research Council et al., 2008, p. 2), but should emphasize opportunities for meaningful interaction in decisions. It is unclear whether an open comment period, like that in many EIA procedures, is sufficient for affecting the quality of the decision (Eckerd, 2014).

Creating opportunities for effective public participation in the specific context of EIA is particularly challenging. Many EIA guidelines and regulations do not articulate clearly the goal of public participation (e.g., whether it is to improve public access to information or ensure that governments make more equitable siting decisions), which makes assessing the value of participation more difficult (O'Faircheallaigh, 2010). EIA documents are often long, technical, and hard to read, especially for the average citizen (Killingsworth et al., 1989), and may not be written in the dominant language of a region (Li, 2009). In contexts where projects are funded by international development banks, the timing and approach to public engagement can be influenced by funding agencies to the detriment of actually providing needed input into the EIS (Mirumachi and Torriti, 2012). Finally, the types of participation opportunities offered in many EIA processes--providing written or verbal comments on a draft document--tend to fall on the less-engaged side of a stakeholder-engagement spectrum (Arnstein, 1969). In spite of (or perhaps because of) these challenges, little is known about the impact of stakeholder participation on the content of EIS documents.

The varied content and formatting of EIS documents and the breadth of public comments makes their systematic assessment quite difficult. This analysis uses a series of text mining methods to systematize the process of measuring what resource impacts are identified during the environmental impact assessment process; measure the distribution of public sentiment about those tradeoffs voiced in written comments; and observe whether public values are associated with a shift in tradeoffs between the draft and final EIS. The cases we examine are EISs prepared for federally developed or approved water and energy-related projects across California. We address two basic research questions: (1) What is the balance of environmental impacts associated with water and energy infrastructure development and management?; (2) How does the content of stakeholder feedback received during the draft review phase differ from draft content, and does this correspond to changes in the final EIS?

2. Materials and methods

2.1. Case selection and data sources

In the US, NEPA applies to any plan or project that is implemented by, receives funding from, or requires approval (e.g., permits) from a federal agency. Analysis under NEPA is a multi-stage process. Most projects start with an Environmental Assessment (EA), which provides an overview of the project, discusses several alternatives in project construction or design, reviews the projected environmental impacts associated with each alternative, and lists all agencies and individuals consulted during the review. If the agency decides that the impacts of the preferred alternative are minimal, it will issue a Finding of No Significant Impacts (FONSI).

If the agency decides that potential impacts are greater than minimal, it will develop a full EIS. The EIS process opens with a notice of intent and public scoping process, and the agency (in collaboration with the public) decides what resource concerns will be assessed in the EIS. The agency then prepares a draft EIS (DEIS), which includes a description of the project and its socio-environmental setting, description of several *alternatives* (changes that could affect the project's impacts e.g., in construction practices, project size, or technology), an assessment of the potential environmental impacts of each alternative across several resources, and a justification of the agency's preferred alternative. The DEIS is typically available for public comment for 45 days. The agency then incorporates the public feedback, including providing substantive responses to comments, in the final EIS (FEIS). After a (typically 30-day) waiting period, the agency closes the EIS process with a Record of Decision (ROD) published in the Federal Register. The ROD documents the agency's selected alternative, rationale, and any mitigation activities it will undertake (CEQ, 2019).

We analyze water- and energy-related projects in California that received a FEIS between 2012 and 2017. Using the EPA's EIS database (EPA, 2019), we searched for all draft and final

EISs issued between 2012 and 2017 with keywords pertaining to water (*water*, *flood*, *reservoir*, *dam*, *wetland*, *delta*, *rain*) or energy (*wind*, *hydro*, *solar*, *gas*, *transmission*, *oil*, *geotherm*). We identified 47 projects fitting this sample frame for which a final EIS had been issued by December 2017. We are able to access the three requisite elements of our analysis--a draft EIS, public comments on the draft EIS, and final EIS--for 27 of these projects. This 27 project subset constitutes our sample.

Table 1. Overview of US federal agencies and project types included in sample

Lead Agency	N	Project Type	N	Year (FEIS)	N
Bureau of Land Management	5	Energy/Transmission Line	2	2012	4
Bureau of Reclamation	7	Energy/Geothermal	1	2013	7
Federal Energy Regulatory Comm.	3	Energy/Solar	4	2014	3
US Fish and Wildlife Service	1	Energy/Wind	2	2015	8
US Forest Service	3	Energy/Oil & Gas Policy	1	2016	3
National Park Service	1	Energy & Water/Hydropower	3	2017	2
US Army Corps of Engineers	6	Water/Conservation	3	Total	27
Western Area Power Administration	1	Water/Flood Control	4		
Total	27	Water/Infrastructure	4		
		Water/Policy & Operations	2		
		Water/Restoration	1		
		Total	27		

As shown in table 1, three agencies figure prominently in our sample: the Bureau of Reclamation, the US Army Corps of Engineers, and the Bureau of Land Management. All three agencies have historically played a major role in water and energy infrastructure development in the western United States (Reisner, 1993), and we would likely observe a similar distribution of agencies for other western states and in other time periods. The split between water and energy projects is fairly even, with 10 energy projects, 14 water projects, and 3 hydropower projects that span both areas. Finally, the projects themselves are proposed by a variety of organizations, including the lead federal agencies, California state agencies, and local utilities.

We focus on California for several reasons. First, by selecting a single state, we limit variation in both the regulatory regime and propensity for public participation that may exist across jurisdictions, an important consideration given our small sample size (Eckerd, 2014). Second, California has its own EIA law, the California Environmental Quality Act (CEQA), which has similar requirements to NEPA but for projects developed or approved by state agencies. Almost all of the projects considered developed one joint NEPA/CEQA document, with the remainder developing a NEPA EIS and then adding a CEQA supplement. Thus, assessments are developed to meet the requirements of both laws. As CEQA also has fairly robust public participation requirements (Cal. Code Regs. §15201), we would expect to see more extensive commenting by the stakeholders relative to states that only are using NEPA. Finally, given variance in project types and settings, we believe that it is useful to hold state-level institutional context constant as opposed to selecting projects across multiple states that are subject to different state environmental laws and political climates.

2.2. Analysis

Text mining in environmental governance research has commonly been applied to a large number of relatively short sections of text drawn from limited-purpose documents. Recent examples include newspaper articles (Arnold et al., 2017), citizen safety complaints (Scott, 2018), meeting minutes (Hui et al., 2018; Scott et al., 2018), and congressional statements (Nowlin, 2016). The corpus (collection of written texts) used for this analysis is quite different. Our corpus consists of just total 81 documents: a DEIS, public comments made on the DEIS, and a FEIS for 27 water and energy infrastructure projects analyzed in California. In contrast to the aforementioned cases, the EISs we analyze are much longer, do not follow a consistent format, and address multiple topics at once. Each EIS document addresses the project purpose and need, project setting and environmental context, potential impacts of various alternatives, mitigation actions, and other related issues.

While there are many different ways one could analyze the content of EISs, we focus on the proportion of text that is spent discussing what we term "impact areas"--categories of resources that might be affected by the proposed project. Our simple method of comparing draft and final EISs, described in more detail below, is then to measure the amount of content in each document focused on each impact area, and then to compare whether the distribution of focus differs between the draft and final versions.

While EISs face fairly rigid requirements with respect to the overall structure, the authors of the document have some leeway over formatting and how much detail is provided on different potential impacts. Keeping the structure of an EIS constant, differences in impact area focus might arise because a project has a greater number or more intensive impacts on a particular resource, so more text is needed to analyze them. For instance, we would expect the EIS for a dam to spend more text discussing water resources than one for a highway overpass. By focusing on the percentage of text spent on different impact areas, we should be able to observe changes in the substantive focus of the EIS both between its draft and final iteration and as a result of public comments. Our argument is that if EIS authors are actually integrating public comments into the text outside the required response (typically contained in an appendix), the fraction of time spent on those impact areas that the public cares about should increase in the final EIS. That said, we also recognize that environmental impacts can be considered in breadth (as we do by focusing on quantity of content focus) and depth (by focusing on the specific nature of impacts discussed); while this analysis focuses on the breadth of attention given to different impact areas, we return to the question of measuring depth of focus in the discussion section below.

To make the text extraction process a bit neater, we developed simplified pdfs containing only the main body sections of the EIS, omitting appendices and reference sections. For the set of comments associated with each EIS (often contained in an appendix of the FEIS), we saved a separate file that contained only the relevant comment and response section. Table 2 summarizes the length of draft and final EISs after the pre-conversion cleaning step.

Table 2. Document length (pages) descriptive statistics, after pre-conversion cleaning

	Min.	Median	Mean	Max.
Draft EIS	209	475	630	2269
Final EIS	82	520	660	2631
Δ(Final-Draft)	-374	23	30	362
Tokenized sentences (drafts and finals)	1098	5447	6970	22592

To assess the extent to which each simplified EIS document focuses on defined impact areas, we use a supervised learning approach that classifies sentences into predefined categories. We focus on seven basic categories: water resources, air resources, biodiversity, habitat, aesthetic resources, socio-cultural resources, and climate change. These categories were selected for a combination of reasons. First, topics such as biodiversity and habitat represent prominent environmental issues in infrastructure governance that are sufficiently general as to be relevant to a wide swath of projects. EISs typically have highly detailed sections focusing on more specific topics such as terrestrial animal and aquatic animals; the intent of using more general categories is reflect higher-level differences within and between documents. Second, stated goals for NEPA include to "*assure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings.. [and to] preserve important historic, cultural, and natural aspects of our* *national heritage, and maintain, wherever possible, an environment which supports diversity, and variety of individual choice"* (42 U.S.C. § 4331(b)). Sociocultural and aesthetic impacts are expected to be considered in EISs alongside impacts to ecological functions and earth systems.

A sentence can discuss more than one of these impacts, such as a case where a project is expected to increase sedimentation (topic = water resources) and thus harm a fish population (topic = biodiversity). Thus, this is a multi-class (seven category), multi-label (zero, one, or multiple) classification task.

Classification involves three basic steps: (1) building a training set of texts that are prelabeled; (2) fitting and validating a classification model using these training data; and (3) classifying text of interest using the trained model. To develop a training set, we built a web scraping tool to crawl the EPA's EIS document library and download all available documents (including drafts, appendices, addendums, comments, etc.), more than 11,000 documents of varying lengths. We then selected a subset of processed sentences from each document that had characteristics of neat sentences (i.e., real sentences from the text rather than tokenized sentences that contained messy content resultant from the pdf-to-text conversion process) such as consistent spacing, lack of multiple numeric sequences in a row, and no abnormal characters. This resulted in 2.83 million sentences across more than 9,000 documents.

We then developed a dictionary of words and phrases associated with each of the seven impact categories. Two examples: the water resources category includes words and phrases such as "water quality", "effluents", and "stormwater", and the sociocultural category contains words and phrases such as "environmental justice", "cultural resources", and "recreational activity". The dictionary was created by the authors based upon review of EIS and related documents, with key terms selected based both on frequency of occurrence and on unambiguity--that is, words and phrases which specifically correspond to one category rather than possibly fitting into several. The dictionary is shown in the appendix. Using a simple regular expression search, we identified whether each sentence contained a given phrase, and if so labelled it as pertaining to said category.

We then sampled 20,000 sentences from each classification label (to create a balanced training set) for inclusion in our training set. To produce null training examples (sentences that should not be classified as falling into any of the seven categories), we positively identified null sentences based upon the presence of words or phrases denoting topics not in our classification set, such as “property acquisition”, “fossils,” or “scoping meetings.” We then supplement these data with additional sentences tokenized from Wikipedia articles where we are confident that content does not relate to an impact area category, including the pages for beer, Star Trek, and Lebron James. While the specific Wikipedia entries used were arbitrarily chosen according to the authors’ interests, there is an underlying purpose. Whereas EIS sentences that do not contain topic keywords could still relate to environmental impacts, the content of these Wikipedia pages does not, thus avoiding type II labelling error. Further, these entries relate to EIS-adjacent topics (e.g., water, agriculture, science and technology, recreation) but not environmental impacts specifically. From the perspective of word context-based classification models (described below), most EIS content has some inherent contextual similarities; training on contextually adjacent, but null, examples is intended to help avoid false positives due to general environmental focus.

The classification model is an artificial neural network (ANN) classifier. Our ANN is comprised of an input layer (a processed representation of the sentences for classification), an output layer (predicted classification labels), and a hidden layer of nodes through which input signals are transmitted into output predictions. Input nodes are interconnected with hidden processing nodes, which are in turn interconnected with output nodes. The way an ANN learns is by adjusting the weights placed upon these connective edges to determine how and when input signals are passed to subsequent nodes. The ANN classifier iteratively trains chunks of sentences which in total comprise 80% of the labelled training data, and then validates on the remaining 20% that were not used to optimize, and then repeats this process multiple times to minimize data loss, or the gap between observed and predicted labels. Our ANN is built using the *keras* R package (Allaire and Chollet, 2018), which relies upon Keras, an API built for neural network models (Chollet, 2015), and uses TensorFlow (Abadi et al., 2016).

To quantify sentence content for input into the ANN classifier, we use word embeddings. Word embeddings are a type of *vector-space model* that map words within a multidimensional space using continuous dimensions (Mikolov et al., 2013a). Word locations reflect each words' context, essentially quantifying the idea that words that are observed together frequently in text are likely more closely related than words that are not. The multidimensional location of a word reflects the fact that words can be similar--or different--in multiple respects (Mikolov et al., 2013b). For instance, hydropower facilities and bridges share similar contexts of water and infrastructure, but hydropower facilities also relate to energy while bridges relate to transportation. Word embeddings reduce the dimensionality of text input by representing words on a fixed set of dimensions. We use the GloVe pre-trained word vector model (Pennington et al., 2014), specifically the large-scale model which encodes 2.2 million words on 300 dimensions, trained on an 840B word dataset (Pennington et al., 2014).

We finally apply the fitted model to tokenized sentences to predict topical focus. A given label was assigned if the predicted probability for a topic was greater than 0.50 (a fairly standard cutoff for empirical ANN classification tasks). An unclassified sentence is then one where the model does not have enough viable information to confidently apply any of the possible labels. Using word embeddings enables viable classification even for sentences that do not contain the exact words or phrases used to make our training data. Because the input layer to the ANN is a representation of the words of a sentence in 300 dimensional vector space, the model learns based upon the relative location of these words in context, not the specific words or ordering. A simple example is that because our pretrained data classify sentences with words such as "salmon", "pollinators", "native plants", and "macroinvertebrates" as relating to the biodiversity topic, the model can learn to associate other, unspecified animal- and plant-related words with the biodiversity topic as well. To conclude this section, table 3 briefly summarizes the analysis steps described above:

Table 3: Summary of analysis steps

Step 1: Collect and clean EIS documents.
Step 2: Make a training dataset of sentences with labelled topics.
Step 3: Train classification model to probabilistically tag the sentence topics.
Step 4: Tokenize sentences from the corpus of California water and energy EISs and comments.
Step 5: Classify topic(s) of each tokenized sentence.
Step 6: Summarize distribution of topical focus for DEIS, FEIS, and comments for each project.

3. Results

The results presented in this section address two issues: (1) the environmental impacts associated with water and energy infrastructure development and management; and (2) how the impact areas emphasized in stakeholder comments received during the draft review phase differs from draft content, and whether this feedback appears to correspond to changes in the FEIS. The first result we present concerns the distribution of impact area topics within, and between, EIS processes. Figure 1 plots the proportion of sentences extracted from each final EIS that are classified within each of the seven focal impact areas (water resources, air resources, biodiversity, habitat, socio-cultural resources, and climate change), out of all observed sentences including those not classified as pertaining to any of the focal categories. In no case were more than 50% of extracted sentences classified within one or more of our focal categories. In other words, the majority of sentences received no classification. This ratio comports with observational results from a subset of hand-coded sentences that were used to help hone the topical categories.[1] This implies there is a lot of content in an EIS document that does not directly pertain to environmental impacts.

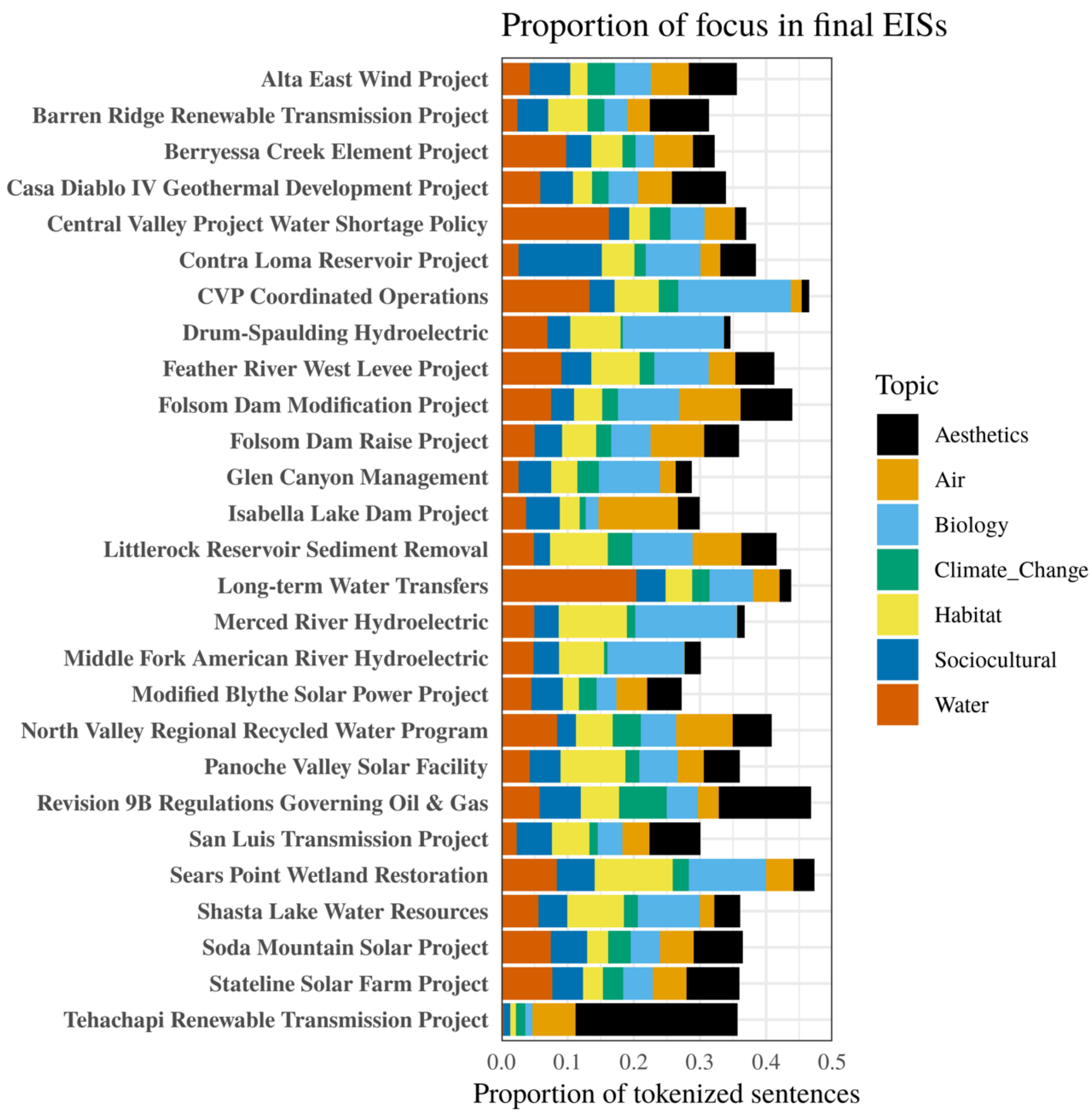


Fig. 1. Classified sentences by topic area focus as proportion of final EIS content

[1] Hand coding was performed by the analysts on around 700 sentences from sentences extracted from a few example EISs. The primary intent was to test the pre-selected categories and identify potential keywords for use in the topic dictionary.

Overall, figure 1 matches what we might expect given the nature of individual projects, serving to ground truth our automated content analysis approach. For instance, projects where functional and managerial considerations primarily concern water capture, storage, and transfer devote a great proportion of content to water resource impacts. Key examples include several EISs related to the Central Valley Project (CVP)--a massive network of dams, reservoirs, canals, and related water infrastructure in California's Central Valley--including the CVP's Coordinated Operations [Plan], Long Term Water Transfers [Program] (which regulates transfers into and out of the CVP system), and CVP's Water Shortage [Policy] (a drought response program). All three projects have significant, direct water resource impacts, and this is reflected in the relatively high proportion of content devoted to water resources. In contrast, we see that individual hydroelectric projects (e.g., Merced River Hydroelectric [Project], Middle Fork American Hydroelectric [Project], and Drum-Spaulding Hydroelectric [Project]) devote comparatively little airtime to water resource impacts and more to habitat-related impacts. This is likely because individual dams operations focus more on how the dam will impact habitat (e.g., altering water temperature and flow speed, inundation, or sediment capture) rather than larger scale hydrologic changes (e.g., groundwater recharge, river levels, etc.). Furthermore, most dam projects focus minimally on aesthetic impacts in contrast to wind (e.g., Tehachapi Renewable Transmission [Project]) and solar (e.g., Stateline Solar Farm [Project]) farms, both cases where aesthetic considerations are recognized by scholars as being particularly salient (Firestone et al., 2009; Torres-Sibille et al., 2009).

Figure 1 shows the proportion of total content we classify as pertaining to a given impact area out of all tokenized sentences (including sentences not classified as pertaining to any of the impact categories). In the next set of results, we focus exclusively on sentences classified as relating to one or more impact area categories. Thus, the results show the relative degree focus on a given topic out of all content classified as related to one or more of the seven impact categories.[2]

Figure 2 visualizes topical focus among all classified sentences for four sample projects. Each path in figure 2 traces the proportion of all classified sentences in a given document that are assigned to a given impact area (i.e., the total for each path sums to one). The outer circle in each panel represents 0.50 (50% of labelled content focuses on a given impact area), while the middle circle represents 0.25. The yellow and blue lines in each panel show the distribution of sentences by topic for the draft and final EISs, respectively. The red line in each panel shows the emphases measured from public comments. In all four cases, one can readily see that the draft and final EISs closely overlap. This is a consistent finding in our sample: the distribution of impact area foci does not change much between draft and final versions.

[2] Particularly in the case of written comments, there are generally an order of magnitude fewer sentence tokens. Thus, we believe that focusing on relative proportions within classified sentences is the most beneficial comparison. That said, since fewer comment sentences are labelled in any category on average (~26%) than DEIS and FEIS sentences (both around 36%), it is possible that the overall proportion of categorized text drives differences between comments and EISs. To explore this, we computed similar results but based upon the total number of sentences (including sentences not classified in an impact category). The overall conclusions are similar, but the results are a bit messier because the total number of sentences varies more than the relative percentages. Particularly in the case of written comments, there are generally an order of magnitude fewer sentence tokens. Thus, we believe that focusing on relative proportions within classified sentences is the most beneficial comparison.

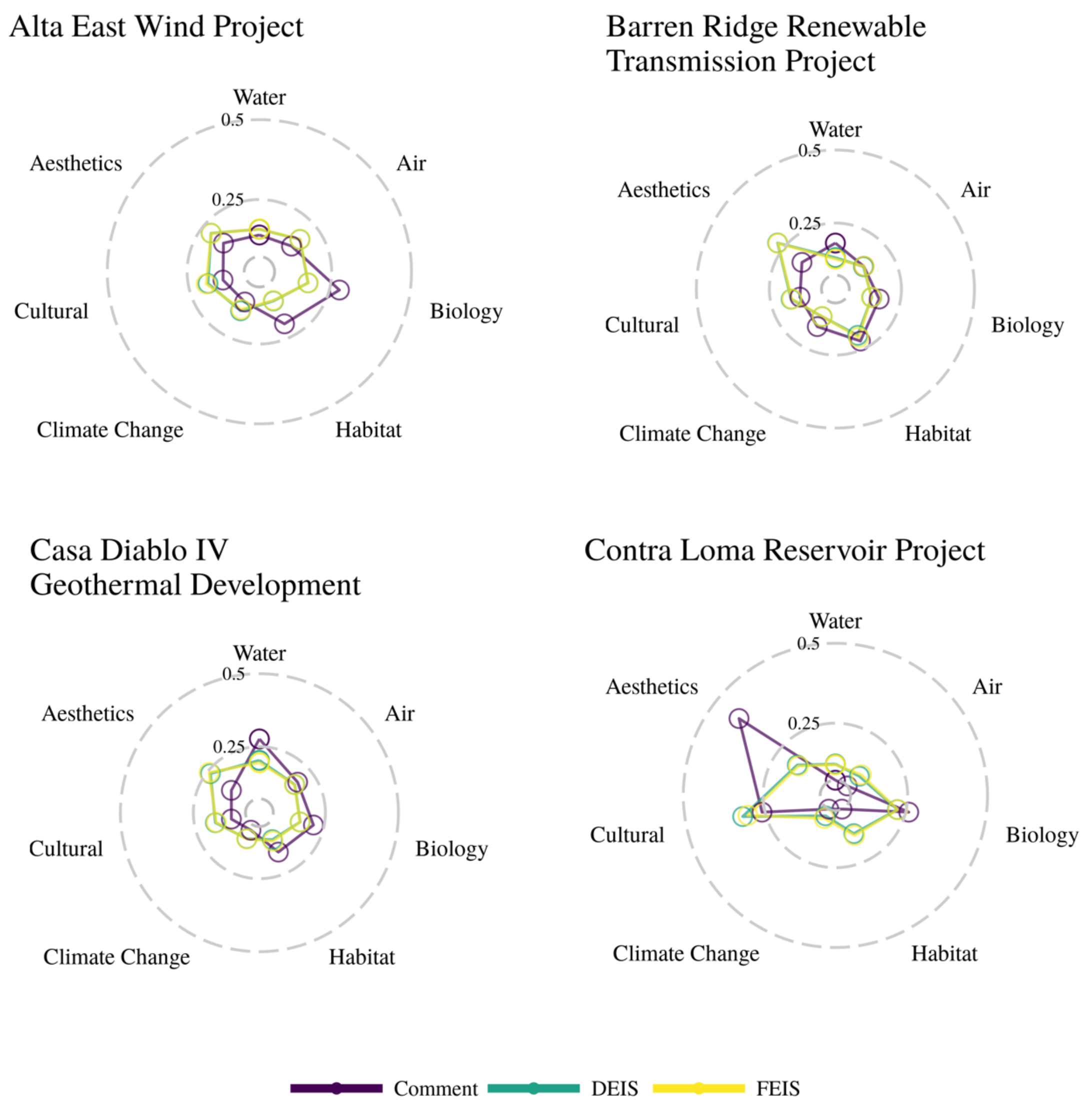


Fig. 2. Impact area foci for four sample projects' DEIS, comments, and FEIS

Figure 2 also shows that the foci of public comments tends to diverge from the foci of EIS documents. One might expect public comments to generally focus on one or two impact areas. However, the four sample projects shown in figure 2 are emblematic of the broader sample in that the focus of public comments varies substantially across projects.

Figure 3 aggregates the topical focus across all 27 observed EIS processes. In figure 3, the upper and lower bounds of each box represent the 25th and 75th quartiles, and the middle line in each box is the median. The middle box in each topic represents the proportion of content focusing on this impact area in comments received. In three cases (biology, climate, and habitat) median focus in comments is almost identical to that in the draft and final EISs. For aesthetics, air, sociocultural, and water, median focus in comments is lower than that observed in the impact assessments.

Importantly, climate change receives less consideration overall than the other six impacts, while average focus across the other six areas is relatively similar. Comparing average focus across topics by document type, a one-way ANOVA test for equality of means is easily rejected for DEISs, FEISs, and comments ($p < 0.000$ in all three cases). Applying the Tukey range test (Tukey, 1949) shows that climate change focus is significantly lower than the average focus for all but air quality and socio-cultural resources for DEISs, FEISs, and comments.

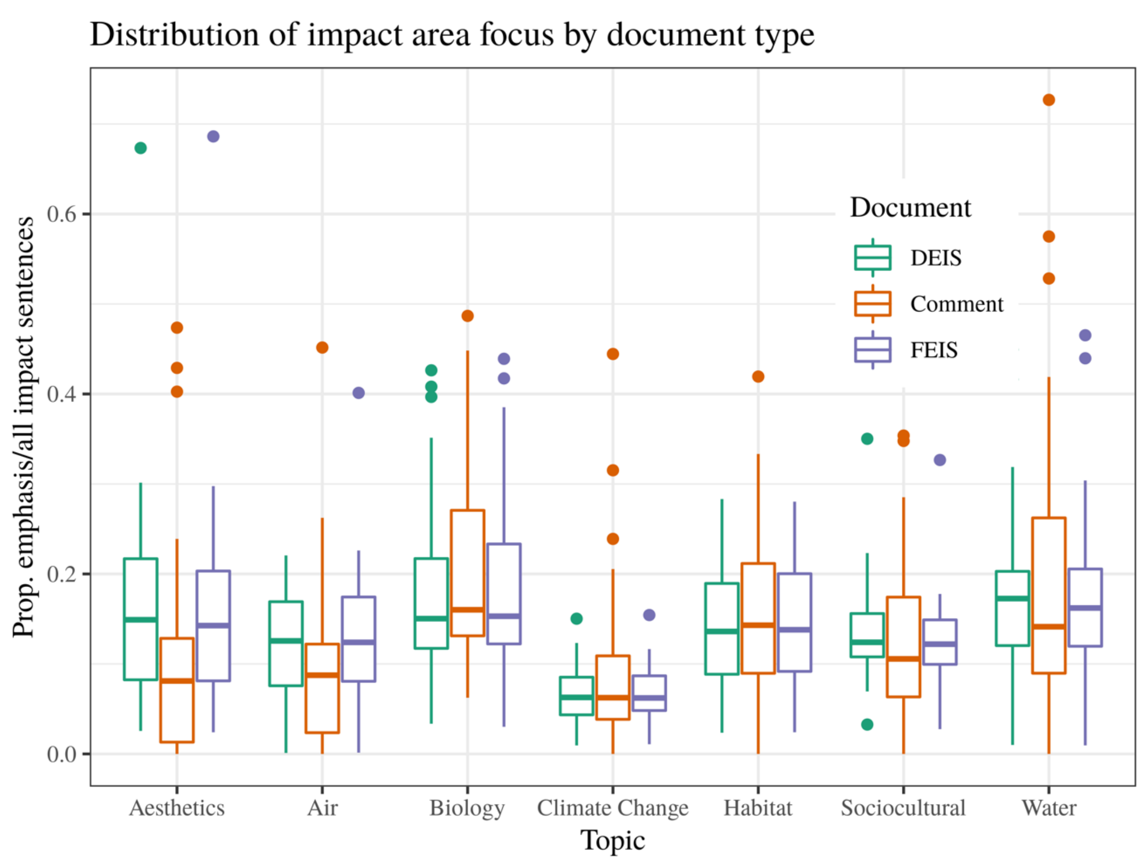


Fig. 3. Distribution of topical focus by document stage

Finally, figure 4 summarizes the percentage change between DEIS and comments, comments and FEIS, and DEIS and FEIS for each topic area. While there is fairly wide variation regarding what is emphasized in public comments versus the EISs themselves, there is minimal change in impact area focus between draft and final EISs, with none significantly distinguishable from zero. This calls into question the basic program logic of NEPA. If having a formal period for stakeholder review and participation generates new information and fosters collective learning (Gerlak and Heikkila, 2011; Reed, 2008), one way in which this can be reflected is through an EIS devoting more content to a given issue. Thus, we anticipate that final EISs would differ from the initial drafts by shifting a bit in the distribution of topical focus to discuss the interests raised by public comments. We do not see this pattern. While the EISs do spend time (as required) "respond[ing] to any substantive comments on the draft EIS" (40 CFR §6.207), this is contained in the appendix that we assess to measure the content of comments. We do not see any shifts in the impact area focus of the main FEIS toward the content of the comments--the measure that would suggest that the comments have a substantive impact on the content of the FEIS.

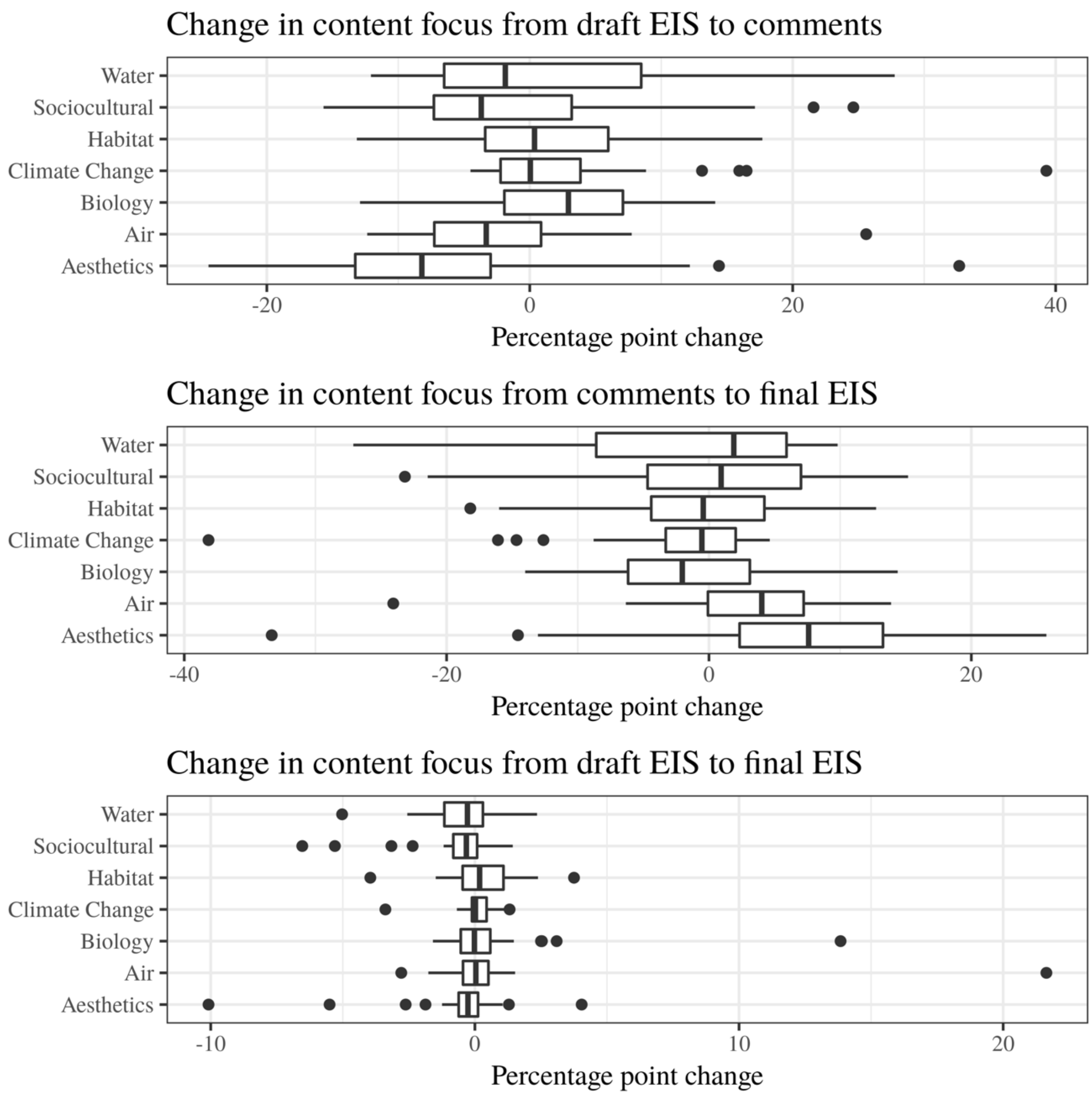


Fig. 4. Distribution of changes between draft and comments, comments and final, and draft and final by topic area

4. Discussion

4.1. Substantive reflection

Environmental decision-making is all about making tradeoffs. This is certainly true in the case of major water and energy infrastructure projects and programs, where efforts to preserve or improve one environmental resource pose a detriment to other resource systems. Environmental impact assessments, both the US NEPA process we focus on in this analysis and similar procedures used in 191 other countries, intend to provide a more holistic view of these multidimensional decision-making challenges. However, since the passage of NEPA in 1969, there have been almost 33,000 full EIS review processes conducted in the US, yet accessing the information contained within these documents requires sifting through pages of highly technical language and the effects of NEPA remain largely unknown (Farber and Miller, 2010; Wentz, 2016).

Our results show that a diverse array of impact areas are considered in EISs, with each receiving on average a similar fraction of attention within the whole document, suggesting that NEPA is effective in creating information about the impacts of proposed projects and potential tradeoffs among different valued resources. The exception is climate change, which on average was discussed less across the EISs in our study.

We also find little to no substantive change in the content--measured as fraction of text devoted to each impact area--between draft and final EISs, despite public comments focusing on substantially different impact areas than the main EISs. This would seem to be *prima facie* evidence that the public review and comment period is of little significance, since FEISs do not demonstrate considerable update of new information nor tend to delve more deeply into a topic area based on comment feedback. Our findings reinforce an earlier study, which asked when and why public comments receive substantive responses from the lead federal agency (Eckerd, 2014). This study found little engagement with public comments, with over 50% of submitted comments (and up to 80% for some agencies) receiving only minimal acknowledgement in the FEIS. In tandem, these studies suggest that providing the opportunity for public comments on the DEIS has minimal substantive impact on the process.

Before simply concluding that low-engagement forms of public participation like public comments (Arnstein, 1969) are meaningless, it is worth considering possible reasons that might contribute to our findings. First, many EIS processes undergo one or more rounds of review prior to issuance of the formal DEIS. For instance, required scoping processes conducted before drafting a DEIS solicit input from affected federal, state, and local parties that in effect asks, "What issues should we consider when writing this EIS?". Thus, we might expect the DEIS to partially reflect the impact areas of concern to key stakeholders, in which case further comments by these same stakeholders are unlikely to result in changes between the draft and final documents, but public participation would still have impacted the content of the EIS. The empirical challenge of assessing the full extent of this process is the lack of publicly accessible information on the scoping phase and other facets of document preparation (Farber and Miller, 2010).

Second, given that NEPA has been in place for almost 50 years, field officers, consultants, and other parties who help develop these assessments are expected to have a working knowledge of what types of impacts are potentially most salient, analytic methods or presentation schemes which have worked well or poorly in the past, and who the key stakeholders are and what their concerns might be. Thus, the conceptual draft-comment-revise model is perhaps superseded by preemptive response. Having reviewed our subset of EIS processes carefully, it is clear that similar dynamics are at play in terms of the specific project alternatives that are discussed within an EIS process. It is not uncommon for an EIS, for instance, to state that a large number of alternatives (ten or more) were considering during scoping, but that the DEIS considers a much more limited subset (e.g., the No Action Alternative, the Proposed Action, and a small modification of the Proposed action). Even when the DEIS considers several more options, most are given only minor attention and it is clear that only one or two options are truly in play.

4.2. Methodological reflection

A major intent of this paper was to explore the extent to which modern computational text analysis tools make it possible to understand large scale environmental planning and impact assessment documents in systematic fashion. Summarizing document content and foci is a critical first step for understanding what environmental impacts EISs assess and how tradeoffs among these impacts occur. However, there are also many unresolved barriers that prevent a fuller, more useful accounting.

While the percentage of an EIS's or comment's content that focuses on a particular topic area may not have shifted between draft and final versions, we cannot say for certain whether the meaning of that content remained static. For instance, imagine a project whose DEIS receives criticism that estimates about endangered species impacts are flawed. The authors could potentially flip their conclusion (to say the species impacts are or are not significant) while spending the same number of words on the topic; this change would not be visible in our analysis, but it would suggest that the public comments had a big impact. (In hand-coding a subset of our cases in preparation for the automated analysis, we did not observe any substantial flips in conclusion between versions, and we believe this potential outcome would not be widespread.) Even if project decisions do not change, one can easily envision a DEIS and a FEIS that devote the exact same amount of words and pages to a given impact area, but differ in the information provided. For instance, a FEIS might describe impacts as being more severe than posited in the DEIS. Thus, meaningful change between draft and final documents can be a matter of relative frequency, the nature of the discussion itself, or both.

In light of this, we recognize two primary near-term steps as being particularly important: disambiguation of project alternatives and impact severity measurement. Both are somewhat significant technical challenges. First, while looking at the overall distribution of content related to specific impact areas provides a big-picture view of how different water and energy projects balance environmental tradeoffs, to fully understand the impact of EIS decision procedures we need to consider the impacts of different potential project alternatives. A typical EIS document contains a detailed assessment of potential project outcomes under several different alternatives. Examples of alternatives are reduced or enlarged project footprints or different possible facility sitings within the project area. There are several factors that make processing information about specific alternatives difficult, particularly cases where impact discussion do not reference a particular alternative or when alternatives are defined in relative fashion (e.g., “Alternative B will have similar impacts on wildlife to that of Alternative A.”). When looking at overall document content, this is not a problem--we can reasonably assume that an EIS that spends more time discussing wildlife impacts is proposing a project that carries greater potential to impact wildlife. For understanding the internal choice set, however, this means that the nature of individual alternatives must be defined in reference both to impact areas and to other projects.

Accounting for impact severity also presents several challenges. First, sentiment classification is commonly used in text mining as a way of coding positive and negative language. In a movie review, for instance, classification can be based on the words that occur in association with the movie (e.g., “That movie was great!”). From an environmental impact perspective, however, there is an added layer of complication: all project alternative are typically discussed in terms of how they affect a given issue or impact area, but it is not inherently clear what the directionality of the issue or area should be. For instance, “increased dust” is an environmental bad, but “increased biodiversity” is an environmental good. More challenging are contextually determined goods and bads such as streamflow, which could be good in such a context as "increased summer streamflow for fish habitat" but bad in the case of "increased streamflow due to impervious surface areas shedding stormwater." Dust, biodiversity, and stormwater do not carry emotional connotations, and so developing an environmental impact training dictionary is necessary to conduct conditional sentiment classification that incorporates whether more or less of the subject in question is beneficial. It is also worth noting that the language used in environmental impact assessments is purposely anodyne and unemotional (e.g., "reduce" instead of "harm" or "reduction" instead of "degradation"), therefore missing many of the linguistic hallmarks that typically help with sentiment classification tasks.

To address this, we propose to build a training dictionary that can be used to train a domain-specific sentiment classifier. What this would primarily entail is assigning a directional valence to environmental keywords--that is, denoting whether an increase, expansion, or proliferation in a given resource or condition is an ecological benefit or cost. In many cases, this would not be straightforward; depending on context and circumstance a forest fire, for instance, can be ecologically beneficial or detrimental. However, at a basic level this type of "environmental sentiment dictionary" could then be paired with part-of-speech tagging to identify subject-object-verb relationships in sentences and thus link project actions to positive and negative environmental impacts. For instance, a sentence that speaks to a decrease in salmon stocks would be classified as detrimental, thus providing both a topic area (salmon) and impact (harm).

In conclusion, we are excited about the potential for computational text analysis tools to help make inroads into our understanding of the functions, outputs, and outcomes of environmental review and impact assessment processes. This paper specifically highlights open theoretical and practical questions about how public participation shapes policy decision-making and the implementation of information-based regulation. The ability to apply systematic, replicable measures across a large number of projects and processes presents a way to more fully test extant theories of participation (e.g., Fung, 2015) and build upon analyses of stakeholder involvement in specific domains such as hydropower facility relicensing (Ulibarri, 2015) and forest restoration (Bixler and Kittler, 2015).

However, public participation and information-based regulation is only one avenue amongst many lines of environmental governance inquiry. For instance, there is a similar potential to use EIS processes to better understand adaptation and learning in multilevel governance (Pahl-Wostl, 2009) by comparing outputs over time and parsing where and when new information enters EIS processes. The network of authors, providers of technical input, and commenters provides an interesting, ongoing glimpse into the structure and function of social in complex institutional environments (Bodin and Crona, 2009). Further, EISs contain direct information about the ways (or lack thereof) that agencies and infrastructure developers/operators conceive of and seek to mitigate climate change risks in design, siting, and operational planning. The NEPA process serves to generate a massive amount of information about all manner of environmental governance questions, and merits our tools and attention.

Acknowledgements

This work was supported by UC Water Security and Sustainability Research Initiative funded by the University of California Office of the President (UCOP) (Grant No. MR-15-328473).

5. References

Abadi, M., Barham, P., Chen, J., Chen, Z., Davis, A., Dean, J., Devin, M., Ghemawat, S., Irving, G., Isard, M., Others, 2016. TensorFlow: A System for Large-Scale Machine Learning, in: OSDI.

usenix.org, pp. 265–283.
Allaire, J.J., Chollet, F., 2018. keras: R Interface to “Keras.”
Arnold, G., Nguyen Long, L.A., Gottlieb, M., 2017. Social networks and policy entrepreneurship: how relationships shape municipal decision making about high-volume hydraulic fracturing. Policy Stud. J. 45, 414–441.
Arnstein, S.R., 1969. A Ladder Of Citizen Participation. J. Am. Inst. Plann. 35, 216–224. https://doi.org/10.1080/01944366908977225
Badr, E.-S.A., Zahran, A.A., Cashmore, M., 2011. Benchmarking performance: Environmental impact statements in Egypt. Environ. Impact Assess. Rev. 31, 279–285. https://doi.org/10.1016/j.eiar.2010.10.004
Bartlett, R.V., 1997. The Rationality and Logic of NEPA Revisited, in: Clark, R., Canter, L. (Eds.), Environmental Policy and NEPA, Past, Present, and Future. St. Lucie Press, Boca Raton, FL.
Bazerman, C., Little, J., Chavkin, T., 2003. The Production of Information for Genred Activity Spaces: Informational Motives and Consequences of the Environmental Impact Statement. Written Communication 20, 455–477. https://doi.org/10.1177/0741088303260375
Beierle, T.C., 2002. The quality of stakeholder-based decisions. Risk Anal. 22, 739–749.
Bixler, R.P., Kittler, B., 2015. Collaborative Forest Landscape Restoration: A meta-analysis of existing research on the CFLR Program. Pinchot Institute for Conservation. Available online at www. xalioxs. pinchot. org/pubs/548.
Bodin, Ö., Crona, B., 2009. The role of social networks in natural resource governance: What relational patterns make a difference? Glob. Environ. Change 19, 366–374.
Buckwalter, N.D., 2014. The Potential for Public Empowerment through Government-Organized Participation. Public Adm. Rev. 74, 573–584. https://doi.org/10.1111/puar.12217
Caldwell, L.K., 1988. Environmental Impact Analysis (EIA): Origins, Evolution, and Future Directions. Impact Assessment 6, 75–83. https://doi.org/10.1080/07349165.1988.9725648
Cashmore, M., Gwilliam, R., Morgan, R., Cobb, D., Bond, A., 2004. The interminable issue of effectiveness: substantive purposes, outcomes and research challenges in the advancement of environmental impact assessment theory. Impact Assessment and Project Appraisal 22, 295–310. https://doi.org/10.3152/147154604781765860
CEQ, 2019. NEPA | National Environmental Policy Act - Agency NEPA Implementing Procedures [WWW Document]. Council on Environmental Quality. URL https://ceq.doe.gov/laws-regulations/agency_implementing_procedures.html (accessed 2.16.19).
Chollet, F., 2015. Keras [WWW Document]. URL https://keras.io
Eckerd, A., 2014. Risk Management and Risk Avoidance in Agency Decision Making. Public Administration Review 74, 616–629. https://doi.org/10.1111/puar.12240
Eckerd, A., Heidelberg, R., 2019. Administering Participation: Citizens and NEPA. American Review of Public Administration. https://doi.org/10.5465/AMBPP.2017.17356abstract
EPA, 2019. Environmental Impact Statement (EIS) Database [WWW Document]. URL https://cdxnodengn.epa.gov/cdx-enepa-public/action/eis/search (accessed 3.14.19).
Evans, R., 2014. Environmental Reviews and Case Studies: Decision Making in the Environmental Impact Assessment Process. Environ. Pract. 16, 290–301. https://doi.org/10.1017/s1466046614000295
Evans, R., 2013. The environmental impact statement: A rhetorical analysis (PhD). Texas Tech University.
Farber, D.A., Miller, M.L., 2010. A Simple But Fundamental Step: Put All EISs & EAs on the Web. https://doi.org/10.2139/ssrn.1703624
Firestone, J., Kempton, W., Krueger, A., 2009. Public acceptance of offshore wind power projects in the USA. Wind Energy 12, 183–202. https://doi.org/10.1002/we.316
Fung, A., 2015. Putting the Public Back into Governance: The Challenges of Citizen Participation and Its Future. Public Adm. Rev. 75, 513–522. https://doi.org/10.1111/puar.12361
Gerlak, A.K., Heikkila, T., 2011. Building a Theory of Learning in Collaboratives: Evidence from the Everglades Restoration Program. Journal of Public Administration Research and Theory 21, 619–

644. https://doi.org/10.1093/jopart/muq089
Glucker, A.N., Driessen, P.P.J., Kolhoff, A., Runhaar, H.A.C., 2013. Public participation in environmental impact assessment: why, who and how? Environ. Impact Assess. Rev. 43, 104–111. https://doi.org/10.1016/j.eiar.2013.06.003
Golden, M.M., 1998. Interest Groups in the Rule-Making Process: Who Participates? Whose Voices Get Heard? Journal of Public Administration Research and Theory 8, 245–270. https://doi.org/10.1093/oxfordjournals.jpart.a024380
Gregory, R., Keeney, R., von Winterfeldt, D., 1992. Adapting the Environmental Impact Statement Process to Inform Decisionmakers. J. Policy Anal. Manage. 11, 58. https://doi.org/10.2307/3325132
Hansen, A.M., Krnv, L., Cashmore, M., Richardson, T., 2013. The significance of structural power in Strategic Environmental Assessment. Environ. Impact Assess. Rev. 39, 37–45. https://doi.org/10.1016/j.eiar.2012.10.004
Hui, I., Ulibarri, N., Cain, B.E., 2018. Patterns of Participation and Representation in a Regional Water Collaboration. Policy Stud. J.
Kabir, S.M.Z., Momtaz, S., 2013. Sectorial variation in the quality of environmental impact statements and factors influencing the quality. J. Environ. Planning Manage. 57, 1595–1611. https://doi.org/10.1080/09640568.2013.824415
Karjalainen, T.P., Järvikoski, T., 2010. Negotiating river ecosystems: Impact assessment and conflict mediation in the cases of hydro-power construction. Environ. Impact Assess. Rev. 30, 319–327. https://doi.org/10.1016/j.eiar.2010.04.004
Killingsworth, M.J., Jimmie Killingsworth, M., Steffens, D., 1989. Effectiveness in the Environmental Impact Statement. Written Communication 6, 155–180. https://doi.org/10.1177/0741088389006002002
Koontz, T.M., Newig, J., 2014. From Planning to Implementation: Top-Down and Bottom-Up Approaches for Collaborative Watershed Management. Policy Stud. J. 42, 416–442. https://doi.org/10.1111/psj.12067
Koski, C., Siddiki, S., Sadiq, A.-A., Carboni, J., 2016. Representation in Collaborative Governance: A Case Study of a Food Policy Council. Am. Rev. Public Admin. 48, 359–373. https://doi.org/10.1177/0275074016678683
Li, F., 2009. Documenting Accountability: Environmental Impact Assessment in a Peruvian Mining Project. PoLAR: Political and Legal Anthropology Review 32, 218–236. https://doi.org/10.1111/j.1555-2934.2009.01042.x
Loomis, J.J., Dziedzic, M., 2018. Evaluating EIA systems' effectiveness: A state of the art. Environ. Impact Assess. Rev. 68, 29–37. https://doi.org/10.1016/j.eiar.2017.10.005
Martin, A., Sherington, J., 1997. Participatory research methods—Implementation, effectiveness and institutional context. Agric. Syst. 55, 195–216. https://doi.org/10.1016/s0308-521x(97)00007-3
Mikolov, T., Chen, K., Corrado, G., Dean, J., 2013a. Efficient Estimation of Word Representations in Vector Space. arXiv [cs.CL].
Mikolov, T., Yih, W.-T., Zweig, G., 2013b. Linguistic regularities in continuous space word representations, in: Proceedings of the 2013 Conference of the North American Chapter of the Association for Computational Linguistics: Human Language Technologies. aclweb.org, pp. 746–751.
Mirumachi, N., Torriti, J., 2012. The use of public participation and economic appraisal for public involvement in large-scale hydropower projects: Case study of the Nam Theun 2 Hydropower Project. Energy Policy 47, 125–132. https://doi.org/10.1016/j.enpol.2012.04.034
Morgan, R.K., 2012. Environmental impact assessment: the state of the art. Impact Assessment and Project Appraisal 30, 5–14. https://doi.org/10.1080/14615517.2012.661557
National Research Council, Division of Behavioral and Social Sciences and Education, Committee on the Human Dimensions of Global Change, Panel on Public Participation in Environmental Assessment and Decision Making, 2008. Public Participation in Environmental Assessment and Decision Making. National Academies Press.
Newig, J., Challies, E., Jager, N.W., Kochskaemper, E., Adzersen, A., 2018. The environmental

performance of participatory and collaborative governance: a framework of causal mechanisms. Policy Stud. J. 46, 269–297.
Newig, J., Fritsch, O., 2009. Environmental governance: participatory, multi-level - and effective? Environmental Policy and Governance 19, 197–214. https://doi.org/10.1002/eet.509
Nowlin, M.C., 2016. Modeling Issue Definitions Using Quantitative Text Analysis. Policy Stud. J. 44, 309–331. https://doi.org/10.1111/psj.12110
O'Faircheallaigh, C., 2010. Public participation and environmental impact assessment: Purposes, implications, and lessons for public policy making. Environ. Impact Assess. Rev. 30, 19–27. https://doi.org/10.1016/j.eiar.2009.05.001
Pahl-Wostl, C., 2009. A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. Glob. Environ. Change 19, 354–365. https://doi.org/10.1016/j.gloenvcha.2009.06.001
Pennington, J., Socher, R., Manning, C., 2014. Glove: Global vectors for word representation, in: Proceedings of the 2014 Conference on Empirical Methods in Natural Language Processing (EMNLP). aclweb.org, pp. 1532–1543.
Peterson, K., 2010. Quality of environmental impact statements and variability of scrutiny by reviewers. Environ. Impact Assess. Rev. 30, 169–176. https://doi.org/10.1016/j.eiar.2009.08.009
Reed, M.S., 2008. Stakeholder participation for environmental management: A literature review. Biol. Conserv. 141, 2417–2431. https://doi.org/10.1016/j.biocon.2008.07.014
Rega, C., Baldizzone, G., 2015. Public participation in Strategic Environmental Assessment: A practitioners' perspective. Environ. Impact Assess. Rev. 50, 105–115. https://doi.org/10.1016/j.eiar.2014.09.007
Reisner, M., 1993. Cadillac Desert: The American West and Its Disappearing Water, Revised Edition. Penguin.
Scott, R.P., 2018. Should we call the neighbors? Voluntary deliberation and citizen complaints about oil and gas drilling. Energy Policy 115, 258–272. https://doi.org/10.1016/j.enpol.2018.01.017
Scott, T.A., Ulibarri, N., Scott, R.P., 2018. Stakeholder involvement in collaborative regulatory processes: Using automated coding to track attendance and actions. Regulation & Governance. https://doi.org/10.1111/rego.12199
Sultana, P., Abeyasekera, S., 2008. Effectiveness of participatory planning for community management of fisheries in Bangladesh. J. Environ. Manage. 86, 201–213. https://doi.org/10.1016/j.jenvman.2006.12.027
Torres-Sibille, A. del C., Cloquell-Ballester, V.-A., Cloquell-Ballester, V.-A., Artacho Ramírez, M.Á., 2009. Aesthetic impact assessment of solar power plants: An objective and a subjective approach. Renewable Sustainable Energy Rev. 13, 986–999. https://doi.org/10.1016/j.rser.2008.03.012
Tukey, J.W., 1949. Comparing individual means in the analysis of variance. Biometrics 5, 99–114.
Ulibarri, N., 2015. Tracing Process to Performance of Collaborative Governance: A Comparative Case Study of Federal Hydropower Licensing. Policy Stud. J. 43, 283–308. https://doi.org/10.1111/psj.12096
Wentz, J., 2016. Using Online Databasing to Unlock the Full Value of Environmental Impact Assessment.

6. Appendix 1: Topic dictionary

Air quality
carbon monoxide, PM2.5, PM10, PM 2.5, PM 10, NOX, dust, air quality, criteria pollutants, nonattainment, particulate matter, particulates, emissions
Water resources

TMDL, nonpoint source, NPS pollution, heavy metals, NPDES, run-off, water quantity, water quality impacts, liquid effluents, stream health, erosion control, effluent, effluents, groundwater, water delivery, sedimentation, hydrologic condition, snowmelt, turbidity, urban runoff, stormwater, surface runoff, pH, DO concentration, discharge water, flood event, flooding
Biological resources
invasive species, invasives, native species, native plants, endangered species, species composition, spawn, breed, prey, survival, noxious weeds, nests, migratory species, migratory birds, fish, juveniles, wildlife, salmon, Salmon, migration, migrate, pollinators, macroinvertebrate
Habitat
ecosystem, habitat, ramping, spawning area, gravel bed, wetlands, Pinyon-juniper, habitat connectivity, wetland habitat, riparian habitat, uplands, riparian area, grazing area, channel conditions, riparian-wetland areas, native grasses, rip-rap
Climate change
climate model, climate change, global warming, greenhouse gas, GHG, GHGs, ocean acidification, energy use, energy consumption, greenhouse gasses, carbon emissions, oil and gas development, climate projections, sea level rise, drought, precipitation, wildfire
Socio-cultural resources
Environmental justice, environmental justice, EJ, socioeconomic, low-income, minority, recreational activity, recreational uses, resource access, economic benefits, cultural resources, recreational benefit, hazardous waste, toxic waste, fishing, hunting, hiking trail, biking trail, hiking trails, biking trails, sacred, public health, migratory workers, public access, historic resource, biking, walking, swimming, harvest
Aesthetics
noise pollution, background noise, vividness, intactness, unity, viewer, light pollution, visual quality, visual character, parks, noise, visibility, aesthetic, wilderness, viewshed, vibration, visual impact, scenic, vistas, noticeable, lighting, visible