NagO- An ontology on UK dependent territories, their link to the Nagoya Protocol policy framework and terminology from related domains

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ABSTRACT:

The Nagoya Protocol on Access and Benefit Sharing is a transparent legal framework which governs the access to genetic resources and the fair and equitable sharing of benefits arising from their utilization. Compliance with the Nagoya protocol has become an important part of any genetic-based research activity and is increasingly discussed, implemented and monitored. Gathering information about countries and their Nagoya Protocol status from different open access databases and archives revealed data challenges around legal agreements, asynchronous data sources and semantic ambiguities. This is an issue for homogenous data integration, knowledge accessibility and consequently compliance with the Nagoya Protocol.

The proof-of-principle **Nagoya Ontology** (NagO) was developed to semantically model the complex policy framework around the Nagoya Protocol and to unveil the legal relationships between sovereign states and their external territories, illustrating the United Kingdom as a study case. NagO includes biodiversity, geography, administrative and constitutional terms and adds them to the semantic web. It allows for the end user not only to query for particular places of interest relating to the United Kingdom but also governmental structures and Nagoya protocol affairs. It was created to signify a first ontology on the Nagoya framework and sovereignty affairs, to provide consolidated, machine-readable knowledge available to stakeholders to support FAIR and essentially transparent, interoperable and sustainable knowledge management.

NagO is free and openly accessible in English on "https://github.com/hseifert/NagO".

Keywords: ontology, semantic web, Nagoya Protocol, Overseas territory, sovereignty, Crown dependency

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1. INTRODUCTION

The Nagoya Protocol on Access and Benefit Sharing (ABS) is a transparent legal framework which governs the access to genetic resources and the fair and equitable sharing of benefits arising from their utilization [1]. Complying with the Nagoya regulations ensures legal use and re-use of genetic material while supporting fair procedures during biodiversity studies. Providing detailed provenance information and clear re-usage conditions play a key role in ensuring the re-usability of research data according to the FAIR (Findable, Accessible, Interoperable, Re-usable) Guiding Principles for scientific data management and stewardship [2]. Even with the framework provided by the ABS Clearing House (ABSCH) and the support of the national focal points (NFP), establishing a direct link between the research data from genetic resources and the relevant Nagoya information remains a challenge. And even if this information can be found through diverse search engines there is no quick access to information about the Nagoya Protocol status, especially if it comes to external territories of a country. Currently, the ABSCH website offers a lot of country profiles but in the case of biodiversity hotspots outside the country's mainland (e.g. Indian Ocean Islands) it can get very difficult to retrieve information on such a region's Nagoya Protocol status, or more specifically to do a reverse search from a

sampling spot of interest back to the according sovereign affiliation.

Hence, there is a niche for efficient information technology tools to provide knowledge about A) the complex processes around the Nagoya protocol framework in general and B) relationships between sovereign states and their external territories in a consolidated way in order to enhance transparency and thereby supporting Nagoya protocol compliance.

In order to help stakeholders estimate whether genetic data they plan to produce or re-use might fall under Nagoya regulations, we developed a Nagoya Lookup Service, which provides up-to-date information on the Nagoya party status for a geolocation specified by GPS coordinates [3]. The efforts for developing this tool revealed discrepancies in publicly available data sources, for example on legal agreements (for some countries the signature to the protocol extends to their external territories and for others it does not), debated country borders (different countries claiming the same region) or asynchronous data sources (mismatches of information between various sources). These discrepancies create additional challenges for achieving Nagoya compliance and limit the application of automated systems to support compliance. Such limitations can be approached by moving from a pure data integration of open data sources to knowledge integration.

There are several cases of external territories, debated areas, disputed territories or crown dependencies which cannot simply be linked to their sovereign authority, due to the fact that data integration itself relies on publicly available, standardized, formal data. There are islands and external territories across the globe that may have a very unique relationship with their authorizing country and a distinct agreement in terms of the Nagoya Protocol. Information about these constitutional connections and what they mean for the Nagoya regulations is neither always accessible on the open web, nor always reliable. Especially with an increasing focus on the compliance of the Nagoya Protocol there is the need for more consistent, precise information on legal relations between states and their external territories, e.g. as mentioned above when sampling in a biodiversity hotspot off the mainland.

Having open access data sources providing these geographical, sovereignty and document information help with handling the heterogeneity and the (little) amount of data available. Especially hotspots for high impact biodiversity studies being around these smaller islands and disputed territories [4,5] fuel the importance

of tools for reliable sovereignty classifications. It is a matter of preventing biopiracy in these areas by complying with the Nagoya Protocol and the FAIR principles. There is also an urge to work against research colonization where sampling efforts would be skewed towards easily accessible areas (with as little bureaucratic complexities as possible), exploiting the local biodiversity while acquiring the benefits. This can be countered by having a transparent data landscape and accessible information on the sovereignty and Nagoya Protocol status. There are already efforts by working groups like the UNGEGN [6] towards a homogenous terminology in geographic semantics but it still remains a challenge. The elaborate web search for this project has shown that special information behind the conceptual framework and deeper knowledge than the data available on the ABS Clearing House, is not easily and publicly accessible. Personal correspondence with the governmental authorities reinforces that thought and once again shows the niche for semantic development and the need for intensified efforts towards FAIR data (and eventually knowledge) handling.

NagO as an ontology contributes to a central, transparent, open, machine-readable source of knowledge and FAIR data management. It is developed to provide formal language for the entities relevant to Nagoya protocol processes. As a study case, the sovereignty branch is specifically focused on the United Kingdom and its external territories. There are many grey areas in terms of legal dependencies and sovereign affiliations. Hence, NagO shall advance the status of the semantic structures currently available, seeing that providing reliable, long-term knowledge to stakeholders is no longer a sole data integration challenge but poses advanced semantic issues.

2. BACKGROUND

NagO aims to connect the vocabulary of different topics which the protocol is encompassing: biodiversity, geography, sovereignty and the people, processes and documents involved. Some open sources can be unreliable when it comes to legal questions which is specifically problematic when seeking for Nagoya Protocol information if political affiliations of particularly interesting research areas are unclear. These grey areas can be addressed by NagO being a more stable source of knowledge encoding this relevant policy framework. If stakeholders were to utilize NagO, this would propose an improvement aiming towards linked

open data and would mean sustainable data maintenance and data (re-)usage while also facilitating information accessibility by making it machine-readable.

The challenge is transforming from a multi-component data integration not only to community-based linked open data, but also moving to knowledge integration to bridge the observed data discrepancies.

NagO, as the research artifact of this work, is publicly available on Github and can perspectively be added to the OBO Foundry [7] as a formal integration into the open knowledge representation for "open use, collaborative development, non-overlapping and strictly-scoped content" [7].

3. APPROACH

NagO was created following the Basic Formal Ontology concept [8] and the guidelines under the OBO Foundry [7]. For the sovereignty branch of NagO the Island Rights Initiative [9] provides the majority of information by displaying the constitutional links and governmental relationships of every external territory of the United Kingdom. The Island Rights fact sheet as well as personal correspondence with their authorities and the Foreign and Commonwealth Office provided information needed for the planning of the governmental branch. A general overview was developed and then extended with document terminology as well as Nagoya Protocol processes and involved instances. As soon as the general overview had been completed, the list of NagO terms was systematically searched for in existing ontologies in Ontobee [10] as well as UNBIS Thesaurus [11], GEMET[12], OECD Stats[13], WikiData[14] and Biodiversity A-Z[15]. The complete list of search keys can be found in the appendix. Very few of the necessary vocabulary already existed in publicly available ontologies. Of the few term definitions found, most did not comply with the semantic structure compliant with the OBO Foundry principles or they were not precise and/or accurate for the content scope of NagO. The definitions from existing platforms and corresponding supplementary documents were harmonized.

Term definitions were discarded if they:
- did not follow a genus differentia,
- showed circularity, or
- were just descriptive, like all example-based phrases.

The intended principle for harmonizing existing term definitions was looking for commonalities among sources. The consensus between all researched knowledge sources was declared as an overlap of definitions. Any incomplete or incoherent definitions were amended and extended according to the OBO definition principles, aligning them to the upper level semantics under BFO[8] and thereby keeping NagO semantically coherent, interoperable and machine-readable. All knowledge sources and supplementary documents have been referenced in the object annotations as definition source, accordingly.

Existing IRI's have been referenced, the re-use of as many existing IRI's as possible was intended but new IRI's within the NagO namespace were created correspondingly wherever applicable.

Ontologies which provide terminology for NagO include ENVO[16], IAO[17], BFO[8] and RO[18] and were automatically imported using the ontology development kit [19]. The Dublin Core Metadata Initiative terms[20] and NCBITaxon [21] have been added with a manual import in Protegé[22].

As mentioned above, NagO is composed of biodiversity, geography and sovereignty vocabulary as well as people, processes and documents involved in the policy framework. In order to put these terms into perspective they were looked at in a broader context. Specifically looking at term definitions gave an insight of how terms are related to each other. The basis for this step was reading about administrational and political processes and unveiling the distinct people involved, the roles they have and what input is needed for certain processes. The ABS Clearing House offers information on country profiles and documents in relation to the Nagoya protocol [23]. Information on legal processes and organizations can be found on United Kingdom governmental websites as well as information on the people involved in administrational duties and processes and especially the roles they have [25-30].

Wherever publicly available data did not yield the required detail of information, personal correspondence with the governmental departments was inquired for detailed information. The OBO Foundry delivers definitions and relations for the biodiversity and territory branches of NagO (ENVO, SDGIO, GO, NCBITaxon and GEO, GAZ respectively). However, the ABS Clearing House itself also provides openly accessible information on the role of genetic material and the instances involved as part of the Nagoya protocol text [31].
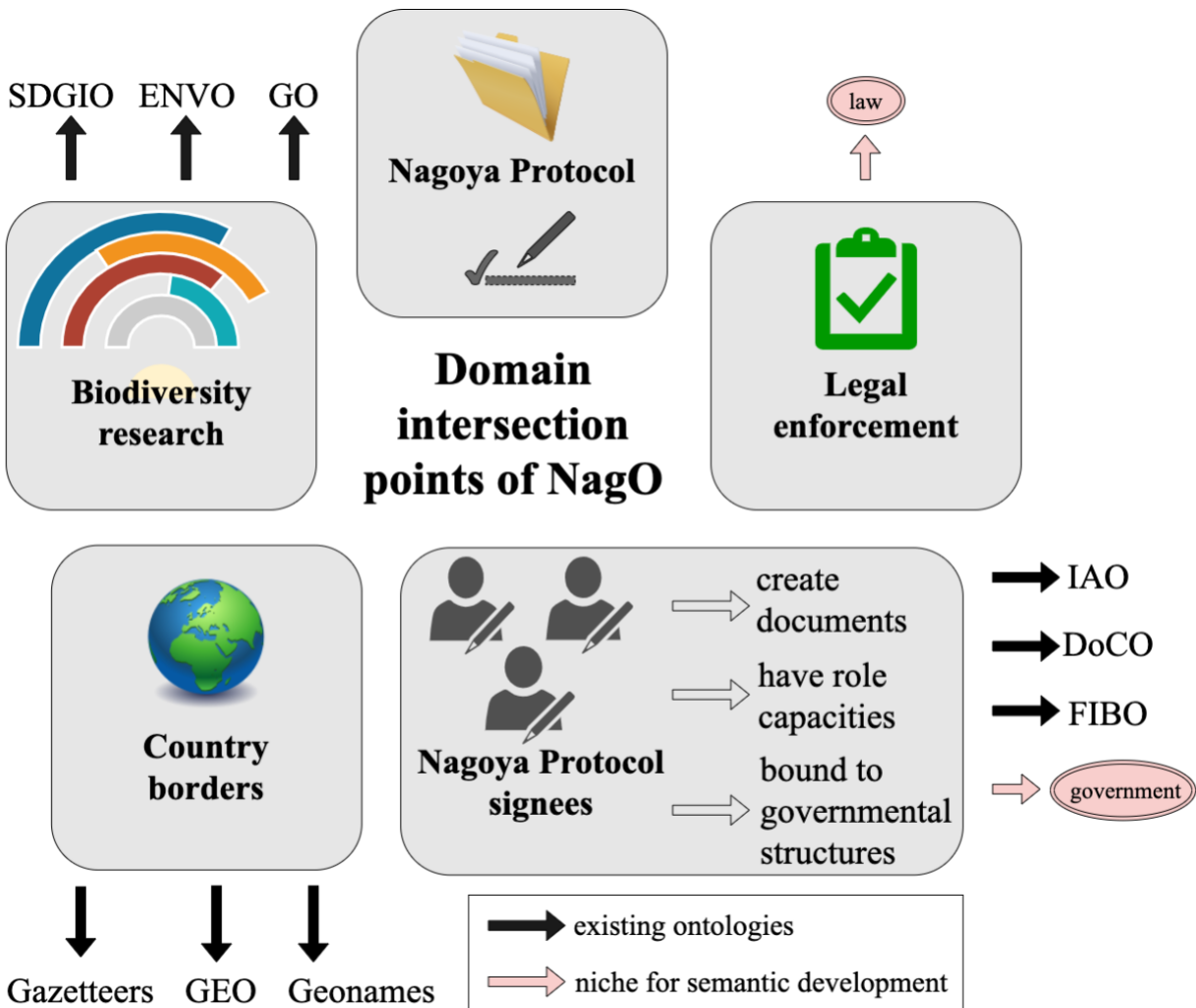
Figure 1. Overview of NagO domain scope intersections with associated topic and possible connections to existing ontologies

4. KEY FEATURES

Figure 1 depicts the domain scope intersections of NagO with its associated divisions as adjacent vocabulary scopes.

There are five branches which NagO consolidates: With the Nagoya protocol regulating the access to genetic material and the transparent sharing of benefits arising from their utilization, NagO can firstly be connected to biodiversity vocabulary. As the Nagoya protocol impacts biodiversity research for Nagoya party countries, the domain of NagO intersects with ontologies that already include biological and environmental vocabulary such as ENVO[16], SDGIO[32], GO[33] and NCBITaxon [21].

Because the Nagoya protocol is individually signed by first-order administrative divisions, it applies within country borders. Here, NagO's territorial vocabulary of the UK's external regions (the instances of British Overseas territories and Crown dependencies as well as 'commissioning' and 'governing' terms) can intersect with existing geographical ontologies like GAZ or GEO. However, there is a niche for even more standardized publicly accessible knowledge when it comes to sovereignty matters like conflict areas where different countries claim the same region, or specific agreements between sovereign authorities and their external territories.

Likewise, the country-specific legal enforcement of the implemented laws, which the Nagoya protocol results in, is only represented in NagO in terms of adding ministerial departments. Currently, there is a niche for

semantic development in terms of OBO-compliant, centralized knowledge of legislative, judiciary and executive structures within a country.

Another key aspect of NagO is the Nagoya Protocol itself, the signees involved and the administrational processes behind it (e.g. 'national administrative process', 'Nagoya protocol signatory', 'head of state' or 'head of government'). The three different instances allowed to sign the actual protocol are the head of state, minister of foreign affairs or the head of government [34]. These particular people and other administrative people secondarily involved during the process of a country becoming a party to the protocol create documents, have certain role capacities which are realized during certain activities along the process (e.g. 'commissioner', 'governor') and they are bound by the country-specific governmental structures ('ministry of defence', 'administrative process', 'ministerial department'). This branch is connected to territorial and sovereignty vocabulary through governmental/ministry terms. Again, there is room for more semantic development when it comes to accessible, standardized and up-to-date knowledge regarding internal, governmental structures to allow for a more elaborate branching of terms.

The NagO vocabulary of this particular branch can also be connected to existing ontologies via document components [DoCO, 35] or information artifacts [IAO, 17] created during the signature process.

In summary, NagO combines these different existing domains with some thematic overlap, extends the FIBO [36] is published as part of the data management and scientific realm, there is an overlap of scope with NagO in terms of the FIBO agreements, law and organizations ontologies published for business stakeholders.

Figure 2 displays an example branch of NagO showing how the protocol as an international agreement is connected to processes and people. It is also an example of how Nagoya protocol specific vocabulary and instances (e.g. 'Nagoya protocol signatory process' and 'Nagoya Protocol') branch out into a broader context ('legal process' and 'protocol' respectively).

The three possible signees of the protocol are also presented and show how people are connected to and tie in with the conceptual framework of the Nagoya protocol. During the research for this project some patterns were revealed. An example can be viewed in figure 3. Here, geographic territories are related to people and processes. The pattern detected and subsequently used includes processes and their participants who hold specific role capacities realized during those processes. In this case, the commissioning role for South Georgia and the South Sandwich Islands is realized in Nigel Phillips while he is also realizing the governing role during the governing process for the Falkland Islands. The general pattern of a person (functionary) having a specific span of role capacities (functions) which are realized during certain activities with certain input, output and a subject can be applicable to a variety of other domains, too.
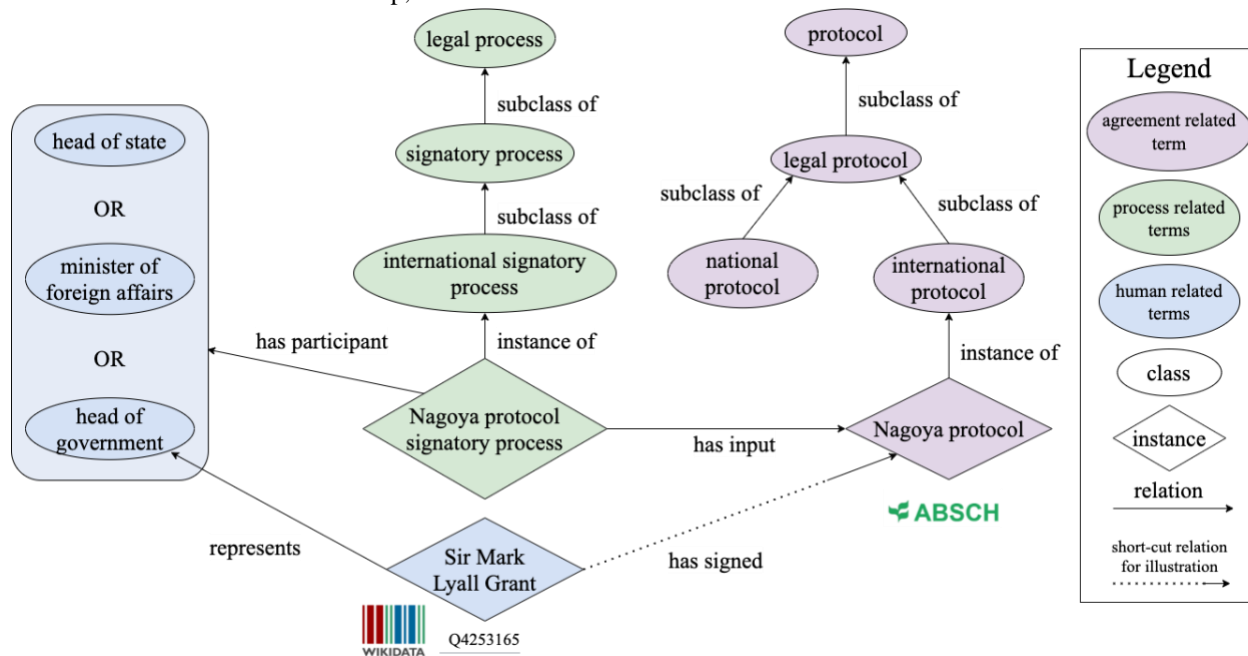

Figure 2. Branch of NagO showing relations between people, processes and agreements and how Nagoya instances fit into a broader context
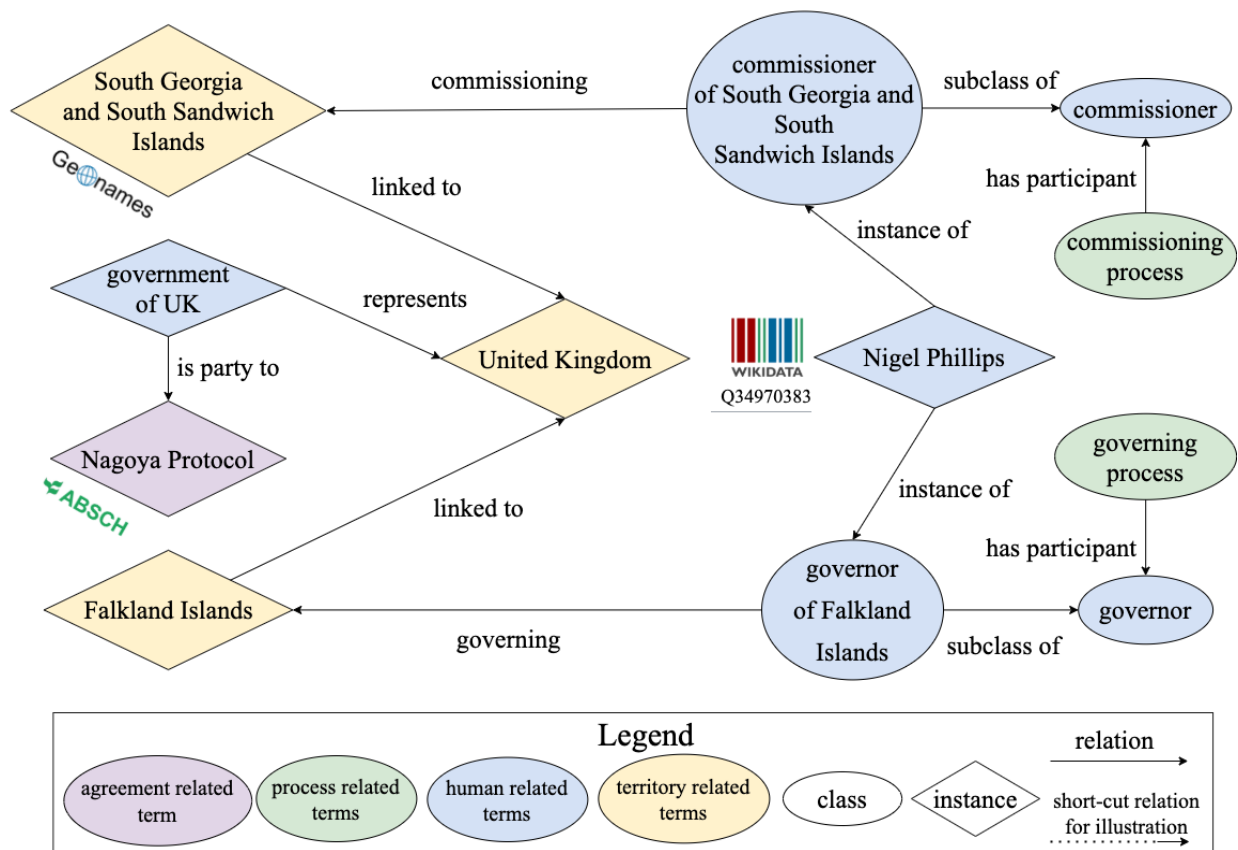
Figure 3. Branch of NagO showing an example pattern of the functionary Nigel Phillips and his functions related to geographical territories

Both figures 2 and 3 include shortcut relations used for this illustration. In NagO itself these relations are more complex and are encoded in OWL respectively, using more than one axiom. The relation "represents" is carefully chosen here as the ambassador Sir Mark Lyall was acting on behalf of the UK government at the time of signing the Nagoya protocol documents. The "linked to" relation is used as a direct association between entities. For the context of this work, but also relating to other domains, "protocol" means convention or agreement and not the actual paper documents.

Other patterns revealed during this work include:
- Territory instances and the execution of a certain government type (e.g. self-governance)
- UK external territories and their connection to the United Kingdom
- Ministerial departments and their connection to the head of state

Summarized it can be said that the domain of NagO may be narrow but contains classes of general interest. It connects vocabulary from different topics, as mentioned before, by relating Nagoya protocol specific terms to existing semantic realms. Semantic patterns were revealed and used throughout the development, providing a generic structure applicable to other domains, too (e.g. assigning capability to objects/humans).

At application level NagO is semantically rigorous but it does include shortcut terminology as it is a proof-of-principle artifact. However, the axioms have been chosen very consciously. For example, while acknowledging that no one element of administration can perform all the governance, "capable of part of" has been used as these axioms.

Rather than creating BFO roles for terms, using "has participant" involves less graph traverses and is more efficient for querying people and the processes they are involved in. The same consistency was used for other triples in this ontology as well.

Metrics

Metric	Value
Axiom	7805
Logical axiom count	1689
Declaration axioms count	873
Class count	588
Object property count	114
Data property count	13
Individual count	198
Annotation Property count	126

Table 1. Overview of NagO metrics

5. USAGE SCENARIOS

NagO allows users to carry out diverse semantic searches. First of all, the resolution of legal connections between geographic locations is higher now that the variety of external territories of the UK are added. Of all external territories from the United Kingdom, 100% of them are semantically linked to the United Kingdom to find the relevant ABSCH country profile of these territories. Without using NagO, in order to determine that the relevant Nagoya authority for islands like Jersey and Guernsey is linked to the United Kingdom, a user would take several steps through search engines. For example:

When searching Google (incognito window) for the following string: "Which ABS country profile is relevant for the Bailiwick of Guernsey?", a link to the United Kingdom is only mentioned on search page 2 (12th search result) and there is still no indication for the ABSCH website at all. The island of Jersey seems queried more often because when searching Google for "Which ABS country profile is relevant for the Bailiwick of Jersey?" a link to the United Kingdom is mentioned in the second search result on page one, but there is still no indication for the ABSCH website to find out more about the Nagoya Protocol information needed for these regions. Trying to find out to which extent a certain territory is connected to the United Kingdom (through the monarch, historical links or through the government and constitution) lead to dozens of different databases and fact sheets providing the knowledge from governmental authorities after a time-consuming web search with limited to no machine-readability.

That means, so far users have faced a challenge when looking for more information on the Nagoya party status from interesting research hotspots located near or in external territories of the UK or other. With the theoretical modelling of NagO, the information on that territory can now be gathered from a centralized source of knowledge in an efficient way. But not only is the knowledge resolution higher for the external territories of the UK, but by having this machine-readable source it allows users to do a reverse search, too. For example, when a researcher knows of a certain microbial strain of interest located near the Cayman Islands they could query NagO for "Cayman Islands", the link to the UK will be returned accordingly in the query output and the user can find the according ABSCH country profile where more information on the Nagoya party status can be gathered.

Due to the complexity and volatility in terms of sovereign connections on a global level and the regular changes in law and constitution, NagO acts as a starting point and proof-of-principle. There are a variety of different connections between the United Kingdom and its external territories. Some territories are self-governing, others are regulated through a commissioner and/or through the Foreign & Commonwealth Office, for other regions the link is merely formed through the monarch [25]. Not only is NagO an efficient, central source of knowledge in terms of finding the Nagoya protocol status for a region, but connecting NagO into the broader knowledge community and making it interoperable furthers the understanding of general sovereignty matters, constitutional processes and instances.

In the broader context, NagO can not only be used to query constitutional links of geographic regions, but also finding role capacities of people involved, Nagoya Protocol relevant processes and instances and a deeper understanding of the policy framework around it.

6. DISCUSSION AND OUTLOOK

The simple question of which territory belongs to which mainland and governing authority could have been done through a gazetteer, however, adding the expert knowledge to geographical data and making it machine-readable and interoperable requires a formal knowledge representation like NagO. It provides information accessible from one place whereas otherwise even just looking for the National Focal Point to contact when sampling e.g. at the British Antarctic Territory or Montserrat would result in browsing through several web pages and contacting governmental representatives for further direction. Sovereignty and its meaning for biodiversity and general environmental sciences should also be considered. For the current global climate crisis [44] policy decision making plays a big role to make a

change. As international conventions, like the Nagoya Protocol, cannot legally be enforced (since there is no global international authoritative executive force), the actual impact is made per country. Hence, the knowledge around environmental governance within sovereign instances and all decisions made, laws enforced and processes regulated should not be as impenetrable as it currently seems [45,46]. Instead, transparency is needed to avoid further obstacles. Therefore, NagO semantically models the relations from entities to the policy framework as precisely as possible to give that insight while there are shortcut relations used as a workaround for more complicated internal structures which remain to be acquired. This implies, more data and knowledge about global sovereignty matters needs to be aggregated in the future to be able to describe this and any agreement between sovereign entities.

Seeing the complexity of the sovereign relations of the UK with its Overseas Territories and Crown dependencies NagO, and because NagO perspectively includes more sovereignty domains than just the UK, the ontology obviously needs regular updates. A sustainable long-term maintenance could be assured by implementing NagO under the OBO Foundry and adding relevant knowledge through crowd-sourcing. NagO can be the first step towards a more transparent data landscape for legal questions such as the Nagoya Protocol framework and territorial connections. The director of the Island Rights Initiative Susie Alegre states *"The UK's relationships with its OTs is as varied as the OTs are. While this reflects the huge variety in their circumstances, it leaves a lack of clarity in terms of the UK's responsibilities and the OTs ability to represent the needs and aspirations of their people on the international stage. At this time of flux for the UK and the OTs, there is an urgent need to review and clarify these relationships to ensure that the OTs and the UK benefit from those relationships and that the UK's duty to ensure the well-being and the development of the political aspirations of the people in the OTs is reflected in the legal and practical frameworks that govern those relationships"* [37].

When evaluating the mapping of the UK's responsibilities in terms of human rights in Crown dependencies and Overseas Territories it becomes clear that the complexity of the topic extends to a lot more areas than just the Nagoya Protocol [38]. The constitutional links between countries and their external territories have an impact on more than research and

human rights, outside the scope of this work, which could potentially be added.

The research on the governmental relationships between the UK and its external territories has shown very distinct and complicated scenarios with each and every one of the regions. In general, the Overseas territories are covered by the Foreign and Commonwealth Office and the Crown dependencies are covered by the Ministry of Justice. However, each individual region usually has an Attorney General holding the role of a legal advisor who could be contacted for Nagoya Protocol questions, however, some territories also have an assigned governor responsible for the territory [25]. In specific cases like the Sovereign Base Areas (Akrotiri and Dhekelia) the Attorney General explicitly does not give advice to members of the public [39] and in other regions it gets even more controversial and debated, like the UK's claim on the British Antarctic territory [40]. This knowledge can also potentially be added to NagO in terms of contact information annotation for certain regions. However, even after elaborate efforts to get contact information for all separate Overseas Territories and Crown dependencies, it is very difficult to acquire said information from the relevant authorities.

The same applies for actual names of the protocol signees. After personal correspondence with the National Focal Point of the United Kingdom, Keith Barber, it was unveiled that Ambassador Sir Mark Lyall Grant, the then Head of the UK Mission to the United Nations, signed the Nagoya Protocol on behalf of the UK government and it was the Foreign Secretary of the day who signed the UK's instrument of ratification for the Nagoya Protocol. The Foreign Secretary heads up the Foreign and Commonwealth Development Office of the UK government.

In addition to sovereignty complexities, there are several cases where two or more countries claim the same territory, too [41]. For these cases NagO should have a pioneering role as a proof-of-principle for more similar ontologies to follow which could also integrate country specific knowledge on foreign affairs and these territorial claims. Due to the fact that relations and statutory frameworks are constantly changing over time, there should be knowledge representations unveiling not only document structures, administrative processes and instances, but also those territorial claims, relationships inside and outside the borders and displaying constitutional transparency.

As a future perspective, the particular functionaries and their roles and activities could be extended, especially where additional contact information would be

annotated. Currently, the in-depth revelation of global sovereignty relations, active people involved in foreign affairs and the corresponding documents created is outside the scope of this work. Nevertheless, there is a tool for retrieving information on multilateral environmental agreements called InforMEA [42]. InforMEA holds information and documents on (inter)national agreements, also including the Nagoya protocol. Adding the official documents created during the signing and ratification of the United Kingdom to this website would be one step towards accessible knowledge for an end user. InforMEA also offers a glossary including environmental governance and biodiversity terms with definitions, which could potentially be interconnected with NagO.

In the future, NagO could also be integrated into the Sustainable Development Goals Interface Ontology [SDGIO, 43], which is an ontology originally requested by the UN environment programme to specify terms and relations within the domain of the 2030 Agenda. Possible SDGIO intersection terms could be 'permission to access', subclasses of environmental processes or geopolitical entities (e.g. 'fragile state' where debated areas or conflict zones could be added, too). The United Nations System Document Ontology (UNDO), which "provides a formal representation of UN document basic entities and their relationships" [24], could also be joined and integrated with ontologies like NagO and/or SDGIO.

Various stakeholders and end users can only benefit from a consolidated knowledge source rather than having many very narrow domain ontologies. Connecting these while complying with standardized principles (e.g. OBO Foundry) should generally be aimed for as best practice.

In summary, NagO acts as a consolidated source of knowledge for various stakeholders and also gives this standardized framework around the Nagoya Protocol to build on and to be expanded into other domains, too.

NagO is a proof-of-principle ontology to demonstrate that there is a niche for more semantic development in terms of policies, agreements, laws, environmental governance and sovereignty matters. As part of the NagO development it became clear how elaborate and difficult data and knowledge aggregation can be due to the complex political relations being documented in a great number of different archives and databases. This work shows that there is a clear need for more in-depth research on this topic as an effort towards FAIR data and especially interoperable, sustainable knowledge.

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9. APPENDIX

Overview of search keys used (Ontobee, GEMET, UNBIS, OECD, Wikidata, Biodiversity a-z):

External territory, Overseas territory, dependent territory, first-order administrative region, country, document, legal document, protocol, Nagoya protocol, conflict, territorial dispute, disputed area, debated area, conflict zone, ABSCH, Access and benefit-sharing clearing house, Clearing House, responsible for, governed by, authority, signed by, signatory, located in, is subject of, administered by, governing, commissioning, claimed by, issued by, executing, legal protocol, official signatory process, national administrative process, ministerial department, governing process, commissioning process, Foreign&Commonwealth Office,