Making the Circular Economy Online: A Hyperlink Analysis of the Articulation of Nutrient Recycling in Finland

Author details

Niko Humalisto (corresponding author)
University of Eastern Finland
Department of History and Geography
niko.humalisto@uef.fi
ORCID ID: https://orcid.org/0000-0002-7803-1208

Maria Åkerman
VTT Technical Research Centre of Finland
Research unit: Ethics and responsibility of innovations
maria.akerman@vtt.fi
ORCID ID: https://orcid.org/0000-0001-6895-3375

Helena Valve
Finnish Environment Institute
Environmental Policy Centre
helena.valve@ymparisto.fi
ORCID ID: https://orcid.org/0000-0002-1484-4568

Word count

8190 (including list of references)

Funding details

This work was supported by the Academy of Finland under Grants 286368 and 287972

Disclose statement

No financial interest or benefit that has arisen from the direct applications of our research

Abstract

The circular economy (CE) is currently generating considerable expectations. However, although the concept describes an aspired future, it does not provide clear guidance for policy-making. As policy outcomes often rest on initiatives and investments generated in a bottom-up fashion, our attention must be directed to the processes that make policies accessible and interesting to those who might take the initiative; given the importance of online publicity, digital methods are needed to scrutinize how the CE is articulated on the World Wide Web. Here we develop this agenda by presenting findings from a hyperlink analysis of a government funding call for nutrient recycling in Finland. We show how multiple versions of the policy topic unfold online, as emergent hyperlink clusters prioritize specific agents, material circuits, and policy visions over others. Despite the apparent openness of the funding call, selective linking practices create self-reinforcing administrative and sectoral silos. The topic consequently becomes connected with activities and agendas to create path dependencies, to strengthen existing divisions rather than advocate change, and to consolidate the power of dominant actors. As a consequence, we argue that CE policy design must also recognize the way policy is shaped through online publicity creation.

Key words: circular economy; policy articulation; digital methods; hyperlink analysis; nutrient recycling

In 2015, the EU launched an action plan for a circular economy (European Commission 2015). This plan set targets for a shift from a 'take-make-dispose' economic model to one within which waste flows are eliminated by shared and extended use of products, as well as efficient recycling and recovery of materials. The basic idea of a circular economy is to decouple economic growth from the increasing use of natural resources and negative environmental impacts, and has a long history in environmental economic thinking and industrial ecology (Ghisellini *et al.* 2016). However, the CE agenda tends to describe an aspired future state rather than provide clear guidance for the policy choices made today (Gregson *et al.* 2015, Hobson 2016). As such, the openness of the concept has made it a useful communicative and expectations-creating device for environmental policy-making (Lazarevic and Valve 2017), to the extent that actors with conflicting interests can support this seemingly uncontroversial concept.

This openness has raised three kinds of responses in the academic literature. First, researchers have discussed the different conceptualizations and models of CE, with the aim of increasing the coherence of the concept (e.g. Ghisellini *et al*. 2016, Kirchherr *et al*. 2017). Second, frameworks and models have been developed for identifying optimal CE solutions for different sectors and spatial scales (e.g. Korhonen *et al*. 2018, Reike *et al*. 2018). Finally, several studies approach the CE as a fundamentally political issue, emphasizing that the CE opens up normative choices related to policy goals and instruments (Lazarevic and Valve 2017, Fitch-Roy *et al*. 2019, Niskanen *et al*. 2020). These choices further affect the evolution of business models, technologies, and modes of material organization (Levänen *et al*. 2018, Lazarevic and Valve, 2020). In this perspective, research seeks to analyze the actualization of CE policies and principles at different levels (Gregson *et al*. 2015).

These studies suggest that the expectations raised by CE policy declarations should be regarded with caution: the CE policy portfolio adopted by the EU builds on objectives and approaches that differ little from those established already decades ago. Alas, policy-making has become path-dependent and self-reinforcing, implying that there is little room for radical alterations (Fitch-Roy *et al*. 2019). Likewise, when attention is shifted to specific economic activities, it becomes apparent that material reorganization may not reach beyond the 'low-hanging fruits' that are easy to implement and economize (Lazarevic and Valve 2020).

Whilst there is arguably a demand for additional analysis focusing on how CE principles translate to policies and further to practices and business modes, we argue here that more needs to be known specifically about the ways in which top-down, yet loosely defined, CE policies and specific bottom-up economic activities end up as mutually constitutive. Asking this question is important because in the EU CE policy, considerable emphasis is put on open-ended funding schemes aiming to boost CE innovation. At the same time, the institutional and even material changes co-evolving with CE transformation remain unspecified. As a result, the policy outcomes rest in many ways on the initiatives generated in a bottom-up fashion (Fitch-Roy *et al*. 2019). This directs attention to the processes that seek to make the policies public, accessible and interesting to those who might take the bottom-up initiatives. In the processes of publicity creation, it may also be in the interest of some actors to narrow down the openness of CE definition and to indicate that they, or their stakeholders, are the right target for the funding allocations.

In order to create currently lacking understanding about the politics of open-ended CE policies, we examine the political character of CE publicity creation through a specific case: the advancement of nutrient circular economy in Finland. Within the EU, nutrient recycling has been raised as one of the key components of the CE (European Commission 2015). Global concerns over the steady supply of phosphorus have created pressure to support its recycling; the call is for the substitution of mineral fertilizers made from virgin raw materials with recycled fertilizer products. According to the European Commission, a shift to organic fertilizers could also help sustain healthy soils and improve the energy efficiency of agriculture (European Commission 2013, EIP-Agri 2017). Since the promotion of nutrient recycling in Finland faces challenges that are common across the EU, the findings from the Finnish case study can provide lessons that have wider relevance for CE policy-making.

Since 2010, Finland has sought to become ‘a model country in nutrient recycling’. In 2015, recognizing the modest achievements reached thus far, a governmental program (Finland, a Land of Solutions 2015, p. 25) was launched which promised to significantly speed up progress. The government envisioned a radical, but collectively beneficial change: according to the government program, at least 50% of manure and community wastewater sludge should be treated by advanced processes by 2025 (Finland, a Land of Solutions 2015, p. 25). To meet these targets, the government placed its trust in the mobilization of actors to innovate and experiment with CE solutions. This policy has close resemblance to the EU circular economy package: in both cases, considerable funding commitments to boost research and innovation play a significant role, whereas changes in legislation or in economic incentive structures have been modest (Fitch-Roy *et al*. 2019).

The Finnish policy model relies heavily on funding calls to generate publicity; as a result, policy promotion and actor mobilization occur increasingly through online digital media (e.g. Hestres 2015, Elgin, 2016, Marres 2017). In the case studied here, the government invited actors from across society to develop pilot and demonstration projects to enhance nutrient recycling (Prime Minister's Office 2016, p. 70–71). Accordingly, we undertake a textual and visual analysis of the Finnish government's web pages for nutrient recycling initiatives to study how this process takes place online, focusing particularly on the effect of hyperlinks, in order to better understand how such calls work to promote some visions of the CE over other potential visions.

Hyperlinks are a technical feature through which content producers create passages from one web page to another. In addition, hyperlinks serve articulating functions as communicative and strategic inscriptions that allocate attention on the web (Rogers and Marres 2000). In other words, hyperlinking enables a policy to become more articulated and provided with specifying characteristics (Latour 2004, Valve and McNally 2013). Therefore, through mapping the formations that have been created through the selective act of hyperlinking on the web, we can specify how, and in relation to which actors and activities, nutrient recycling policy gains publicity at a particular moment and becomes defined in policy terms.

We argue that exploring the web through hyperlink mapping and digital content analysis enables critical engagement with publicity creation. The first advantage is obvious: a digital analysis allows researchers to examine the publicity creation of a CE policy initiative without making strong presumptions regarding the actors or activities relevant for the process. Digital mapping also provides a view that is independent of the accounts given by individual actors. Furthermore, digital mapping serves the purpose of unfolding the underlying, although not openly controversial, tensions between different, mutually exclusive versions of the CE (Lazarevic and Valve 2020).

Hyperlink analysis has been deployed in examining open controversies (e.g. Eklöf and Mager 2013; Munk 2014), but we claim here that it can also usefully support the investigation of latent tensions that co-evolve with the articulation of an open-ended policy topic. The uneven distribution of hyperlinks creates differentiated online topologies (Marres 2012). Here, emergent *hyperlink clusters* indicate how the nutrient recycling initiative gains publicity, but simultaneously also more specific content, through selective linking practices. Thanks to hyperlinking, the policy topic becomes more articulated (Latour 2004; Valve and McNally 2013). We examine the common characteristics of the different hyperlink clusters, and which biomass types gain the most attention, enabling us to reach a better understanding of the tensions between different articulations which co-evolve with publicity creation.

In what follows we present the study's methodological background, before showing how hyperlinking has created connectedness – as well as disconnectedness – between nutrient recycling-related web pages in Finland, and discussing how this process allocates attention to specific materials and biomass types.

Hyperlink Analysis: Mapping the Terrain 'From Within'

In order to investigate the online articulation of CE policy, we first need an understanding of the World Wide Web as a site for governance and policy communication. The Web acts as an open-ended environment in which the state can practice governance and advocate policies (De Maeyer 2012, Elgin 2015). Furthermore, it enables direct and reciprocal communication between state institutions, research organizations, businesses, and the general public (McNutt 2008), and offers space for policy deliberation (Martin and Rice 2014) and articulation of critique (Rogers and Marres 2000).

The Web is a network topology composed of individual nodes (websites) and directed links (hyperlinks) between those nodes (Kleinberg 1999). It is a networked, but nonetheless uneven landscape, because hyperlinking is a selective action: some pages become more hyperlinked than others (Badouard and Monnoyer-Smith 2013). This unevenness has concrete consequences: hyperlinks affect the popularity of websites because search engines that guide web users rank hyperlink-receiving web pages higher in their search results. What follows is a 'rich get richer' dynamic, increasing the user traffic for highly ranked sites and thus strengthening the significance of evolving nodes (McNutt and Pal 2011, p. 450).

Hyperlinks create differentiating patterns of attention within the Web (Helmond 2013). They indicate recognition. For example, policy officers and communications experts who produce content for policy websites select other pages as relevant by linking to them (Schulman 2008, Marres 2017). Hyperlinking is thus a way to enroll relevant websites in policy-making and to mobilize positive examples to motivate action (Yi and Scholz 2016). Conversely, private companies or civil society organizations can hyperlink to governmental pages in order to indicate their connectedness to the policy agenda (Badouard and Monnoyer-Smith 2013).

The analysis of hyperlinking and its outcomes therefore provides us with complex empirical tasks. We seek to map and examine connection-making as it co-evolves with the web environment. There is thus little solid ground under our feet. The situation is reminiscent of an expedition into unknown terrain. Few landmarks to guide mapping pre-exist, but they need to be found along the way.

The hyperlink clusters can be identified with the aid of hyperlink analysis tools. Nonetheless, it is impossible to study hyperlinking from the outside without 'going into' the web. Nothing similar to aerial or satellite images can be produced from this landscape. By using the computational hyperlink analysis tools, the researcher becomes entangled within the landscape they are mapping just as, for example, anthropologists become entangled with the cultures they are investigating (Marres 2004). Moreover, this entanglement is not mediated solely by the digital methods in use: it is not enough to put methods into use and wait for the results. Analyzability requires that the analyst actively directs and tailors the methods to fit to the landscape that unfolds.

In our study, hyperlink analysis was not a straightforward choice to investigate the online articulation of nutrient recycling policy. The Web is not the same as it was in the early 2000s, when the first software for hyperlink analysis began to emerge. Due to the platformization of the Web, the Internet is accessed most often through mobile phone applications and different gated (social media) platforms such as Facebook or Twitter, where content is distributed through sharing particular perma-links instead of homesites with specific 'links' pages (Helmond 2015, Hendriks *et al*. 2016). Consequently, researchers have recently turned their attention to activities such as 'liking', 'following' or 'retweeting' (Ooghe-Tabanou *et al*. 2018). When designing our methodology, we also examined how nutrient recycling agendas were distributed across social media. It turned out that in early 2017, there were only a handful of actors disseminating nutrient recycling content through Facebook or Instagram; moreover, it was more or less the same narrow set of actors tweeting under the hashtags signifying nutrient recycling agenda. Thus, we abandoned the idea of exploring policy articulation through social media and subsequently turned our attention to the Web.

We also considered was the quality and interpretation of the data produced by digital tools. Hyperlink analysis benefits from researchers being familiar with the topic in order to guide the curation of quantitative data (De Maeyer 2012). Our hyperlink analysis is part of a four-year research project on nutrient recycling policies in Finland.[1] The project had introduced us to the governance framework and the key actors. In order to strengthen the analysis of policy articulation, we also needed a tool for sorting out the qualitative content of web pages. For this purpose we chose Google Scraper, which has also previously been applied along with hyperlink analysis (Munk 2014).

Finally, despite our efforts towards careful research design, some challenges linked to the interpretation of the hyperlink formations remained. The hyperlink clusters that emerge are not direct outcomes of nutrient recycling-specific hyperlinking; nutrient recycling is promoted through web pages that predate the governmental program. Likewise, some of the hyperlink connections may not have been initiated by the program. However, these uncertainties do not alter the fact that hyperlink clusters are shaped by government intervention and the promotional activities it initiated. Our mapping unfolds the features of this historically constructed landscape as they were in February 2017.

Figure 1 summarizes the key phases of our analysis. It identifies the specific tasks and accompanying methods that enable us to identify the landscape features (hyperlink clusters) we set out to search (points 4 and 5 in the figure). The figure also provides an idea about the findings, featuring sketches of the hyperlink clusters that the analysis enabled us to differentiate. The following sections describe the journey in more detail, presenting the findings along with the 'travelogue'. In a digital analysis such as ours, data collection and analysis cannot be separated: 'the process of data collection structures the data analysis' (Marres 2017, p. 94). Our findings tell about hyperlink connections emerging after the launch of the government initiative on nutrient recycling in April 2016.[2]

Place Fig. 1 somewhere here

Online Promotion of Nutrient Recycling

Like all journeys, our mapping of the nutrient recycling landscape had to start somewhere (see phase 1 in Figure 1). Using a computational hyperlink analysis requires identifying a corpus of web addresses (URLs), but the programs do not define that on behalf of the analyst. Our approach to gathering the corpus began by identifying a point of departure that would be central to the investigated topic as well as sufficiently thematically specific. The justification for having one instead of multiple points of departure was that nutrient recycling did not appear as a contentious issue, and therefore finding opposing sites would not be necessary.[3] The site needed to belong to an actor dedicated to recycling nutrients, and who can influence peer recognition. Thus, the web pages of governmental departments, which have multiple priorities in addition to recycling nutrients, make poor candidates.

After making initial queries through search engines, our expedition was set to depart from the homepage of a company called *Biovakka*. Their site met the pre-set criteria: the company is a biogas producer that is well known for its pioneering work in nutrient recycling.[4] Moreover, the site sent hyperlinks to policies, business cooperatives, research and other sites having relevance in recycling nutrients.

Our manner of gathering the corpus resembled the snowball sampling technique used in choosing interviewees in ethnographic fieldwork (phase 2 in Figure 1). We used the hyperlinks sent by Biovakka as suggestions about where to proceed on the web. We continued following the hyperlinks sent by the suggested sites. While exploring the links, we wrote down the URLs of the sites we visited and made observations about the recyclable materials that were referenced there, to be used in the later phase of our analysis. The manual mapping of these paths continued until the point of saturation, meaning that the path had turned into a network of web pages that were directing hyperlinks to each other. After gathering 56 URL coordinates, we had a solid network of pages relevant to the online articulation of recycling nutrients.

From the identified corpus of web pages, we sent off an 'electronic spider' called Hyphe (see phase 3 in Figure 1).[5] The spider crawled through the hyperlinks sent from the web pages of the selected corpus, enabling us to transform the hyperlinked paths into a co-linked network of web pages. This type of crawling rapidly amasses large numbers of hyperlinked websites for further analysis, but curating this corpus – to decide which sites to include and exclude – is a slow qualitative task necessitating iteration (De Maeyer 2012, Ooghe-Tabanou *et al*. 2018).[6] *Inter alia*, we decided to exclude search engines and the homepages of Web and graphic designers, as they did not display any agencies related to nutrient recycling; further, based on the pre-charting of the on-line environments of nutrient recycling, we did not include the generic references to social media platforms, but did include the specified sites, such as a Facebook group dedicated to the topic. As a result, the power of the platforms or search engines as the mediators of relations in the Web is not illustrated in the data.

Thanks to Hyphe and our curation on two rounds of crawls, we extracted 593 web pages and 912 links between them for further analysis. The interlinked pages consisted of heterogeneous actors and activities, varying from governmental websites to the homepages of different kinds of companies, research institutes, pilot projects, blogs, news articles and discussion forums. To increase the validity, we cross-checked our data set by making queries through search engines and social media platforms in order to determine whether there were relevant sites that were not found through our web exploration methods. After concluding that we had not missed any critical pages, we felt confident in moving forward. However, although the data about the sites and landscape connections were now available, the picture remained messy (see the image of phase 3 in Figure 1).

Fragmented Connectedness: Old Agendas and Emergent Patterns

Figure 2 presents the 'end product' of our hyperlink analysis. The clusters of web pages are marked with distinct colors and labeled based on our qualitative interpretations of the perspectives from which they articulate nutrient recycling. The layout of the figure was co-produced with *Gephi* (see phase 4 in Figure 1), a software that allows online explorers to visualize the forms of connectedness that have been extracted from the Web (Bastian *et al*. 2009, Munk 2014).[7] In the figure, a node is the symbol of a website and an arrow between two nodes indicates a hyperlink association between them; the size of a node is indicative of the total number of hyperlinks sent and received, enabling us to represent the most referenced and the most actively hyperlinking hubs.[8]

Place Figure 2 somewhere here

Figure 2 distinguishes five hyperlink clusters that differ in terms of their constituent web pages and hyperlink-created relations. The emerging patterns raise questions about the characteristics of the clusters and the organizations and activities they bring together. In other words, if the clusters of web pages are outcomes of selective hyperlinking and articulating logic, what is the underlying logic that brings the web pages together and makes one cluster different from another? We examined this logic on the basis of the notes we made about the contents of the websites that have the key roles in assembling the hyperlinked cluster.

In some cases, the logic appears quite apparent. The most visible network, located at the bottom of the figure in green, is *bioeconomy agenda*, and is structured by one giant node (the large size of this node is based on the active hyperlinking). The node refers to a website that also has an English version: www.bioeconomy.fi. The page belongs to the Finnish government's promotional website that is maintained by three Finnish ministries: Agriculture and Forestry; Economic Affairs and Employment; and Environment. As stated on the website, the rationale is to present 'Bioeconomy in Finland: cases, contacts, national strategy'. Therefore, we concluded that the site was designed to promote the realization of the national bioeconomy strategy, which also includes nutrient recycling.[9]

When following the trails of the hyperlinks that were sent from the bioeconomy site, we realized that the site was performing the tasks it had been designed to do. It created visibility for bioeconomy as a policy topic and, for businesses that claim to contribute to the development of bioeconomy and deconstruction of the fossil fuel economy. However, the hyperlinks sent from the web page also do more unexpected things: nutrient recycling becomes attached to the *bioeconomy agenda*, and in conjunction with this agenda, to Finnish forest and energy industry giants and their interest organizations. These actors are further conjoined with governmental research institutes, such as the VTT Technical Research Centre of Finland. The connectedness of the websites of the industrial corporations and the technical research institute is not surprising, but we did not anticipate that nutrient recycling would become so closely associated with the industry-dominated bioeconomy agenda.

However, this outcome makes obvious sense. Hyperlinking provides capacities to governmental actors (the three Ministries in question), who have already been assigned the task of generating publicity. The use of bioeconomy.fi as the leading communication channel is, from the government's point of view, a cost-effective choice: the site already has structures and moderators up and running. Furthermore, nutrient recycling fits into the broad definition of bioeconomy. Nonetheless, one side-effect of this integrative act is that nutrient recycling receives significant online publicity as a topic that echoes the interests of large forest industry corporations and other industrial actors.

The second cluster, marked in red in Figure 2, gathers around the web pages of the Finnish environmental administration and its funding instruments. These sites gain strength thanks to incoming links; the hyperlinking pages are mostly for research and development projects that acknowledge public support by sending hyperlinks. We name this cluster *environmental administration*; it is brought together by governmental programs that provide funding for research and experimentation related to nutrient recycling. However, the sites providing information about the funded projects have not yet achieved the status of obligatory passage points. It appears that these development and experimentation activities are scattered, and that the web pages of the projects are not significantly interconnected by hyperlinks.

The third cluster, marked in orange in Figure 2, is *rural development*, which brings together web pages of institutions, instruments, and information sharing platforms. The structure of this cluster resembles the environmental administration cluster in the sense that both are characterized by a multi-nodal pattern. The largest nodes located at the furthermost right corner of the image are sites dedicated to the marketing of regional development funds. However, the hyperlinks from these nodes were directed to sites that lacked any specific association with nutrient recycling; furthermore, we soon learned that the clusters named 'environmental administration' and 'rural development' bring together organizations rather than projects, innovations, or knowledge bases. Among those hyperlinked sites there are no companies or non-governmental organizations, merely other public bodies.

In this hyperlink cluster, the websites that gain most attention include those belonging to the Ministry of Agriculture and Forestry. These web pages both receive and make hyperlinks actively. The web pages granting publicity to specific nutrient recycling measures are among the most important points of passage. As such, the dominance of public institutions in the network creates an impression of a hermetic, inter-governmental circulation of attention.

After distinguishing these three visually prominent clusters, we were uncertain how the rest of the network could be differentiated. To continue, we made use of the Gephi clustering algorithm (Blondel *et al*. 2008) to investigate the visually less apparent hyperlink clusters; the algorithm suggested that the three larger nodes in the upper-left corner of Figure 2 can be treated as a single cluster. However, it was still challenging to identify common nominators for the web pages that constitute the cluster marked blue in Figure 2. The hyperlink cluster is scattered; none of the sites has developed into a central assembling node, and the sites were created by both governmental organizations and private sector actors of different scales. Moreover, the sectors in which they operated ranged from energy production to waste water management and soil enhancement.

After several visits to the websites and the sites to which they hyperlink, we had a 'eureka moment': nutrient recycling pilots and experiments were the common denominator of this cluster. The orientation towards operationalization of nutrient recycling suggested that, unlike the previous clusters which had organized around the web pages of established policy sectors and funding instruments, the blue cluster was an emergent outcome of *innovation promotion* initiatives. The largest nodes in the cluster belong to public intermediary organizations (Kivimaa 2014); they directed hyperlinks to websites communicating about manifold pilot projects, the networks of front-runner municipalities of carbon and nutrient neutrality, and start-ups making use of nutrient recycling innovations.

Finally, in the center of Figure 2 we identified a cluster of nodes marked in purple. These nodes gained strength primarily thanks to the incoming hyperlinks sent from different directions, thus indicating that they are important reference points for the other clusters of the network. These most frequently linked web pages belong to Finnish universities and research institutes conducting research on agriculture and natural resource management. Their centrality within the network, therefore, is not a coincidence but rather an outcome of other clusters pointing apparently towards the knowledge base which nutrient recycling can build upon. At the margins of this cluster, we also find the web pages presenting news material from the Finnish Broadcasting Company and other media agencies; the website of the farmers' union is also visible in this hyperlink cluster. Based on the contents of the most linked web pages, we can assume that the pages gain recognition as providers of *expertise and knowledge*.

Different Clusters, Different Materials

The five hyperlink clusters that we distinguished with Gephi indicate that nutrient recycling as a policy topic is articulated through hyperlinking patterns that have become differentiated so that they follow the boundaries of administrative and economic divisions. Some of the hyperlink clusters emerge around the web pages of economic fields (industry) and policy sectors (rural policy), whereas others join the websites and documents that share a similar role or commission (knowledge production). In order to broaden our understanding of whether the identified clusters also differ in terms of materials, we moved to analyze which waste or surplus biomasses the clusters identify as constitutive for nutrient recycling. Based on our previous research (Lazarevic and Valve, 2020), we expected that the hyperlink clusters might also be materially selective, articulating nutrient recycling in terms of specific biomasses.

In order to determine whether the hyperlink clusters differ in terms of the materials that gain publicity, we made use of the online tool GoogleScraper (phase 5 in Figure 1). We queried how often specific words occurred in selected sets of web pages belonging to the identified clusters (Marres and Weltewrede 2013, Munk 2014). While selecting the search terms, we made use of our notes about the contents of web pages during the compilation of the web page corpus (phase

1 in Figure 1). Our query focused on six biomass types: animal manure, household biowaste, agricultural side flows, industrial side flows, sewage sludge, and biogas digestate.[10]

GoogleScraper reported the frequency with which the queried biomass types occurred in the texts on the web pages of the hyperlink clusters; we then examined their shares in relation to each other. The limitation, naturally, was that the frequency of occurrence told us nothing about the *way* in which a biomass is mentioned: GoogleScraper does not recognize qualitative differences in the usage of terms, such as whether a reference is neutral, positive or negative.[11] However, the quantitative approach allowed us to examine the distribution of attention between the recyclable materials in hyperlink clusters.

Table 1 presents the materials that occurred most frequently in the web pages making up the different hyperlink clusters. Although most of the biomass types received references from across the clusters, the table also points to certain differences between them. This fragmentation suggests that online communication is differentiated between materials. The key finding here is that nutrient recycling becomes articulated through some biomass types and their circuits rather than others, based on the different issue networks discussing nutrient recycling.

The table also shows that when a cluster organizes around web pages that provide visibility to a specific economic sector, the materials that gain most visibility are those that the sector generates. In the bioeconomy cluster, industrial biomasses gain most attention, whereas in the rural cluster, manure accounts for over half of all biomass references. In the environmental administration cluster, the material focus is related to specific responsibilities, as e.g. sewage sludge is a much-debated topic with regard to its impacts on environmental health. The results of the content analysis strengthen the credibility of the initial observation made about the activity or sector-based differentiation of hyperlinking patterns.

Place Table 1 somewhere here

Discussion

The circular economy is characterized by what Hajer (2003) refers to as institutional ambiguity. There is no self-evident or predetermined administrative locus for the topic; instead, its promotion calls for cross-sectoral cooperation, and questions the adequacy of existing categorizations. Policy initiatives also open negotiations about the concerns, actors and materials that are critical for CE transformation. The opening processes of publicity creation are essentially political: allocating attention and recognition. This is the case even when the policy topic is not openly contested or politicized (Gregson *et al*. 2015).

Our case study shows how institutional ambiguity becomes diminished on-line. The mapping of the Finnish online landscape illustrates how nutrient recycling as a generic phenomenon gains content online, and differentiates into hyperlink clusters with distinctive approaches to nutrient recycling. The online landscape, identified with the help of digital mapping tools, resembles an uneven physical landscape: some of the clusters, such as the bioeconomy cluster, are more distinct and dominant than the low ‘humps’ shaped by hyperlinks to and from grassroots nutrient recycling experimentations and pilot projects, for example. Between these landscape elements we can find crisscrossing ridges that lead to the websites that provide a joint knowledge base. Of the different formations, the clearly distinguishable clusters point to the most dominant locations through which nutrient recycling becomes articulated online.

The unevenness of the online landscape reflects the different functions that publicity creation and hyperlinking serve. The Finnish Government has used the web to communicate its policy initiatives and provide information about nutrient recycling. This means that the online landscape qualifies as a ‘PR version of things’ (Marres 2004, p. 28). In this landscape, public organizations dominate, even though the original corpus also included sites created by private sector and civil society actors. The websites of public organizations weave together hyperlink clusters. The bioeconomy cluster, which dominates the landscape, is more or less an outcome of online policy dissemination. Meanwhile, knowledge about the funding schemes and their coordination is found on the pages of the environmental administration.

The online landscape appears as a path-dependent outcome of the sector-specific networks and working modes within the government. However, as has been emphasized in previous studies, the emergence of the nutrient circular economy requires changes that go beyond administrative and sectoral divisions (Buckwell and Nadeu 2016, Särkilahti *et al*. 2017, Valve *et al*. 2020). This is also the case with the more general transition towards the CE (Smith *et al*. 2010). Therefore, our finding should be interpreted as a warning about the ways in which administrative and sectoral silos become self-reinforced during the articulation of an open-ended policy initiative that originally sought to act as a cross-cutting program.

Our findings support what has earlier been noted about the significance of institutional lock-ins and path-dependencies in CE policy-making (Stahel 2016, Kuokkanen *et al.* 2017, Fitch-Roy *et al.* 2019). Our approach adds to this debate with by showing how institutional and material coupling occurs on the Web, and how policy articulation that occurs online contributes to the creation of path dependencies. First, new policy incentives are easily communicated through sites that already have an established mediator position and a strong web presence. In the studied case, the open-ended CE policy initiative gained publicity through hyperlinked web pages that attached the initiative to pre-existing policy agendas. This creates an image of nutrient recycling as a theme or component added on the top of existing digital publicity. Second, the 'rich get richer' dynamics of the web environment (Marres 2017) may further strengthen the trajectories through which attention is generated and allocated. The tendency of attention to accumulate should be acknowledged in the design of environmental policy dissemination.

Third, established websites are not neutral platforms, but locations that indicate where, and to whom, the topic belongs and in relation to what other themes, actors, and materials it is to be understood and acted upon. A critical engagement that is sensitive to the materials helped us to unravel the fact that not all waste and surplus materials gain on-line attention with equal intensity. Thus in the studied case, the policy initiative became articulated in terms of materials that are marginal in terms of their nutrient recycling potential. The visibility granted to industrial side-flows and sewage sludge indicates that these materials carry economic and political weight. However, in Finland, manure accounts for 75 per cent of all recyclable phosphorus in the country (Marttinen *et al*. 2018). In the EU, the figure is 70 per cent (Buckwell and Nadeu 2016). Therefore, a large-scale transformation towards a nutrient circular economy cannot be achieved if investments, including research and innovation efforts, focus on industrial side flows and sewage sludge, and bypass manure. Asking 'which wastes are being recovered as resources' (Gregson *et al*. 2015, p. 220) – or which wastes and materials gain on-line attention – is thus important not only because the selective recovery of materials serves some interests more than others, but because the outcome may affect the achievement of the overall policy objective.

Due to similarities which the Finnish policy setting has with the EU-wide policy, our findings also serve attempts to understand the instantiation of the circular economy in the EU. The common emphasis given to funding commitments generates conditions for a political economy in which publicity and attention count as valuable assets in the struggle for funding and investment. While our data enables us to say little about the extent to which the different hyperlink clusters are mutually exclusive, the differentiation encountered here indicates potential tensions. By helping trace how emergent topics become related to existing settings and how path-dependencies are being enacted on-line, hyperlink analysis is a valuable tool not only in making sense of controversies (Munk 2014, Elgin 2015) but also for investigating these kinds of non-politicized, yet political, questions.

Conclusions

The typically open-ended and institutionally ambiguous nature of CE policies implies that policy interventions gain content only after they become specifically linked to actors, institutions, and business domains. In these circumstances, publicity creation becomes part of the policy process. Here we have drawn attention to the political, content-giving role played by CE publicity creation and suggest that the policies are, in part, articulated online. Making use of hyperlink analysis and digital content analysis, we have unraveled how different and partially conflicting, yet easily unrecognized, articulations of the CE evolve in a particular case.

The hyperlink clusters we identified are an outcome of pre-existing digital infrastructures; the logic of the web; and of the choices made by government bodies organizing policy dissemination; civil servants responsible for dissemination in practice; policy intermediaries and private actors.

Given the path-dependent and selective modes in which the clusters allocated attention to different actors and biomasses, the case studied here underlines how difficult it is to generate publicity for a policy initiative advocating radical change through an open call for bottom-up solutions. Although the CE initiative did not name actors or organizations directly as the key contributors, online communication linked – digitally, but still quite concretely – policy to web pages providing visibility for specific actors, activities, materials, and policy domains.

During publicity creation, politics is played out on two levels. First, our findings suggest that CE policies multiply on-line. Although no open contestations exist, more than one version of the couplings critical for the circular nutrient economy emerge on-line. The different articulations are not just supplementary, but point to the prioritization of different actors, activities, and materials. Second, the articulations are not equal in strength or visibility. Our case study indicates that CE policy initiatives can become integrated, and perhaps lost, in pre-existing agendas and debates before they develop on-line trajectories of their own. At the same time, existing sectoral divisions and agendas may gain additional strength. From this it follows that the dimensions which are critical only for a particular initiative among the broad application area of CE policies may gain only marginal visibility. In the studied case of nutrient recycling, manure became sidelined in the hyperlink-mediated articulation. The significance of publicity creation, along with the tendency of on-line attention to accumulate, should be recognized in CE policy-making and dissemination.

Acknowledgements

This work was supported by the Academy of Finland under Grants 286368 and 287972. The authors thank Noortje Marres for providing special opportunities for us to familiarize ourselves with digital methods. We are very grateful to Hanna Oksanen for the visualizations used in the article; and the editor and the reviewers for their helpful comments and guidance.

References

Adam, S., Häussler, T., Schmid-Petri, H. and Reber, U., 2015. Identifying and analyzing hyperlink issue networks. In: G. Vowe, and P. Henn, eds. *Political communication in the online world: Theoretical approaches and research designs*. New York: Routledge, 233–247.

Badouard, R. and Monnoyer-Smith, L., 2013. Hyperlinks as political resources: The European Commission confronted with online activism. *Policy and Internet*, 5 (1), 194–286.

Bastian, M., Heymann, S. and Jacomy, M. 2009. *Gephi: An Open Source Software for Exploring and Manipulating Networks Association for the Advancement of Artificial Intelligence*. https://gephi.org/publications/gephi-bastian-feb09.pdf [accessed 14 Jul 2020]

Blondel, V. D., Guillaume, J. L., Lambiotte, R. and Lefebvre, E., 2008. Fast unfolding of communities in large networks*. Journal of Statistical Mechanics: Theory and Experiment*, 2008 (10), P10008.

Bruns, A., 2007. Methodologies for Mapping the Political Blogosphere: An Exploration Using the Issue Crawler Research Tool. *First Monday* 12 (5), https://journals.uic.edu/ojs/index.php/fm/article/view/1834/1718 [Accessed 14 Jun 2020]

Buckwell, A., Nadeu, E., 2016. *Nutrient Recovery and Reuse (NRR) in European agriculture. A review of the issues, opportunities, and actions*. RISE Foundation, Brussels.

De Maeyer, J., 2012. Towards a hyperlinked society: A critical review of link studies. *New Media and Society*, 15 (5), 737–751.

Eklöf, J. and Mager, A. 2013. Technoscientific Promotion and Biofuel Policy: How the Press and Search Engines Stage the Biofuel Controversy. *Media Culture & Society,* 4 (35), 454–471.

Elgin, D.J., 2015. Utilizing Hyperlink Network Analysis to Examine Climate Change Supporters and Opponents. *Review of Policy Research*, 32 (2), 226–245.

EIP-AGRI, 2017. Focus Group Nutrient Recycling. Final Report, November 2017. https://ec.europa.eu/eip/agriculture/en/publications/eip-agri-focus-group-nutrient-recycling-final [accessed 14 Jun 2020]

European Commission, 2013. Consultative Communication on the Sustainable Use of Phosphorus (COM(2013) 517).

European Commission, 2015. Closing the loop - An EU action plan for the Circular Economy, (COM(2015) 614).

Finland, a Land of Solutions, 2015. Strategic Programme of Prime Minister Juha Sipilä’s Government 29 May 2015. Government Publications 12/2015. https://valtioneuvosto.fi/en/sipila/government-programme [accessed 14 Jun 2020]

Fitch-Roy, O., Benson, D. and Monciardini, D., 2019. Going around in circles? Conceptual recycling, patching and policy layering in the EU circular economy package. *Environmental Politics*, DOI: 10.1080/09644016.2019.1673996

Ghisellini, P., Cialani, C. and Ulgiati, S., 2016. A review on circular economy: The expected transition to a balanced interplay of environmental and economic systems. *Journal of Cleaner Production*, 144, 11–32.

Gregson, N., Crang, M., Fuller, S. and Holmes, H., 2015. Interrogating the circular economy: the moral economy of resource recovery in the EU. *Economy and Society*, 44 (2), 1–26.

Hajer, M., 2003. Policy without polity. Policy analysis and the institutional void. *Policy Sciences*, 36, 175–195.

Hendriks, C. Duus, S. and Ercan S., 2016. Performing politics on social media: The dramaturgy of an environmental controversy on Facebook. *Environmental Politics*, 25 (6), 1102–1125.

Helmond, A., 2013. *The algorithmization of the hyperlink computational culture, a journal of software studies*. http://computationalculture.net/the-algorithmization-of-the-hyperlink/ [accessed January 2020]

Helmond, A., 2015. The Platformization of the Web: Making Web Data Platform Ready. *Social Media + Society* 1, 2, https://doi. org/10.1177/2056305115603080

Hestres, L., 2015. Climate change advocacy online: theories of change, target audiences and online strategy. *Environmental Politics*, 24 (2), 193–211.

Hobson, K., 2016. Closing the loop or squaring the circle? Locating generative spaces for the circular economy. *Progress in Human Geography*, 40, 88–104.

Kirchherr, D.K., Reike D. and Hekkert, M., 2017. Conceptualizing the circular economy: An analysis of 114 definitions. *Resources, Conservation and Recycling*, 127, 221 –232. https://doi.org/10.1016/j.resconrec.2017.09.005.

Kivimaa, P., 2014. Government-affiliated intermediary organisations as actors in system-level transitions. *Research Policy,* 43 (8), 1370–1380.

Kleinberg, J., 1999. Authoritative sources in a hyperlinked environment. *Journal of the ACM*, 46 (5), 604–632.

Korhonen, J., Honkasalo, A. and Seppälä, J., 2018. Circular economy: The Concept and its limitations. *Ecological Economics*, 143,37–46. https://doi.org/10.1016/j.ecolecon.2017.06.041.

Kuokkanen, A., et al., 2017. The need for policy to address the food system lock-in: A case study of the Finnish context. *Journal of Cleaner Production*, 140, 933–944.

Latour, B., 2004. How to talk about the body? The normative dimensions of science studies. *Body and Society*, 10 (2-3), 205–229.

Lazarevic, D. and Valve, H., 2017. Narrating expectations for the circular economy: towards a common and contested European transition. *Energy Research & Social Science*, 31, 60–69.

Lazarevic, D. and Valve, H., 2020. Niche politics: Biogas, technological flexibility and the economisation of resource recovery. *Environmental Innovation and Societal Transitions*, 35, 45–59. https://doi.org/10.1016/j.eist.2020.01.016.

Levänen, J., Lyytinen, T. and Gatica, S., 2018. Modelling the interplay between institutions and circular economy business models: A case study of battery recycling in Finland and Chile. *Ecological Economics*, 154, 373–382.

Marres, N., 2004. Tracing the trajectories of issues, and their democratic deficits, on the web: the case of the development gateway and its doubles. *Information Technology & People*, 17 (2), 124–149.

Marres, N., 2012. On Some Uses and Abuses of Topology in the Social Analysis of Technology (Or the Problem with Smart Meters). *Theory, Culture & Society*, 29 (4/5), 288–310.

Marres, N., 2017. *Digital Sociology: The Reinvention of Social Research*. Cambridge: Polity.

Marres, N. and Weltevrede, E., 2013. Scraping the social? Issues in live social research. *Journal of Cultural Economy*, 6 (3), 313–335.

Martin, N. and Rice, J., 2014. Rebalancing Climate Change Debate and Policy: An Analysis of Online Discussions. *Environmental Policy and Governance*, 24, 338–350.

Marttinen, S., et al., 2018*. Towards a breakthrough in nutrient recycling: State-of-the-art and recommendations for developing policy instruments in Finland.* Natural resources and bioeconomy studies 26/2018. http://urn.fi/URN:ISBN:978-952-326-578-3 [accessed Jan 2019]

McNutt, K., 2008. Policy on the Web: The Climate Change Virtual Policy Network. Canadian *Political Science Review,* 2 (1), 1–15.

McNutt, K. and Pal, L.A., 2011.'Modernizing Government': Mapping Global Public Policy Networks. *Governance: An International Journal of Policy, Administration, and Institutions*. 24 (3), 439–467.

Munk, A., 2014. *Mapping Wind Energy Controversies Online: Introduction to Methods and Datasets* (November 1, 2014). Available at SSRN: https://ssrn.com/abstract=2595287 [accessed 12 Dec 2019]

Niskanen, J., Anshelm, J. and McLaren, D., 2020. Local conflicts and national consensus: The strange case of circular economy in Sweden. *Journal of Cleaner Production*, 261, 121117.

Ooghe-Tabanou, B., Jacomy, M., Girard, P. and Plique, G., 2018. Hyperlink is not dead!, https://hyphe.medialab.sciences-po.fr/docs/20181004-ACM-WebStudies-HyperlinkIsNotDead.pdf [accessed Jan 2020] https://doi.org/10.1145/3240431.3240434

Prime Minister's Office. 2016. Action plan for the implementation of the key projects and reforms defined in the Strategic Government Programme. Government Publications 7/2017. [accessed August 2020] https://valtioneuvosto.fi/documents/10616/1986338/Action+plan+for+the+implementation+Strategic+Government+Programme+EN.pdf

Reike, D., Vermeulen, W.J.V. and Witjes, S., 2018. The circular economy: New or refurbished as CE 3.0? — Exploring controversies in the conceptualization of the circular economy through a focus on history and resource value retention options. *Resources, Conservation and Recycling*, 135, 246–264.

Rogers, R. and Marres, N., 2000. Landscaping climate change: A mapping technique for understanding science & technology debates on the World Wide Web. *Public Understanding of Science*, 9(2), 141–163.

Schulman, S.L., 2008. Hyperlinks and marketing insight. In: J. Turow. and L. Tsui, eds. *The Hyperlinked Society*. University of Michigan Press: Ann Arbor, MI, 145–158.

Smith, A., Vos J. and Grin, J., 2010. Innovation studies and sustainability transitions: The allure of the multi-level perspective and its challenges. *Research Policy*, 39, 435–448.

Stahel, W.R., 2016. The Circular Economy. *Nature*, 531, 435–438. https://www.nature.com/news/polopoly_fs/1.19594!/menu/main/topColumns/topLeftColumn/pdf/531435a.pdf [accessed 13 Jan 2020]

Särkilahti, M., et al., 2017. Replacing centralised waste and sanitation infrastructure with local treatment and nutrient recycling: Expert opinions in the context of urban planning. *Technological Forecasting & Social Change*, 118, 195–204.

Valve, H. and McNally, R., 2013. Articulating scientific practice with PROTEE: STS, loyalties, and the limits of reflexivity. *Science, Technology & Human Values*, 38 (4), 470–491.

Valve, H., Ekholm, P., Luostarinen S., 2020. The circular nutrient economy: needs and potentials for nutrient recycling. In: M., Brandão, D., Lazarevic, G., Finnveden eds. *Handbook of the Circular Economy*. Edward Elgar Publishing Ltd (forthcoming 2020)

Venturini, T., Jacomy, M. and Pereira, D., 2014*. Visual Network Analysis.* http://www.tommasoventurini.it/wp/wp-content/uploads/2014/08/Venturini-Jacomy_Visual-Network-Analysis_WorkingPaper.pdf [accessed 14 Jun 2020]

Yi, H. and Scholz, J.T., 2016. Policy Networks in Complex Governance Subsystems: Observing and Comparing Hyperlink, Media, and Partnership Networks. *The Policy Studies Journal*, 44 (3), 248–279.

Figure and Table Captions

Figure 1: The five phases of online exploration.

Figure 2: The identified clusters of hyperlinked websites. The layout of the data is created by the force vector algorithm, ForceAtlas2 (Bastian *et al*. 2009). The algorithm renders the connectedness of the hyperlink data visually interpretable, without affecting the original connectedness. Nodes having two or less hyperlink associations have been excluded from the image for the sake of clarity.

Table 1: The most frequently occurring biomass types within the different clusters.

Notes

[1] https://www.syke.fi/projects/qumare [accessed 16 Jan 2020]

[2] See https://mmm.fi/en/article/-/asset_publisher/ravinteet-kiertoon [accessed 16 Jan 2020]

[3] See Bruns (2007) and Adam *et al*. (2015) for the alternative means of choosing a corpus for a hyperlink analysis.

[4] For example, see https://ec.europa.eu/eip/agriculture/en/news/inspirational-ideas-biovakka-manure-management-produce-biogas-and-nutrients-finland [accessed 7 Jan 2020]

[5] See http://hyphe.medialab.sciences-po.fr for further information [accessed 15 Dec 2018]

[6] A hyperlink explorer needs to be aware of possible data gaps. If Hyphe reports that a website is not sending any hyperlinks, the explorer needs to verify whether this muteness is a question of a software-based limitation or an actual situation that the site does not make links. When we encountered a site where hyperlinks were sent but Hyphe did not recognize them, we added the pages into the second crawl.

[7] The image is actively constructed by testing and probing the hyperlink data. The rudimentary form of the network is a tangle of criss-crossing edges (hyperlinks) and nodes (websites). We needed to test different kinds of options in order to make the data visually interpretable. Eventually, we settled on an algorithm called ForceAtlas2 (Bastain *et al*. 2009). It is important to note that the algorithm transforms the connectedness of the hyperlink data into a visually interpretable form without affecting the original connectedness – the manipulation leaves the actual topology of the network intact.

[8] Despite the simplicity of the associative principle (two nodes share a link or they do not), identification of the clusters also required iterative experimentation. The analysis proceeded through interplay between quantitative (Blondel *et al*. 2008) and qualitative visual tools (Venturini *et al*. 2014).

[9] The Finnish Bioeconomy Strategy (2014), https://www.bioeconomy.fi/facts-and-contacts/finnish-bioeconomy-strategy/ [accessed Jan 2020]

[10] Agricultural side flows here refer mainly to surplus grass and industrial side flows of sludge from the pulp and paper industry.

[11] For other limitations of GoogleScraper, see Marres and Weltewrede (2013). Word searches of this type are also complicated by the Finnish language, in which nouns are inflected according to grammatical rules. We attempted to tackle this problem by including all the most common cases.

Figure 1. workflow JPG.jpg

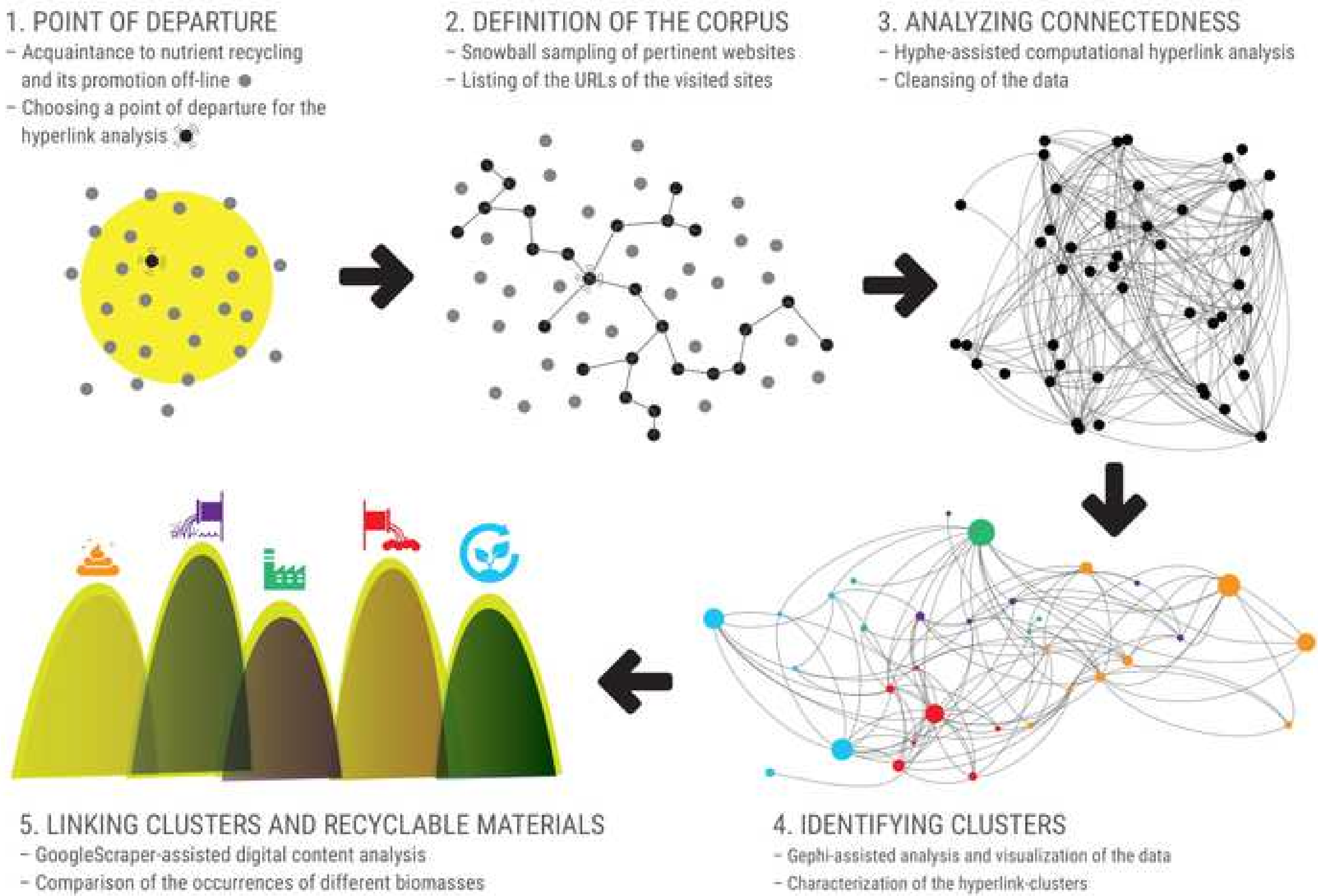

FIGURE 2, networks JPG.jpg