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Automated Matchmaking Tool to Facilitate Federal–Community Adaptation Implementation

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Chemical and Material Risk Management Program

DASD (Env)



SERDP • ESTCP
SYMPOSIUM
2018 | Enhancing DoD's Mission Effectiveness

Every year, 100s of casualties, damages, and disruptions inflicted by extreme events



Rochester, NY in winter, 1991



Tyndall AFB, 2018

Climate Change Adaptation Planning

Executive Order -- Preparing the United States for the Impacts of Climate Change



very few [climate adaptation planning] measures have been implemented.

(National Academy of Sciences, 2016)



Keene, New Hampshire
Climate Adaptation Action Plan

Adaptation planning is a decision-intensive and complex process

- Good job connecting science + planning
- Do not prioritize impacts and strategies

planners + science ...

***need* planners + implementing partners**

- Do not identify co-benefits of actions or implementation responsibilities
 - Cost and time
- Adaptation plans identify the **need for federal partners**, yet **few identify** which ones

artise Regions Topics Search

Filter by topic: ▼ Filter by tool function: ▼

Filter by steps to resilience: ▼ Filter by region: ▼

ate-related risks and opportunities, and to help guide

the dist... filter by topic and/or tool

nk.

Aquatic Connectivity Assessment and Prioritization Tool

Assessing Health Vulnerability to Climate Change: A Guide for Health Departments

Users in the North

SERDP • ESTCP
SYMPOSIUM
#SerdpEstcp2018

Existing tool for identifying federal grants

GRANTS.GOV > Search Grants

SEARCH GRANTS

SEARCH: Grant Opportunities ▾ "urban flooding" GO ?

BASIC SEARCH CRITERIA:

Keyword(s): "urban flooding" ✕

Opportunity Number: ✕

CFDA: ✕

SEARCH

OPPORTUNITY STATUS:

Forecasted (0)

Sort By: Relevance (Descending) Update Sort

Date Range: All Available Update Date Range

NO RECORDS FOUND

Opportunity Number	Opportunity Title	Agency	Opportunity Status	Posted Date	Close Date
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Opportunity: A more effective tool for matching climate vulnerabilities to federal agencies that can help fund these projects and reduce climate vulnerabilities!

SEARCH

OPPORTUNITY STATUS:

Forecasted (2)

Posted (84)

Closed (287)

Archived (4,514)

FUNDING INSTRUMENT TYPE:

All Funding Instruments

Cooperative Agreement (51)

Grant (43)

Opportunity Number	Opportunity Title	Agency	Opportunity Status	Posted Date	Close Date
EPA-R7WWPD-17-002	URBAN WATERS MIDDLE BLUE RIVER AMBASSADOR	EPA	Posted	06/27/2017	08/15/2017
INL17GR0043-WHPCOSTARICA-PREVSTRA-070617	Developing Prevention and Urban Design Strategies for Municipalities in Costa Rica to Prevent Crime and Drug Trafficking	DOS-INL	Posted	07/06/2017	08/31/2017
W81XWH-17-PCRP-HDRA	DoD Prostate Cancer Health Disparity Research Award	DOD-AMRAA	Posted	05/25/2017	09/28/2017

Existing search engines



Reduce likelihood of structural damage resulting from increases in severe \



Can such a model be built using machine learning techniques?

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Goal

Federal Agency Strategic Plans (SP)

Federal Strategic Plans (SPs)

- Prepared by every federal agency
- **Approved** every four years by OMB

	USACE	FEMA	DOT	EPA	HHS
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Keene, New Hampshire
Climate Adaptation Action Plan

Reduce the likelihood of structural damage ...					
Create, adopt, implement city building codes ...					
Create alternative route options for movement of ...					
Safely and efficiently remove stormwater from the built ...					
Engage energy providers to enhance local renewable ...					

Automated completion using a machine learning model

Prioritized federal partner by climate action

ASAP

- Automated StrAtegic Prioritization (ASAP) matchmaking tool to Facilitate Federal–Community Adaptation Implementation
- *Can be used by feds, public, and private sectors*

Which machine learning technique did we use?

We want to be able to mathematically trace
how the machine learning occurred

Probability based

- Random forest
- Neural networks
- Deep learning

Vector-based

- Keyword search (TF-IDF) – Algorithm 1
- Semantic Indexing (LSI) – Algorithm 2

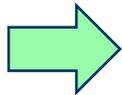
Algorithm 1: Keyword vector space

Keyword model
(frequency)

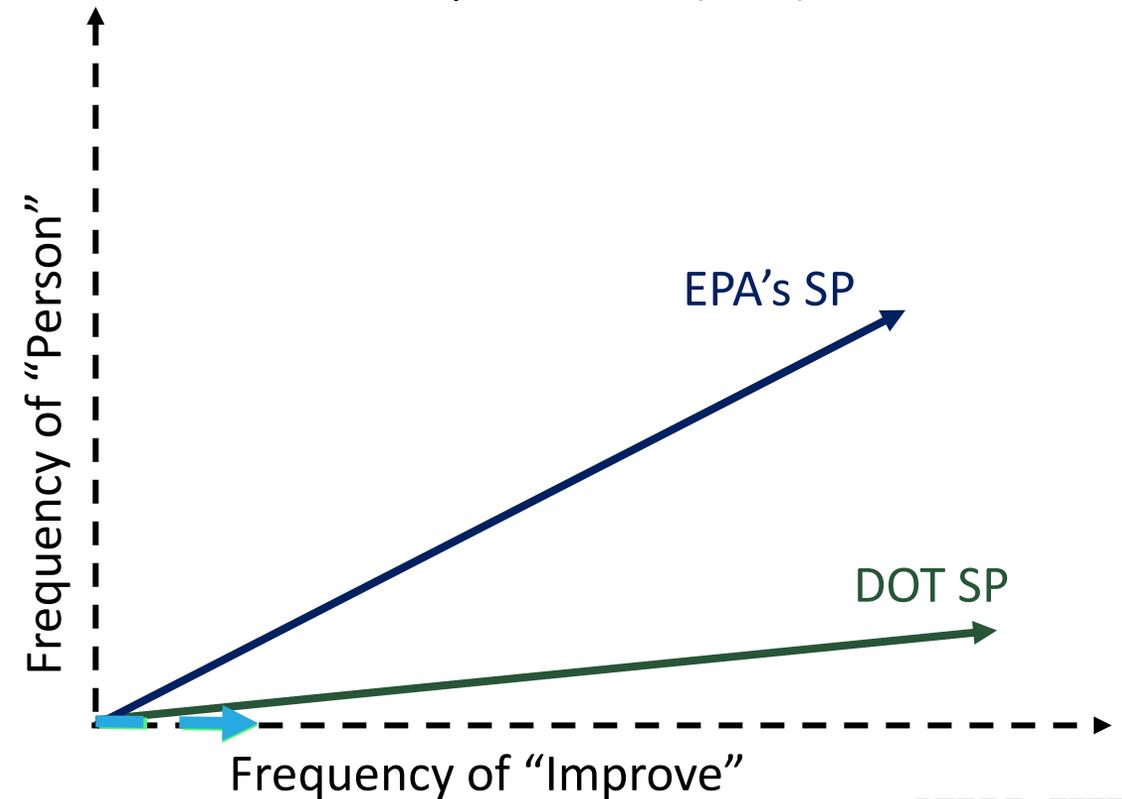
	DOT SP	EPA SP
Improve	8	8
Person	1	5

Query that model
(frequency)

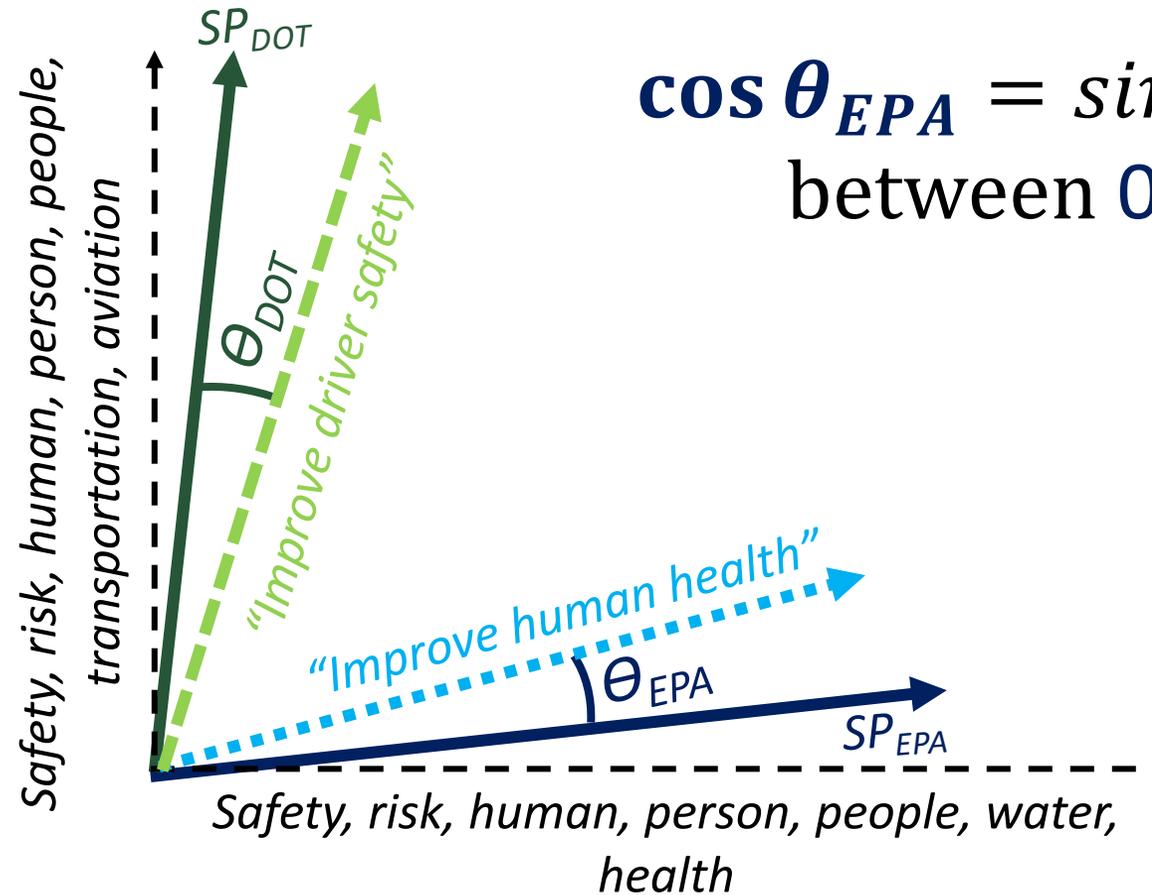
	"Improve driver safety"	"Improve human health"
Improve	1	1
Person	0	0



Vector Space Model (VSM)



Algorithm 2 – semantic space model

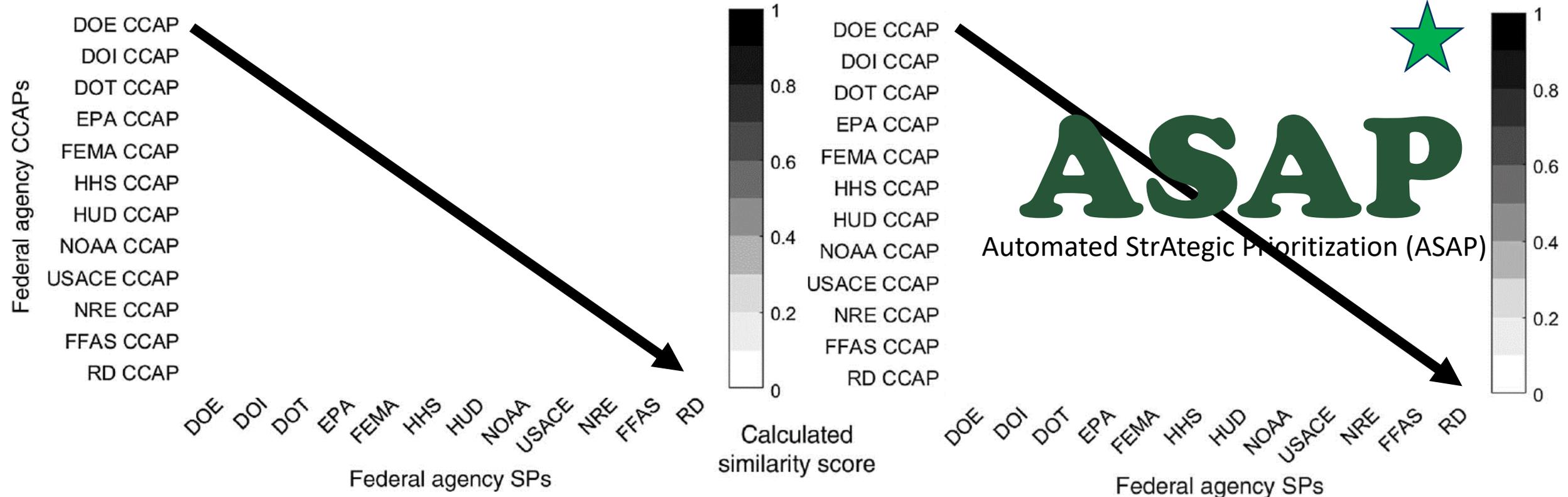


$\cos \theta_{EPA} = \text{similarity score}$
between 0 and 1

Verification matrices

Algorithm 1: keyword model

Algorithm 2: semantic model

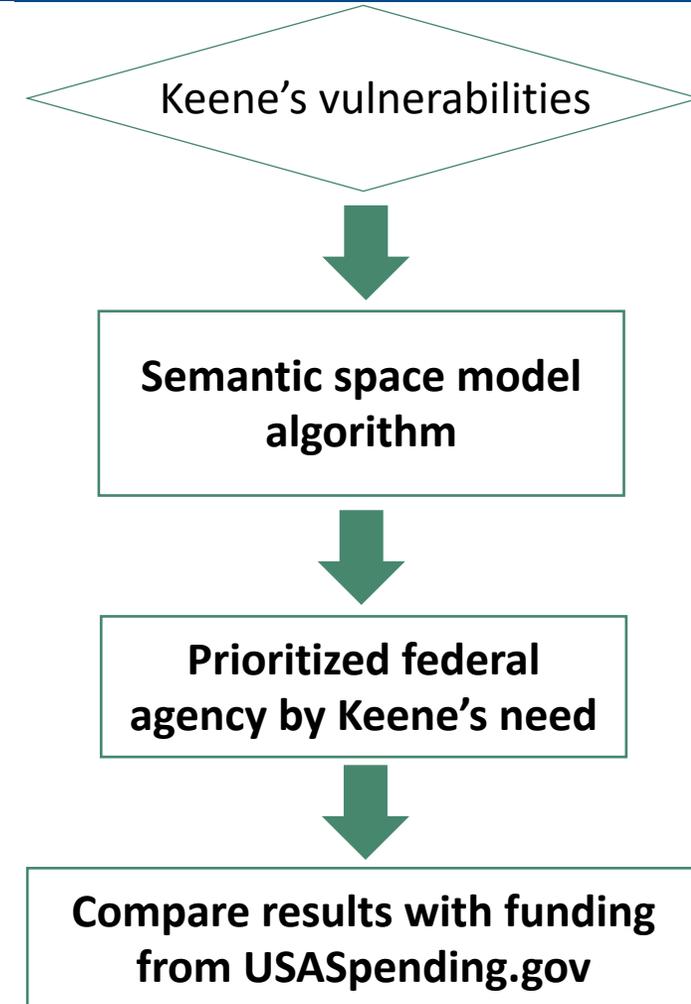


Case Study: Keene, NH



Keene, New Hampshire
Climate Adaptation Action Plan

- Early climate activist
- includes a section on assessing the **community** and **sector specific climate vulnerabilities**
- Keene split its climate vulnerabilities **into 12 sectors**, each containing **1 - 5 paragraphs**
- **Does not** contain information about **previous** federal funding, or **future** federal partners.
- **Compare** output for the case of Keene to awards and subawards from the ***USASpending.gov***



Sector-specific climate vulnerabilities in Keene, NH

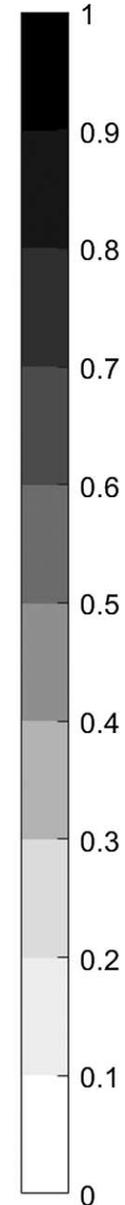
Keene's sector-specific vulnerabilities

- Building 1
- Building 2
- Building 3
- Building 4
- Trans. Infra. 1
- Trans. Infra. 2
- Trans. Infra. 3
- Trans. Infra. 4
- Water Infra. 1
- Water Infra. 2
- Water Infra. 3
- Energy Sys. 1
- Comm. Infra. 1
- Comm. Infra. 2
- Comm. Infra. 3
- Open Spaces 1
- Open Spaces 2
- Wetlands 1
- Wetlands 2
- Wetlands 3
- Wetlands 4
- Flora 1
- Flora 2
- Flora 3
- Fauna 1
- Fauna 2
- Fauna 3
- Food Supply 1
- Food Supply 2
- Economy 1
- Economy 2
- Economy 3
- Public Health 1
- Public Health 2
- Public Health 3
- Public Health 4
- Public Health 5
- EMS 1

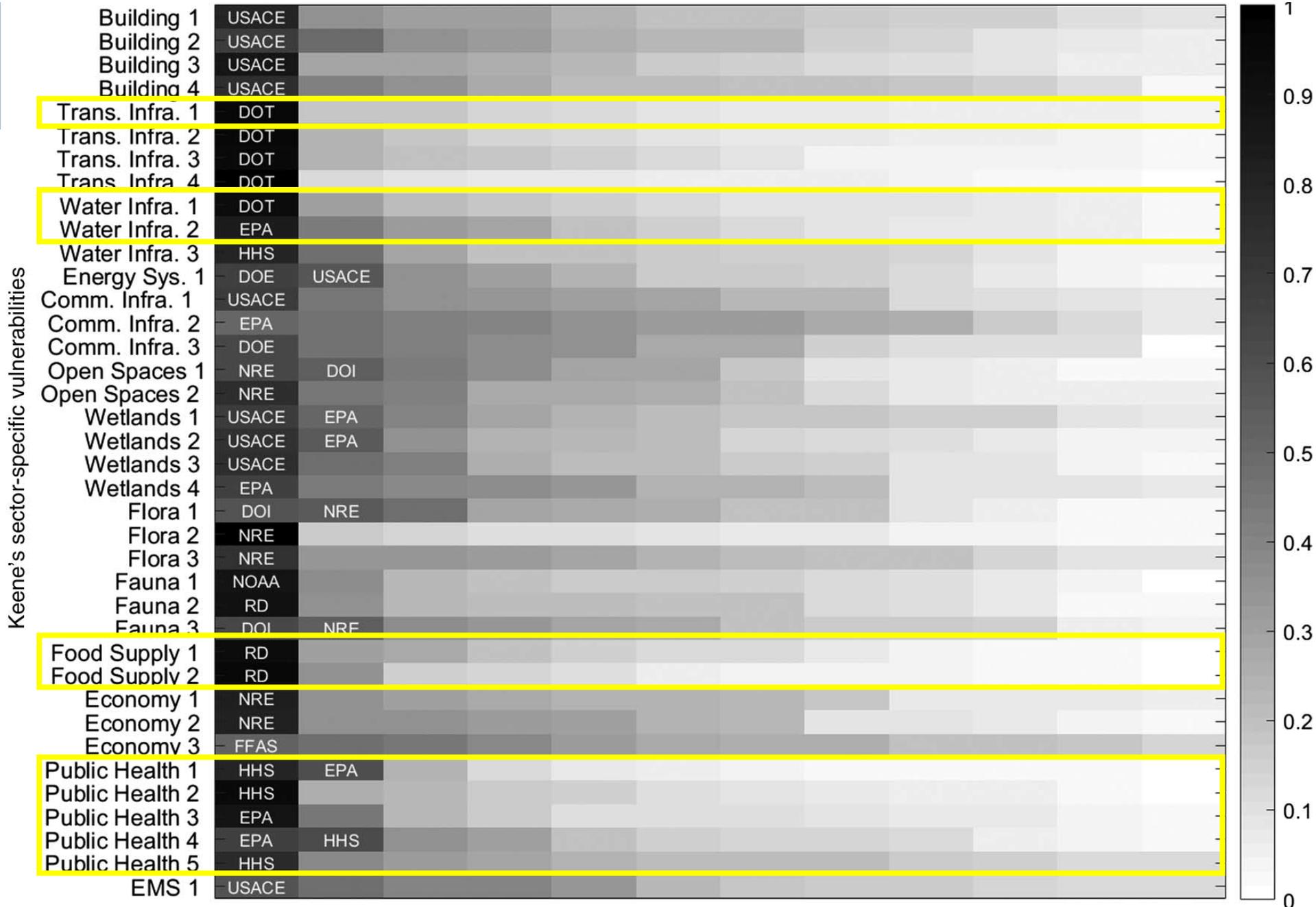
DOE DOI DOT EPA FEMA HHS HUD NOAA USACE NRE FFAS RD

Federal agency SPs

ASAP score



Sector-specific climate vulnerabilities in Keene, NH with highest scoring federal partners



Keene, NH Results: did highest priority issues have high scores?

Transportation Infrastructure #1 *“Large amounts of snowfall and icestorms all have the ability to affect roadways and bridges”*



USASpending.gov: In 2015, Keene was awarded a DOT grant to buy snow removal equipment!

Water Infrastructure #2 *“The capacity of existing culverts, the design of current stormwater infrastructure increases in impervious surfaces all contributed to the system’s vulnerability”*



USASpending.gov: In 2011, Keene received an EPA grant to improve their storm and wastewater infrastructure through EPA’s capitalization grant!

Food Supply #1 and #2



Keene, NH Results: partnerships and cobenefits

Water Infrastructure

ire	HHS	
-----	-----	--

Public Health #1-5

lth	HHS	
lth	HHS	
lth	EPA	U
lth	EPA	
lth	HHS	

EPA and DOT are Keene's primary federal partners

ASAP allows both federal agencies and communities to:

- Identify **other** federal partners to **proactively** plan for climate adaptation
- Identify **co-benefits** of agencies/adaptation measures
- **Reduce the planning-to-implementation time** post disaster to reduce costs to the private and public sectors

All of which are shown **to increase quality of plans** and for which no quantitative tool existed

Conclusions

In response to increases in climate damages and increased planning efforts, we found:

- Need to improve connection between planners + implementers
- Opportunity for automated machine learning matchmaking tool

To address that need, we built a semantic vector-based tool called ASAP:

- We tested it, and found it identified highest priority problems with relevant funding – and correctly identified top federal partners

In added value:

- Coordinate adaptation & disaster response needs with federal agencies
- Reduce public and private costs following disasters
- Quantitatively identify federal-federal partnerships for a first step towards a more cohesive government-wide climate strategy

Path forward

- USACE launching ASAP for public use!
- Continued improvements
 - Case studies with ASAP tool when launched
 - Testing and improving different machine learning algorithms
 - Incorporating new machine training data as it becomes available

How to learn more

Automated Strategic Prioritization Matchmaking Tool to Facilitate Federal–Community Adaptation Implementation

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J. Water Resour. Plann. Manage., 2018, 144(12): 04018081

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Questions

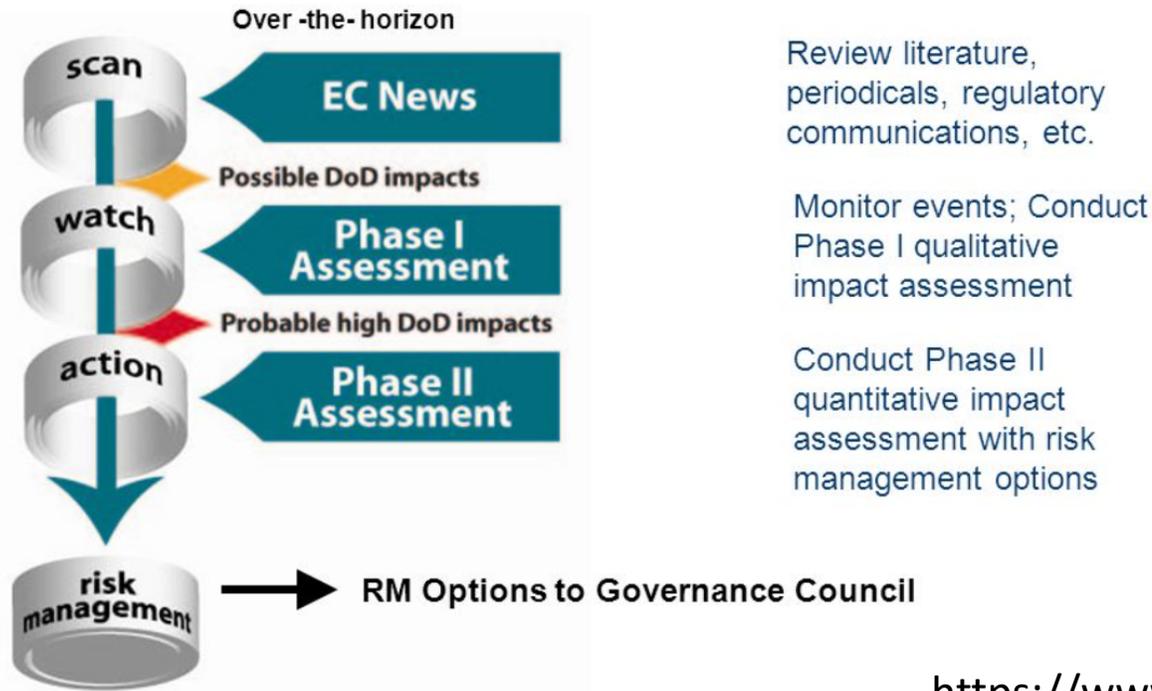
- 1) How might your research be applied to decision making at the department of defense?
- 2) What other methods might you use to train a model on semantics?
 - Supervised vs. unsupervised
- 3) Now that you are within the government, how would you approach the problem differently?
 - Ask lots of questions!! Learn the fed story and why implementation is difficult.

How might your research be applied to decision making at the department of defense?

- Automated scanning and screening of emerging contaminants

EC “Scan-Watch-Action” Process

Acquisition, Technology and Logistics



<https://www.denix.osd.mil/>

What other methods might you use to train a model on semantics?

- Supervised vs. Unsupervised (method I used) learning

Extra slides

- How might this be used?
- Future efforts?
- Why didn't you use DoD?
- How did you choose agencies?
- What type of data would you use to validate?

Expanding beyond Keene

- ASAP matched Keene's communication infrastructure and emergency services vulnerabilities with USACE, EPA, and DOE, and USACE, respectively (Fig. 5; Table S2). Expert analysis indicates that FEMA might be the best primary match for these issues—hence the lower ASAP scores of the matched agencies. As discussed previously, FEMA's training dataset is not of the same quality as the other agencies included. Future development of the ASAP tool will strengthen FEMA's training data and could also expand the boundary of inquiry to all federal agencies.

- Climate change **poses significant risk** to the federal government and individual taxpayers yet **Opposition and concern vary greatly**
(Lee et al, Nature Climate Change, 2015)

- Many local adaptation plans **fail to prioritize impacts and strategies**
(Woodruff and Stults, Nature Climate Change, 2016)
Recent successes
- This raises concerns **whether adaptation plans will succeed very few measures have been implemented.**
(Woodruff and Stults, Nature Climate Change, 2016)
(National Academy of Sciences, 2016)

- Further delay of adaptation actions** increases the risk to the nation
(Government Accountability Office, 2015)
(Risky Business Project, Bloomberg et al, 2017)

In the United States, **substantial climate change adaptation planning is occurring** at all levels of the government and

Planning to implementation time

Failure rate

Training Data

Federal Strategic Plans

- Prepared for every agency
- Approved every four years

Verification Data

Federal Climate Change Action Plans (CCAPs)

- Prepared by every agency
- Proxy for risks and vulnerabilities within community climate action plans

Sustainable Solutions

To America's Water Resource Needs

Civil Works Strategic Plan 2014-2018



US Army Corps
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USACE JUNE 2014

Climate Change Adaptation Plan

Algorithm 1: Keyword vector space

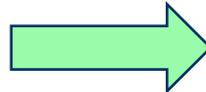
Federal Strategic Plans

DOC	DOE	DOI	EPA	FEMA	HHS	HUD	USACE	USDA
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	DOC	DOE	DOI	EPA	FEMA	HHS	HUD	USACE	USDA
Term 1									
Term 2									
Term 3									
Term 4									
Term 5									
Term 6									
Term 7									
Term 8									
Term 9									

Rank by term frequency (TF)

Scale up rare terms (IDF)



	DOC	DOE	DOI	EPA	FEMA	HHS	HUD	USACE	USDA
Term 1									
Term 2									
Term 3									
Term 4									
Term 5									
Term 6									
Term 7									
Term 8									
Term 9									

Matrix of weighted words by Strategic Plan

Algorithm 2: Semantic vector space

	DOC	DOE	DOI	EPA	FEMA	HHS	HUD	USACE	USDA
Term 1									
Term 2									
Term 3									
Term 4									
Term 5									
Term 6									
Term 7									
Term 8									
Term n									

Matrix of weighted words within the Strategic Plans



Quantify mathematical relationship between terms



	DOC	DOE	DOI	EPA	FEMA	HHS	HUD	USACE	USDA
Terms 1,5,6,9									
Term 2,3,4									
Terms 7,8									

Matrix of related semantic terms within the Strategic Plans

Verification of model concept

Federal climate change adaptation plans (CCAPS)

- Prepared by every agency
- **Proxy** for risks and vulnerabilities within community climate action plans

		Federal SPs				
		USACE SP	FEMA SP	DOT SP	EPA SP	HHS SP
Federal CCAPS	USACE CCAP					
	FEMA CCAP					
	DOT CCAP					
	EPA CCAP					
	HHS CCAP					

Automated completion
 Algorithm 1: keyword
 Algorithm 2: semantic

Federal Strategic Plans (SPs)

- Prepared by every agency
- **Approved** every four years by OMB