Machine learning for Nature-based Solutions

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Objective

This study aimed to support the development of Nature-based Solutions (NbS) by using machine learning tools. By exploring a combination of technologies like Natural Language Processing and named entity recognition we aimed to extract and classify NbS as well as their associated barriers/enablers for implementation. Official project title and number: Machine learning to identify good practices with Nature-based Solutions (project code KB-46-005-018).

Method

As depicted in Figure 1, we took several steps in our project, testing tools which might help us to go from a cloud of NbS literature to a structured database on NbS:

- Define a few relevant kinds of data for a database on NbS:
  - NbS definition;
  - NbS taxonomy (e.g. types of NbS, types of problems addressed etc);
  - NbS location;
  - Barriers and enables for realising NbS.
- Select NbS literature to test the tools with;
- Create a top-down codebook of 'NbS language';
- Test tools for finding relevant information in NbS literature.

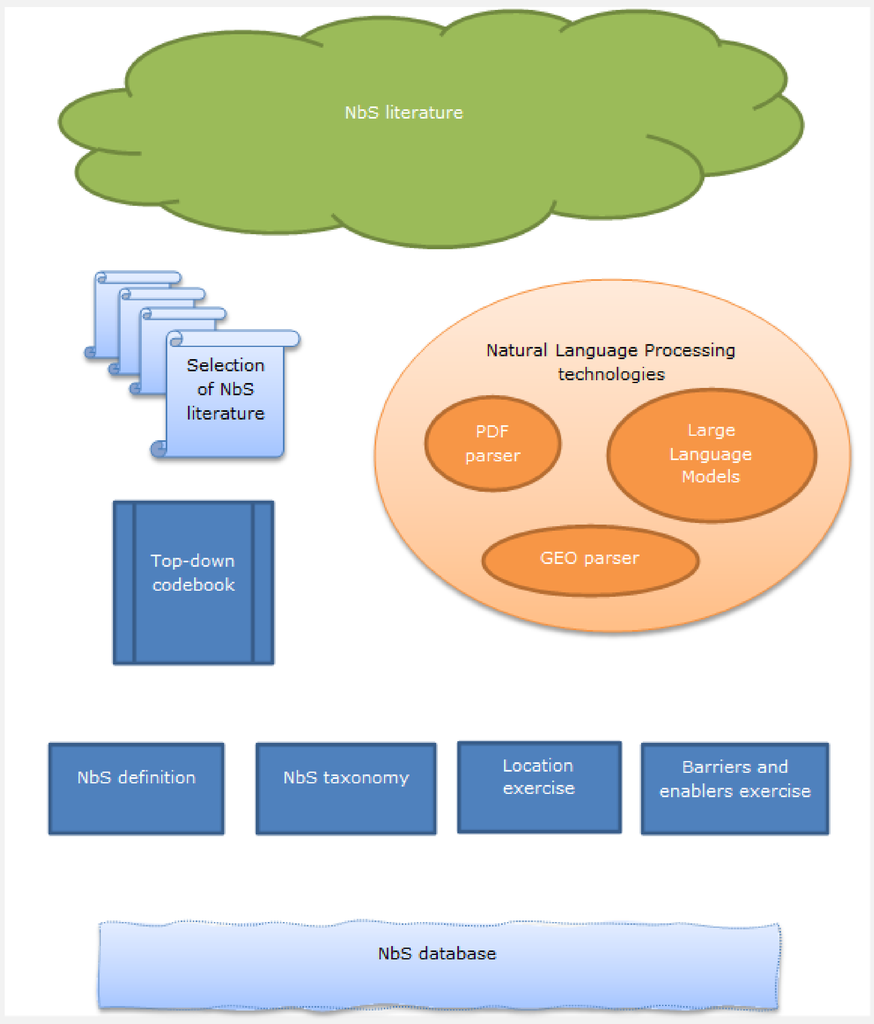

Figure 1. Steps in the project to test machine learning tools for finding relevant information in literature on Nature-based Solutions.

Results

- We first used IPCC literature on NbS, assuming that this long-established forum was using consensual definitions and language. However, we found that this literature is not focused on NbS but rather on climate change and adaptation. So the IPCC language sample was less relevant for this project.
- We looked for a new set of literature through simple queries in Scopus and this set of articles performed better.
- The top-down codebook was helpful for the researchers with AI expertise to become familiar with the topic of NbS. But AI tools like a keyword extraction algorithm were also able to sort language in a bottom-up way.
- The language in NbS literature seems too fuzzy at this point in time to produce a reliable classification and to fill a database.
- We then broke down the effort in three separate analyses:
  - Identify the NbS itself, and create a taxonomic classification of the NbS;
  - Resolve the geographical location of the NBS;
  - Associate barriers and enablers to the NBS.
- Of these analyses the first one was promising, while the second and third remained difficult. An example of the taxonomy created with AI is shown in Figure 2.

Taxonomic ID	Label level 1	Level 2	Level 3
1	Nature-based solution		
1.1		Reduce greenhouse gas emissions	
1.1.1			Enhancing carbon sequestration
1.1.2			Reducing emissions from land use
1.1.3			Protecting carbon-rich ecosystems
1.2		Protect water resources	
1.2.1			Filtering and purifying water
1.2.2			Reducing erosion and sedimentation
1.2.3			Minimizing nutrient pollution
1.2.4			Increasing water storage
1.2.5			Regulating water flow
1.2.6			Replenishing groundwater
1.2.7			Absorbing floodwaters
1.2.8			Slowing down floodwaters
1.2.9			Protecting coastlines
1.3		Improve food security	
1.3.1			Improving soil health and fertility
1.3.2			Diversifying agricultural systems
1.3.3			Promoting agroecology
1.3.4			Expanding sustainable fisheries and aquaculture
1.3.5			Supporting wild food harvesting
1.3.6			Enhancing food preservation and storage
1.3.7			Reducing vulnerability to climate change
1.3.8			Conserving biodiversity
1.3.9			Promoting sustainable land and water management
1.4		Restore biodiversity	

Figure 2. NbS taxonomy and definitions obtained from Bard for use in experimental taxonomic transformer classifier. (showing only the first half of the taxonomy)

Conclusions

- The language in NbS literature is still fuzzy so it poses limitations for the use of machine learning.
- Language processing tools seem the most effective ones for now.
- Presently available language processing tools have limitations regarding copyrights of inserted data sources and hallucination (=fabricating non-existing results)

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