Sustainability and Responsibility in ICT-enabled urban environmental research and decision-making

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The world's urban areas are vital in addressing many of our pressing challenges. Environmental research is per definition about tackling challenging environmental issues. With an increasing digitalisation and use of information and communication technologies (ICTs) in all aspects of our lives, ICT is now "everybody's business". This also introduces new opportunities in environmental research, with approaches and methods like crowdsourcing, online co-creation, public participation GIS, web crawling and machine learning. However, new opportunities bring also new challenges and responsibilities among researchers and practitioners. Potentially conflicting interests are for instance the responsibility of protecting the rights of the individuals along with the importance of achieving common and collective goals needed for transformation towards sustainable urban systems. Another potential conflict is the impact of collecting and storing large amounts of digital data versus the resources associated with this. There might be a win-win between joint assessments of, e.g. elements of data privacy, data redundancy, data reuse and ICT-related energy consumption.

Reaching the goals set by the 2030 Agenda for Sustainable Development depends on a holistic and interdisciplinary consideration across environmental, social and economic systems. A systems approach, including working across disciplines and sector boundaries, is therefore crucial. Within the EU, the framework of Responsible Research and Innovation (RRI) has developed over the last years. Research must reflect awareness and incorporation of the interactions, feedbacks and overlaps between the various dimensions and actors (e.g. society, decision makers, citizens, researchers). RRI is to a large degree about anticipating and evaluating impacts. There is still, however, a call for making the concept of RRI more operational and applicable.

In this paper we combine theoretical and conceptual deliberations with empirical casework to address the following issues:
- How can a joint consideration of sustainability, including the sustainable development goals, and principles of RRI enable positive impact and systemic change in urban systems?
- How do considerations of sustainability and RRI connected to ICT, relate to each other in practical terms?
- How can researchers working with ICT-enabled methodologies establish practices and collaborations that are essential for the implementation of both sustainability and RRI strategies?

We present findings that support the need for looking at urban sustainability and RRI in a joint manner. The outcomes from a review of the literature on how the concepts of sustainability and RRI are applied within urban environmental research is presented and evaluated in the context of sustainable urban systems. The theoretical base is combined with empirical work carried out in the iResponse project (http://iresponse-rri.com/, 2015-18) on socially responsible crowdsourcing for environmental research and decision-making in the urban environment, funded by the Norwegian Research Council addressing RRI in ICT. The empirical material is developed through case studies using ICT methods on environmental challenges, interviews and stakeholder workshops, as well as survey data. We present the outcomes from lessons learned on how the RRI aspects, i.e. inclusion, anticipation, reflexion, responsiveness, have been applied and operationalised during the process and how the ICT-enabled project activities are situated within the urban sustainability.

Of Dog Kennels, Data Infrastructures, and Global Contaminations: Toward a Constitutional Logic of Big Data

Zane Griffin Talley Cooper

In 2009, in Valparaiso, Indiana, Kathy DeFries, owner of Excel Machine, opened Coco's Canine Cabana inside the other half of her 15,000 square-foot machine shop. With no shortage of tropical paraphernalia, dogs have over 10,000 square feet of play room, and can lounge freely under the latticed palm frond roof of the central cabana (Wieland, 2009). Shortly after Kathy launched this business, China instituted a temporary ban on rare earth mineral exports – first to Japan, and then to the United States – which immediately incited both nations, as well as the technology and automotive industries, to reexamine their strategic and economic dependence on Chinese rare earth oxides, key ingredients in defense technology, hard disk drives, and cell phones (Thibodeau, 2010; Aston, 2010). The following year, Seagate, the world's largest manufacturer of hard disk drives, warned consumers that prices of their drives could be subject to fluctuation, depending on the outcome of the ban, one of the first public statements from a major corporation noting the geopolitical constraints inherent in obtaining rare earth minerals (Hatch, 2011). This paper works to illustrate not only how this wayward dog kennel is threaded through global processes of mineral extraction, but also how its presence is central to establishing a heuristic understanding of how the manufacturing conditions of hard disk drives shapes the forms of big data infrastructure.

We need a stronger analytic that allows for more meaningful differentiation between what big data does (its operational logic) and what it is (its constitutional logic). These two processes of acting and becoming are certainly entangled, intimately and intricately feeding off of each other, but at times we must consider one against the other in order to theorize and posit new and more sustainable material practices. The cloud's constitutional logics are deeply ecologically entangled with industry and environment, its material forms continually negotiated through and situated within socio-politico-environmental situations. Minerals must be mined, ore must be processed, and components must be manufactured, all before the cloud can even begin to assemble its operative agents. What is the nature of resource movement in this sphere? How is it bounded, by what forces, and to what ends?

To attend to the diffuse materialities at play in the accretion of big data stuff, I suggest we view the constitutional logics of big data as contaminating forces that are themselves contaminated by external ecologies, creating thick webs of contingency. Contamination, in this sense, is not infection, but rather a building, a working, and an operating across difference – a collaboration in the service of "precarious survival" (Tsing, 2015). Thinking in terms of contamination challenges organicist models like Bratton's stack (2015), making them less ubiquitous, and prone to upsets. Contamination also decenters public-facing tech companies from an otherwise pyramidal narrative, illuminating the roles of older histories and industrial actors beneath and between our nascent harbingers of technological futures. I seek a more nuanced conception of how cloud infrastructure contaminates and is contaminated by historically situated socio-economic forces that operate largely in the undertheorized periphery of popularly perceived lifecycles of media technology. Through this lens, Coco's Canine Cabana emerges as a tool to help us reconceptualize, territorialize, and more concretely materialize big data infrastructure.

Data-Driven Technologies for Good and Ill in the Pursuit of Sustainability

Rod Dobell and Justin Longo

A decade ago, a brief proliferation of concern with 'green computing' and the environmental impact of information technology emerged in academic circles (Fuchs, 2008; Hilty, 2008) , advocacy groups (Global Witness, 2009) , and the popular press (Brodkin, 2007) . Capping the decade, the OECD (2009) reviewed the range of government and corporate initiatives accumulated over the previous ten years—notably standards, regulations, and incentive programs aimed at individual computer unit energy efficiency, recycling programs, and (later) the energy efficiency of data centers—concluding that, while much needed to be done, and the effectiveness of initiatives still needed to be evaluated, these efforts were aimed at spurring innovation, increase green ICT adoption, and promote environmental-related ICT skills and awareness in large organizational settings.

A decade is a long time in many contexts, though more so in this case. As the proposal for the workshop on "Environmental Impact of Data-Driven Technologies" makes clear, the world of digital technology nearing the end of this decade presents different challenges than existed at the close of the previous one. The movement of computing from the desktop to the ubiquitous 'cloud', and the pronounced shift to computing devices in the hands of disparate consumers rivaling those under the control of corporate IT departments, have changed the nature of the sources of environment impact from computing. This movement, expanding in concentric circles outward to encompass more participants, mirrors the currents of governance from closed to open (Noveck, 2015) . As with the open governance movement, data-driven technologies have shifted control from clear centres of authority to less easily identifiable networks of activity.

The workshop proposal asks crucial questions about how the environmental impacts of computing technology can be mitigated. But beyond the specific engineering and economic questions, there is a larger context—the challenges of sustainability in the complex social-ecological systems within which human activity occurs. Environmental sustainability relies on a combination of social norms promoting pro-environmental behaviour change as much as it does on technological advances (what Robinson and Tinker (1998) have labelled as the sustainability policy wedges of 'resocialization' and 'dematerialization'). We note that to undertake sustainability evaluation successfully demands consideration of the feedback loops embedded in complex social-ecological systems, and examination of the changes in human decision-making process through restructurings of institutional arrangements and social or cultural norms, moving beyond limited consideration of material throughput only (López-Ridaura, Keulen, Ittersum, & Leffelaar, 2005; López-Ridaura, Masera, & Astier, 2002). This paper seeks to update the 'green computing' literature of a decade ago in light of the shift in the locus of control over computing resources from the corporate centre to the disparate individual. And while the adoption of new technologies will often have negative environmental impacts, we also explore the sustainability consequences of increasing the capacity for expanding the sphere of participants (both human, and artificial) in collective decision making and behaviour.

CarbonIT: is a grand accounting of the energy costs and benefits of IT even possible?

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How much energy does information technology use? How much does it save? Is it possible to give a grand accounting, at the national, international, or global level, of whether IT is helping or hurting the battle to stem climate change by ending reliance on fossil fuels?

Numerous studies exist on major aspects of IT energy use. Most focus on a particular element of information infrastructure: data centers, Internet transmission, personal computers, devices connected to the Internet of Things, and so on.

Some of the news is surprisingly good. The electrical efficiency of computers (tubes, transistors, chips) has increased at a rate comparable to Moore's Law, doubling about once every 18 months since the ENIAC (Koomey et al. 2011). Due to this gain and other improvements to energy efficiency, US data centers' electricity consumption has grown little since about 2007; it is projected to increase only slightly, or even drop, between now and 2020 despite an ever-increasing number of centers and servers (Shehabi et al. 2016). A recent meta-study of electrical intensity in fixed-line Internet transmission networks, defined as kilowatt-hours per gigabyte transmitted, estimates a halving of that intensity every 2 years from 2000-2015, roughly in line with the efficiency gains in computers (Aslan et al. 2018). Many major cloud computing firms have invested heavily in renewable energy sources (but some of the largest growth in consumption is happening in northern Virginia, powered mainly by conventional power plants; Cook et al. 2017). Intriguing new ideas, such as placing server farms on the ocean floor (for cooling) and powering them with ocean waves, are being tested.

On the downside, the number of Internet-connected devices continues to increase, and certain high-energy-intensity uses (such as Bitcoin mining) display exponential, unsustainable growth rates. The efficiency improvements in personal devices (computers, phones) described above are calculated on a cost-per-computation basis, not on absolute energy consumption, which depends on how many computations are actually performed, including during sleep — a number which may be growing. is Jevons-paradox phenomena crop up regularly; for example, the vast majority of US Internet traffic today is video streaming, an Internet function that would have been impossible at the bandwidths of the year 2000. If history is any guide, future bandwidth gains will be eaten up by new, as yet unknown uses. Except for equipment purchases, energy consumption rarely even registers as a factor in consumer decisions about IT functions.

All this translates into a global race between efficiency gains and renewable energy investments, on the one hand, and increasing numbers of new devices and high-intensity uses of Internet-connected technology, on the other. This is one half of the grand accounting I want to investigate.

The other half of the accounting regards how much energy IT saves. This is a much harder question to answer because there are so many modalities: smart buildings, smart grids, thousands of small-scale savings like computer-controlled fuel injection in cars, less travel due to working from home, IT feedback loops that improve energy efficiency, and so on. Smart grids, smart office buildings, and smart homes hold considerable promise for further efficiency gains. However, realization of those gains so far is highly variable, in part because efficiency is not the only (and often not the primary) goal in adding new IoT devices to homes, buildings, and grids. IT contribution to energy savings is also hard to estimate because we can only model and guess at how energy use might have evolved in the absence of IT. One promising indicator is that according to the IEA, electricity demand growth estimates from even 15 years ago have proven far too high, even though many more devices are on the grid (International Energy Agency 2017).

This paper will be more of a "what we want to know" exercise, rather than a definitive accounting. The second half, building on the previous paragraph, will explore more of the available literature on this topic and propose questions that need to be answered, perhaps with some discussion of how that might be done. It's unlikely to be a well-baked paper by the time of the Data & Society meeting, but there'll be more there there by then.

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Genomics Research, Climate Change, and the Data Center Industrial Complex

Mél Hogan

I am proposing to workshop a draft paper that bridges my two main projects and areas of interest. The first is my long-standing research on the data center industry, and specifically the ways in which it is taking over custodianship of natural resources, like land, water, and electricity (see forthcoming *Ephemera* piece attached). The second is my new (book) project that looks at how the Big Five of tech – Apple's *ResearchKit*; Amazon's *Genomics in the Cloud*; *Microsoft Genomics*; *Google Genomics*; and Facebook's *Genes For Good* app – have used their momentum of building proprietary data center industrial complexes to be able to offer 'free' storage to genomics researchers and DNA sequencing companies. Because no university of publicly run organization can offer even a fraction of the storage and computational power of these for-profit corporations, data – and genomic data in particular, for which the stakes are much higher – is managed at the whims of Big Tech and their shareholders.

Genome scientists worldwide estimate producing approximately 40 exabytes of data to sequence between 100 million and 2 billion human genomes globally by 2025. The storage infrastructure required to sustain this does not currently exist. Focusing on this moment of infrastructural expansion is crucial for understanding the increasingly complex relationship between climate change, the environment (land, water, people), Big Tech, and genomics research (as well as its marketing and future deployments). Since the advent of the internet in the late 1990s, it has been the case that the cheaper storage gets, the more data is created and, in turn, stored for future analysis. Data is the most valuable commodity in our economy – it has become a currency that pays for the development of Big Tech infrastructure, which in turn determines the worth of the data (Vonderau and Holt 2015; Veel 2017). Big Tech is increasingly enslaving nature in order to maintain and grow its operations while also demonstrating concern for climate change via large scale sustainable infrastructural developments. In other words, to green their cycles of production, Big Tech invests in infrastructure that not only sustains but also unwittingly serves to encourage consumption at a time of severe social and political unrest and environmental instability. In these material expansions, there is tremendous infrastructural, financial, and political support for ongoing consumption and its embedded values: scientific progress, entrepreneurship, innovation, and social control.

By focusing on "The Big Five" I draw out the technosocial-medical imaginaries of the largest market capitalization companies, i.e., those that have the most control and power over global markets and politics. My main goal for the workshop is to map out the various issues listed above, in order to weave together the concerns by challenging the very distinctiveness of these sites as objects of study. My ideal takeaway would be to formulate a clear argument or a series of provocations about the links between genomics research, climate change and the data center industrial complex.

Invisibility, Breaks, and Contesting Land: Information Communication Technology Infrastructure and Development as a Tool of Colonialism

Mitch Jackson

While much has been written in science, technology, and media studies on challenging the idea of code, software and algorithms as neutral, this paper hopes to challenge the idea of information communication technology (ICT) development and its hardware components as neutral. ICT development in Canada specifically is often advanced behind an infrastructural invisibility that is able to obfuscate the neoliberal and colonial ideologies that inform the building of these ICT networks. ICT infrastructures have a general “rule of invisibility” and their “major physical parts are often literally invisible” (Sandvig, p. 12). This paper hopes to demonstrate how these ICT infrastructures can be made visible, what is at stake in challenging their visibility, and how they contribute to Canada’s colonial relationship with Indigenous peoples. By examining the colonial components of ICT infrastructure, the goal is to challenge the perceived neutrality and invisibility of ICT infrastructure. It is determined that the major colonial component of ICT infrastructure in Canada is that it is used by the state to lay claim to unceded Indigenous land, while physically disrupting the land and its surrounding environment. Two examples of ICT infrastructure development will be studied, the first being the construction of telegraph lines in the territory of the Plains Cree in the late 1800s, and the construction of the Mackenzie Valley fibre optic cable in 2016. The specific case study of the Mackenzie Valley cable demonstrates the cost of the highly hyped technology of fibre optic internet connection, in terms of the associated destruction of habitat, land, and improper waste disposal.

Assessing the environmental impact of data driven technologies; Case of data centers.

Narcisse Mbunzama

Keywords: data driven technologies, data centers, environmental impact.

Data centers consume high levels of energy to power the IT equipment contained within them, and extract the heat they produce. Because of the industry's heavy reliance on power, data centre metrics have historically used operational efficiency as a proxy for sustainability. More recently the industry has begun to recognise that its focus needs to go beyond energy consumption, with the creation of metrics for issues such as carbon, water and compute efficiency. However, single-issue metrics often consider only the operational phase, omitting impacts from other issues, during other stages in a facility's lifetime. Further approaches exist to assess more holistically the impact of data centres, such as building environmental assessment methods, but none have the capacity to capture fully the interlinked nature of a system, where improvements in one area and to one impact, can adversely affect a totally different area and totally different impacts. The following paper will summarize the approach of the data centre industry to environmental impact, and provides direction for future research. It will describe the energy consumption of the data driven technologies industry and in particular data centres; current knowledge on the environmental impact of the industry; and how single-issue metrics have risen to prominence.

Accounting for Carbon Neutrality: Microsoft's Carbon Ledger and the Management

Anne Pasek

There is a gap between forms of environmental critique that call for greater awareness of the cumulative climate impacts of cloud computing on the one hand, and corporate environmental policies that seek to preempt and respond to these critiques on the other. For example, while Microsoft's Azure cloud services have expanded explosively in the past decade, composed of more than 50 new data centers and 130 edge nodes, Azure has also since 2012 been a "carbon neutral" operation. Through the institution of an internal price on carbon, Microsoft now measures, taxes, and seeks to negate its climate impacts through a series of carbon offsets, renewable energy purchases, and efficiency retrofits. Such measures complicate the scope and trajectory of contemporary environmental critique, suggesting that instead of merely stressing the quantity of carbon dioxide produced by data centers, we must now investigate the management and meaning of such numbers within the corporate space itself.

This paper looks closely at Microsoft's carbon neutral claims, emphasizing the central role of accounting and virtual commodities in the management of environmental externalities. I argue that carbon neutrality is a feat that is only thinkable through the logics and affordances of the spreadsheets in which environmental impacts and offsets are calculated and communicated. Resultantly, I read the Microsoft case study through the history of double-entry bookkeeping with its insistence on numerical balance and equivalencies. These findings suggest that, while the Microsoft carbon program has produced significant environmental gains that go beyond mere greenwashing, there are still unaccounted forms of harm produced and disguised in the translation of local material conditions to globally fungible numbers. Resultantly, this study stresses the ambivalent politics of enumeration, suggesting that a more efficacious form of environmental critique in the future will be made through situated decarbonization struggles rather than a quantitative emphasis on global impacts alone.

Chelan County and the Uneven Metabolisms of Bitcoin's Materialities

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Drawn to some of the cheapest electricity rates in the world, cryptocurrency miners have flocked to central Washington state. Powered mostly by dams, the extremely low electricity rates allow miners to maximize the ever-narrowing profit margins of cryptocurrencies like Bitcoin whose production, by design, requires increasing amounts of computational power over time. If Bitcoin's infrastructure allows anyone with a computer to plug into the network and begin mining, only those with specialized hardware and cheap electricity are able to do so profitably. While popular accounts of Bitcoin's energy usage correctly report the massive scale of energy consumed by the network and the potential environmental ramifications of said consumption; in practice, the material geography of Bitcoin is highly uneven and intertwined with the infrastructural, ecological, and economic structures on which it depends. As the shifting infrastructure of Bitcoin touches down in particular places and at particular times—whether drawn by free dorm room electricity, plentiful cool air in northern latitudes that help regulate the temperatures of overheating hardware, or cheap electricity prices drawn from the seemingly inexhaustible supply of hydropower—the network enrolls the world in ways familiar to political ecology.

Over the past three years, the dams of Chelan County, WA, its watershed and fish, the electrical grid and the laborers who maintain it, and the cleared land with warehouses filled with computers have all been enrolled as part of the vast, seemingly placeless algorithmic infrastructure of Bitcoin. While the Bitcoin network is able to harness the potential of nearly any computer connected to the internet, when and where it touches the ground en masse produces deep, material marks upon the land and the people who live there. In this article, we examine these scars through the lens of a specific county in rural Washington, untangling the processes that occur as a seemingly virtual infrastructure metabolizes the very real material resources of one place to produce digital goods used in another. In so doing, we shed light on not only the material costs of networks like Bitcoin, but also their historical ties to older processes of accumulation.

KEYWORDS: bitcoin, resource extraction, materiality, algorithms

From QR Payments to Permaculture: Climate change and ecological impacts of financial technology platforms in rural China

Xiaowei Wang

In this paper, I look at the ecological impacts of financial technology (FinTech) in rural China and how systems of financial technology such as mobile payment and electronic credit scoring have tackled national agricultural labor shortage and the environmental damage caused by unsustainable agricultural practices. With a population of 1.3 billion, China's food security and agricultural production rests upon nearly half of the overall population who still live in rural areas, practicing agriculture for food production.

Food production and agriculture have enormous impacts on our environment and climate in ways that are often invisible. It is estimated that food production and agriculture contribute to at least 1/3 of global greenhouse gas emissions, making agriculture one of the largest greenhouse gas (GHG) emitting industries[1]. By geography, 44 percent of agriculture-related GHG outputs occurred in Asia.[2] The large percentage of GHG outputs being centered in Asia is correlated to farming practices and farm size, as smaller farm sizes require extensive manual labor that is often compensated with over-fertilization, and fertilizers contributing to 13% of agricultural GHG. While the US has farms that average 444 hectacres3, China has farms that average 0.1 hectacres[3]. The implications are huge: farms of this small size require endless manual labor to maintain production, unable to be automated in the ways harvesters and threshers go through large vegetable fields in the US. In the past 20 years, agricultural labor shortages in China have worsened, directly causing environmental havoc in overuse of pesticides, fertilizers and land mismanagement as farmers struggle to cope with labor shortage via chemicals. [45]

Within the nascent field of studying computing's environmental impacts, systems based, ecological analyses have been typically neglected in favor of straightforward electricity analyses or life cycle analyses that only look at the impacts of isolated components, such as electricity use of servers or GPUs. These approaches ignore different scales of analysis and the complexity of human- environmental networks. Existing approaches are problematic in multiple ways, given how labor and economy are intrinsically tied to ecological change, the geographic specificity of environment, ecological habitats and biomes, and the complex dynamics of global ecological change. While computation intensive processes and electronics manufacturing do use electricity and resources, the ecological impacts are different depending on scale and geographic region -- for example, hardware manufacturing might drastically impact one geographic region short term, with

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global environmental impacts being more subtle and long term. At the same time, computation intensive resources might alleviate or even decrease carbon footprints through changes in labor and human behavior, such as early examples of telecommuting.[6]

In my paper, I argue that Chinese FinTech platforms such as WeChat Wallet and Alipay are directly driving agricultural and ecological change in the countryside via social and spatial change. These platforms are changing social and spatial networks in rural China through specific features of the platforms, developer experience of the APIs and mobile payment user experience. Through time-series satellite image analysis of crop cover and land use change, analysis of WeChat and Alipay APIs and payment platforms, ethnographic interviews and survey data, I closely look at Shandong Province. In Shandong, Alibaba's Taobao.com platform and Alipay have created hybrid industries, new livelihoods and technology now complements the seasonal cycles of agriculture. I show how FinTech was pivotal in bringing e-commerce to the countryside, with broadband and 5G infrastructure. As a result of these technologies, agricultural labor shortages have declined in the region from migration. Crop health has been boosted, and increased agricultural labor has eased fertilizer use, improved regional environmental pollution, and created sustainable, lower GHG emitting farming practices. These conditions show the understudied consequences of technology on labor and food production, areas pivotal to climate change.

Towards of the end of the paper, I examine the impacts of such findings, future research directions and problems. Although seemingly positive in aiding sustainable agriculture, the Chinese FinTech platforms used are private and corporately owned. The broader impacts of such research are many: currently, GHG emissions contribute to climate change, which in turn negatively affects agriculture, an industry that produces enormous amounts of GHGs. These emissions are continuing to increase, as agriculture mitigates uncertain weather from climate change, fueling a negative feedback loop. From a systems outlook, intervening upon agriculture is an effective way of addressing climate change. The potentials of labor intensive, sustainable smallholder farms that are economically viable with technology as a core driver are not only exciting but crucial, reflecting the importance and uses of computation outside of urban spaces, in understudied areas of rural agriculture. Through technologically enhanced rural life and new socioeconomic practices of farming, we can scale such practices that tackle energy use and climate change from rural China to the rest of the world.

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