A network analysis of UK environmental charities and their trustees

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Abstract. Understanding networks of organisations and individuals is paramount to comprehend how resources, funds, and information may flow between actors. This is particularly important in climate change discourse in the entanglement of politics, economics, science and society. The voluntary sector in the UK gains little attention in this conversation, but this study begins to investigate the capacity of environmental charities and their trustees as important actors in promoting positive change through computational network analysis. Most environmental charities were found to be isolated with self-contained trustees, but some regional and social communities were identified amongst those with relations. Furthermore, the public and private sectors proved to be salient as trustees in the forms of local government district councils and limited companies. Increased connectivity and some key actors were found by introducing non-environmental charities into the study, consolidating the need to treat the system as a whole with an appreciation for the complexity of societal structures.

Keywords: environmental charities, network analysis, climate change

1 Introduction

Climate change is one of the most pressing and pervasive issues humankind has faced. It is an intrinsically complex problem that is sending reverberations through many entrenched structures of our globalised world [1]. Due to the increasing inter-connectivity of these systems, it is difficult to dis-entangle the fields that sit within these webs, which include science, society, politics, and economics, as they all affect one another. Networks of organisations and individuals from these overlapping domains can create channels between actors that may allow for the flow of resources and funds, and the dissemination of information [2][3]. As a result, connectivity may be considered synonymous with the power held by these bodies. Within the political and economic spheres, such actors have the capacity to influence public perceptions of climate change by means of promulgating their agendas through their ties to society [2][3]. This is important to understand in terms of the mobilisation of individuals to take action either in favour of, or against, adaptation and mitigation policies, especially in social media conversations [4] and in electoral voting [5].

When it comes to the UK's effort in tackling the climate crisis, the discourse tends to be focused on the public and private sectors: the roles they play and the changes they can make. However, in a time where people are looking for ways to do their part and help out, more and more are turning towards philanthropy [6]. This ranges from billionaires setting up or funding large-scale charities, to village community groups participating in local, small-scale conservation projects.

Previous work in this field has been produced looking at the interaction of US corporate businesses with think tanks, public relations firms, trade associations and *ad hoc* groups, in order to investigate the spread of contrarian views on climate change [2][3]. In the UK, a study was performed in Greater Manchester investigating the communications and collaborations between stakeholders in the public, private, and third sector [7]. Inspired by these studies, this research shifted the conversation in the UK to the voluntary sector, and begins a discussion on the capacity of environmental charities and their trustees as key actors in promoting positive change for the climate. A general overview of the UK charitable sector was constructed at the start of this study, as part of a content analysis of available data, to identify the types of charities that exist, what they do and who they help. Then, the scope of research focused on how environmental charities interact with one another through applied network analysis, before an attempt was made to situate them as a part of the larger whole to answer how change may be best introduced to this system and where.

2 Methods and Materials

All data used throughout this study was procured from the UK Charity Commission data download service, which provides files of various information about charities both registered and removed from the Central Register of Charities in England and Wales [8]. The variables utilised from four of the files were: registered charity number, charity name, linked charity number, registration status, trustee ID, and trustee name. Classification codes were also used to discern what the charities do, how they operate, and who they aim to help. In all of the available files, registered charity number was the only constant variable and was therefore used as the thread to tie all of the data together across sets. From the register, 338,246 unique charity numbers were identified; 170,763 of which were existing at the time of extraction while 167,483 had been removed and thus not included in this study. Out of all existing charities, 170,419 had a description of what they did, and 19,081 of those claimed their purpose as 'environment/conservation/heritage'. 19,060 of these had available data on their trustees. The final table collated from the wrangled data included the charity number and name, the charity's trustees' names and their IDs, and the what, how, and who of the charity aims. In instances where charities had multiple subsidiaries, all with the same registration number, only the main parent charity name was used by using linked charity number.

To perform network analysis, Gephi 0.9.2 was used: an open source software for exploring and manipulating networks, as well as the python package

NetworkX [9]. The required inputs were a nodes and an edges list; the latter defined all connections between pairs of nodes, ascribed by some commonality. Connections investigated in this study include shared causes of charities; pairs of who-how codes; ties between charities based on common trustees; and ties between trustees based on common charities. In each of these cases, the networks were un-directed. Layouts utilised included the Event Graph Layout (authored by Spekkink, W.) for bipartite graphs, and ForceAtlas2 [10]. The latter is force-directed, approximating node repulsion with Barnes-Hut calculations. Many standard variables were extracted from the networks to gauge general ideas of connectedness, such as average degree and the ratio of nodes to edges, as well as the number of connected components [11]. Various centrality metrics were also calculated to discern the relative influence of actors within the network and identify the most important. Betweenness centrality was found to measure how often a node appeared on shortest paths between nodes, and eigenvector centrality was used to quantify the importance of nodes from connections and on a high-score, low-score basis [12].

3 Results

3.1 Overview of charitable sector

In the register of existing UK charities, 17 purposes were defined. The charitable cause of 'environment/conservation/heritage' ranked as the 10th most common, with the label assigned to just over 11% of charities. The average number of causes claimed by a charity was 2.5, which inferred that charities could claim multiple purposes and operate in different domains of the sector. Of the 19,081 environmental charities, 2,377 were registered as exclusively for 'environment/conservation/heritage'. Meanwhile, the rest experienced varying levels of overlap with the other 16 charitable purposes which was built as a network. In terms of weighted degree, 'environment/conservation/heritage' ranked as the 10th most connected cause, suggesting that its connectivity with other purposes was reasonably aligned with its size. The greatest connections to these charities were seen with education/training, arts/culture/heritage/science, and general charitable purposes; each with 12,244, 8,281, and 6,737 ties, respectively. The weakest overlaps were with the armed forces/emergency services, human rights/racial or religious harmony/equality, and accommodation/housing; with 301, 1,093, and 1,166 ties. This gave a strong indication of the interconnectedness of the voluntary sector, as the network of charitable purposes was saturated with all possible edges between purposes. It situated environmental charities in the middle of the domain, and the following work looks at who and how these charities help.

3.2 The 'who' and 'how' of environmental charities

From investigating groups of interest for charities and their forms of relief, the most targeted groups that environmental charities helped were the general public, children/young people, and other charities or voluntary bodies. The most

common three actions taken to support these people were the provision of buildings/facilities/open space, advocacy/advice/information, and other services. In the 'who-how' network, Figure 1, all groups of people and all forms of aid were connected to each other directly, demonstrating a complete overlap.

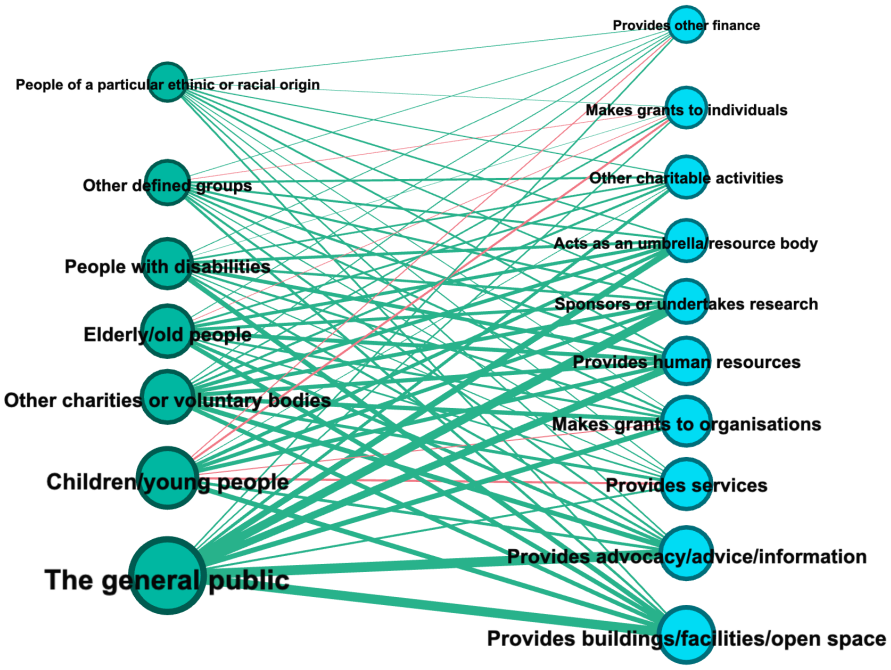

Fig. 1. A who (left) - how (right) network for environmental charities, which identifies links between the target audiences for charitable actions and the type of actions being performed. The size of each node indicates the number of charities ascribed to that aid/group. Meanwhile, the colour of the edges indicate whether the weight of connection is greater than (green) or less than (red) the baseline average from all charities, and the thickness of each edge is related to the magnitude of difference from this baseline.

The five most common ties in the network for environmental charities were between the general public and children/young people, and the top three forms of aid. For all other groups of people, these actions were also the most significant, with the exception of other charities and organisations which received most of their help, naturally, through grants made to organisations. When compared to the who-how connections from all charities (seen in the edges of Figure 1), environmental charities appeared to focus more on the general public through increased means of providing advocacy, advice and information; buildings, facilities and open space; and by sponsoring or undertaking research. On the other

hand, they proved less concerned with providing various grants or finances to children/young people than the charity-wide average.

3.3 Identifying structures in the voluntary sector

The first attempt at identifying structures of environmental charities was done by looking at a network of their trustees, and seeing if they were affiliated with more than one organisation and making ties from them. This produced 110,533 nodes, each a trustee, and 430,736 edges, giving an average degree of 7.79 and 15,938 total connected components. Roughly 5% of all trustees were found in the top 13 largest of these components, but the greatest of which contained only 1.43% of total trustees. This showed an overall lack of connectivity, but demonstrated some clear signs of small groups and structure. Eigenvector centrality was calculated in order to discern the most important actors, and this identified hubs of trustees where those coming out on top were all members of agricultural associations: Devon County Agricultural Association (DCAA), Royal Cornwall Agricultural Association, and Wales Federation of Young Farmers, respectively. These were charities with relatively big numbers of trustees; DCAA had the most with 88. Community detection was performed and an example of regional structure was found in a cluster that contained DCAA. This community was made of 237 trustees to 17 different charities, 10 of which were based in the South West dedicated to causes such as sheep breeding, historic building preservation, agriculture, landscape conservation, and local parish needs.

The next network constructed used environmental charities as nodes instead of edges, and made connections from shared trustees between them. A significantly smaller ratio of nodes to edges was formed from this data. This network had an overall average degree of 0.415. Only 24.07% of charities showed at least one link to another, and this sample population gave only a slightly higher average degree of 1.726. As aforementioned, metrics of actor importance were calculated with eigenvector centrality. The top 15 actors existed in the same component and were bound by the common trustee of Ludlow Trust Company Ltd, though exhibited no regional connection. However, the clusters with the second and third highest eigencentrality values were tied by local government district councils, Tandridge and Reigate & Banstead Borough, both in east Surrey. The fourth highest was then another limited company, (The) Cowdray Trust Ltd.

To further this network and reflect the inter-connectedness of the sector, as revealed in Section 3.1 through the overlap of charitable purposes, a once-removed data set was created; non-environmental charities were included if they had a trustee involved in environmental causes. This created a network where the greatest component contained 18.63% of the charities in the system: much more connected than when focused solely on environmental charities. Subsequently, this inspired the expansion of this network to include all non-environmental charities that shared either a direct or indirect connection to an environmental one. The largest connected component in this network contained 36,841 charities total (21.6% of all registered charities with available data on what they do),

where 14% were environmental and 86% non-environmental. Using NetworkX, the shortest paths were calculated from non-environmental charities to environmental ones. Figure 2 shows how more charities were included with every 'hop' from environmental nodes and the break down of their charitable purposes.

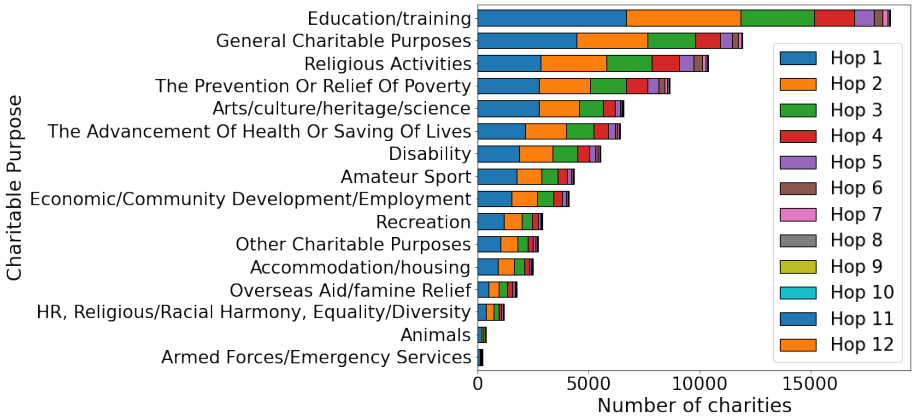

Fig. 2. A bar chart showing the types of non-environmental charities connected to environmental ones in a giant, connected component, and how many of each charitable purpose is added to the network with every 'hop' removed from environmental nodes.

The most significant increase of charities to the network was in the first 'hop', and by the sixth 99% of all charities in this 'n hop' network were added. Meanwhile, the most introduced charitable purposes were education/training, general charitable purposes, religious activities, the prevention or relief of poverty, and arts/culture/heritage/science. Figure 3 shows how the breakdown of charitable purposes in the giant component of the 'n hop' network compared with all charities and solely environmental charities. On average, the breakdown of charitable purposes across all charities and within the 'n hop' network were broadly the same, whilst environmental charities diverged from the expected composition of causes with more significance on arts/culture/heritage/science, amateur sport, and economic/community development/employment.

From the giant component of the 'n hop' network, betweenness centrality was calculated to identify the top actors that acted as 'bridges' between charities, which was dis-aggregated by charitable purpose, as in Figure 4. In conjunction with Figure 3, this revealed that despite religious activities not being particularly prevalent in environmental charities, they were over-represented in the 'n hop' network compared to the charity-wide average, and became the most influential charities, followed by those focusing on HR, religious/racial harmony, equality/diversity; environment/conversation/heritage; arts/culture/heritage/science; and education/training. From the raw values of betweenness, the top 1% (roughly 368 charities) of centrality scores were 60% charities claiming religious activities

as one of their purposes. The top three of these were The Methodist Church

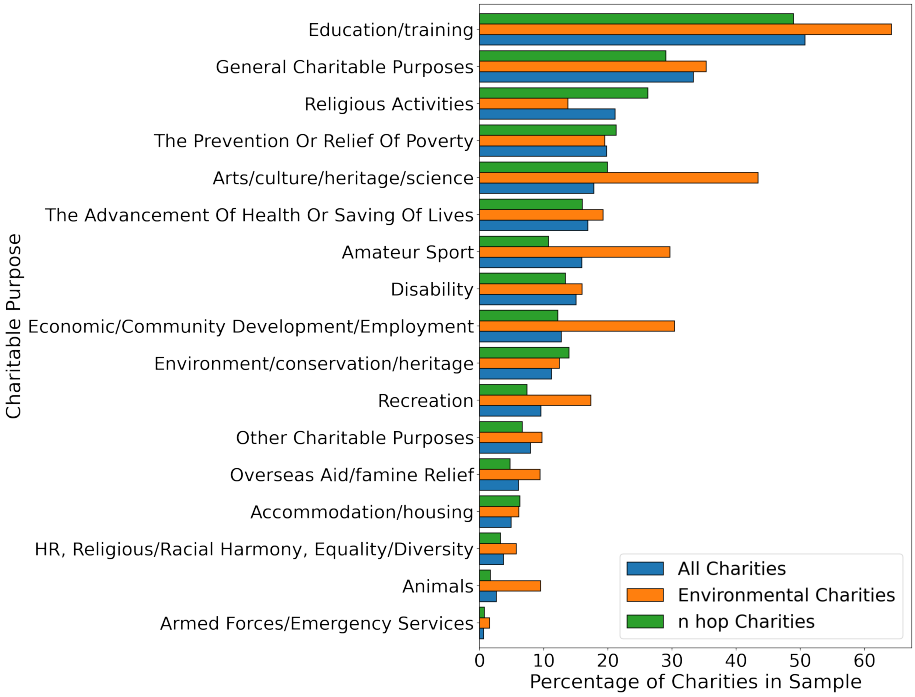

Fig. 3. Comparisons of the breakdown of charitable purposes in three samples of charities: all charities, environmental charities, and those in the 'n hop' network's giant component

in Great Britain, the London Diocesan Fund, and the Church Commissioners for England, all of which helped the general public by varying means. At the same time, the top 1% of environmental charities (51 charities) by betweenness were, again, largely populated by charities concerned with the conservation and heritage of religious buildings or organisations. However, some notable environmental charities were present including Canal & River Trust, the Devon County Agricultural Association, the National Trust for Places of Historic Interest or Natural Beauty, the Royal Cornwall Agricultural Association, and the Chichester Harbour Trust. These charities predominantly work for the general public, but the Devon County Agricultural Association also focuses on children/young people and other defined groups. Furthermore, the work of these charities is mostly through the provision of building/facilities/open space, with the Canal & River Trust also providing advocacy/advice/information.

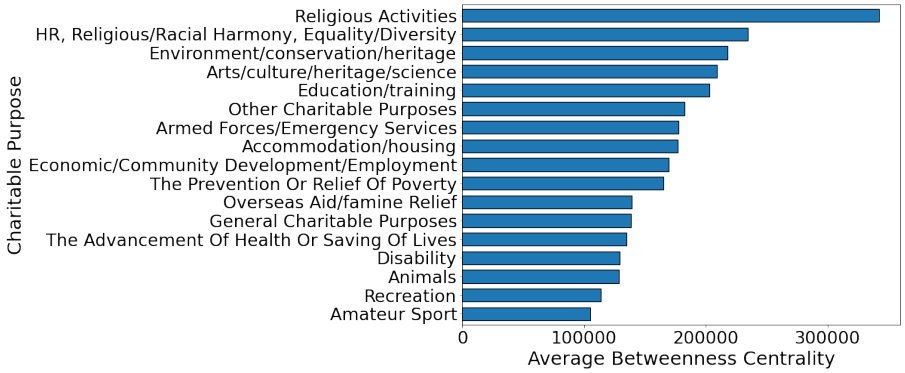

Fig. 4. Betweenness centrality of all charities in the 'n hop' network, dis-aggregated by charitable purpose through averaging the values. This shows which charitable purposes have the ability to influence the network flow more than others, with religious activities as the most influential and amateur sport as the least.

4 Discussion

In the UK voluntary sector, looking at a self-contained view of environmental charities, the majority of them (75.93%) were isolated with a unique collection of trustees. Of the trustees that did show an affiliation with multiple charities, and thus created ties between them, the overlap was relatively small and the whole system was, therefore, not very well connected. However, some examples of social structures were identified as salience was attributed to charities with lots of trustees (particularly agricultural associations), local government district councils, and private limited companies, through centrality metrics. The first two naturally produced some regional clusters, with Devon County Agricultural Association being a part of a larger connection of South West charities, and local government district councils being particularly prevalent in their neighbourhood areas' voluntary sector. These findings alluded to relatively few groups of people with a disproportionate capacity to influence charitable actions on the small-scale, and identified groups that could be key players for promulgating change within environmental charities. The study of who and how charities help revealed that the most targeted group were the general public through providing buildings/facilities/open spaces, advocacy/advice/information, and services, suggesting that this would be the way to start introducing such change.

The presence of governmental bodies and private limited companies was significantly noteworthy when considered in conjunction with the final 'n hop' network, which included all non-environmental charities linked to environmental ones, and produced a giant, connected component that hosted 21% of all registered charities. Conclusively, this conveyed the limitations of studying environmental charities in isolation; it is harder to understand an entire system when focusing on a small cog in a much larger mechanism. From this 'n hop' net-

work, charities working on religious activities proved particularly pervasive by being over-represented in comparison to the charity-wide baseline, and furthermore, they were identified as the most influential purpose overall by centrality metrics. This was despite being only the third most common in the network. Additionally, they were dominant in the list of top environmental actors with their inclusion, most likely, being a relic of the broad charitable purpose title of 'environment/conservation/heritage'. This feature may also support the increased influence of HR, religious/racial harmony equality/diversity charities found in Figure 4, due to its overlap with religion, and the heightened representation of arts/culture/heritage/science within environmental/conservation/heritage charities through heritage links.

This project has produced fertile ground for a lot of work in this field of study, and one of the first issues to be addressed would be these broad categories of what charities do. In particular, the labelling of environmental charities should be more concise for this study that was focused on climate change. Consequently, it cannot be strongly concluded from this work that charities working on religious activities would necessarily be the best to prioritise when hoping to introduce positive change, in regards to the environment, within the voluntary sector. Readdressing the taxonomy of charities could be achieved by employing natural language processing and the written governing documents that are available from the Charity Commission, which all charities have to produce to state their aims. With an improved categorisation of charities, a more robust network could be produced and the network flow could be studied. In particular, the movement of funds throughout the network could be enlightening given the government's entanglement with charities through grants and contracts, and how this may relate to the work they do and their centrality metrics.

In addition, the efforts to identify social and regional structures could be extended into the 'n hop' network, and done more rigorously. The Charity Commission data download service provides regional information that could allow for investigations into the geographical operations of charities in relation to areas significantly at risk to the effects of climate change; focusing on vulnerable communities and those likely to experience exacerbated inequalities on the basis of race, gender, socio-economic status, and sexual orientation. [13] [14] [15].

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