NEPA and climate change: consideration of climate mitigation and adaptation in infrastructure review processes

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Abstract

Addressing climate change requires a shift in the planning, design, and operations of infrastructure. Reducing greenhouse gas emissions will require decarbonizing energy, water, transportation, and other infrastructures. And the long-term resilience of many infrastructure projects will be affected by expected changes in precipitation, sea level, heat and cold spells, and natural hazards like hurricanes and wildfires. Many scholars and practitioners have suggested that environmental impact assessment (EIA)—a required review of the environmental impacts of infrastructure projects—can serve as an opportunity to encourage infrastructure to be more climate friendly. In the United States (like many other jurisdictions), federal agencies are not required to address climate change in EIA reviews, but guidance from the Council on Environmental Quality advises them to consider greenhouse gas emissions and the effects of climate change. This paper applied qualitative content analysis to assess integration of climate change into environmental impact statements (EISs) in the United States. We found that most EISs included some consideration of climate change, most frequently with a few brief mentions rather than extensive integration. We also found more focus on climate mitigation than adaptation, in both recognizing potential impacts and managing those impacts. Surprisingly, infrastructure that is more directly related to climate change—water and energy infrastructure, as well as land management—had lower overall climate integration than transportation, information technology, or buildings and operations. As exploratory work, this research suggests that federal agencies could do more to mitigate greenhouse gas emissions in approved projects and in particular to make infrastructure more adaptive to climate change. The work also raises a number of questions as to whether EIA is the right regulatory tool to encourage climate friendly infrastructure.

1. Introduction

Infrastructure and climate change are closely intertwined. Mitigating climate change—reducing net greenhouse gas (GHG) emissions—will not only require decommissioning carbon-based power plants and building renewable energy infrastructure (Davis et al 2018, Tong et al 2019, Rissman et al 2020), but also addressing the substantial GHG emissions that emerge from the electricity demand of water, transportation, and communication technology, and other infrastructure systems (Bulkeley et al 2014, Kennedy et al 2014, Belkhir and Elmeligi 2018, Singh and Kansal 2018). At the same time, climate change is projected to have substantial impacts on infrastructure systems. For instance, coastal flooding and sea level rise are already damaging critical transportation, energy, and wastewater treatment infrastructure located along the coast (Azevedo de Almeida and Mostafavi 2016), increased likelihood of extreme rainfall events has increased the risk of dam failures (Vahedifard et al 2021), and drought-induced fires have led to preemptive power shutdowns in the United States (US) and Australia (Mitchell 2013, Abatzoglou et al 2020). Ensuring long-term viability of infrastructure
thus requires climate adaptation, defined as ‘adjustment to actual or expected climate and its effects’ (IPCC 2014). Given the multi-decade lifespans of many infrastructure projects, considering climate mitigation and adaptation is imperative as new infrastructure is planned and existing infrastructure re-evaluated.

Environmental impact assessment (EIA) is a globally-used tool to shape the environmental and social sustainability of infrastructure systems. First codified in 1969 under the US National Environmental Policy Act (NEPA), EIA has since been adopted worldwide (Caldwell 1988, Morgan 2012). While the exact requirements vary by jurisdiction, EIA generally entails (1) documenting the potential environmental, social, and health impacts of proposed infrastructure projects and (2) developing and assessing altered impacts from modifications to project design, construction, or operations. Many EIA processes also have a strong focus on providing opportunities for the public to learn about and provide input into infrastructure decisions (Ulibarri et al 2019). As a procedural requirement, EIA itself cannot restrict what infrastructure projects are built where (Baker 2011, Ruple and Capone 2016). Instead, EIA’s aim is to provide information on the relative costs and benefits of a project to allow decision-makers a more informed basis for decision-making (Evans 2014).

In order for EIA processes to help infrastructure managers and regulators pay attention to climate mitigation and adaptation, they need to actually discuss these topics as one of their considered impacts (Enríquez-de-Salamanca et al 2017, Ulibarri and Scott 2019). Globally, only a handful of countries (Australia, Canada, the Netherlands, and New Zealand) have a specific requirement that EIAs should address climate change (Matemilola et al 2019). Many other countries provide guidance for government agencies undertaking an EIA but do not require explicit integration (Agrawala et al 2012, Matemilola et al 2019). As for how written EIA documents themselves account for climate change, existing studies find minimal consideration of climate change (Jiricka-Pürrer et al 2018) or a focus solely on mitigation (Larsen 2014, Matemilola et al 2019). For instance, in studies of EIA documents in Denmark (Larsen 2014) and Nigeria (Matemilola et al 2019), most assessments discussed the impact of associated infrastructure on GHG emissions, but lacked any consideration of climate adaptation. Additionally, considerations of mitigation often focus on emissions resulting from the project’s energy use (e.g., construction of new renewable energy), but not secondary emissions (e.g., deforestation resulting from the new infrastructure) (Larsen 2014, Burger and Wentz 2020, Luke and Noble 2019). Implementation of climate change guidelines was also found to vary significantly across EIA documents within jurisdictions (Hetmanchuk 2020). In the few instances where a sizable portion of documents were found to consider climate change, they nevertheless fell short by either not forecasting potential impacts of climate change on the projects (Kamau and Mwaura 2013) or being relatively inexplicit in how the projects will mitigate or adapt to climate change (Hands and Hudson 2016).

This study evaluates the consideration of climate change impacts in recent NEPA review processes in the US. We build on an earlier assessment (Wentz et al 2016) that reviewed NEPA processes over a three year period (2012–2014), which—like the international research reviewed above—found far more detail related to climate mitigation versus adaptation, but that most EISs (~90%) did have at least minimal discussion of climate change. Our work expands this analysis by (1) extending the period of analysis (2014–2020), (2) extending the range of climate factors considered beyond direct impacts of/to climate change to how climate impacts are managed and monitored, and (3) providing a deeper qualitative assessment of how climate change is considered. Regarding the period of analysis, awareness of and concern for climate change has increased over the last decade (Ballew et al 2019, Leiserowitz et al 2021), which could suggest that NEPA reviews could be paying more attention to climate impacts. The paper begins with a short overview of NEPA and regulatory guidance related to climate change, and introduces the qualitative content analysis methods used to assess climate change integration. We then present an overall assessment of climate integration in selected environmental impact statements (EISs), trends in consideration of mitigation versus adaptation, and trends by infrastructure type and region of the US. We conclude with a discussion of our findings and a reflection on the challenge of addressing climate change through EIA processes.

2. NEPA and climate change

Like other EIA regulations, the National Environmental Policy Act of 1969 (42 U.S.C. §4321) requires federal agencies to consider the potential social and environmental impacts of their decisions, in order to protect and enhance the nation’s environmental well-being. NEPA applies to all plans, programs, and projects overseen by a US federal agency. This includes projects directly implemented by the agency as well as projects implemented by local or state governments or private sector organizations that receive funding or permits from a federal agency. Barring projects eligible for categorical exemptions (i.e., routine projects that are unlikely to have a
significant impact), most projects start with an environmental assessment (EA) to evaluate the likelihood that the proposed action will have a significant environmental impact. Then, if impacts are likely to be significant, the agency prepares an environmental impact statement (EIS), detailing the projected impacts of the project on the range of environmental resources and evaluating the impact of potential alternatives (different approaches to building and/or operating the project).

While NEPA itself does not directly require integration of climate change into analyzed resource impacts, guidance from the Council on Environmental Quality (CEQ) shapes what agencies should consider when undertaking a review. Under President Obama’s administration, CEQ issued draft guidance on addressing climate change in NEPA in 2010 and 2014, with the final version adopted in August 2016 (Council on Environmental Quality 2010, 2014, 2016). This guidance advised agencies to quantify direct and indirect GHG emissions from their actions. However, in March 2017, President Trump directed CEQ to rescind the guidance with executive order 13783. Then, in June 2019, CEQ issued new draft guidance, which directed agencies to quantify GHG emissions only when the amount was ‘substantial enough to warrant quantification’. Finally, in March 2021 (after the timeline analyzed in this paper), the Biden administration encouraged agencies to return to the 2016 guidance (Council on Environmental Quality 2021).

Importantly, all existing versions of CEQ guidance focus on climate change mitigation rather than adaptation. Given EIA’s purpose to address impacts from a project to the environment, this focus makes sense. However, scholars and practitioners argue that because the EIA process entails a comprehensive assessment of infrastructure, it could also be used as a tool to build resilience of the infrastructure projects themselves (Nierop 2014, Wenning et al. 2017). For a full consideration of climate change impacts, attention to climate adaptation is also important (Byer et al. 2009, Posas 2011, Yi and Hacking 2011, Wende et al. 2012). While most countries do not directly mandate attention to adaptation, business and civil society guidelines like those of the UK’s Institute for Environmental Management and Assessment (IEMA) include adaptation as a recommended focus of EIA (IEMA 2020). Likewise, the European Commission’s guidance on integrating climate change and biodiversity into environmental impact assessment encourages EU member states to ask, ‘how might implementing the project be affected by climate change? How might the project need to adapt to a changing climate and possible extreme events?’ (European Commission 2013, p 30).

3 Methods

This research analyzes consideration of climate change in EIS documents published between 2014 and 2020. We focus on EISs rather than EAs; because EISs pertain to projects that are likely to have significant environmental impacts, we expect that they are more likely to include some discussion of climate change.

Data on EIS decisions and associated documents were obtained from the EPA’s EIS database (EPA 2021). Between January 2014 and October 2020, 981 final EIS documents were issued. From the full list of final EISs, we randomly selected 30 projects. The sample size was selected to enable in-depth analysis of each EIS (which are hundreds if not thousands of pages in length), and is similar to that used in studies from other jurisdictions3.

Table 1 summarizes selected projects by year, infrastructure type, and region; see appendix A for all project names, issuing agency, location, and date issued. Infrastructure types were grouped as land/resource management, water/energy infrastructure, and other infrastructure. These groups were developed inductively from the sample, based on shared characteristics vis-a-vis climate change impacts. The land/resource management EISs are for management plans covering land management, timber sales, mining, and terrestrial and marine species. Relative to built infrastructure, these projects have more diffuse impacts on GHG emissions, and the managed resources are likely to be impacted by future climate change. Water/energy infrastructure includes built infrastructure for water supply, flood control, transmission lines, as well as power generation (hydropower, wind, and biomass). Energy infrastructure obviously has a very direct impact on GHG emissions, but moving and cleaning water also has substantial energy demands; both types of infrastructure will also need to withstand future climate change. Finally, other infrastructure includes built infrastructure that is not water or energy related, including transportation, buildings (e.g., prisons, medical research), and information technology. These projects have diverse GHG impacts (and like water/energy infrastructure) will have to withstand future climate change.

With a small sample size, we do not capture the full variation of all EISs published during this time period. However, selected cases mirror national trends in EIS issuance. Scott et al. (2020) analyzed trends in every EIS issued since 2013. They found that a majority of EISs focus on what they call ‘institutional infrastructure’ (a category that aligns with our land/resource management) and a slight minority was built infrastructure.

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3 For example, other publications have reviewed 19 Danish EIAs (Larsen 2014), 25 British EIAs (Hands and Hudson 2016), 18 Canadian EIAs (Luke and Noble 2019), and 15 Canadian EIAs (Hetmanchuk 2020).
Table 1. Description of analyzed EISs.

| Administration | Years                          | Count |
|----------------|--------------------------------|-------|
| Obama          | 2014 (6), 2015 (6), 2016 (2)   | 14    |
| Trump          | 2017 (5), 2018 (6), 2019 (3), 2020 (2) | 16    |

| Infrastructure type          | Project types                      | Count |
|------------------------------|------------------------------------|-------|
| Land and resource management | Land management (8), species management (3), marine resources (3), mining (1) | 14    |
| Water and energy infrastructure | Flood control (3), water supply (1), transmission (1), hydropower (1), biomass (1), wind (1) | 8     |
| Other built infrastructure   | Transportation (3), military (2), prison (1), information technology (1), medical (1) | 8     |

| Region          | States and territories | Count |
|-----------------|------------------------|-------|
| Midwest         | IA, IL, IN, KS, MI, MN, MO, NE, ND, OH, SD, WI | 3     |
| Northeast       | CT, ME, MA, NH, NJ, NY, PA, PR, RI, VT | 3     |
| South           | AL, AR, DE, FL, GA, KY, LA, MD, MS, NC, OK, SC, TN, TX, VA, WV | 6     |
| West            | AK, AZ, CO, HI, MT, NM, UT, WY | 15    |
| Multiple        | Projects involving states in two or more regions | 3     |

In comparison, half of our sample is land/resource management and the other half is built infrastructure (water/energy and other infrastructure). Likewise, they found that the majority of EISs were in the western US, with the remainder spread between the other regions; half of our cases are located in the western US, with the rest spread across the Midwest, South, and Northeast.

To analyze treatment of climate change in each EIS, we employed qualitative content analysis, an approach to systematically describe the topics and themes covered in a text (Saldaña 2015). We used a deductive coding scheme, drawing on categories determined a priori from existing literature (rather than those emerging from the data themselves). We developed eight ‘climate integration’ categories (table 2): criteria that signal that an EIS is adequately incorporating climate change considerations, including whether they situate the project in a specific climate context, whether they discuss mitigation, whether they discuss adaptation, and whether they include specific strategies to enhance mitigation or adaptation potential of the project. Many of our categories were adapted from Matemilola et al (2019), who summarized assessment criteria proposed in existing policy guidance and academic research (Byer et al 2009, Posas 2011, Yi and Hacking 2011, Wende et al 2012, European Commission 2013). Table 2 provides an overview of these categories.

To identify potentially relevant text in each EIS document, we first searched for climate-relevant words and phrases, such as carbon dioxide, climate model, drought, wetter, and hotter. (See appendix B for a full dictionary). We also skimmed the full documents to identify additional potentially relevant sections of text. For identified text, we read it in detail and categorized it as pertaining to one or more of the climate considerations categories (or as not relevant). Once all project documents were coded, two authors independently assigned each EIS an overall numeric rating for each category: 0 (category not present), 1 (minimal mention), or 2 (extensive discussion). In general, minimal consideration meant a brief (few sentence) mention of the category, while extensive meant it was treated in detail. The exact thresholds varied by category. For instance, for consideration of a project’s impacts on climate change, ‘extensive’ meant that EISs quantified multiple ways that the project would impact GHG emissions, and often include both direct and indirect emissions. ‘Minimal’ might include a few sentences discussing potential sources or sinks of GHGs, but did not directly estimate these. Likewise, in monitoring, ‘minimal’ reflected projects that included standard air quality monitoring but not linked to climate change, while ‘extensive’ reflected projects that explicitly monitor weather variables to observe climate change, plan to monitor GHG emissions and compare them to baseline, and/or plan to measure carbon sequestration. Intercoder reliability was 85%; cases with conflicting ratings were reconciled by the lead author. An overall ‘climate integration’ score per EIS was calculated by taking the mean across all eight categories.

Finally, to understand trends in climate integration, we cross tabulated each category and the overall climate integration metrics against infrastructure type and presidential administration.
Table 2. Climate integration categories.

| Category                              | Definition                                                                 | Sample text                                                                                                                                 |
|---------------------------------------|---------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------|
| **Existing climate**                  | Whether the EIS discusses the historical climate (e.g., temperature, wind patterns, CO₂ concentrations, precipitation) in the region of interest | ‘Permafrost temperatures in 2016 (the most recent set of complete observations) at many observation sites around the Arctic were among the highest on record (as long as 1978-present, but duration of records vary). Increases in permafrost temperature, since 2000, have been greatest in cold permafrost of the Alaskan Arctic, Canadian high Arctic, and Svalbard’. (Final Environmental Impact Statement for Issuing Annual Catch Limits to the Alaska Eskimo Whaling, p 138) |
| **Projected climate**                 | Whether the EIS discusses the future climate the project would be operating in | ‘Barrows et al (2016) conducted a more specific case study of potential climate change refugia within 6.2 miles (10 km) of the Combat Center based on fine-scale habitat suitability modeling. After developing a model of suitable habitat for desert tortoises under current conditions, they then predicted future climate refugia with a 1 °C and a 3 °C increase in summer temperatures’. (Land Acquisition and Airspace Establishment, p 5–15) |
| **Climate change impacts on the project** | Whether the EIS discusses the predicted impacts of climate change in the region of interest, including how ongoing climate change would affect the feasibility of actions detailed in the document | ‘The effects climate change would have on Caldwell Canyon could be long term and moderate but are uncertain. The MRP establishes an adaptive management strategy that would be used to modify actions caused by a potential increase or decrease in water on the site, timing of precipitation, or increased evapotranspiration’. (Caldwell Canyon Mine and Reclamation Plan, p 41) |
| **Project’s impacts on climate change** | Whether the EIS discusses how the project would affect net greenhouse gas emissions | ‘The management activities proposed to capture mountain goats would result in fossil fuel consumption from helicopters and trucks, but the greenhouse gas emissions associated with these activities would be negligible because of the limited number of flights that would be anticipated’. (Olympic National Park Mountain Goal Management Plan, p 17) |
| **Alternatives on climate change impacts** | EISs include multiple ‘alternative’ ways the project could be built or implemented. This category evaluates whether the EIS considers the implications of the alternatives for climate mitigation or adaptation | ‘In addition, alternative 2 does not propose the new wilderness and research natural areas that the proposed action and alternative 1 recommend. Further, it does not include the plan components related to climate change that are contained in the revised forest plan under the proposed action and alternative 1. It does, however, incorporate the strategies for climate change management on the Coronado, which are described in appendix A of the revised forest plan’. (Final Programmatic Environmental Impact Statement for Revision of the Coronado National Forest Land, p 21) |
| **Mitigation strategies**             | Whether the EIS includes specific methods to decrease or offset short- or long-term greenhouse gas emissions | ‘When possible, use vehicles with hybrid or electric technology to reduce or eliminate criteria pollutant emissions from fuel combustion’. (Nationwide Public Safety Broadband Network Final Programmatic EIS, p ES-63) |
| **Adaptation strategies**             | Whether the EIS includes specific methods to lessen climate change-related impacts on the project | ‘Objectives to accelerate the rate of modification to enhance or restore forest structure in the ponderosa pine and mixed conifer types under the action alternatives would improve the resiliency of these vegetation types to climate change. Because of their limited extent in the section, they provide the habitat for many species that do not exist elsewhere in the section. Such restoration would have positive outcomes in limiting susceptibility to stand-replacing fire’. (Kaibab National Forest Plan Revision, p 62) |

(continued on next page)
Table 2. Continued

| Category                  | Definition                                                                 | Sample text                                                                 |
|---------------------------|-----------------------------------------------------------------------------|----------------------------------------------------------------------------|
| Climate change monitoring | Whether the EIS includes provisions to track climate conditions or improve upon climate change monitoring systems | 'Pursue opportunities to install one or more solar-powered weather stations in the NCA to collect data on temperature, precipitation, wind speed, humidity, soil moisture, solar radiation, and other variables that could signal changing climatic conditions'. (Proposed Resource Management Plans for the Beaver Dam Wash and Red Cliffs National Conservation Areas, p 51) |

4. Results

4.1. Climate integration in EIS documents

We first assess the overall distribution of climate integration scores (figure 1). The majority of EISs reviewed (22 of 30) score at or below 1, meaning that on average they contain minimal to no discussion of climate change across the eight categories; the mean climate integration score is 0.83. Three EISs scored over 1.6 (i.e., have full discussion across six or seven categories), with a maximum score of 1.75, and one scored zero.

To give a sense of the range of ways climate change was treated in EIS documents, we next describe a representative high, medium, and low climate integration case.

High: the 2015 EIS for the construction permit for the SHINE Medical Facility in Wisconsin (Midwest region) discusses an institute to accelerate the commercial production of medical radioisotopes without the use of uranium. The EIS document analyzed the project’s construction, purchase of equipment, and initial operations, and offers a thorough overview across all categories from existing climate to the project’s impact on climate change. The project quantifies GHG emissions for both construction and long-term operations, and considers the impact of numerous alternative scenarios, including different locations for the facility. The project also includes multiple mitigation and adaptation strategies, from use of high efficiency appliances to developing plans to deal with increased storm and flood events. Lastly, it includes air quality monitoring and a GHG emissions inventory. Overall, the EIS document scored a 1.5, with extensive discussions of five categories.

Medium: the 2019 EIS for the Chugach National Forest Management Plan assessed management of forest systems in South Central Alaska (West region). The document includes recommendations for the wilderness area and an analysis of diverse recreational opportunities. The document analyzes global climate processes and evaluates their potential impacts on the sensitive Arctic environment. However, the EIS only briefly discusses specific impacts of climate change on habitats and activities in the forest itself. The document mentions the forest as a carbon sink because of sequestration, but does not say how sequestration will change under the new
forest plan. The EIS also does not include any specific actions to impact net GHG emissions or make the forest more resilient to climate change. The average score for this EIS document was a 1.0, with extensive discussions of existing climate and projected climate.

Low: the 2018 Lassen Lodge Final Environmental Impact Statement offers a thorough synopsis regarding the construction, operation, and maintenance of the Lassen Lodge Hydroelectric Project in northern California (West region). This document is particularly interesting because it does not account for any climate change-related processes despite the fact that the project revolves around a new renewable energy source and depends on water in a region that is likely to face changes in future snow and rain patterns (Berg and Hall 2017, Gergel et al. 2017, Mallakpour et al. 2018). In fact, the document mentions the word ‘climate’ twice in its entirety. The document does discuss large-scale regional phenomena like El Nino and the fact that California has historically faced frequent droughts. However, none of the models used to estimate environmental impacts account for variable hydrology (historic or projected). The only discussion of mitigation is, ‘being a renewable resource, the project provides power that may displace generation from nonrenewable sources. Displacing the operation of non-renewable facilities may avoid some power plant emissions, thus creating an environmental benefit’ (Lassen Lodge Final Environmental Impact Statement, p 3). No mention is made of offsetting GHGs, let alone quantifying them. The overall climate integration score for the Lassen Lodge Final Environmental Impact Statement document was 0.5, with no mention to minimal mention in all categories.

4.2. Climate integration by category
Across EIS documents, some climate integration categories received far more attention than others. Figure 2 presents the number of EISs that discussed each category in detail, mentioned it briefly, or did not mention the category at all. In first considering the context for discussion of climate change, 73% of EISs provided treatment of the climate context the project would be operating in, with 50% doing so in detail. Fewer projects (60%) discussed a project’s climate future, with 30% doing so in detail. Fewer projects (60%) discussed a project’s climate future, with 30% doing so in detail.

In comparing attention to mitigation versus adaptation, this research confirms findings from other countries that EIA documents tend to focus more on mitigation. A strong majority of EISs (80%) at least mentioned the project’s likely impacts on climate change, with 50% providing a detailed discussion. Four EISs considered only short-term GHG impacts, 11 considered only long-term impacts, and 9 considered both. The most commonly cited sources or sinks of GHG emissions were construction activities (n = 13), sequestration from trees and soils (both positive and negative) (n = 6), use of renewable energy (n = 5), and long-term facility operations (n = 5). Nine EISs quantified the project’s impact on GHGs, while 12 made qualitative statements about the direction of impact.

In contrast, only 53% discussed the impacts of climate change on the project, with 23% in detail. The most common climate-related impacts were extreme weather events including drought, floods, and hurricanes (n = 11), sea level rise (n = 7), wildfires (n = 7), and heatwaves (n = 7). Interestingly, one EIS (Leavenworth Federal Correctional Institution in Kansas) determined that it would not be affected by climate change because it was not on the coast (despite also discussing temperature and precipitation related impacts of climate change at a general level). With one exception, all assessments of climate change’s impacts on the project were entirely qualitative in nature, without specific estimates of frequency or magnitude of impacts.
Seventy percent of EISs considered how the various alternatives considered in the EIS would influence the project’s climate impacts. The majority focused on the impact of alternatives on GHG emissions \((n = 16)\); one EIS considered the way alternatives would affect types of climate impacts the project would face and three considered both GHG mitigation and climate adaptation.

Turning to specific mitigation and adaptation strategies, more projects identified concrete strategies to reduce GHG emissions or increase sequestration (50%) than adaptation strategies (30%). However, the fact that only 8 EISs (27%) discussed either mitigation or adaptation strategies in detail suggests that relatively little attention was given to lessening climate change impacts (whether adaptation or mitigation). Examples of mitigation and adaptation strategies adopted by the EISs include ecosystem restoration, best management practices (BMPs) for construction, and energy efficiency for buildings.

Finally, only 27% of EISs suggested that the project’s implement any climate change related monitoring. Most projects that included any discussion of climate-related monitoring implemented various forms of air quality monitoring, mostly related to everyday air pollutants (e.g., \(\text{NO}_2\), \(\text{PM}_{2.5}\), ozone). Only one project (proposed resource management plans for the Beaver Dam Wash and Red Cliffs National Conservation Areas) planned to develop tools to quantify carbon sequestration and to install weather stations to monitor temperature, precipitation, and other weather data.

### 4.3. Trends by infrastructure type and presidential administration

We next consider how climate change integration varies by type of infrastructure (figure 3). Overall, EISs focusing on other infrastructure had the most integration across all categories (mean of means = 1.05), followed by water/energy infrastructure (mean = 0.83) and then land/resource management (mean of means = 0.71). In particular, land/resource management EISs were less likely to discuss an existing climate context or to develop GHG mitigation strategies than water/energy infrastructure or other infrastructure; they were, however, more likely to include adaptation strategies. Other infrastructure was most likely to consider the project’s impacts on climate change, the effect of alternatives on climate change impacts, and to include mitigation strategies. Water/energy infrastructure was most likely to discuss a projected climate context.

Finally, we compare average climate integration by Presidential Administration. Under President Obama (before rescission of the CEQ climate guidance), mean climate integration was 0.81, while under President Trump (after rescission of the guidance), mean integration was 0.84, a minimal change. However, there was an increase in projected climate and climate impacts on the project in EISs issued under Trump, and a decline in consideration of the project’s impacts on climate change, alternatives on climate change impacts, mitigation strategies, or climate monitoring (figure 4).
5. Discussion

This study assessed integration of climate change into EIS documents in the US. Overall, we found that most EISs included some consideration of climate change, most frequently with a few brief mentions rather than extensive integration. A few EISs hardly discussed climate change at all, and a few had thorough integration across multiple dimensions of climate impacts. We also found more focus on climate mitigation than adaptation, in both recognizing potential impacts and managing for those impacts. This reflects previous findings both from the US and other countries (Larsen 2014, Wentz et al. 2016, Matemilola et al. 2019). Given that NEPA guidance (and EIA guidance from many other jurisdictions) only targets mitigation, this is not surprising.

However, it is worth considering that perhaps adaptation is a harder problem to address. Measuring the impacts of a project on climate change entails quantifying projected changes in greenhouse gas emissions. While there are definite uncertainties associated with this task (Jonas et al. 2019) and the manager has to make decisions about where to bound the system (Larsen 2014, Burger and Wentz 2020, Luke and Noble 2019), the uncertainties are far more bounded than in adaptation. Tackling adaptation requires estimating how relevant temperature, precipitation, or other changes will impact the project, which often requires downscaling climate models to a resolution that is meaningful for a specific infrastructure project (Ulibarri and Scott 2019). Managers may not feel comfortable developing adaptation strategies in settings with large uncertainties or very novel climates (Clifford et al. 2020) and in some cases regulatory guidance actually prevents them from doing so (Ulibarri and Scott 2019).

We also observed a greater focus on documenting climate impacts than determining ways to minimize climate impacts. Some projects did quantify the relative impact of each alternative on climate change (mostly net GHG emissions), and around one-quarter of projects talked about explicit ways that the project was designed to lessen emissions or be more adaptive. However, NEPA is a procedural requirement, and agencies have no obligation to select the least environmentally-damaging alternative (Baker 2011, Ruple and Capone 2016). That agencies can comply by simply documenting impacts and demonstrating that they took a ‘hard look’ at those impacts means there is no hard incentive directly from NEPA for federal infrastructure to be more climate-friendly.

4 The ‘hard look’ doctrine is a principle of administrative law that courts apply in determining whether an agency has complied with NEPA. Specifically, courts’ interpretation of NEPA requires federal agencies to “take a ‘hard look’ at how the choices before them affect the environment, and then to place their data and conclusions before the public”. Or. Nat. Desert Ass’n v. BLM, 625 F.3d 1092, 1099–1100 (9th Cir. 2010) (citing Calvert Cliffs’ Coordinating Comm. v. US Atomic Energy Comm’n, 449 F.2d 1109, 1114 (D.C.Cir.1971)).
Regarding infrastructure type, we found that ‘other’ infrastructure had the most complete climate integration relative to either water/energy infrastructure or land/resource management. This is surprising, as ‘other’ is the category with the least environmental overlap. Broadband networks, transportation projects, and prisons do emit GHGs and may be located in places that will face flooding or heat waves, but their direct operations are less directly tied to the climate. Water and energy infrastructure likely have significant GHG impacts (both positive and negative depending on the infrastructure type) and could be located in places where they need to adapt. An excellent example is the Lassen Lodge Hydropower Project, which is a renewable energy project (i.e., it should displace more GHG-intensive energy sources) located in an area facing likely changes in hydrology and wildfire risk, but which hardly mentioned climate change. Land and resource management have less direct GHG impacts, although forests and soils are both large sources and sinks of carbon depending on their management (Fahey et al 2010, Ruiz-Peinado et al 2017, Tong et al 2020). As resources like timber and wildlife are very dependent on the climate, land and resource managers have been documented as facing substantial pressure to adapt to climate change (Clifford et al 2020) — but this pressure did not translate into increased attention to climate adaptation (or mitigation) in the EIS documents. These findings suggest that the extent of climate change consideration does not appear to map onto the actual climate impacts of the project.

Finally, temporal trends were fairly muted, with almost no difference in average score for projects published when the Obama Administration’s guidance on consideration of GHG emissions and climate change existed versus those published after it was revoked in 2017. The exception was that projects published after rescission were more likely to discuss a projected climate and to discuss the impacts of climate change on the project (e.g., to think about adaptation) — neither of which was a component of the CEQ guidance. Our findings suggest either that the CEQ rule had not been widely adopted or that agencies continued to follow this guidance after it was revoked.

### 6. Conclusion

Addressing climate change requires a shift in the planning, design, and operations of infrastructure. Reducing greenhouse gas emissions will require decarbonizing energy, water, transportation, and other infrastructures. The long-term resilience of many infrastructure projects will be affected by expected changes in precipitation, sea level, heat and cold spells, and natural hazards like hurricanes and wildfires. Many scholars and practitioners have suggested that EIA — a required review of the environmental impacts of infrastructure projects — can serve as an opportunity to encourage infrastructure to be more climate friendly (Posas 2011, Yi and Hacking 2011, Agrawala et al 2012, He 2013, Enríquez-de-Salamanca et al 2016).

This paper adds to a growing set of research on whether existing EIA reviews consider climate change by assessing EISs produced under the US’s National Environmental Policy Act. Besides focusing on a longer time-frame than existing US analyses (Wentz et al 2016), this paper extends beyond existing research to consider both climate change mitigation and adaptation, as well as assessing consideration of climate change and whether the infrastructure project is designed to lessen climate impacts. Most prominently, however, our work is novel in comparing across multiple types of infrastructure, which we found was a significant influence on the extent of climate integration. Surprisingly, infrastructure that is more directly related to climate change — water and energy infrastructure, as well as land management — had lower overall climate integration than transportation, information technology, or buildings and operations. This suggests that a priori expectations around where climate should matter more are not driving the extent of integration.

The most substantial methodological limitation is the small sample size (although it is average relative to many other studies of climate integration in EIAs (Larsen 2014, Hands and Hudson 2016, Jiricka-Pürrer et al 2018, Luke and Noble 2019, Matemilola et al 2019, Hetmanchuk 2020)). The small sample size was selected to enable a more nuanced qualitative understanding of climate integration. With this basis, future research can utilize automated text analysis and natural language processing to build a larger sample size and allow a quantitative understanding of when and why we see differences in climate integration. Such an assessment could provide more concrete recommendations for bolstering climate considerations in NEPA.

This work also raises a larger question of whether NEPA is the right tool to address climate change. As discussed earlier, NEPA’s procedural focus means that projects with substantial environmental impacts (e.g., large GHG emissions) are legal as long as agencies took a ‘hard look’ at those impacts (Ruple and Capone 2016). Additionally, EIA addresses individual project decisions, and those decisions may map poorly onto regional — let alone global — collective action problems. There is a robust discussion about whether and how EIA should consider cumulative effects from multiple projects across a region (Blakley and Franks 2021). In the context of climate change, each individual project may have a relatively minor effect on GHG emissions in a region (as was the case in many of the EISs assessed for this project), enabling the EIA assessment to deem the impact ‘less than significant’, but collectively these projects might tip the scale. Dealing with cumulative...
effects also depends on the size and scope of the project. NEPA decisions relate to everything from an individual hydropower dam to a nationwide broadband network, and these two decisions might have very different significance thresholds even with a similar magnitude of GHG emissions. Finally, while this assessment—like many others (e.g., Byer et al. 2009, Posas 2011, Yi and Hacking 2011, Wende et al. 2012)—has contended that a full consideration of climate change should include the impacts of climate change on the project, regulatory barriers may prevent this (Ulibarri and Scott 2019). For instance, some agencies avoid discussing adaptation in NEPA reviews by pointing to the large uncertainties in estimating climate impacts as opposed to projecting net GHG emissions (Ulibarri and Scott 2019). Using EIA processes to create more climate-friendly infrastructure will require attention to solving these procedural challenges.

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Data availability statement

The data that support the findings of this study are available upon reasonable request from the authors.

Appendix A. EIS documents assessed

| Title                                                | Federal register date | Agency                                      | EIS number      | State |
|------------------------------------------------------|-----------------------|---------------------------------------------|-----------------|-------|
| Kaibab National Forest Plan Revision                 | 3/7/2014              | Forest Service                              | 20140058        | AZ    |
| New York Gateway Connections Improvement Project to the US Peace Bridge Plaza | 4/4/2014              | Federal Highway Administration              | 20140101        | NY    |
| Grand Parkway Segments H and I-1                     | 5/9/2014              | Federal Highway Administration              | 20140132        | TX    |
| Thunder Bay National Marine Sanctuary Boundary Expansion | 8/1/2014              | National Oceanic and Atmospheric Administration | 20140208        | MI    |
| Bogue Banks Coastal Storm Damage Reduction           | 8/15/2014             | US Army Corps of Engineers                   | 20140226        | NC    |
| Dallas Floodway Project                              | 12/19/2014            | US Army Corps of Engineers                   | 20140365        | TX    |
| Leavenworth Federal Correctional Institution and Federal Prison Camp | 4/10/2015            | Bureau of Prisons                           | 20150092        | KS    |
| Utah Greater Sage-Grouse Proposed Land Use Plan Amendments | 5/29/2015            | Bureau of Land Management                   | 20150149        | UT, WY|
| Shasta Lake Water Resources Investigation             | 8/14/2015             | Bureau of Reclamation                       | 20150222        | CA    |
| Saddle Lakes Timber Sale                             | 10/23/2015            | Forest Service                              | 20150293        | AK    |
| Plains and Eastern Clean Line Transmission Line Project | 11/13/2015            | Department of Energy                        | 20150316        | OK, AR, TN, TX |
| Construction Permit for the SHINE Medical Radioisotope Production Facility, Final Report, NUREG-2183 | 11/30/2015            | Nuclear Regulatory Commission               | 20150299        | WI    |
| Title                                                                 | Federal register date | Agency                        | EIS number  | State   |
|----------------------------------------------------------------------|-----------------------|-------------------------------|-------------|---------|
| Morehead City Harbor Integrated Dredged Material Management Plan     | 6/10/2016             | US Army Corps of Engineers     | 20160128    | NC      |
| Proposed Resource Management Plans for the Beaver Dam Wash and Red   | 9/2/2016              | Bureau of Land Management      | 20160199    | UT      |
| Cliffs National Conservation Areas; Proposed Amendment to the St.     |                       |                               |             |         |
| George Field Office Resource Management Plan                         |                       |                               |             |         |
| Arecibo Waste-to-Energy and Resource Recovery Project                | 2/3/2017              | Rural Utilities Service       | 20170022    | PR      |
| Deepwater Horizon Oil Spill                                        | 4/14/2017             | National Oceanic and Atmospheric Administration | 20170054 | AL      |
| Alabama Trustee Implementation Group Final Restoration Plan I and    |                       |                               |             |         |
| Environmental Impact Statement: Provide and Enhance Recreational     |                       |                               |             |         |
| Opportunities                                                       |                       |                               |             |         |
| Disposal and Reuse of Surplus Property at Naval Station Newport,     | 6/23/2017             | United States Navy            | 20170110    | RI      |
| Rhode Island                                                        |                       |                               |             |         |
| Land Acquisition and Airspace Establishment to Support Large-Scale    | 7/28/2017             | Federal Aviation Administration | 20170142 | CA      |
| Marine Air Ground Task Force Live-Fire and Maneuver Training at      |                       |                               |             |         |
| Marine Corps Air Ground Combat Center                                |                       |                               |             |         |
| Nationwide Public Safety Broadband Network Final Programmatic        | 9/29/2017             | Department of Commerce        | 20170185    | AL, AR, FL, GA, KY, LA, MS, NAT, NC, NM, OK, PRO, SC, TN, TX |
| Environmental Impact Statement for the Southern United States        |                       |                               |             |         |
| Olympic National Park Mountain Goat Management Plan                  | 5/4/2018              | National Park Service         | 20180077    | WA      |
| CP District-wide Salvage Project                                     | 5/21/2018             | Forest Service                | 20180100    | CO      |
| Final Programmatic Environmental Impact Statement for Revision of the | 6/22/2018             | Forest Service                | 20180134    | AZ, NM  |
| Coronado National Forest Land and Resource Management Plan           |                       |                               |             |         |
| Lassen Lodge Final Environmental Impact Statement                    | 8/3/2018              | Federal Energy Regulatory     | 20180175    | CA      |
| Commission                                                          |                       |                               |             |         |
| Final Environmental Impact Statement For Issuing Annual Catch Limits | 11/16/2018            | National Marine Fisheries     | 20180274    | All     |
| to the Alaska Eskimo Whaling Commission for a subsistence hunt on    |                       | Service                       |             |         |
| bowhead whales for the years 2019 and beyond                         |                       |                               |             |         |
| Northwest Colorado Greater Sage-Grouse Proposed Resource Management  | 12/7/2018             | Bureau of Land Management     | 20180296    | CO      |
| Plan Amendment and Final Environmental Impact Statement              |                       |                               |             |         |
| Caldwell Canyon Mine and Reclamation Plan                            | 5/17/2019             | Bureau of Land Management     | 20190103    | ID      |
| Title                                                                 | Federal register date | Agency                      | EIS number | State |
|----------------------------------------------------------------------|-----------------------|----------------------------|------------|-------|
| Chugach National Forest Land Management Plan                          | 8/30/2019             | Forest Service              | 20190210   | AK    |
| Authorization of Incidental Take and Implementation of the LCRA       | 9/6/2019              | Fish and Wildlife Service   | 20190217   | TX    |
| Transmission Services Corporation Habitat Conservation Plan           | 4/10/2020             | National Highway Traffic Safety Administration | 20200079   | REG   |
| Borderlands Wind Project Final Environmental Impact Statement and Proposed Resource Management Plan Amendment | 4/10/2020             | Bureau of Land Management   | 20200083   | NM    |

Appendix B. Dictionary of climate change related words

Adaptive, adaptive capacity, carbon, carbon cycle, carbon dioxide, carbon emissions, carbon sequestration, climate, climate adaptation, climate change, climate feedback, climate mitigation, climate model, climate projection, climate risk, CO₂, desertification, drier, drought, energy, feedback loop, fossil fuels, global temperature, global warming, greenhouse effect, hotter, increased wildfire, IPCC, meteorology, methane, ozone, renewable energy, sea level rise, severe weather, storm surge, temperature, weather, wetter.

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