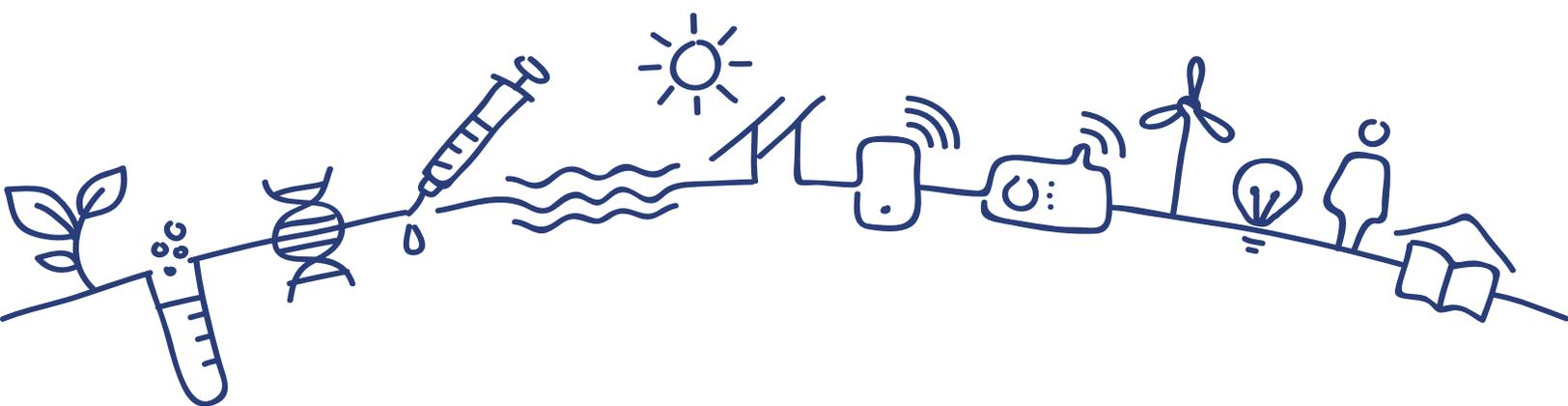


50

BREAKTHROUGHS

Critical scientific and technological advances
needed for sustainable global development



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LIQTT

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NOTES ON METHODOLOGY AND LAYOUT

Traditionally studies focused on future-facing topics have relied on surveys of experts, using approaches like the Delphi Method¹, a structured iterative process of interviews and reviews. Early in our study, we discovered two challenges with such a process. First, the absence of a broad, credible evidence base about what works has led to entrenched opinions. Second, such an approach would likely have led to a laundry list of 50 *technologies* or *devices*, rather than to a robust problem analysis which logically leads to the *breakthroughs* required—agnostic to specific technologies.

Hence, this study employs a six-part approach to reach its conclusions:

- 1 Describe and analyze the 5-10 most important contextual facts about the specific problem.
- 2 Identify the key challenges, which have kept effective solutions from becoming a reality.
- 3 Identify, based on input from recognized topic-specific experts, the most promising interventions to overcome those hurdles.
- 4 Determine the dependence of each of these interventions on: policy reforms, infrastructure development, education and human capital development, behavior change, access to user finance, an innovative business model, and finally, a new breakthrough technology.
- 5 We focus on interventions with a significant dependence on a breakthrough technology, and identify the important parameters the technology needs to fulfill. Based on the underlying technical challenges, we then estimate the time-to-market by when these breakthroughs may become deployable products.
- 6 Finally, we identify the most important hurdles to sustainable, large-scale deployment, based on many of the factors listed above (e.g., policy reforms, etc.), and score the difficulty of deployment on a 5-point scale: simple, feasible, complex, challenging, and extremely challenging. The purpose of this final analysis is to encourage technologists and funders to understand these challenges before making major investments in their work.

Each chapter is divided into three parts: Core Facts and Analysis, Key Challenges, and Scientific and Technological Breakthroughs. The 5-point scale and the complexity we ascribe to each of the factors and constraints relevant to the deployment of a particular technology are illustrated in **Table A**. The lowest score (feasible) is reserved for cases when the particular constraint is not relevant to deployment; the constraint is given the highest score (extremely challenging) if it can be a serious bottleneck to deployment. The aggregate score reflects the overall degree of difficulty, considering the collective weight of the individual constraints. The methodology is clearly subjective. **Exhibit A** is a sample of how we have illustrated the difficulty of deployment for each breakthrough across the study. This particular sample highlights a CHALLENGING breakthrough.

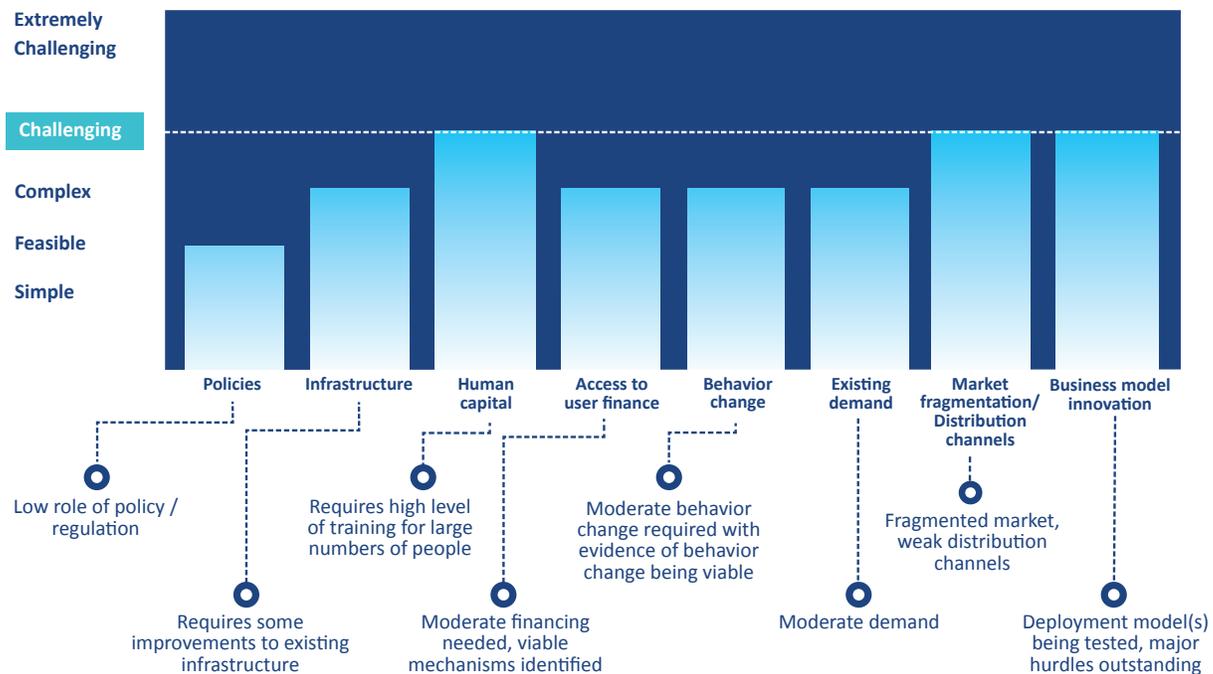
¹ A structured communication technique, originally developed as a systematic, interactive forecasting method which relies on a panel of experts who anonymously reply to questionnaires and subsequently receive feedback in the form of a statistical representation of the 'group response', after which the process repeats itself. The Delphi method is based on the assumption that group judgments are more valid than individual judgments. It was originally developed by the RAND Corporation in the 1950's to forecast the impact of technology on warfare.

Table A

	Simple	Feasible	Complex	Challenging	Extremely Challenging
Policies	Minimal role of policy/regulation	Low role of policy/regulation	Regulated market with supportive policies	Highly regulated market with policy changes required	Highly regulated and controversial changes required
Infrastructure	Minimal need for infrastructure	Dependent on existing infrastructure	Requires some improvements to existing infrastructure	Requires moderate improvements to infrastructure	Requires major improvements to infrastructure
Human capital	Minimal need for human capital development	Low-moderate need for human capital development	Moderate need to train a limited number of people	Requires high level of training for large numbers of people	Requires national scale training programs
Access to user finance	Financing not required	Limited financing required	Moderate financing needed, viable mechanisms available	Significant financing required, limited mechanisms available	Significant financing required, no identified mechanism
Behavior change	No behavior change required	Minimal behavior change required	Moderate behavior change required with evidence of behavior change being viable	Major behavior change required, potentially on daily basis	Significant behavior change needed on daily basis, changes contrary to cultural norms
Existing demand	Strong existing demand	Existing demand	Moderate demand	Low demand, needs to be built	Extremely low demand or not a perceived need
Market fragmentation/ Distribution channels	Highly concentrated market or well defined channels	Fairly concentrated market and/or well defined channels	Moderate fragmentation of customers, under-developed channels	Fragmented market, weak distribution channels	Highly fragmented, challenging to reach customers
Business model innovation	Clear deployment models existing at scale	Deployment model in process of scaling	Deployment model(s) being tested	Deployment model(s) being tested, major hurdles outstanding	No identified deployment model, major hurdles identified

Exhibit A

Breakthrough – Difficulty of deployment



HUMAN RIGHTS

Human rights typically refer to a set of legal entitlements accorded by states that have signed and ratified specific international laws and protocols, usually translated into domestic legislation. They include civil and political rights, economic, social and cultural rights, protections for specific vulnerable populations, and restrictions of particular actions or weaponry in the context of conflict.

Adoption of the Universal Declaration of Human Rights and subsequent international legal instruments, have led to a marked improvement in the protection of human rights around the world. Still, universal respect for human rights is far from being a reality. Severe violations of the rights of individuals and communities are common at the hands of state or non-state actors. Interventions aimed at either preventing the abuse of human rights or ensuring ex-post accountability for perpetrators, tend to diminish in scope and effect especially when faced by the systemic absence of rule of law, real or perceived impunity, the lack of rapid-response preventative mechanisms, and the difficulty of collecting adequate evidence for prosecution.

In recent years, new information and communication tools—particularly digital photography and social media platforms—have played a very important role in increasing transparency and collecting and collating all types of evidence. Our analysis concludes that more progress can be achieved with the help of 3 technological breakthroughs.

- ▶ Low cost (under \$50) wearable, or otherwise easily concealable, cameras with automatic geocoding and timestamps, capable of 'SOS' data preservation (e.g., via satellite)
- ▶ Low cost (under US\$25,000) aerial vehicles—satellites or unmanned aerial vehicles—to capture high resolution imagery
- ▶ A simple point-of-use, low cost DNA-based rape kit capable of delivering rapid results



Human rights, as a standardized, broad, international construct, were developed formally after the Second World War. The Universal Declaration of Human Rights—embracing the notion that “*All human beings are born free and equal in dignity and rights*”—was adopted by the United Nations General Assembly in December 1948. The declaration, even today, remains the foundation of international human rights law.

CORE FACTS AND ANALYSIS

Since coming into effect, the Universal Declaration of Human Rights has inspired a multitude of instruments (over 80 declarations, treaties, covenants, conventions and bills), with various degrees of enforceability under national or international law. Some of the constructs within these instruments still remain aspirational. **Table 1** summarizes the chief instruments that embody the broad set of human rights as codified into various legal instruments (Weissbrodt & de la Vega, 2007).

- ▶ The International Bill of Human Rights which is comprised of the Universal Declaration of Human Rights, the International Covenant on Civil and Political Rights, and the International Covenant on Economic, Social and Cultural Rights.
- ▶ Six core treaties which specify protections for specific vulnerable populations like children, migrants, the disabled, and the Convention Against Torture.
- ▶ A range of Humanitarian Laws governing the conduct of armed conflict including the Geneva and Hague Conventions.
- ▶ A number of topic-specific treaties, such as the ban on landmines and cluster bombs, and the Rome Statute, which created the International Criminal Court (ICC) to prosecute war crimes, crimes against humanity and genocide.

A summary of key human rights instruments

International Bill of Human Rights	<ol style="list-style-type: none"> 1. Universal Declaration of Human Rights: equality, liberty, fair trial, privacy, nationality, marriage, religion, employment, clothing, medical care, free/compulsory elementary education, etc. 2. International Covenant on Civil & Political Rights: self-determination, life, cruel/inhuman/degrading punishment, slavery, liberty/security of person, treatment of prisoners, legal rights, etc. 3. International Covenant on Economic, Social & Cultural Rights: economic/social/cultural self-determination, subsistence, working conditions, standard of living, housing, education, etc.
Six core Human Rights treaties	<ol style="list-style-type: none"> 1. Convention on Elimination of [...] Racial Discrimination 2. Convention on Elimination of [...] Discrimination Against Women 3. UN Convention Against Torture 4. Convention on the Rights of the Child 5. Convention on the Rights of Persons with Disabilities 6. International Convention on the Protection of the Rights of all Migrant Workers and Members of their Families
Humanitarian Law (governing conflict)	<ol style="list-style-type: none"> 1. Geneva Conventions (on conduct of war) <ul style="list-style-type: none"> • Four conventions (treatment of wounded & sick, prisoners of war, protection of civilians) • Two amendment protocols (protection of victims of international armed conflict, non-international armed conflict and adoption of additional distinctive emblem (for medical services)) 2. Hague Conventions (prohibition of chemical & biological weapons, etc.)
Other topic-specific treaties	<ol style="list-style-type: none"> 1. Mine Ban Treaty 2. Convention on Cluster Munitions 3. Rome Statue of the International Criminal Court (for genocide, war crimes, crimes against humanity)

Table 1. Human rights instruments can be roughly grouped into 4 categories. First, the International Bill of Human Rights which lays the foundation for a broad set of instruments. Second, 6 core treaties specific to the rights for various vulnerable groups (e.g., children, women, migrants). Third, international humanitarian laws governing the rights of combatants and non-combatants in armed conflict. Fourth, a number of topic-specific treaties, like the treaty against landmines.

1

Human rights violations involve a wide range of perpetrators and victims

Despite the formal presence of various human rights instruments, rights—of individuals or specific groups of individuals—are routinely violated by a wide range of actors, from representatives of the state like the military and law enforcement agencies, to non-state actors such as armed groups, corporations, citizenry, and organized crime groups. **Table 2** illustrates a typology of typical violations.

Typology of human rights violations

PERPETRATORS	TYPICAL VICTIMS				
	Workers	General citizenry	Minorities and marginalized communities	Women	Combatants
Military, Paramilitary & non-state armed groups	Forced labor	<ul style="list-style-type: none"> • Human shields • Use of banned weapons 	<ul style="list-style-type: none"> • ‘Ethnic cleansing’ • Forcing children into war 	<ul style="list-style-type: none"> • Rape as a weapon of war • Sexual slavery 	<ul style="list-style-type: none"> • Torture • Extrajudicial killing • Denial of POW rights
Law enforcement agencies	Forced labor	Denial of due process	Denial of due process	Harassment of victims of sexual violence	N/A
Businesses	<ul style="list-style-type: none"> • Exploitative conditions or wages • Child labor 	Environmental destruction	Appropriation of land and other resources	Exposure to dangerous conditions	N/A
Citizenry	Abuse of domestic workers	Inter-community violence	Inter-community violence	Raped based on ethnicity or religion	N/A
Organized crime	Human trafficking	<ul style="list-style-type: none"> • Human trafficking • Terrorizing civilian population 	N/A	Sex trafficking	N/A

Table 2: Human rights violations can be committed by a range of perpetrators, against different types of victims. This is an indicative typology of what types of violations may occur at the hands of different types of perpetrators.

Military or paramilitary forces, and non-state armed groups

Armed groups—state or non-state—are often accused of using excessive force and violence on civilian populations, extra-judicial executions, and sexual violence in conflict settings. For example, after a pro-independence referendum in 1999, East Timor (occupied by Indonesia since 1975) was allegedly attacked by pro-Indonesia militia who killed over 1,400 civilians and displaced 90% of the population. Beginning the mid-nineties, the Democratic Republic of Congo witnessed heavy conflict involving state militia and rebel groups,¹ with thousands of casualties and reports of widespread sexual violence (Human Rights Watch, 1999). In Colombia, both the FARC rebels and right-wing paramilitaries have been accused of large-scale violence and killings (Human Rights Watch, 2013). Similarly, armed forces representing Israel have been accused of causing excessive civilian casualties in Lebanon in 2006 (Human Rights Watch, 2007), as have Indian armed forces in Kashmir since the 1990s (Amnesty International, 1995). In many conflicts, rape has been used as a weapon of war (UN Human Rights, 2014).

¹ The conflict involved the militaries of Congo, Rwanda, Uganda, Zimbabwe, and Namibia. Rebel groups include *Rassemblement Congolais pour la Democratie*, Movement for the Liberation of Congo, National Congress for the Defence of the People.

Law enforcement actors

Representatives of the police, judiciary, and other law enforcement agencies can commit violations against citizens through arbitrary detention, torture, denial of justice, and extrajudicial killings. Prominent examples of police brutality include the long-standing record of the Egyptian police, which eventually led to the 2011 popular uprisings (The Economist, 2013), and the Georgian police, where a majority of the force was fired after reforms were enacted in wake of the 2003 Rose Revolution (World Bank, 2012). Such allegations are not restricted to developing countries. The US, the UK and other OECD countries have been accused by several human rights groups of gross violations through acts of extraordinary rendition, and indefinite detention in prisons like the one in Guantanamo Bay, in the aftermath of 9/11 (Human Rights Watch, 2014).

Private businesses

Large international and national corporations are regularly accused of exploiting workers, subjecting them to hazardous working conditions, forced displacement of local populations, environmental pollution, and use of child labor. Prominent examples of allegations include the forced displacement of the Ogoni people (as well as complicity in the execution of Ken Saro-Wiwa, the noted human rights activist) by the Shell oil company in Nigeria in collusion with the Nigerian military regime (New York Times, 2009), heavy pollution of the rainforest in Ecuador by Chevron (New York Times, 2014), and use of ‘sweatshop’ labor by textiles, fashion and apparel (TFA) companies such as Nike, Reebok, Adidas, Gap and Disney (Harrison & Scorse, 2010). Such violations can be committed by multinational companies, their local suppliers (including sub-contractors), private security firms they hire, or other value chain partners. Four industries—extractives, retail & consumer goods, pharmaceuticals & chemicals, and infrastructure & utilities—account for the vast majority of documented violations by businesses (Wright, 2008).

Citizenry

Members of the citizenry can commit violations against their fellow citizens for a number of reasons. Traditional practices in many cultures around the world often discriminate against women and girls, through practices like child marriage, dowry-related abuse, female genital mutilation, and even ‘honor killings’ (WHO, 2013) (Human Rights Watch, 2014). In ethnically-driven or religious conflicts communities can turn on each other, as seen in the Rwandan genocide in 1994 (UN Human Rights Council, 2014), the wars in the former Yugoslavia from 1992-95 (International Criminal Tribunal for the former Yugoslavia, 2014), and the 2002 riots in Gujarat, India (Jaffrelot, 2003).

Organized crime groups

Groups such as the Juarez drug cartel in Mexico (Congressional Research Service, 2007), and the many gangs arising from the breakdown of law and order in Russia (Stoecker, 2000) have reportedly been responsible for widespread trafficking of illicit drugs, humans and weapons, and terrorizing populations. Gangs cause an estimated two-thirds of violent deaths worldwide (Small Arms Survey, 2013) (Lind & Mitchell, 2013).

2

The only metrics for assessing any country’s human rights record are subjective

While one measure of the rights of citizens is the number and types of international instruments their government has adopted, there is often a limited correlation between a country’s formal laws and the

reality of their enforcement. Given the intrinsic subjectivity involved in characterizing the nature and severity of human rights violations, it is very difficult to objectively measure the strength of human rights protections in a country. However, there are some indicators which attempt to quantify subjective analyses, the most well-known being the World Bank's Governance Indicator and the Freedom in the World Score by Freedom House.

The World Bank Governance Indicator (World Bank, 2014) uses aggregated surveys of citizens, institutions and experts to score the quality of governance of countries along 6 dimensions: voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law, and control of corruption. This index measures issues beyond human rights; at the same time, it does not fully address human rights with the necessary level of specificity. Based on this indicator, the worst-ranked countries include Uzbekistan, Equatorial Guinea, Saudi Arabia, China and Iran, and the best-ranked countries include Norway, Sweden, Denmark, Switzerland, New Zealand and Costa Rica. Senegal, India, Indonesia and Mexico are in the middle of the rankings.

On the other hand, the Freedom in the World score (Freedom House, 2014) on political and civil liberties is based on expert analysis (from academic institutions, think tanks, and human rights organizations) based on news report, academic publications, NGO reports, etc. According to Freedom House, the political rights score evaluates the "electoral process, political pluralism and participation, and functioning of government"; the civil liberties score assesses "freedom of expression and belief, associational and organizational rights, rule of law, and personal autonomy and individual rights." Interestingly, the scores according to this assessment roughly align with the World Bank Governance Indicator rankings.

3

There is a strong link between a country's level of development, and the protection of the rights of its citizens

It is important to note that human rights violations are not exclusive to low income countries. Governments, militaries and corporations from high income countries are routinely implicated in major human rights abuses, usually against citizens of lower income countries without the wherewithal or national-level regulatory protection to prevent the abuses, or find recourse. There is also ample evidence that religious and ethnic minorities even in wealthy countries suffer systematic violations of their rights (Human Rights Watch, 2014). Still, it is natural that human rights protections accorded to citizens of a country are a function of the strength of the rule of law in that country. **Exhibit 1** shows the World Bank Governance Index and the Freedom House score for countries grouped into quintiles along the UN's Human Development Index, or HDI (UNDP, 2014), a composite index combining health, economic capacity and education. According to this analysis, the lower the HDI score of a country, the worse its human rights indices tend to be.

The relationship between human development, governance and human rights

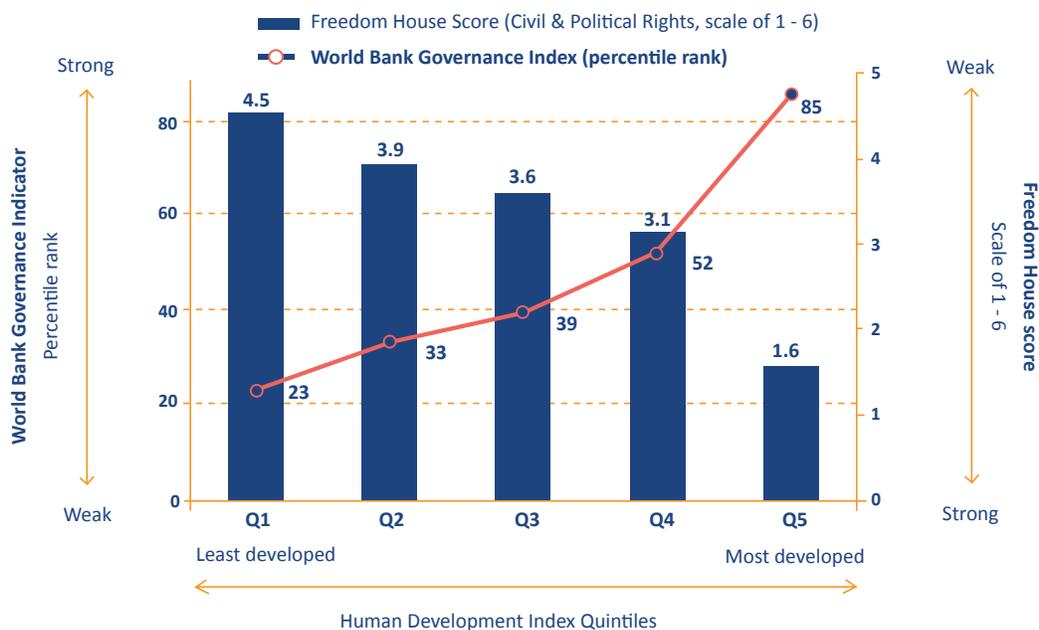


Exhibit 1. With some notable exceptions, the human rights protections given to citizens of a country tend to be a function of the level of human development in the country. This exhibit groups countries based on their Human Development Index score, and plots the average scores or ranks according the World Bank Governance Indicator (left axis), and the Freedom House index of civil and political rights (right axis; in which a lower score indicates better protection of human rights).

4

Human rights interventions fall into 5 broad categories

Advocacy campaigns are aimed at changing policies or legislation at the national or international level in order to protect vulnerable groups, or for engendering formal responses to violations. They can be overtly public, or entirely behind-the-scenes and completely out of the public eye. Recent high-profile examples of advocacy campaigns include the global multilateral effort to secure bans on the use of landmines and cluster bombs (UN, 1997) (UNODA, 2014), the 'Bring back our girls' social media campaign to urge the Nigerian government to rescue the more than 270 schoolgirls kidnapped by the Boko Haram militia group (The New York times, 2014), as well as the campaign to legalize same-sex marriage in the US (Becker, 2014).

Name-and-shame campaigns are the most common type of human rights intervention, involving public embarrassment of alleged violators, or actors who can influence them but seemingly are turning a blind eye, with the intention of provoking corrective action. These typically take the form of accusatory reports in popular or influential media, public protests, email chains or online petitions to their customers or constituents, or other forms of media campaigns to the same effect. One of the earliest and best known examples of name-and-shame campaigns is the one that led to the widespread boycott of Nestlé's food products because of the company's aggressive push for its breast milk substitutes in low

income countries—and the alleged link to death and disease among affected babies (Muller, 1974). Arguably, name-and-shame campaigns can be considered a form of advocacy.

Criminal prosecution is usually the preferred mechanism for ex-post accountability, from the point of view of the victims. Given the broad range of violations, it is likely that most of the prosecuted cases are handled in routine criminal courts. In some cases, special local courts or other forums are created, like the *Gacaca* system for the Rwandan genocide (UN Outreach Programme on the Rwanda Genocide, 2007). In cases when it appears unlikely that the accused will be tried fairly in the home country, prosecutions are conducted at the ICC,² or at other special international tribunals such as the one for the former Yugoslavia (International Criminal Tribunal for the former Yugoslavia, 2014).

Civil litigation, especially against large companies, is a more recent phenomenon in which victims or their families seek financial compensation from the accused company. For example, companies like Chevron and Shell have been sued in US courts under the auspices of the Alien Tort Claims Act,³ for their alleged violations in Ecuador and Nigeria, respectively (The New York Times, 2014) (The New York Times, 2009).

Standardization and certification of business practices, with compliance monitoring, has contributed to improvements in corporate responsibility in recent years. Examples include fair-trade certification of food and other farm-based products (Fair Trade USA, 2012), the ‘Voluntary Principles on Security and Human Rights’ for the extractive and energy industries (developed by a coalition of governments, NGOs and corporations), and the Kimberley Process Certification Scheme to monitor extraction and flow of diamonds across international borders to control the flow of conflict diamonds. Such mechanisms, to date, have been largely voluntary, and are too recent to have a long-term impact yet.

5

In recent years, new communication tools and social media platforms have significantly improved transparency

The recent proliferation of technologies like camera-enabled mobile phones and social content sharing platforms have dramatically increased the ability of affected communities to document and disseminate information about and evidence of violations, as well as create global awareness of events and issues that may have otherwise gone largely unnoticed. One prominent example is *Ushahidi* from Kenya (MIT, 2014), a crowd-sourced, SMS-based reporting tool which tracked incidents of violence in the aftermath of the 2007 elections in the country. Since then, it has been used in South Africa, Haiti, The Democratic Republic of Congo, and Gaza. Similarly, platforms like Twitter and Facebook are widely credited with having enabled the popular uprisings that together comprised the ‘Arab Spring’ (Howard, et al., 2011). Other examples include *CGnet Swara*, a mobile enabled network, which has helped tribal communities in India document police violence (International Center for Journalists, 2012), and *HarassMap*, a platform for crowd-sourcing and documenting cases of sexual harassment and abuse in Egypt (M. Chalabi, 2013).

In addition to increasing transparency, such technologies have had a disintermediating effect; vulnerable communities and groups can now make their voices heard globally, without relying on international NGOs or formal media channels as much as they did even at the turn of the century. The broader manifestations and benefits of information and communications (ICT) tools are discussed in the section on Digital Inclusion.

² Note that only citizens of countries which have adopted the Rome Statute of the International Criminal Court, can be prosecuted at the ICC. The US, Israel, China, India and number of other countries have not adopted the statute. In addition, recent controversies have led to the African Union, as a whole, opposing the ICC’s policies (Hickey 2013).

³ Also known as the Alien Tort Statute, and since 1980 has been used to allow foreign citizens to seek remedies in US courts for human rights violations committed by American entities (or entities with a US presence) outside the US.

KEY CHALLENGES

Human rights violations occur, remain overlooked, or go unpunished for a host of reasons. Perhaps the most demoralizing and daunting of these is the willingness of people and communities to accept—and even inflict—abuse on individuals and communities who they perceive as ‘different’ from them. There are a number of challenges that prevent universal protection of human rights from being a reality.

1

Lower income countries tend to have weaker legal frameworks and enforcement mechanisms

As suggested in [Exhibit 1](#), lower income countries tend to have weaker laws and policy frameworks to protect and promote human rights. In some cases, the laws are deliberately exclusionary, or even outright discriminatory. Even if appropriate laws are on the books, many lower income countries lack the law enforcement and judicial capacity to enforce them. Corruption and a lack of incentives exacerbate capacity gaps, and cultural practices—especially when it comes to women and minorities—make matters worse. Recent examples include the spate of anti-gay laws in a number of African countries (Amnesty International, 2014) and in Russia (Amnesty International, 2014), the new polygamy law in Kenya (Africa Review, 2014), anti-blasphemy laws in Islamic countries like Pakistan (Chowdhry, 2013), and the Armed Forces Special Powers Act in India, which has been used to impose long-term military or paramilitary presence in areas with religious, ethnic and separatist conflicts (Asian Human Rights Commission, 2014).

2

Perpetrators in positions of power often feel real or perceived impunity

When laws or enforcement mechanisms are weak, individuals and corporations in positions of power feel a certain degree of immunity from prosecution. The same can apply to countries with powerful militaries and political alliances: the many American invasions of weaker countries (Human Rights Watch, 2006), Israel’s actions in Lebanon and the Occupied Palestinian Territories (Human Rights Watch, 2014), and Russia’s interventions in Georgia and Ukraine (Human Rights Watch, 2014), have all been documented by human rights organizations as examples of such aggression.

3

During ongoing conflicts, there are few early-warning signs that can alert appropriate authorities about imminent atrocities; even when there is adequate early warning, effective rapid-response preventive mechanisms are difficult

In the past three decades, there have been several major human rights atrocities against people ostensibly under the protection of UN Peacekeepers or other forces. In the case of the Rwandan Genocide of 1994, there is now clear evidence that the UN peacekeepers knew about the imminent threat to the Tutsi community. According to most accounts, however, the genocide went on partly because of political paralysis among institutions in a position to intervene (Dallaire, 2003). Similarly, the UN Protection Force for the former Yugoslavia (UNPROFOR) was seemingly aware of the impending massacre of civilians in Srebrenica in 1995, but for reasons similar to those in Rwanda, did not prevent the incident (Human Rights Watch, 1995). In the 2010 mass rapes in Luvungi in the Eastern Congo, on the other hand, there are conflicting reports on how much the local UN Peacekeeping troops knew about the imminent threat of large scale sexual violence (Heaton, 2013). In the Darfur genocide that began in 2003, many atrocities—especially during the early years—occurred when there was no legitimate protection force around. A UN Peacekeeping mission (UNAMID) was not authorized and deployed until 2007; even since then, UNAMID has been limited in its ability to fully prevent atrocities in Darfur (UN Security Council, 2014).

As these examples show, war-related atrocities occur because there is no military protection of civilian populations, the legitimately appointed protection force does not have advance warning of an impending atrocity, or the ability of the force to intervene is frequently undermined by political or other considerations.

4

Often, there is lack of verifiable evidence to prosecute perpetrators

Timely, credible evidence is a prerequisite for holding violators legally accountable. Evidence can come in various forms: victim or witness accounts, photographs, video, aerial imagery, and biological or chemical residue. Obtaining and preserving verifiable evidence is, however, challenging.

Digital cameras, while increasingly ubiquitous, can be confiscated by violators and critical data destroyed

The proliferation of phone-based digital cameras has led to a dramatic increase in the ability of victims and witnesses to document violations, especially in conjunction with social networking tools. The obvious challenge is that perpetrators will attempt to confiscate all the cameras they can find. Even if imagery is presented in a court of law, its veracity (e.g., time and location of the photographed scenes) can be challenged. Importantly, there is no broadly available platform for preserving footage and imagery related to human rights on public or restricted archives. Mass commercial platforms can be unreliable with respect to security, validation, and digital chains-of-custody. Furthermore, the lack of reliable internet or phone network access in many conflict areas means that important data and recordings can be lost or destroyed before they can be saved or transmitted.

Aerial imagery is still expensive, and relatively low resolution

For some types of violations (e.g., large-scale destruction of entire villages, or tracking the movement of militia and vehicles, exodus of populations, mass burial sites), aerial imagery—rather than ground level photographs or video—is more useful. This can be collected via satellites, aircraft or drones. For example, satellite imagery was used to document the Sri Lankan military attack on the Tamil population in 2009, where civilians were trapped in no-fire zones. Similarly in 2010, Amnesty International’s Remote Sensing for Human Rights Program used satellite imagery to detect mass destruction of civilian housing in Kyrgyzstan (Amnesty International, 2014). The challenge is that the satellite imagery available to civilians is still of relatively low resolution and only useful for outdoor settings visible from the sky (without cloud cover). Satellites are also expensive, although low cost satellites are now being developed by some companies. While high resolution aircraft-based aerial imaging is available (e.g., through unmanned aerial vehicles, or UAVs), it is restricted to military use and very expensive for civil society to commission. Lower cost drones can only be deployed locally and for a limited amount of time, and must be flown to the point of interest from a nearby location. This makes it risky for users (Digital Globe, 2013) (Gertler, 2012) (Astrium, 2012).

Biological (DNA) evidence is still a nascent technology, especially in developing countries

Recent advances in DNA-based technologies have led to significant improvements in the ability of law enforcement agencies to conduct accurate forensic investigations. In the US, this has contributed to a number of exonerations of individuals wrongly convicted of serious crimes (The Innocence Project, 2014). The technology has also been used to develop rape kits to preserve the perpetrator’s tissue samples for prosecution. These kits, however, require a trained medical examiner, gathered evidence needs to be processed in a lab with sophisticated equipment, and the overall system is expensive—well over \$100,000 per analyzer. Moreover, biological samples can disintegrate quickly or be tampered with, rendering them inadmissible in a court of law. While some preservation mechanisms exist, they may not be feasible at the location where samples are collected (RAINN, 2014) (Engadget, 2012).

SCIENTIFIC AND TECHNOLOGICAL BREAKTHROUGHS

The human rights of individuals and communities, especially those without power or voice, will only be adequately protected if attitudes about fairness and justice change, and strong institutions capable of protecting the rule of law are developed. Even as those fundamental improvements are achieved, a small number of technological breakthroughs can improve evidence collection, increase transparency, and thereby enhance the prospects for accountability.

Low cost (under \$50) wearable, or otherwise easily concealable, cameras with automatic geocoding and timestamps, capable of 'SOS' data preservation (e.g., via satellite)

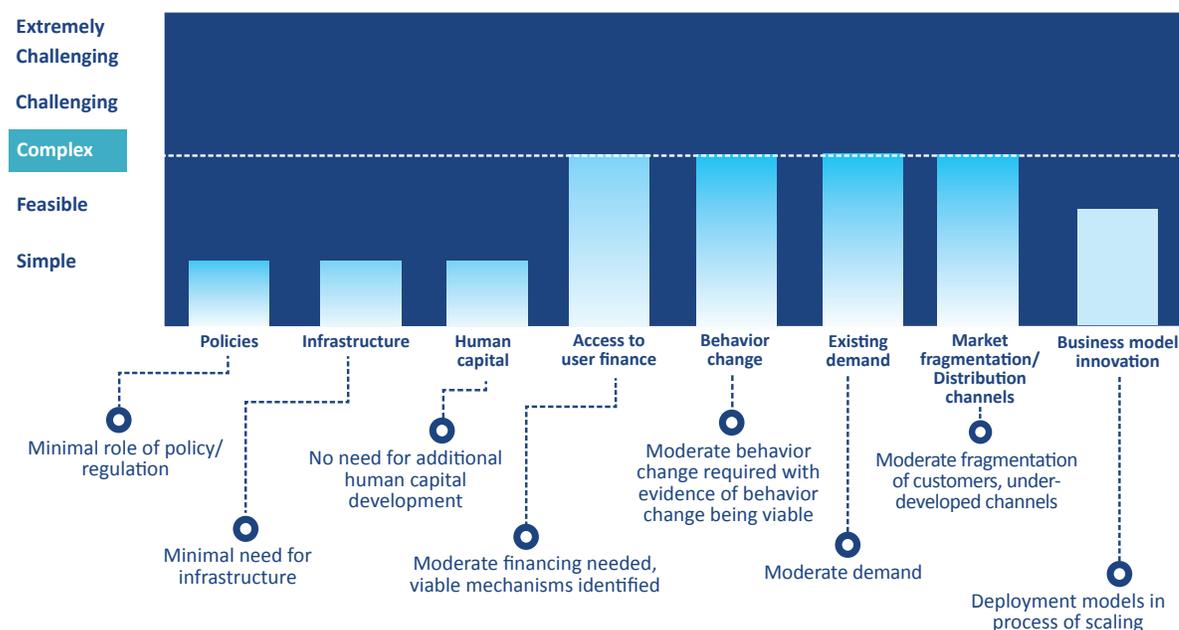
The proliferation of mobile-phone based digital cameras and cloud-based social media platforms has allowed citizens to make impromptu recordings of events of interest and post them online. This ability to instantly shoot-and-upload has led to an unprecedented level of citizen journalism and activism, and in turn, the documentation of human rights violations. While this steady march towards miniaturization of computing devices and sensors is eroding long-held notions of individual privacy, it has given an increasingly powerful tool to victims and witnesses of human rights violations to document incidents and push for accountability.

Crucially, any data stored in devices like mobile phones is dependent on phone networks and the internet for uploads or wider sharing. During emergencies and conflict situations, access to these is unreliable. Moreover, anyone with the intention of committing a violation will attempt to confiscate all phones, and any other visible recording device, before data can be shared. A particularly valuable feature for a wearable miniature camera would be the capability to preserve data (e.g., via one-time SOS satellite uplink), especially in a situation where the data may otherwise be destroyed. If such a device comes equipped with geocoding and timestamps, the imagery captured will be even more powerful with respect to legal admissibility.

Over the past 1-2 years, wearable cameras like Google Glass have begun appearing on the market. However, they are still quite conspicuous, and far too expensive (well in excess of \$1,000) even for the average consumer in developed countries. Still, given the speed with which these technologies are developing, it is quite likely that inconspicuous wearable cameras will become common in high income countries within the next 3-5 years. It will likely take another 3-5 years for these devices to become affordable enough for low income populations.

Once they are available on the market at the right price point, there is reason to believe that adoption will not be difficult, especially judging by the example of mobile phone-based cameras. It is important to note, however, that much of citizen journalism today happens because people carry their mobile phones everywhere. It is not clear if consumers will find enough reason to carry a separate wearable device a routine basis, or if there will be a demand for such devices, except in higher income consumer segments (especially since mobile phones already have cameras). As such, we believe that the difficulty of deployment will be COMPLEX.

Breakthrough 1 - Difficulty of deployment



Low cost (under US\$25,000) aerial vehicles—satellites or UAVs—to capture high resolution imagery

Aerial images (via satellites or UAVs) can provide crucial evidence for tracking movements of large groups of people, such as combatant units. The ideal mechanism to capture aerial imagery for protecting human rights will have the following characteristics:

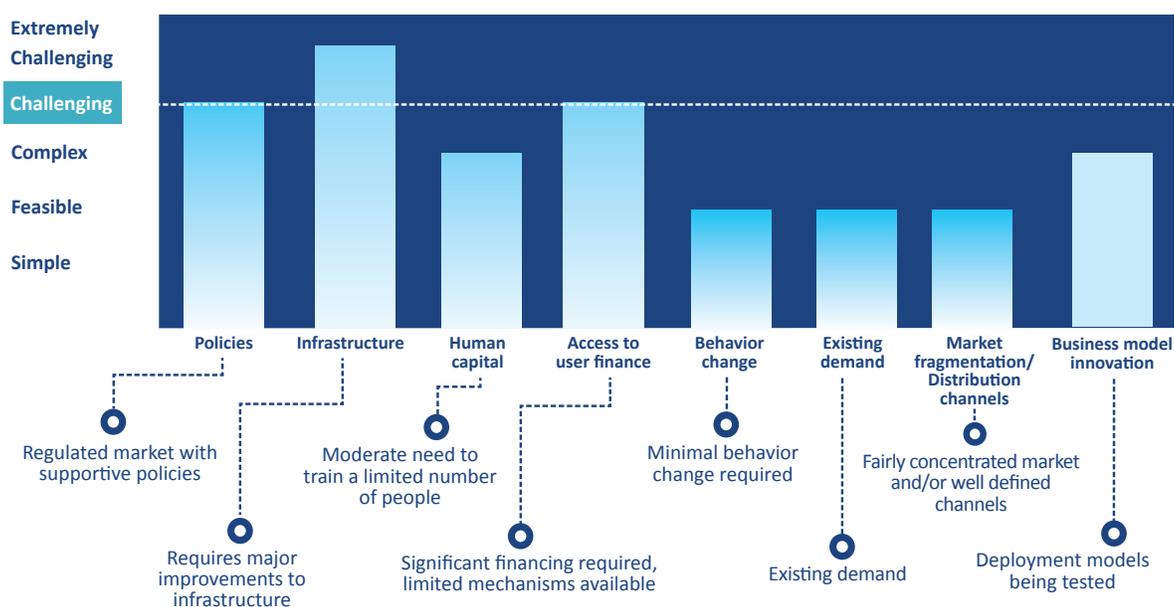
- ▶ The images are of high enough resolution, to identify distinguishing features of vehicles or even individuals.
- ▶ The aerial vehicle should be deployable (in the case of UAVs) or usable (in the case of already deployed satellites) on demand, and capture images for sufficiently long periods, in diverse weather conditions and at sufficiently safe heights.
- ▶ Be affordable for human rights organizations to own, or use as a service.
- ▶ Have contingency transmission mechanisms, so that images are not lost due to disruptions in flight.

Over the past 2-3 years, low cost UAVs or drones have become increasingly available to the public. They can be deployed on-demand for capturing high resolution images, with in-flight transmission. However, the affordable drones (i.e., ones that cost less than \$5,000) can only be used for relatively short periods of time (1-2 hours or less), and are vulnerable to bad weather. Also, a small number of companies (e.g., PlanetLabs) are beginning to develop low cost, low orbit satellites. However, the resolution of images captured from the altitudes they can be deployed at, is still low.

Still, these technologies are evolving rapidly, and are already being used in a wide range of applications. Therefore, there is reason to believe that an adequate combination of capabilities required for documenting human rights violations will become available within 3-5 years. Drones, in particular, will

likely be heavily regulated, and governments (and other actors) committing human rights abuses may attempt to deter their use. However, these hurdles will not be insurmountable given the difficulty of enforcing any regulatory restrictions. As such, usability and deployment is expected to increase dramatically over the next few years. The existing market, in the shape of human rights organizations and media outlets, is niche. Given these factors, we believe the difficulty of deployment is CHALLENGING.

Breakthrough 2 - Difficulty of deployment



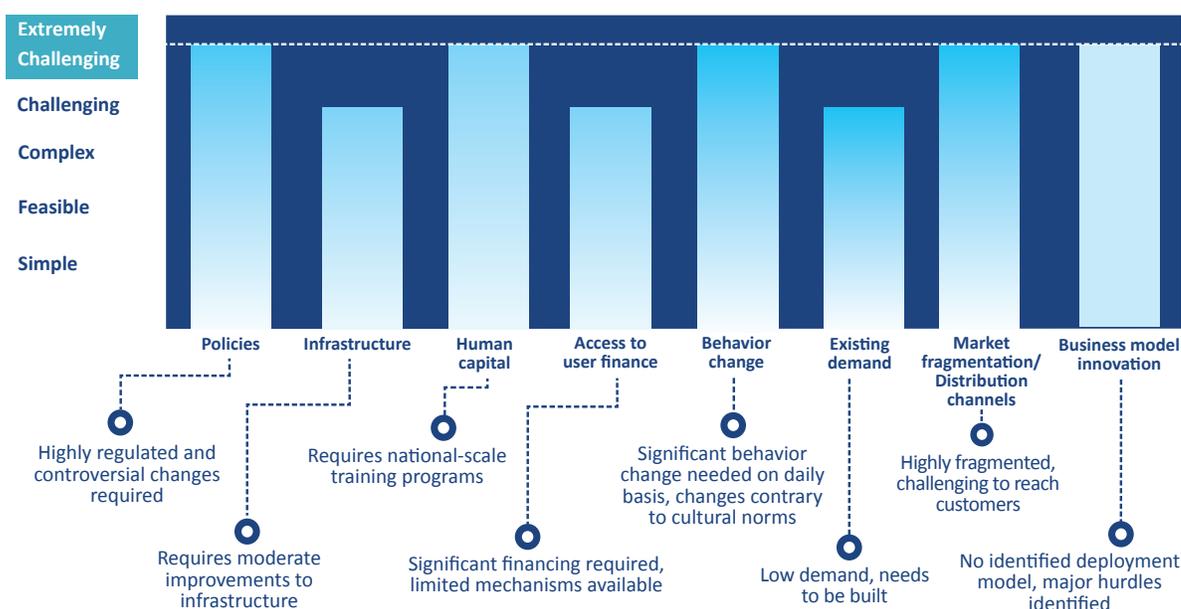
Breakthrough 3

A simple point-of-use, low cost DNA-based rape kit capable of delivering rapid results

Sexual violence occurs for a whole host of reasons, including gender discrimination, societal and interpersonal power dynamics, and impunity that comes from the lack of accountability. A major challenge is that even if a woman overcomes the stigma associated with being a victim of sexual violence and lodges a formal complaint, there is limited evidence to make a robust legal case. Rape kits—to preserve semen and other degradable biological tissue, and conduct DNA analysis on the samples to match against potential perpetrators—are becoming increasingly common in higher income countries. However, these require skilled technicians and a sophisticated, expensive laboratory to analyze the samples. To be useful in low resource or conflict settings, a rape kit would have to be very low cost (under \$10 per test, with the processing equipment not more than a few hundred dollars), usable off-grid, and not require much clinical training to use. In addition, the analysis should be rapid, with the ability to digitize and transmit relevant data for secure (presumably cloud-based) storage. Similar low cost DNA-based technologies being prescribed—and developed—for medical diagnostics, seem to be 3-5 years from becoming available on the market. In principle, a DNA-based rape kit should not take more than 5 years beyond that.

However, once such a technology is developed, it will face significant challenges in deployment, along virtually every dimension. Enough facilities (e.g., health clinics) will need to have the device at hand, those administering the test will need some level of training, and financing will be necessary to cover the costs involved. Without financing it will also be very difficult to ensure a steady supply and maintenance of the kits and the processing equipment. Moreover, policy changes will be necessary to determine how the judicial systems of different countries can best use such evidence in their legal proceedings. But most importantly, the behaviors of victims and the community will still have to evolve considerably. Rape kits can be administered only if a victim seeks help immediately after the incident, while the biological evidence is still intact. In other words, deploying such a technology will be EXTREMELY CHALLENGING.

Breakthrough 3 - Difficulty of deployment



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