Sustainability in OpenStreetMap

Building a more stable ecosystem in OSM for Development and Humanitarianism

By Erica Hagen

The world of OpenStreetMap is unique, and its use in development and humanitarianism is still evolving. Globally, the OSM community has links to and similarities with a number of areas: the free and open source software movement (FOSS), the open data and civic technology movement, ICT for Development (ICT4D) and related areas such as humanitarian tech, and, of course, geography, "neo-geography", and Geographic Information Systems (GIS). It also bears a relation to data for development, and digital data collection. And, ultimately, OSM is a kind of wiki - a "Wikipedia for maps".

When OSM is used for development and humanitarian purposes it also tends to face some of the same challenges as development work which is non-technological - challenges of interventions and initiatives in resource-poor locations around the globe. In such cases, the ultimate aim is to have a positive impact on economic and social development in the country, or, to mitigate, prevent, or address emergencies. One of the toughest challenges is to sustain these impacts in the long term, beyond short projects or interventions.

This white paper will explore the many facets of OSM in development and its "sustainability". It examines the definition of sustainability, reviews existing literature about sustainability in ICT4D, and four dimensions of "sustained benefit" which can help us to understand factors that will influence longer term success of work involving OSM in development. The paper outlines challenges for seven different actors which typically work with OSM in developing economies. It details challenges that tend to arise for these actors in achieving sustainability in the four dimensions. It then suggests a way forward for funders, practitioners, and others to move toward greater benefits for all given the constraints of OSM globally, the ethical considerations of digital open mapping, and the challenges of open source and open data projects generally as technology matures.

1. BACKGROUND

INTRODUCTION:

OpenStreetMap (OSM) is the world's largest project around building a shared map of the world, which is open and free to use and to edit. Known as the "Wikipedia of Maps", because anyone can edit and use the map information, OSM currently has more than 1 million contributors. It is now used as the standard map in many of the apps and products we use every day. It provides a free and citizen-generated digital map, as opposed to commercially owned proprietary products like Google Maps.

Over the past several years, a number of OSM mapping projects have been initiated by organizations like the World Bank, the Red Cross, and smaller organizations and individuals with the aim of supporting a wide variety of development and humanitarian objectives. OSM mapping has taken place in response to natural disasters (like the Haitian and Nepalese earthquakes), in order to empower slum communities to advocate for development priorities (such as Kibera, in Nairobi), to help mitigate or prevent disease outbreaks (Ebola, and malaria), or simply to increase transparency and open data use among government officials and others already using GIS (for example in Kinshasa, DRC).

However, in many of these locations, a key question has arisen: how can OSM mapping in developing country contexts be more sustainable? In some cases, mapping projects have developed in response to situations which required quick localized maps, and sustainability-related questions have only arisen later -- such as how to use the maps to address other needs in the country, how to expand coverage, and how to ensure maps do not become out of date and are kept relevant. In other instances, challenges have arisen around issues like keeping trained mappers engaged; building and funding mapping organizations; working with government more productively; and developing local project management capacity.

MAPPING, ICT4D, FOSS, & TECH4GOOD

In the long history of map-making, creating maps has typically been considered a rarified skill, and maps themselves have been restricted to powerful individuals and rulers. Even in the early digital age, detailed online maps were not available to ordinary citizens (Google maps did not arise until 2005). OpenStreetMap was launched in 2004, and offered a revolutionary opportunity: the ability to not only create one's own digital map, but to do so jointly with a virtual community of mappers, and share the results openly and freely.

OSM drew inspiration from the free and open source software (FOSS) movement, which contributed to the development of various OSM mapping tools. The creation of a shared online database of editable map information also drew from both the ideology and technology of "Wikis", such as Wikipedia. OSM thus became known as "the Wikipedia of maps." The early concept of the World Wide Web also popularized the "democratization of data", or easy access to crucial public information by every citizen, regardless of locality. Both FOSS and Wikis relied heavily - almost entirely - on a culture of volunteerism. OSM was no different. From this vantage, it is clear how OSM had the potential to flip the narrative of mapping as a tool of the powerful - or even just the highly skilled - on its head.

While initially created by mappers for the purposes of getting around in the UK and Europe, the potential of open and free maps for the humanitarian/development sphere became quickly apparent. Early experiments in humanitarian mapping (Humanitarian OpenStreetMap Team, Map Kibera, Jumpstart) inspired more and more individuals and groups to start using OSM outside of its European origins. In the development context, OSM not only shares the benefits—e.g. providing information and software free of charge, engaging an enthusiastic global user community—but also the pitfalls of the open source movement. Many of these have to do with the sustainability and maintenance of the information, code, contributors and user community and their interaction with the global economy.

The application of OSM in global development can encounter some of the same challenges found elsewhere in the development realm. A new field known as Information and Communication Technologies for Development (ICT4D) started to grow quickly in the early 2000's, when development practitioners saw potential to impact development outcomes through technology. The rise of the mobile phone and accelerated communication and information access via the internet inspired a lot of technological experimentation in development and humanitarian assistance -- many of which failed. Questions around sustainability of tech-related pilot initiatives were quick to arise. Many pilots produced interesting early results, but they were often criticized as lacking suitability to context, and the ability to be sustained without intensive ongoing resources. Hardware would break down or be too hard to use; software was prone to computer viruses; electricity was hard to come by and internet access even more so; data and SMS messages were expensive. There was also the misguided expectation pilots would just keep going on their own, often expecting that poorer people could and would invest time and money into technology, often based on its potential alone. Prominent failures—such as One Laptop Per Child (OLPC), and telecenters, or free stand-alone internet access points—sparked criticism of overly ambitious techno-centric thinking from the developed world. But there were clearly places where the impact of technology-based initiatives could be felt. Projects like

Ushahidi and FrontlineSMS harnessed existing local technology and made use of simple information and data like blog posts, SMS messages and easy to use software.

OSM has proven to be a very useful tool for a wide variety of challenges around the world for which maps are critical. However, those who use it also face difficulties in sustaining mapping efforts in the very kinds of difficult environments where it may make the biggest impact. These challenges are often similar to those faced in ICT4D, but there are also unique factors OSM. This research is aimed at examining this question of sustainability, with particular attention to the Open Cities initiatives of the Global Facility for Disaster Reduction and Recovery (GFDRR) of the World Bank Group.

We will look at the following questions:
1. What is the most appropriate and useful definition of sustainability for OSM in development?
2. What does the literature say about sustainability, particularly in the ICT4D field, which could be relevant to OSM?
3. What can we learn from selected OSM mapping communities and their sustainability-related challenges? How do sustainability challenges differ based on type of organization?
4. What tactics might improve sustainability for these and future OSM communities?

2. PRIOR RESEARCH ON SUSTAINABILITY

DEFINING SUSTAINABILITY

Sustainability is often used to refer to the environmental footprint of a project (maintaining an ecological balance, and "doing no harm"), or, to the ability of project managers to access continued funding streams. However, from a project design or organizational strategy standpoint, "sustainability" should incorporate not only environmental and economic concerns, but also other factors that impact the potential longevity of a project's impact.

The idea of **"sustained benefit"** is in many ways a useful conceptualization. Rather than thinking narrowly of whether an individual project might be able to outlast its initial funding, or too broadly about global ecosystems, we may consider:

*To what extent [will] the **benefits** of a program or project continue after donor funding ceased? (OECD, nd)* [1,2]

Benefits might be thought of as what we sometimes call **positive impacts** when evaluating a project. We would then need to look at what the benefits are, and whether in each instance they should be sustained. Marais and Meyer, drawing from Miller[3] suggest asking the following questions:

- *What is the scope and nature of the benefits?* In other words, what are the specific benefits of the project? Do benefits refer to increased access to the technology that is deployed (ie, enabling more people to create OSM map data), or to the benefits that result from access to and use of the technology (ie, using the map data to locate new water points, or improve health systems)?

- *Is there a real need for the benefits to continue once funding has been withdrawn?* Is this project intended to be sustainable, or should it merely demonstrate that change is possible? Or, perhaps the intention is to achieve a designated short-term goal, then end?

- *For how long after the funding* or other resources end *should the benefits be realized?* Are the benefits required to last over the short, medium or long term? Are the benefits interim in nature, i.e. are they required to last only until they catalyze the realization of other benefits?

- *Does an inherent demand for funding exist,* and should it be *sustained by the system?* Is the intervention inherently financially unsustainable, i.e. does it require continued external funding? At what level?

- *Do the benefits justify the cost thereof?* Should the intervention include mechanisms to access continued funding or financing once the initial funding has been withdrawn? Do the benefits evaporate if the funding is not continued? At what level should this work be financed?

This way of thinking about "sustainability of benefits" is somewhat narrowly focused on projects, and specifically those which have been donor-funded, but the overall concept of sustained benefit will help frame the discussion of sustainability. It also helps direct focus to the specific benefits that should continue, versus an approach that seeks to sustain a particular program or organization without first considering why we seek to sustain it or which aspects need to be sustained.

The kinds of benefits or impacts that we want to sustain while using OSM in the development and humanitarian field tend to fall into a few main categories. These include: furthering open data and government mapping; improvement of data for decision makers; social benefits for communities through better data access and use; sectoral direct

[1] OECD, n.d. DAC criteria for Evaluating Development Assistance. http://www.oecd.org/development/evaluation/49756382.pdf
[2] Or, if not donor funded, after initial program resources were expended or initial program targets were met

[3] Marais and Meyer, p. 3. (2015) http://ci-journal.net/index.php/ciej/article/view/1169; Miller, D. (2004). Building sustainable change capability. Industrial and Commercial Training, 36 (1), 9 - 12.

benefits; improving mapping skills and career advancement; and growing the global community of mappers. For more details, see box on page 11.

SUSTAINABILITY DIMENSIONS

Early work on sustainability of ICTs in development focused on telecenters[4] and early e-governance information systems. Kumar and Best outlined a "sustainability failure model"[5] with five modes, or ways in which these early ICT4D initiatives failed to sustain over time. Combining these modes with further detail suggested by Ali and Bailur, we have *five dimensions of sustainability*. Rather than focus on failure analysis, we will use these dimensions to describe the core ingredients of sustainability.

We will first review these five dimensions, and then use this lens to analyze the various actors common to OSM in development, and their sustainability challenges.

ONE: FINANCIAL/ECONOMIC SUSTAINABILITY

Economic or financial sustainability refers to the long-term ability of ICT projects to generate enough income to meet their operational and maintenance costs, as well as ongoing overhead.[6]

This is perhaps the best known and most referenced aspect of sustainability - whether it is possible to meet ongoing needs for resources. It could mean finding a way to source commercial opportunities, working through volunteerism, accessing long term donor or government resources, or innovating other income streams.

TWO: CULTURAL/SOCIAL SUSTAINABILITY

Social and cultural sustainability, according to Ali and Bailur, requires user buy-in and participation, taking into account local traditions, considering differences within communities, empowering marginalized groups,

sharing and aligning goals with local people and adapting to evolving community needs. Social sustainability is about looking beyond equitable access and asking whether the access is actually to something useful (such as a government service) and provides relevant content.[7]

Batchelor has a succinct definition of social sustainability: it is achieved "when social exclusion is minimised and social equity is maximised".[8] His focus on social exclusion is something we will bring into our discussion, because while an OSM project or organization may appear to be sustaining itself financially, ultimately if it is excluding key sectors of the society, the benefits will be sustained only narrowly.

Marais brings additional focus to the importance of social sustainability, cautioning, "Many ICT4D initiatives are still technocentric and focus only on providing ICT and access to it, ignore 'socially-led' strategy (are not sociocentric), are mostly top down, expect development to happen if access to technology is provided, and in practice disregard the actual needs of people (Chigona, Pollock and Roode 2009, 3). This leads to a "socio-techno divide" that needs to be closed: in human and technology development. The lack of sustainability is then embedded in the top-down technocentric approach due to an assumption that technology is an autonomous force that causes desirable developmental changes in the lives of people."[9]

THREE: TECHNOLOGICAL SUSTAINABILITY

Technological sustainability is the ability for a technology to exist for a long period of time without major shifts in hardware or software affecting its availability or durability.[10] This kind of sustainability means that the selected hardware and software are chosen with longevity in mind. They are easy to access and appropriate to context, and do not require outlays of expense that are not planned for into the future. Often, this means using open source tools and

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[4] i.e. Kumar and Best (2008) "Sustainability Failures of Rural Tele-centers: Challenges from the Sustainable Access in Rural India (SARI) Project"
[5] Kumar and Best (2006)."Impact and Sustainability of E-Government Services in Developing Countries: Lessons Learned from Tamil Nadu, India."

[6] Ali & Bailur, 2007. Referencing (Proenza, 2001)
[7] Ibid.
[8] Batchelor et al 2003, p. 31
[9] Marais, 2015, p. 5
[10] Ibid, referencing (Misund and Hoiberg, 2003)

avoiding proprietary systems or those which do not have local expertise.[11]

However, incentives are all too often structured around the quick win, resulting in unsustainable technologies or technical processes that become embedded into institutions or organizations. Therefore, this aspect is not only about the hardware and software itself, but also the expectations around who will use, maintain, and pass along the knowledge. It also includes sustainable data systems, which are frequently set up in silos and without long-term considerations around storage, access, and use.

FOUR: POLITICAL/INSTITUTIONAL SUSTAINABILITY

Political and Institutional sustainability is closely related to social sustainability, but in this case points to the buy-in of key institutional actors. It recognizes that implementation of ICT for development projects is a highly political process, and the ICT artifact needs to become institutionalized and accepted by these political actors.[12]

Institutionalization of key benefits within systems (for example governmental or large international non-governmental service providers) is often itself a form of sustainability. However, Abel Pires da Silva and Walter D. Fernández, reviewing a large number of case studies, have found that there is an additional layer of difficulty when a project involves government information systems: "…project implementations in public sector institutions are especially prone to sustainability failure because these projects involve heterogeneous actors with competing interests and backgrounds, such as national agenda and international politics, competing rationalities and culture. In addition, they require government institutions to undergo a change in business culture."[13]

Marais and Meyer suggest asking, "Have the fundamental characteristics of the system been modified in such a way that the system will continue to sustain the benefit that has been introduced by the intervention?"[14]

Speaking of health systems, Braa and Sahay have argued that technology and development initiatives become sustainable by "shaping and adapting the systems to a given context, cultivating local learning processes, and institutionalizing routines of use that persist over time."[15] For instance, OpenStreetMap may be used by government for planning, and routine procedures may change. Some project benefits may thereby be able to sustain in other forms even if the project itself is short-term.

FIVE: ENVIRONMENTAL SUSTAINABILITY

Environmental sustainability means that the practitioner is concerned with responsible implementation around the use of IT equipment, incorporating reuse, refurbishing, recycling as well as environmentally friendly disposal of obsolete equipment.[16] In technology projects, there are sometimes a large number of hardware that are distributed or required, and this would be a key consideration. For instance, a project that sources a large number of computers or tablets without plans for their eventual disposal or reuse when they reach the end of their effective life would not be environmentally sustainable.[17] In OSM projects, this usually is less of a concern overall since usually the hardware isn't custom and many projects rely on using existing hardware.

AGILE DEVELOPMENT & SUSTAINABILITY

In a more market-driven technology field there is another point of view, captured by the saying "fail early, fail often," - this is known as agile development, or prototyping and iteration. This means that when introducing a new technology concept, even in the context of an intractable development problem, quick trials and adaptations are beneficial in order to find out what will best serve the client and the market. We also speak of demand-driven development: if the technology intervention is desirable, it will be in demand by the "consumer". Depending on the

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[11] The Principles for Digital Development (https://digitalprinciples.org/) also recommend choosing open source whenever possible.
[12] Ibid, multiple references
[13] Da Silva and Fernandez, p. 2718

[14] Marais and Meyer, 2015, p. 3
[15] Braa and Sahay, 2004, p.338
[16] Silva and Fernández, 2016
[17] Kumar and Best, 2006

technology, this may alleviate some if not most of the demand on public or donor funding as the consumer will pay for some of the cost.

TRAGEDY OF THE COMMONS?

This individualistic approach to sustainability is different from that of looking to modify a large system's characteristics through institutionalization. OSM is is unusual in that it can be both part of an institutions' central functioning and decision making, and also a part of personal use and commercial products. Our projects may seek both to modify large systems and government (inherently slow to change), and to innovate and iterate for individual clients and customers.

However, at the same time, OSM is a public good just like any open public data, which brings in another level of ethical and social considerations. There are system-wide needs, such as the promotion of open data at national levels, which may not be the top priority for any of the individuals, organizations, or projects taking place. This "tragedy" of the commons[18] which needs to be considered by the OSM community as a whole. Larger organizations, institutions, and donors may be best positioned to support these goals. An analysis of OSM benefits should be careful to take into account this complexity. This is why we ultimately will recommend an ecosystem approach to the use of OSM in development - one which takes into account all levels of actors, from the individual to the international, and the various incentives of each type of actor.

GENERATIVITY & SUSTAINABILITY

Finally, the concept of **generativity** may further add to our understanding of project sustainability.[19] The idea of generativity means having the ability to develop new things with the technology, not just use it for what its original or current purpose may be. Five characteristics constitute the generative potential of a technology: capacity for leverage, adaptability, ease of

mastery, accessibility and transferability. OSM is often a generative technology - the map data is typically used to build other things, such as designed maps using software like QGIS or MapBox, basemaps for a variety of applications, routing directions, or a website for a specific sector like Open Schools Kenya[20]. It is easy to download and use the data in open formats. However, a high degree of mastery is often required to generate new things, often including relevant coding skills. When looking at achieving sustained benefits, we may want to assess the extent to which an OSM project has transferred enough skills that users are able to create new things using the tools, if not actually create new tools or build new software.

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[18] "The tragedy of the commons is a problem that occurs when individuals exploit a shared resource to the extent that demand overwhelms supply and the resource becomes unavailable to some or all." https://science.sciencemag.org/content/sci/162/3859/1243.full.pdf

[19] Terje Aksel Sanner, 2017

[20] www.openschoolskenya.org

BENEFITS OF MAPPING INITIATIVES

The following list summarizes the kinds of benefits we frequently aim for in OSM mapping initiatives. Prior to beginning our work or planning for the future, we should clarify the top priority benefits we hope to achieve and sustain.

1. Open Data/Mapping in Government and Institutions
   - Increased institutional acceptance of OSM/open data/citizen generated data in government, universities, other institutions
   - Building relationships between governments and citizens
   - Providing open data to government and citizens
   - Affordability as compared to traditional mapping efforts
   - Government integration of OSM in its own systems
2. General improvement of data for policy and decision makers
   - Data allowing for decision makers of all kinds (governmental and non-governmental) to plan and make better choices.
   - Access to data at all levels helps citizens and community groups to encourage and lobby for policies based on evidence
   - Improvement of key open data in areas that are less mapped and more vulnerable, leading to social impacts and policy
3. Social benefits for local communities through better data access and use
   - Local NGOs and CBOs are able to better plan
   - Individuals can make decisions based on shared data
   - Accountability for marginalized groups through greater transparency; opportunities for groups to use map data for advocacy
   - Strong community linkages lead to better integration with local needs
   - Equity of data access
   - Community social impact when field projects are undertaken
4. Sectoral Direct Benefits
   - Positive impacts on specific sectors of development when data used for projects and planning, e.g., disaster preparedness or response, water point distribution, health.
   - Geographic data can be used to place new projects, determine need, indicate vulnerability to disaster, and more.
5. Mapping Skills and Career Advancement
   - Training of geographers and professionals to use OSM in their work, and move away from traditional closed data and proprietary software
   - Creating opportunities in mapping related livelihoods
   - Building local expertise in mapping and data
   - Student skill development, practical experience, and learning
   - Integration of OSM into curricula
6. Growing the Global Network of Mappers
   - Building relationships between local mapping groups and international tech communities
   - Growing the international community of mappers to respond to challenges such as disaster or resilience needs as they may arise

3. TYPES OF ACTORS: GROUPS, ORGANIZATIONS, INDIVIDUALS

Mapping tends to be organized somewhat differently in each country, with many different groups, arrangements, and types of mappers. Individual mapping projects may feature multiple actors, each playing different roles. Each actor has their own strengths, related to the way they prioritize their goals and seek to have an impact. We will now begin to consider OSM in development specifically, using the concepts of sustained benefits and the breakdown of sustainability dimensions detailed above. We will first look at the typical actors working in OSM for development, and at some case studies which highlight the challenges to sustainability that actors often face. Looking at each actor separately will allow us to better consider how they face different challenges to sustaining benefits, and how they may prioritize those benefits differently.

The main categories of actors are as follows:[21]

1. Small **local NGO's**/community-based groups

The first grouping consists of local non-governmental organizations and community based organizations. This type of group is particularly sensitive to the needs of local communities as well as national data needs. They form the backbone of much of the local OSM mapping in developing countries. However, in most examples we have found, they have been initiated by and remain largely reliant financially or otherwise on

relationships with either an external support organization or individual foreign "champion". They frequently also depend on the motivation and leadership of one local champion.

Within this category we find subdivisions according to whether the group is a registered and formalized NGO, or just an ad-hoc or unregistered volunteer group, and whether they primarily work on OSM mapping, or primarily work on a particular issue (health, water, etc) and have added mapping as a tool to support their central mission. In such cases, they may require outside assistance from more skilled mappers to do more complex work, and/or keep their skills up-to-date.

For small organizations, sustaining their funding sources is a big challenge. They may rely heavily on funding from their founding organization, work with short term project grants, or work on contracts with INGOs or government for specific data. Internal capacity to manage such contracts and raise funds can be limited. They face difficulty sustaining activity and momentum once projects are complete. Even enthusiastic volunteer-driven groups require minimal ongoing support for mapping to be sustained, to cover basic expenses like logistics and internet. If mappers are compensated at all, they will expect to be compensated in the future, at the same rate or higher, and this may stall mapping if such funding is not available. Access to sufficient mobile devices and other hardware and connectivity is also a challenge for this type of actor. Other more institutional challenges they face include capacity barriers in areas like project management, fundraising, financial management, and technical skills.

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[21] These actors and their challenges are drawn from a series of interviews conducted by the author. See case study boxed text for examples.

CASE STUDY: BANGLADESH: BANGLADESH OSM FOUNDATION, DHAKA

Actors: Chapters; Consultants; INGOs; Government; Universities

In 2013, Open Cities began as a World Bank initiative in Dhaka, aiming to map disaster-prone areas of the city. A local GIS consultant worked with student volunteer mappers. However, volunteers from that project had difficulty continuing to map because they needed paid work. Hoping to spur the use of OSM in government, and thereby related job opportunities, some of the project leaders provided trainings and actively promoted OSM within government, with limited success. Interest grew, however, among large INGOs, who also work closely with government. Asia Foundation, Red Cross and others created opportunities for further OSM mapping, mainly hiring individual consultants. OSM interest grew rapidly and widely throughout the country. Sustainability of these separate efforts was still difficult, as volunteer students who were trained to support each mapping project were difficult to retain, and quality sometimes suffered when working with beginner mappers each time. In 2017 some of the mappers decided to create an organization, **Bangladesh OpenStreetMap Foundation**, to coordinate the disparate OSM mapping happening nationally and to help ensure quality. BDOSM also began taking on contract or grant work and developing special initiatives, such as updating the road networks nationally.

INCENTIVES TO PARTICIPATE:
1. For students: Learning skills that would be useful to their career and job prospects; receiving a certificate to document participation; minor remuneration in the form of transport and food costs covered.
2. For graduates: Daily remuneration (paid job)
3. To be of service in case of acute need: many mappers also support voluntarily during emergencies

KEY BENEFITS TO SUSTAIN:
1. Creating data for a wide variety of institutional use (both governmental and not)
2. Specific sectoral data for project needs for INGOs
3. Growing career opportunities for graduating student mappers
4. Potential government integration of OSM in its own systems

CHALLENGES:
- **Financial/Economic:** Keeping student volunteers engaged, supported, and adequately trained requires funding. Volunteer turnover is common, (due to lack of resources) resulting in a constant training/recruitment cycle.
- **Technological:** Many times enthusiastic new mappers create data that requires more cleanup. At times this requires keeping data separate and then cleaning it up before sharing to OSM. Multiple concurrent projects countrywide are hard to track.
- **Institutional:** Marketing the concept of OSM both inside government and amongst the NGOs is a constant challenge. Government concerns about having their data open is also a hindrance.
- **Social/Cultural:**
  - Competition: Given the competition among many projects and independent consultants, the Bangladesh OSM Foundation hopes to regulate and coordinate by guiding projects through its membership. It does not expect to take on all OSM work directly, but it does seek to approve all OSM projects and coordinate them nationally, in order to maintain a quality check on OSM work to keep the overall data reliability and trust high.
  - Challenges of the Commons: Base mapping tasks are being under-resourced; updating existing data is not necessarily project-driven either. An organization can support these kinds of tasks only if it has enough resources outside contract work.
  - Brain Drain: Students from higher-level universities usually leave the country right away. To combat this, investment of training efforts has been targeted more to mid-tier schools.

2. Freelance **consultants** serving the aid sector, large firms and government

In some places, individual consulting is the primary way that mapping is organized and OSM data is collected, often in conjunction with imagery tracing and other global supports. There may be quite a lot of interest in using OSM in the government and the international aid sector. These high-level uses generate demand for OSM skills which in turn supports the growth of consulting services, often at an individual level. In some countries, this approach to organized mapping is happening on a smaller scale. In others, such as Bangladesh, it is happening on a larger scale and in conjunction with a nascent national organization and with student groups

Due to a lack of a stable organization which can develop projects or raise grant funding, an individual consultant-based model can face sustainability challenges if not balanced with other kinds of actors. A piecemeal approach to mapping may fail to keep maps up to date, and thereby generate less confidence and interest overall as well as more limited geographic coverage. A social sustainability challenge for this actor is that OSM becomes more restricted in use to those clients, and not more widely accessed, while jobs may be concentrated in a few individuals, particularly well educated males. Sustainability and

growth of the overall map and access to OSM data as well as opportunities can thus be more limited.

3. **Universities** and student groups

Frequently, local universities have been partners in OSM training, and sometimes partner on project implementation. As institutions, universities face a unique set of challenges and opportunities with regard to mapping. Youth Mappers is a USAID program, begun in 2015, targeting universities around the world. A student led, chapter-based program, it is primarily a volunteer based initiative. In most cases, those student chapters work on remote mapping projects; but, in some, student groups also do field mapping. The formal curriculum in some locations has begun to include OSM training modules, and course credit for internships and field mapping projects.

However, at universities, there is often a lack of resources to support basic activities, such as available classroom and computer lab space and internet access. One of the biggest challenges can be to sustain professorial leadership and mentorship over time, and thereby institutionalize OSM in the school via curriculum. A champion within the school is particularly key. Students graduate, and the student groups are not always maintained by the new cohort.

CASE STUDY: TANZANIA: CROWD2MAP

Actors: Small local NGO; links to INGO

The founder of Crowd2Map is a volunteer for the Tanzania Development Trust (TDT), a British charity that has supported grassroots projects in rural Tanzania since 1974, including local activists' efforts to end Female Genital Mutilation (FGM). In 2015, she set up Crowd2Map, having noted that none of their small local organizational partners, all located in rural Tanzania, were mapped. They began training local community leaders as well as remote online volunteers.The mappers were entirely volunteers. Some were local representatives of TDT, who also ran their own organizations, others were local youth and others in their networks. For small community-based organizations, there was first a need to talk to them about the benefits of mapping and being on the map. Most hadn't used laptops or smartphones before. Training in each area has involved local government officials who greatly value the project and the maps of their area that it has provided.
In 2017, the project received its first funding, a micro-grant which allowed equipment purchases and operational funds. It still operates entirely voluntarily, but even volunteers need access to internet, basic equipment, and transportation support. Meanwhile, the rural setting meant that paper maps were imperative and printing and designing them could be costly. Some mappers continue to add to the map if and when they travel around the area and encounter anything unmapped.

INCENTIVES TO BE INVOLVED:
1. Achieve progress on a specific topic of concern, like ending FGM, but also land rights, distance to schools and wider community development.
2. Building skills in technology for better future job prospects, and/or simply personal interest in learning a cutting edge technology.

BENEFITS TO SUSTAIN:
1. FGM prevention through better access to services by girls at risk.
2. Improved knowledge by FGM and related service providers of the extent and locations of area services
3. Visibility of FGM more widely in Tanzania
4. Developing skills in marginalized rural communities

CHALLENGES:
- **Financial/Economic:** At least minimal ongoing support is needed for mapping to continue. C2M has never paid mappers, but has at times provided for transportation and other basic costs incurred, without which many could not take part. There is also a danger that offering payment for mapping might create a dynamic of those who come to it only for the money, especially in very poor areas, meaning they would not sustain it through periods of less funding. The most invested are those with an already-strong dedication to community development and the prevention of FGM and activism related to this, and see how maps of their communities can help support their work.
- **Social:** Rural areas have special considerations - they tend to be far less tech-savvy and connected than urban areas. These barriers can be overcome, but, do require extra resources and unique mapping systems.
- **Technical:** Access to devices, on a budget of nearly zero. Printing maps cheaply and easily.
- **Institutional:** Interaction with local universities has occurred through setting up new Youth Mappers chapters where institutions exist in these areas. However, institutions are not nearly as prominent in rural areas

4. Local **startups** and companies creating commercial apps and products with OSM

Most highly successful startups and small and medium enterprises (SMEs) in this category are based in high income countries (ie, [MapBox](#)), but some, like [Grab](#), a ride hailing service in Southeast Asia, have also originated in emerging economies. Most other examples of companies using OSM data for commercial products have arisen from foreign technologists (or foreign-educated technologists) who start a company in a developing country location (for instance, [ONA](#)), which then employs local staff and developers. While we are not yet seeing a substantial number of commercial OSM-based startups in developing countries started locally, this is likely to change as competency in both OSM tools and location-based software development increases. However, the pace of change is very uneven across countries and regions.

Local startups and companies help sustain the OSM map broadly. Revenue generated directly by a commercial software product can provide much better financial sustainability if the company is successful. There are also possibilities for improvement of overall OSM data for many other purposes when companies work on data edits and track quality; right now companies often do validate data and correct many errors globally. Companies also increase the overall long-term sustainability of the global map, by integrating it into the commercial marketplace and removing full dependency on volunteers and grant or government supported mapping. For commercial purposes, new tools are created, and new kinds of data use are established. Companies and startups are likely to be looking toward one primary goal: making sure the map is as good as possible over time. This is the benefit they will look to sustain - that the map is as accurate, up to date, and complete as possible in the places and ways that fit their business needs.

As with any startup business, success is difficult and comparatively rare for these actors, especially in an emerging market. Frequent lack of skills in building a business, managing teams and money, and acquiring customers can be a challenge. The relationship with the open mapping community must also be fruitfully maintained and data edits shared back with OSM as a whole. A number of companies have not successfully managed this relationship. This can create problems down the road. Meanwhile, negotiating bureaucracy and red tape, and sometimes corruption, can be a huge challenge. It can also be difficult to find local developers who are well versed in OSM, software development, and key business and marketing skills, as well as UX, and other skills required to build a successful technology company. OSM is slowly becoming more well known as an asset to location-oriented businesses but currently those working with maps in developing countries are still more likely to use commercial products (Google, ESRI).

5. OSM **chapters**, networks, and local OSM mapper groups

These may be country-specific chapters, or looser networks of mappers, such as OSM Africa, a virtual network throughout Africa. These groups may organize "mapathons" and State of the Map events in their regions or country, but often aren't formalized as OSM chapters -- which would mean they need to be accepted by and meet strict requirements set by the OpenStreetMap Foundation Board. Many are not even registered as NGOs locally. Some OSM networks are specific to a particular interest area; for instance, GeoChicas is a network in Latin America which has developed to support women in mapping. What defines them is a mission to promote OSM more generally, and create a community of mappers independently of particular companies or NGOs which do mapping. They constitute a kind of interest or user group for OSM enthusiasts. OSM chapters and networks may coordinate country-wide mapping efforts, help prevent duplication or resolve conflicts in mapping areas, and recruit new mappers.

This type of group may be particularly ad-hoc, and without formal incorporation or funding it can be difficult to sustain over time. Chapters need space for

events and meetings, computer lab and internet access for trainings, equipment to share, support for more intensive activities like validation and updating older data. But, if the chapter is incorporated and then funded in a substantial way, it can bring additional challenges of retaining neutrality and being open to all. Particularly if the chapter begins to take on projects which are donor-funded, it may be difficult to distinguish it from a typical mapping-oriented organization, meaning it may be harder to serve the wider OSM community which contains heterogeneous or competing actors. These kinds of sustainability challenges are difficult yet very important to navigate early on.

6. **Government-led** and internal to government mappers

In some countries, GIS officers or those dealing with geodata inside various agencies are using OSM in their work, or at least have been exposed to and trained in OSM tools. In some cases, they are volunteering with OSM outside their work, conducting casual mapping on the side. In other cases, they are orienting entire departments and indeed governments toward open map data, covering huge amounts of information and territory. Many individuals carry their OSM/geospatial skills with them as they transition between government and private sector employment opportunities, and vice versa. In other situations, organizations or consultants implement mapping work in partnership with government, helping to incorporate the process directly.

From a sustainability perspective, however, the reality of governing in lower income countries is that resources are still scarce, and there are incentives to keep data closed. Lack of understanding of and trust in citizen generated data is still a major constraint within government. Legal constraints/legislation restricting citizen activity and inclusion into "official" data records or processes may exist. There is a strong

tendency to work through established and known internal data collection processes and a culture of closed data which can be very hard to change. Politically speaking, sustaining benefits is very difficult when officials leave their posts, particularly when a new government comes in. As well, technologically speaking, entrenched systems or analog systems resist change.

7. **International NGOs** (INGOs) and large aid agencies

INGOs (for example the Red Cross or MSF), and global entities like the World Bank, sometimes conduct mapping projects more or less directly, bringing in outside staff. They often will then hire individual consultants, but may work mainly through existing country offices and their own staff. The Red Cross can work with its network of volunteers, for instance. Larger INGOs and multinational agencies are additionally often able to support large-scale and more technically complex mapping over longer time frames when they do invest in them. They also have the ability to connect data to global research and humanitarian response efforts, and support governments to include complex and advanced mapping technologies and data in their workflows. Some also bridge government and other actors, like the World Bank's Open Cities, helping support government awareness and inclusion of OSM.

Large INGOs and aid agencies, however, may have challenges in sustaining their impact beyond the projects they initiate, especially when working only with ad-hoc individual local consultants. They also can at times face difficulty when large projects with substantial funding come to and end, because expectations by government or consultants and staff may be that mapping work is well-funded, which in itself can be unsustainable. They also may partner with small NGOs or local groups, or startups, but can destabilize the ecosystem when expectations on the capacity of such groups are too high.

DEMOCRATIC REPUBLIC OF CONGO: KINSHASA, OSM RDC CHAPTER

Actors: Chapters, Small local NGO

In 2013, a Belgian GIS professional based in Kinshasa began running occasional OpenStreetMap trainings on weekends for GIS specialists, including government workers and others. There were no resources for this, internet was expensive, and retention was difficult. "Brain drain" was a problem. The business environment was also highly challenging; the informal group of volunteer mappers found that it was having difficulty both getting recognition for its volunteerism, and accessing paid opportunities when they did come up, usually via INGOs who brought in external staff. In 2017, the group decided it would register **OSM RDC** as a local organization to do further training and promotion of OSM while possibly taking on some contracts for partners.

INCENTIVES FOR MEMBERS TO PARTICIPATE: (both before and after registration of OSM RDC):
1. To learn extra mapping skills for current on the job use;
2. New career prospects and potential to earn money from mapping;
3. Interest in social impact through improved data.

PRIORITY BENEFITS SOUGHT BY THE GROUP:
1. Providing maps for specific urgent humanitarian and development needs: ie, refugee areas, response to disease outbreaks, flood or conflict affected areas.
2. GIS professionals from INGOs and government able to use OSM in their work
3. Overall familiarity with OSM and the benefits of open data throughout DRC particularly in humanitarian, government, and development sectors

CHALLENGES:
- **Financial/Economic:** Very scarce resources, starting as voluntary project, failure to connect with externally-driven opportunities in the aid sector. But, funding itself can present a challenge - the moment the organization is formalized to be able to accept money, it can become the basis for competition for opportunities.
- **Institutional/Political:** Very unstable political environment, brain drain, and view of NGOs as primarily profit-making entities. Low trust of the social sector overall. Hard to institutionalize OSM in government with high turnover, lack of sufficient resources, and a related tendency to prefer closed projects over open in order to access more funds.
- **Social:** Competition among mappers can threaten stability and success of an organization. In OSM competition can be detrimental for a number of reasons - not least is that quality of data may suffer, as well as the OSM "brand" if the institutional users are not pleased with outcomes (ie, quality is not controlled well).

OF NOTE:
A different strategy may be needed for sustainability in very low-resource countries with the level of governance challenges seen here. But, it is all the more important in such environments to have good up to date data, and, to avoid wasting money on duplicated data collection

4. SUSTAINABILITY CHALLENGES

In the following sections we will discuss the main challenges to sustainability, for each of the four dimensions of sustainability detailed previously. Prioritized benefits can be sustained only if these challenges are addressed. In each case, the actors that most commonly face each challenge are also listed. Many of these challenges are also shared across all actors, but the primary actors which face each challenge are highlighted.

FINANCIAL/ECONOMIC:

Economic sustainability is achieved when the required resources can be maintained over time. The most common financial/economic sustainability challenges are as follows:

Lack of Consistent Funding:

- Lack of consistent financing from donors leads to one-off projects. (Challenge experienced by: All Actors)

- Governments have minimal resources to maintain up-to-date and comprehensive data. (Challenge experienced by: Government)

- Support from socially oriented venture funders can be short term; succeeding in business is difficult in emerging markets. (Challenge experienced by: Startups)

- Groups require at least minimal ongoing support for mapping to continue, to cover logistics, devices, and other basic expenses. (Challenge for: small NGOs, Chapters, local community/volunteer groups)

- Universities can be challenging to work with, and grant applications (many which require academic participation) can be both complicated, and restrictive. (Challenge experienced by: Universities)

Volunteerism and Livelihood Challenges:

- Competition among mappers for limited resources and project assignments can limit cooperation and coordination essential for long-term sustainability. (Challenge experienced by: Consultants)

- For student volunteers, keeping them engaged/supported and increasing their skill development: frequent turnover in volunteers due to lack of resources and graduating classes results in lower-skilled mappers (since most at a given time are beginners). (Challenge experienced by: Universities)

- Pure volunteerism isn't often viable; however, it can be difficult to determine the best rates to encourage participation and not create high expectations. (Challenge experienced by: small NGOs, and All Actors)

- Lack of a stable organization which can develop projects or raise grant funding, leading to unpredictable work and uncoordinated map coverage Also, a piecemeal approach to mapping may fail to keep maps up to date and thereby generate less interest overall. (Challenge experienced by: Consultants)

- Often an international organization will invest a substantial amount of money into a project, which in turn sparks the creation of a local organization. However, it can be difficult to sustain the level of activity and momentum and transition to other types of resource models, as well as have the capacity to manage without the INGO in other ways. (Challenge experienced by: local NGOs, INGOs)

Challenges in Organizational Leadership, Business Management, Capacity:

- Difficulty of registering a local entity to receive funds and do projects. (Challenge experienced by: Local NGOs, Chapters, Startups)

- Very scarce resources, starting as a voluntary project, and failure to connect with externally-driven opportunities in the aid sector. (Challenge

experienced by: local NGOs, small community/volunteer groups)

- For business startups using OSM, as with any startup, success is difficult and comparatively rare, especially in an emerging market. (Challenge experienced by: Startups)

- Funding itself can present a challenge - the moment an organization is formalized to accept money, it can become a basis for competition. Introducing money into volunteerism changes the dynamic. (Challenge experienced by: Local NGOs, Chapters, small community/volunteer groups)

TECHNOLOGICAL:

Technological sustainability means the ability for a technology to exist for a long period of time without major shifts in hardware or software affecting its availability or durability.[22] It also includes sustainability of data: keeping data up to date, and maintaining data quality; and addressing technical capacity challenges. We have grouped challenges to technological sustainability below:

Hardware and Software:

- Failing to choose sufficiently easy to use, affordable, and accessible hardware. Choosing equipment which cannot be locally maintained affordably; failure to investigate commonly used and owned hardware. (Challenge experienced by: ALL)

- Choosing software that is difficult to teach/use, not locally available or relevant, overcomplicated, tied in to paid model which is not affordable long term. (Challenge experienced by: ALL)

- Using mobiles/other devices with poor locational accuracy. (Challenge experienced by: ALL)

- Insufficient resources to purchase much needed equipment and/or internet access. (Challenge experienced by: local NGOs, small community/volunteer groups)

- Poor or unstable internet connectivity. (Challenge experienced by: ALL)

- No central place to store or hold equipment to share among a variety of users, and possibly no access to large numbers of laptops or mobile devices. (Challenge experienced by: Consultants, Chapters)

- Lack of available classroom and computer lab space and internet access. (Challenge experienced by: Universities)

- Computer systems may be outdated or nonexistent, and internet access unreliable. Proprietary software usually abounds. Entrenched systems or analog systems resist changes.These factors may all come together to challenge the introduction of new technology approaches in an integrated or system-wide fashion. (Challenge experienced by: Government)

Skills:

- Skill gaps: lack of in-depth OSM expertise in country, which may lead to overreliance on external technical support. (Challenge experienced by: INGOs)

- The ongoing need to keep updating software, hardware, and skills can be challenging, particularly when there is not an organizational backing or resources to support new trainings. (Challenge experienced by: Consultants, Chapters)

- Keeping knowledge current on the latest tools and trends. (Challenge experienced by: small NGOs, small community/volunteer groups)

- Creating processes which rely on skills not easily found in-country (such as familiarity with OSM integrations for GIS), or requiring extensive coding skills. (Challenge experienced by: INGOs, Startups)

- Difficulties printing maps cheaply and easily that are appropriate for a low-tech environment; lack of local knowledge of cartography. (Challenge

[22] Ali and Bailur, 2007

experienced by: small NGOs, small community/volunteer groups)

- Maintaining a cadre of skilled, trained mappers over longer periods can be challenging, when they do not have an organized way to continue working or have very little or no funding. (Challenge experienced by: Small NGOs, Chapters, local community/volunteer groups)

- Frequent lack of skills in building a business, managing teams and money, and acquiring customers. (Challenge experienced by: Startups)

- Government may have either no GIS officers or no technical expertise at all in mapping. Where there is capacity, staff may be used to traditional GIS systems and unfamiliar with or suspicious of OSM. (Challenge experienced by: Government)

Data Maintenance:

- Challenges maintaining the base map due to tragedy of the commons issues. Failure to maintain the "content capitol":[23] if the content, or map data, is not updated regularly, then the work is not being sustained. (Challenge experienced by: small NGOs, ALL)

- Challenges in tracking and oversight of newer mapper edits and large numbers of edits (Challenge experienced by: Chapters)

- Validation gaps: lack of resources needed to monitor quality consistently and do key quality assurance checks to quickly address vandalism or unintentional bad edits. (Challenge experienced by: small NGOs, ALL)

POLITICAL/INSTITUTIONAL:

Political and institutional sustainability is achieved when prevailing structures and processes have the capacity to perform their functions over the long term. This means that political challenges have been overcome or accounted for, to the extent possible, and challenges presented by larger institutions in incorporating OSM have been addressed.

Institutional:

- Difficulties integrating OSM into government processes and other major systems. (Challenge experienced by: INGOs, Consultants, small/local NGOs)

- Hard to institutionalize OSM in governments with high turnover and corruption. (Challenge experienced by: Government, INGOs)

- Legal constraints/legislation restricting citizen activity and inclusion into "official" data records or processes may exist. (Challenge experienced by: Government)

- Government resources can also be scarce for keeping data up-to-date and comprehensive, even in cases where government adoption is strong. (Challenge experienced by: Government)

- Smaller organizations and grassroots groups, as well as individual volunteer mappers, may have very little contact with larger institutions. Capacity issues for organizational growth and management may hinder institutionalization. (Challenge experienced by: Grassroots, small NGOs).

- For institutionalization in universities, challenges gaining and sustaining faculty support and leadership. For course inclusion, professors need to be well versed in OSM tools and familiar with learning materials. Students graduate and student groups sometimes are not maintained by the new cohort without stronger institutional support. (Challenge experienced by: Universities)

Political:

- A view of NGOs as primarily profit-making or corrupt entities. Low trust of the social sector overall. (Challenge experienced by: small NGOs)

- Government may be harder to access for grassroots groups. This can hinder sustainability by making it more difficult to integrate maps more widely, as well as making it harder to access funding or resources. It can also hinder legitimization of the data itself. Small groups and businesses might also have less political pull

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[23] Batchelor, 2003

simply due to their size. (Challenge experienced by: small community/volunteer groups, local NGOs, startups)

- Very unstable political environments which can lead to brain drain (Challenge experienced by: small NGOs, Chapters, Government)

- Failure to "sell" open data concept in general, policy adoption and implementation even in countries which sign on to open data policies. There is a need to market the concept of OSM both inside government and amongst NGOs. (Challenge experienced by: NGOs, INGOs, Consultants)

- Turnover and political party shifts within government leading to loss of progress made, when government champions are removed from power or shifted to new roles. (Challenge experienced by: small NGOs, INGOs, government)

SOCIAL/CULTURAL:

Social and cultural sustainability can be said to be achieved when social exclusion is minimised and social equity maximised; that is, participation is spread through the society such that it will not destabilize or exacerbate social inequities. Social and cultural sustainability covers a wide variety of often quite subtle barriers to sustaining benefits, which nonetheless often cause major problems for what at first appear to be very promising projects.

"The biggest socio-cultural obstacle is the perception that "Work must pay". Volunteering, in the sense of "working for free", is not valued or desirable in a context of very low income. Most students face issues covering their studies expenses. Contributing to OSM is a task that involves specific skills that are still relatively scarce locally: using a computer, accessing the Internet, dealing with data or imagery, collecting valuable information and should therefore be compensated. This unfairness feeling is exacerbated when learning that big international companies are in good position to make profit from their contributions." -- Interviewee

Competition/Economics:

- Competitiveness for paid opportunities among members of the national OSM network can threaten the stability of the ecosystem. For Chapters, if incorporated and funded in some way, may be harder to serve the wider OSM community it intends to, which contains heterogenous or competing actors (Challenge experienced by: Chapters, small NGOs, Consultants)

- Uncertainty around whether/how much mappers should be paid, in order to attract the most motivated individuals yet also ensure continuity and inspire a sense of community. Even "pure" volunteerism still needs some ongoing support (just equipment is not enough) - and such volunteers need to have other paid work. (Challenge experienced by: Small/local NGOs, INGOs, Consultants, Startups)

Capacity:

- Lack of capacity locally to manage projects, manage funds, strategy, and leadership. Capacity to navigate the worlds of funding or contracting to get work is a particularly rare skill. This is referred to by Batchelor[24] as "human resource capitol". (local NGOs, INGOs, Consultants, Startups, Chapters)

- Technical project management capacity gaps, or gaps specifically around OSM data management and quality, UX, location based software (Challenge experienced by: local NGOs, Chapters, Startups, ALL)

Tragedy of the Commons:

- Base-mapping tasks (such as road networks or mapping remote rural areas) and updating of data are a necessity, but project funding is rarely enough to cover these needs thoroughly. An organization can support these kinds of tasks only if it has enough resources outside project-driven and contracted work. Volunteer efforts to maintain

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[24] Batchelor, 2003

critical basemaps are difficult to sustain.
(Challenge experienced by: small NGOs,
Chapters)

Social Equity/Access:

- Elite capture: not enough opportunity distribution
when it comes to learning mapping skills.
Opportunities can be restricted to those who are
able to serve as consultants, usually from a sector
of society which is able to access higher-level
education and socioeconomic status, more
commonly male as well. Failure to bring mapping
skills and longer term job opportunities to those
living in marginalized communities that are often
the ones being mapped. (Challenge experienced
by: Consultants, INGOs, ALL)

- Challenges with broadening data and map access
for lower income communities, rural areas, less
well connected areas. Failure to bring online maps
offline through easy printing and other forms of
offline data access. Failure to integrate maps with
local community and citizen users, and create
avenues for meaningful data use that goes
beyond the initial use case. (Challenge
experienced by: ALL)

- Challenges in achieving gender balance.
(Challenge experienced by: ALL)

- Language issues may also hinder sustainability
due to cultural barriers. OSM is not available in
every language, and trainings may exclude local
dialects. This can hinder both expansion of
training and outreach to new mappers as well as
map data access and distribution. (Challenge
experienced by: ALL)

- Brain drain: Students from higher level universities
leave the country. Those from rural areas move to
urban areas. (Challenge experienced by: local
NGOs, INGOs, Chapters, Universities)

- Universities can have trouble with integrating
students into the workforce, and difficulty bringing
activities outside the classroom to do impactful
field mapping without connections to local NGOs
and communities. (Challenge experienced by:
Universities)

- There can also be a social, cultural, and
educational gulf between the business community
and the OSM community in various countries.
Startups sometimes fail to partner with OSM
community successfully. (Challenge experienced
by: Startups)

5. SUSTAINABILITY FOR OSM IN DEVELOPMENT

Sustaining the benefits of OSM must take into account the unique configuration of the global, national, and local mapping ecosystem. Some approaches and tactics to increase desired benefits being better sustained over time are:

For everyone:

Build the Ecosystem
One of the main challenges for OSM in development is typical to open source software project development as well: it is a failure of the commons[25]. Even though OSM has a very robust user community, with thousands of regular volunteers, there is still a problem with needing to support the overall OSM endeavor globally. When it comes to working in developing countries, this problem is even more acute because volunteerism is much less available to people. Some of the things that need to be supported for the entire community to have better, more up-to-date and sustainable data are:

- *Resource the human infrastructure:* networks, groups, trainings, outreach. OSM training and outreach requires space, connectivity, basic funds for trainers, etc. Additional funds are needed to support better outreach for less well-connected demographics, such as: marginalized, poor, disabled, rural, female, without strong educational background, refugees, etc.

- *Lobby for open data:* Doing necessary outreach and education about the benefits of open data, and open map data in particular, takes time and energy and planning. It is a difficult job with continual need. It may also involve events to demonstrate outcomes from using OSM data. Consider adding budget for this to your project funding or your proposals.

- *Build use of OSM amongst NGOs and INGOs and other partners*: Simply reaching out to these potential data users is a big job. However, part of the point of open data is to share it and ensure that others use it, which ultimately strengthens the ecosystem as a whole as more and more users contribute data back. This is also usually not part of a project scope but will be important to the sustainability of the benefits of your project, if they are to extend beyond the initial scope.

- *Recruit data contributors and data sharing*: In addition to building use of OSM, there is also the possibility of encouraging those with map data already in other forms to share it and upload to OSM. Again, this is a contribution to the greater ecosystem but isn't part of program planning very often.

- *Convince private clients and organizations to use OSM:* converting traditional private GIS projects into shared data projects.

Work with Government at all levels
There are many ways to integrate into government data needs, and thereby sustain some of the main benefits of the OSM projects we have seen. Particularly local and sub-national government integration should be considered, as those systems may have immediate data and mapping needs which are somewhat more agile, as well as closer connections to citizens who can participate in mapping. Although working with national systems may be a longer term goal, there are a lot of benefits to working with officials who need to do planning and monitoring right away, with limited budgets.

Encourage the spirit of community and social good.
One thing that was mentioned during interviews for this report was the difference between national OSM communities that began with a notion of OSM as a public good and service, something to volunteer time for and to view as a community of volunteers, versus those which began more as a technical project with a few expert mapping consultants. The observation was

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[25] For more on this see:
https://techcrunch.com/2018/06/23/open-source-sustainability/

that the former had a much easier time growing and thriving in a certain way, without depending quite as much on continuous higher levels of funding. Sharing the idea of OSM as a social good and the benefits being broader than the individual use of maps in a project was more difficult later on. A tactic should be to emphasize and share about the nature of open mapping as early as possible, and to encourage project designs that incorporate this conceptualization. Again, this goes against how typically mapping professionals have seen their work. It can be therefore beneficial to include nonprofessionals, volunteers, interested youth, etc in trainings and outreach.

Examine ideal organizational structures and goals for the country/region in particular

As you can see in the case studies, local groups and organizations are the lifeblood of most mapping taking place on a larger scale in developing countries. Whether for-profit businesses or charitable organizations, they need a thoughtful longer term vision taking into account the pitfalls of different possible approaches as well as their benefits. Strategic planning for sustainability is essential as well as creating a business plan. Not every country is the same; some contexts will better support a small business, others an NGO or CBO.

Plan for data longevity

Data is only as good as its expiration date. Many times, map data is particularly susceptible to becoming obsolete because things change so quickly, particularly in fast-growing economies. What is the plan for updating map data after a project ends, or within the OSM local ecosystem? Who will be responsible for tracking edits and changes? How can you extend the life of the data by incorporating regular updates and reviews?

Increase social sustainability

This can be achieved by widening opportunities for participation in mapping activities, trainings, and especially paid employment or consulting opportunities, with a dedicated focus on expanding access to those who are not already privileged members of the society. A stronger sustained benefit

to mapping will come from increased participation by all sectors of society. This also means supporting existing efforts by less resourced groups rather than repeating the common NGO mistake of failing to cooperate and "reinventing the wheel".

Develop systems for reliability

In very competitive, low trust, under-resourced, and minimally regulated environments, extra measures may need to be taken to ensure reliability of data and OSM projects -- perhaps through chapter-based coordination or "certification" type approaches. This will allow government and other data users to trust the map information. Also, as mapping becomes more complex, validation processes need to match - ad hoc or remote validation may not be enough.

For program planners, funders, external actors:

Resource nuts and bolts of open data/OSM base-mapping and data refresh

Those things that need to be maintained in between specific project needs: the basemaps. They are only as good as their accuracy in the current time period, and in developing countries and urban settings particularly things can change rapidly. Larger entities can focus on solving the challenges of the commons.

Incorporate Universities into Ecosystems

- Provide ways for students to support and learn from real life field projects
- Work out partnerships between schools and NGOs
- Sponsor student internships with local organizations
- Support teachers directly with materials and other resources

Support champions

In a lot of our examples we have champions but we still have unsustainability in certain dimensions. However, we also have not been able to move forward in any of the key projects without this champion, and

much of their success has been thanks to that individual's leadership. It may help to invest directly in the champion, whether financially or with capacity building, training, or other resources, while taking care to ensure they also provide avenues for others to excel.

Analyse incentive structures accurately
It is valuable to assess the incentives of all participants and partners in your mapping projects prior to beginning, and update as you learn. Many of the incentive systems that propel OSM mapping in the developed world are not carried over directly. Question any assumptions about motivations, and create ways to allow for less privileged to participate in projects (for example, recognizing that volunteerism can be expensive to the participant).

Build Capacity
- Build capacity to organize, manage, and administer funds in-country. This may be the single most important contribution to the sustainability of OSM benefits in each country. Ultimately the work will need to be led locally, but currently there are very few opportunities to develop these skills systematically.

- Consider generativity potential. What skills will be needed in order for people to innovate using OSM tools or data? How can those skills be built into programs of increasing tech skills more broadly? Would this mean partnering with coding schools or data analytics trainings? What about training in creativity, design, or business startup skills -- are these necessary counterparts?

Support local mappers
- It can pay off in the long term to hire local OSM groups and individuals, even in highly volatile and challenging locations. Note that these may initially be volunteer mappers. Avoid bringing in short-term external staff if possible.

- At the same time, check to see if there is a coordinating body or organization that can vouch for the work of local hires, and provide oversight. If not, consider supporting the growth of such a group within the project parameters where possible.

- Remember that supporting local mappers is the only way to build long term mapping sustainability, and should be part of the strategy even if in the short term there is a need to work with and through other agencies. This is an area which is ripe for more innovative approaches that can productively support local groups without prematurely overburdening them or causing problems in the local ecosystem. Spend time analyzing the local mapper context accurately including various organizations, networks, and relationships.

- Within local mappers, make a distinction among them. Pay attention to increasing diversity and empowering marginalized groups through projects. By considering the social impact of the project itself, not just the impact of the maps produced, funders can shift the benefits of mapping and increase equity.

For smaller organizations, mappers, and national OSM communities:

Be specific about the core benefits or impacts that will be prioritized by different kinds of groups and projects
If you are involved in a local chapter or organization, what are the benefits you hope to sustain? Be specific and honest. If you are hoping to increase employment for mappers, say so up front and design around that goal. If your goal is to have a particular benefit to one thematic area, say, water and sanitation, and to sustain that in particular, it will be helpful to identify that and focus efforts around sustainability of that benefit. You may have a different set of priority benefits for individual projects you are involved with, and for your organization or group. You can create separate plans for them.

Make a sustainability plan
A real plan, one where you are honest about the goals

and potential for benefits to be sustained, and where you analyze the dimensions of sustainability and how you intend to overcome these challenges.

Consider ways that competition can be made productive to the overall ecosystem and goals of OSM inclusivity and data access, and to decrease competition which is detrimental. Consider ways that competition can be decreased in favor of creating opportunities for the whole local OSM community to work together.

Consider forming a chapter or informal local network to help coordinate mapping and promote the overall ecosystem. Forming an official OSM chapter can be somewhat onerous process and in some cases may be counterproductive to the point above about competition, since it must be a registered organization that can accept funds. An informal chapter or local OSM country network may be sufficient at first.

Address challenges of data quality and keep data current. This may mean coming up with a long-term plan for monitoring edits done in the country and in specific regions, and organizing regular general validation reviews.

6. SUGGESTED AREAS OF FUTURE RESEARCH

As part of this research, a number of interviews with current OSM leaders in several developing countries were conducted. Some of these have been developed into case studies included here. However, there is much more to learn from the specific path of development of each OSM project, group, and ecosystem in each country. Further research could consider the example countries (both those which initially hosted Open Cities, as well as others), looking at both the current "health" of the OSM community and sustainability of mapping as well as the factors which likely contributed to these outcomes. From these examples we can be more rigorous and systematic about learning what the best ways are to support and trigger growth in open map data's impacts and benefits in developing economies. Examining in more detail the local economies and incentive structures which exist in each country and community, and the concurrent impacts of different origins and influences on the particular outcomes might shed light on optimal circumstances and interventions. In particular, the tension between volunteerism and professionalization and their relationship to sustained benefits in OSM mapping is not well explored, but seems to give rise to many key challenges that we see in the case studies.

Social sustainability is a very interesting area of further focus. The Wikimedia foundation, which runs Wikipedia, has identified a goal of Knowledge Equity: "Knowledge equity means focussing on the knowledge and communities that have been left out by structures of power and privilege, and welcoming people from every background to build strong and diverse communities." OSM also strives to create an inclusive and participatory knowledge database - anyone can edit and use the map - so it may eventually adopt a similar credo. But, an increase in access and participation of map editors may not just be the "right" thing to do, but also a sustainability factor - a stronger sustained benefit to mapping will come from increased participation by all sectors of society.

Looking further into market forces and norms that have created barriers to entry, and ways of overcoming those, could be further researched.

A particular area of interest is in using OSM in business applications as one facet of a sustainable model. Further research is needed on existing projects and attempts to create OSM-based businesses in developing countries, the business environment, examples from emerging markets and more developed economies and their potential transferability to Open Cities target countries.

Generativity and social entrepreneurship: undoubtedly, there is already a great deal of research on enterprise development around tech in developing countries. However, generativity is slightly different - it is not only focused on business development and outcomes, but on what must come before innovative businesses - creative use of technology and software development. The goal is to use existing or imported tools to generate entirely new things, which are necessarily more relevant to the local context and demands - an expertise long held by many in developing countries where reuse and repurposing is a way of life. But, generating enough familiarity with complex technologies to spur this may not be occurring at the same rate. This area of exploration might be studied further with regards to OSM in particular.

CLOSING COMMENTS

Sustaining benefits for OpenStreetMap in development is not a straightforward task. OSM sits in a unique place in development, because maps sit in a unique place in development -- they can be both part of institutions' central functioning and decision making, and also a part of unique and personal individual uses and commercial products. Our projects may also seek both to modify large systems and government (inherently slow to change), and to innovate and iterate for individual clients and customers. But at the same time, OSM is a public good just like any open public data. In order to sustain the hard-won benefits of many, many mapping projects globally, more attention to the health of the ecosystem and the failures of the commons to support less project-directed mapping in developing countries is needed.

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