The Feasibility of Mapping ICT Initiatives to the UN Sustainable Development Goals

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Abbreviations, Units and Conversion Factors

Abbreviations

ASU	Arizona State University
ICT	Information and Communication Technology
IOI	ICT Opportunity Index
HDI	Human Development Index
KPI	Key Performance Indicator
MDG	Millennium Development Goal
SDG	Sustainable Development Goal
UN	United Nations

Executive Summary

At the United Nations Sustainable Development Summit on September 25, 2015, world leaders adopted the 2030 Agenda for Sustainable Development, which includes a set of 17 Sustainable Development Goals (SDGs) to end poverty, fight inequality and injustice and tackle climate change by 2030. Each SDG has a set of specific targets, 169 in total, and each target will be measured using one or more indicators, specific measures with which to assess progress.

Can information and communication technology (ICT) companies play a critical role in achieving these 17 ambitious goals? If so, how can that impact be measured? Specifically, is it feasible to connect ICT initiatives at the solution, company and/or industry level to the SDGs in a way that can be quantitatively and specifically measured? What barriers make this difficult or, potentially, impossible?

This report lays the initial groundwork for ICT companies looking to answer these questions so that they may join this global effort in a quantifiable way. Its purpose is to develop a process for mapping ICT solutions to the SDGs, measuring their effect and thus explore how ICT companies might make a meaningful impact on the achievement of these goals.

The research was funded by Dell Giving and implemented by the Global Sustainability Solutions Services, one of the Walton Sustainability Solutions Initiatives at Arizona State University.

The ICT-SDG Impact Assessment Framework

1. SELECT GOALS + TARGETS
Identify target or set of targets to focus on

2. ANALYZE INDICATORS
Summarize, categorize and compare the selected targets

3. DEVELOP A THEORY OF CHANGE
Identify evidence of potential real-world impacts of proposed ICT solutions

4. MAP SOLUTIONS
Map the identified solutions to the SDG

5. ASSESS IMPACTS
Select specific countries and analyze their current state
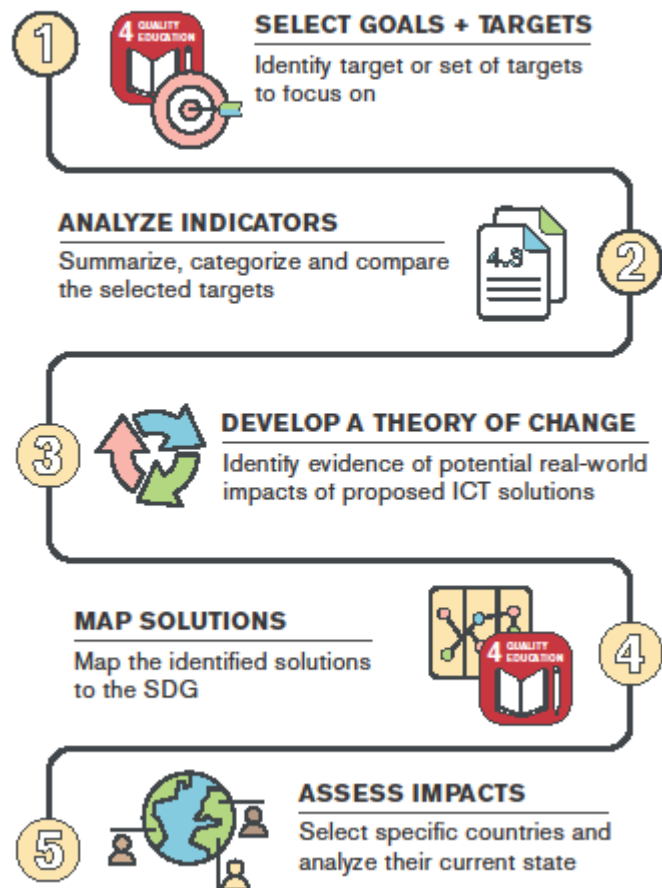
Research Agenda and Methodology

The Global Sustainability Solutions Services team developed the *ICT-SDG Impact Assessment Framework* for mapping an organization's goals and efforts to the SDGs:

1. **Select goals and targets.** For the purposes of this study, the team selected the fourth SDG: *Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all (SDG-4)*.
2. **Analyze indicators.** Summarize, categorize and compare the selected SDG target(s) and their proposed indicators to identify gaps between them, assess the availability of data and likely future developments.
3. **Develop a theory of change.** Develop a *theory of change* (TOC) based on the indicators and their leverage points (drawn from the literature) and then identify evidence of potential real-world impacts of proposed ICT solutions.
4. **Map solutions.** Map the identified solutions to the SDG target based on both direct and indirect impacts as laid out in the theory of change.
5. **Assess impacts.** Conduct an impact assessment by selecting specific countries and analyzing their current state, then using the links from the previous step to estimate the impacts on the SDG target. The exemplar countries selected for this case study cover the different levels of development as characterized by the Human Development Index: U.S. (very high), Mexico (high), India (medium) and Nigeria (low).

Using this process, organizations can evaluate the viability of correlating the organization's ICT solutions to the targeted SDG(s).

Key Considerations and Constraints

- **Targets and indicators are not necessarily aligned.** The U.N. will measure progress on the SDGs with specific indicators (currently still in draft form) that are sometimes aligned closely to their targets and sometimes not. In all cases the indicators are narrower in scope than their targets.
- **The targets fall on different points of the TOC model**. Those that are targeting inputs will be much easier to act on and measure but have the least impact while the SDG targets that are outputs and outcomes will be the reverse.
- **The major constraint is lack of good data.** Very few of the proposed SDG indicators have good data and almost none have thresholds. There are also few quality studies on the impact of ICT on relevant education outcomes.
- **Selecting targets and countries will get easier over the next few years.** As the coordinated global effort to achieve the SDGs ramps up, the process will get

easier. More data will come online as countries and international agencies release reports.

- **For some SDG targets (and their indicators) a rigorous mapping will likely never be possible.** Some of the targets will never be measured sufficiently, in enough places and over long enough periods of time to meaningfully assess changes. For others, the connection to ICT is just too distant and/or weak. Finally, many possible ICT solutions will lack sufficient evidence about their relevant real-world impacts.
- **The SDGs are interlinked.** There are numerous links between the targets. Several other groups of researchers are currently working on systematically analyzing and mapping the links between all of the SDG targets, and taking advantage of their work will be critical in the future to conduct more holistic mapping.

Example Mapping of an ICT Solution to SDG-4

Conclusions

Based on what is known today, ASU Global Sustainability Solutions Services can draw the following conclusions:

- **Mapping ICT solutions to the SDGs is possible in many cases.** Some cases are more direct and easier to map than others, but overall the process is currently very difficult.
- **Insufficient data is the primary barrier.** A lack of meaningful data about the specifics of the SDGs and the relevant impacts of ICT solutions are the main barriers to meaningful mapping and measurement.
- **The country is the level of measurement that matters for the SDGs.** To measure progress on the SDGs, solutions and their impacts must be studied on a country by country basis.
- **Evaluation of the leverage points independently of any specific solutions is critical.**
- **An unexpected and valuable result of the study was identification of the possibility of using a strategic approach to the SDGs.** This could be essential in order to have projects with meaningful and measurable impact on the SDGs. The tools developed in this study can assist in strategically selecting targets and countries.

Next Steps

Next steps for practitioners and researchers:
- Fully quantify the impact of one case study against all of the SDGs.
- Map the impact of all corporate activities of one ICT company against a selection (or all) of the SDGs.
- Expand the analysis on the impacts of the ICT sector on SDG-4 from this report to the impacts of the ICT sector on all 17 of the SDGs.

Next steps for the ICT sector:
- Gather and share better ICT data.
- Find evidence of the impact of ICT solutions on specific SDG goals, targets and especially indicators.
- Create sector-wide alliances to establish standards for mapping solutions to the SDGs, collect more reliable data and collaborate on having a greater impact.

1. Introduction

"Let us harness the power of ICTs to create a new era of Sustainable Development," proclaimed UN Secretary-General Ban Ki-moon in a recent speech (UN News Centre, 2015). Building on the Millennium Development Goals (MDGs) the nations of the world came together in September 2015 to agree on an ambitious global program for human development. The aforementioned agreement, Agenda 2030, consists of 17 Sustainable Development Goals (SDGs) which seek to end poverty, protect the planet and ensure prosperity for all. The achievement of these goals will require not only the enabling power of Information and Communication Technology (ICT) but also the innovation, scale, and reach of the private sector as well.

Figure 1 Visualization of the 17 SDGs (source: UN)

Can information and communication technology (ICT) companies play a critical role in achieving these 17 ambitious goals? If so, how can that impact be measured? Specifically, is it feasible to connect ICT initiatives at the solution, company and/or industry level to the SDGs in a way that can be quantitatively and specifically measured? What barriers make this difficult or, potentially, impossible?

This report lays the initial groundwork for ICT companies looking to answer these questions so that they may join this global effort in a quantifiable way. Its purpose is to develop a process for mapping ICT solutions to the SDGs, measuring their effect and thus explore how ICT companies might make a meaningful impact on the achievement of these goals.

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1.1. Study Methodology

ICT is an enormous and diverse sector which makes for a challenging analysis. Yet, dividing the sector up is restrictive and arbitrary given how much the old divisions are blurring, as for example mobile phones take on many of the capabilities of a desktop computer. This report therefore takes a holistic perspective and inclusive perspective, with analysis relevant for ICT companies ranging from transnationals to start-ups. Specifically the following steps were taken to explore the ability to carry out a mapping of ICT solutions to the SDGs:

1. **Literature Review** covering academic publications, government/NGO reports as well as private sector publications and websites (section 1.3).
2. **Reviewed all SDG targets and indicators**, in particular looking for connections to ICT (section 1.4).
3. **Selected SDG-4**: **Quality Education for in-depth analysis**. Many experts see a lot of potential for ICT solutions in the education sector and education is being described as a fundamental cross-cutting SDG for human development.
4. **Invented the ICT-SDG Impact Assessment Framework**. (section 2)
5. **Conducted an analysis using the framework focusing on four representative countries.** The USA, Mexico, India and Nigeria were chosen to reflect a diversity of culture, geography and development trajectories (as partly reflected in their human development index scores).

1.2. Structure of the SDGs

The SDGs have been designed with a very purposeful structure. The goals are the 17 categories of things that have been deemed essential for global sustainability, e.g. "Quality Education for all". They are meant to be broad, all-encompassing and inspiring. Each goals has been assigned a set of targets which are meant to address the most pressing areas of concern for each of the goals. For education that includes targets ranging from adult literacy to early-childhood development. But while the Targets identify the problems of interest they say nothing about how progress against those problems will be measured. This is the role of the indicators.

The UN has proposed an initial set of indicators of one or more for each of the 169 targets, currently totally 230. Information about the indicators and how

Figure 2 Illustration of the Structure of the SDGs

each is proposed to be measured can be found here: http://unstats.un.org/sdgs/iaeg-

sdgs/metadata-compilation/. These indicators are of key importance for any entity, whether private or public that wants to actually measure the impact of their programs against the SDGs. Therefore they will be the primary focus of this report.

1.3. Private Sector and the SDGs

Unlike with previous development agendas there has been an immediate interest by the private sector in contributing to the SDGs. In addition the UN has been making a concerted effort to include businesses from the get go. While the enthusiasm and commitment on all sides is commendable, how the private sector can actually engage with the SDGs and make a real impact in achieving them is still an unknown. Different approaches are being explored (for more resources see Appendix B) with one popular angle being that expounded by the SDG Compass (http://sdgcompass.org/).
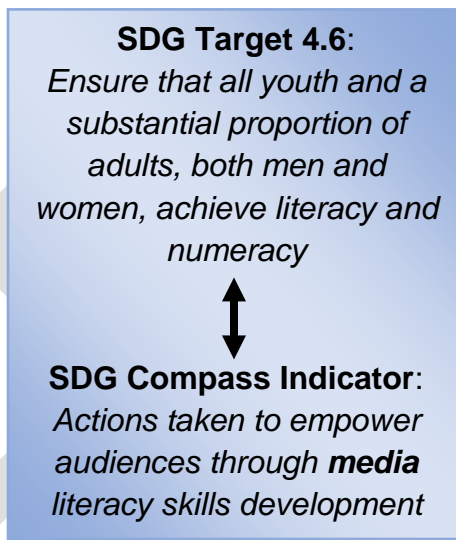
SDG Target 4.6:
Ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy

⇕

SDG Compass Indicator:
*Actions taken to empower audiences through **media** literacy skills development*

Figure 3 Comparison of a SDG with its SDG Compass Indicator

In brief this approach is about aligning a business's current Sustainability related goals and reporting to the SDGs. This emphasis results mostly in a reframing in part because the SDG Compass approach does not call for companies to measure their achievement by improvements in the SDGs themselves. Rather businesses would select their own goals and KPIs (as they do now), but organize them by the SDGs and their targets. Figure 3 shows the type of unbridged gap that results from this approach (see Appendix B for more examples and explanations).

The other emphasis of reports focused on the role of the private sector in contributing to the SDGs, look mostly at potential solutions with profitable upsides. One example is the #SystemTransformation report (https://www.accenture.com/us-en/insight-global-esustainability-initiative-joint-report) which forecasts the impacts of particular solutions such as e-learning by 2030. The potential connection of these solutions to specific targets is explained in one line but no effort is made to illustrate even a hypothetical pathway for how the solutions would lead to meaningful change in the SDG targets let alone evidence of such pathways.

The interest by business leaders in the SDGs is a promising development as the private sector's involvement will be critical to the success of Agenda 2030. So far the efforts in this area look more like a rebranding of the status quo. The key missing piece is attempts to concretely link the activities of a business (and its products and services) to changes in the actual SDG targets and indicators themselves. Bridging this gap will be

critical for business to be able to make real and measurable contributions. Given that the official SDG indicators (i.e. how the SDGs will be measured) are still only in draft form, this report is one of the first attempts to concretely fill this need.

> **Takeaways:**
> - *Business must play a major role if the SDGs are to be achieved.*
> - *Approaches proposed so far are superficial and fail to assess the real-world impact of business on the SDGs.*
> - *The key challenge is to bridge the gap between business solutions/activities and the actual SDG indicators to measure true impact and drive change.*

1.4. ICT and the SDGs

"ICT is the most powerful new tool we have for solving the world's major challenges…yet technology by itself is never a solution. It must be properly deployed," wrote Jeffery Sachs, Director of Columbia's Earth Institute in their report *ICT & SDGs* (Sachs et al, 2016). This important report focused on the role of ICT as an enabler and accelerator of the transformations necessary to achieve the SDGs. In order to take advantage of ICT's cross-cutting potential purposeful actions by both the government and the private sector will be necessary. Many were disappointed at the "almost complete omission of ICTs from the final agreed SDGs (Unwin, 2015)." The analysis of the SDGs, their targets and the proposed indicators for "mentions of ICT" is summarized in Figure 4.

ICT's Inclusion in the SDGs
ICT is mentioned in only 6% of all the indicators and their descriptions.
Explicit ICT inclusion includes:
- Indicator 4.4.1: ICT Skills
- Indicator 4.a.1: Computers & Internet in Schools
- Target 4.b: Scholarships for ICT fields of study
- Target 5.b
  - Indicator 5.b.1: Ownership of Mobile Phones
- Target 17.6
  - Indicator 17.6.1: Technology agreements
  - Indicator 17.6.2: Broadband internet
- Target 17.7 Environmentally Sound Tech

Figure 4. Analysis of Mentions of ICT in the SDGs

The lack of an ICT related goal or even direct mentions of ICT is the reason that the line of research initiated by this study is so necessary. ICT's impacts on the SDGs will be widespread but indirect. Therefore it will be necessary to construct evidence-based maps linking ICT solutions and the SDGs in order to validate any claims of impact.

The importance of ICT for sustainable human development is broadly accepted. For 2016 the World Bank dedicated their annual World Development Report to the vital role ICT plays in accelerating economic and human development (World Bank, 2016). Looking at the SDGs, the #SystemTransformation report identified specific "digital

solutions (that) can contribute directly to the achievement of each and every one of the 17 SDGs and to over half of the 169 targets within them (GeSI & Accenture Strategy, 2016)." The extent of possibilities that ICT presents for solving our most urgent problems is impressive. What is less impressive is evidence that these solutions are impacting our most urgent sustainability problems in the places that need it and at the scale required. In general there is good reason to be cautious about claims of ICT solutions for the SDGs (see Appendix C for details).

1.4.1. Measuring ICT's status around the world

A variety of avenues were explored in a search for publically available data which could tell about the progress individual countries were making in ICT adoption and infrastructure. Appendix C discusses some of the other options which, while not used for this study, could be informative for future analysis. The World Bank publishes two relevant indicators, yearly, for nearly every single country in the world; mobile cellular subscriptions (per 100 people) and internet users (per 100 people).

After studying the data it was decided not to use the cellphone data for inter-country comparisons because the data does not well represent the key issue, what percentage of the population actually has a cellphone. For structural reasons in some countries people with cellphones have many different subscriptions, hugely skewing the totals. Because of these problems the World Bank is shifting to directly measuring the percent of population with a cellphone rather than just totaling up the cellphones in the country as they do now.

The "internet users" indicator is a measure of what percent of people in a given country have used the internet (in any way) in the last twelve months. It's a pretty low standard but at least tells you how much of the population has at least minimal access, knowledge of and ability to use the internet. The following two graphs capture the situation in the world with regards to internet access:
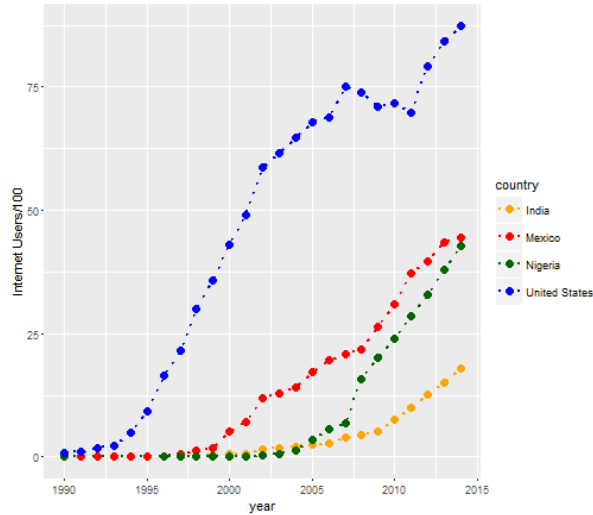

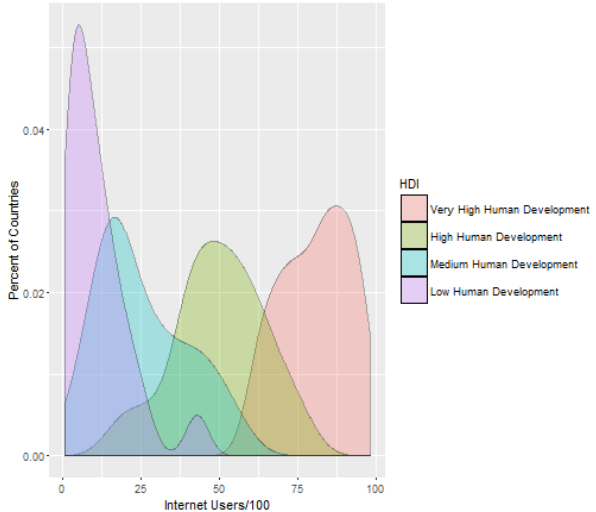**Figure 5 Internet Users in Four Countries over time**

Figure 6 Density Plot Histogram of Internet Users with countries grouped by HDI

Figure 5 shows the differential progress made by the selected four countries in the adoption of the internet. Internet use is increasing everywhere but the rate in a country like India is too slow to expect that by 2030 much more than a bare majority of the country will have ever even been online. Figure 5 is a smoothed histogram of all the countries in the world divided into four groups by HDI status. One can see overlap between the groups (e.g. some medium countries have more internet users than some high countries) but overall there is a clear progression of increasing internet users as one moves up HDI levels. This leaves a huge gap between the Very High Human Development Countries where an average of 80% of people are online to the Low Human Development countries were only an average of 11% are online. These countries clearly have vastly different capabilities to take advantage of the potential that ICT has to offer.

> **Human Development Index (HDI)** is a summary measure of average achievement in key dimensions of human development. We used this system for sorting the countries of the world and chose one example country from each group from highest to lowest: USA, Mexico, India & Nigeria.

The UN and others have pointed to the critical role that ICT could play in enabling the measurement, collection and reporting of data on 230+ indicators in 193 nations. The first place to start would be with data on progress in the ICT industry. The ICT sector collects enormous amounts of data about users and from that we could learn a lot about how ICT is being used in different countries and where the greatest potential is for making a difference with ICT. Unfortunately, the two World Bank indicators (flawed as they are) appear to be the only publically available datasets on ICT in the world's countries.

Takeaways:
- *While everyone agrees on the importance of ICT, it nonetheless plays a very small role in the explicit text of the SDGs.*
- *ICT is seen as an enabler and accelerator of solutions for the SDGs.*
- *There is an enormous array of ICT solutions that proponents believe could directly impact the SDGs.*
- *Extreme caution should be taken in accepting claims of the impact of any particular ICT solution on the SDGs for many reasons including the lack of rigorous evaluation and quality evidence.*
- *Percentage of internet users was the best indicator available to track the progress and status of countries with regards to ICT.*
- *The ICT sector must provide better public databases of ICT related indicators to support the deployment of ICT solutions for the SDGs.*

2. The ICT-SDG Impact Assessment Framework

The Global Sustainability Solutions Services team developed the *ICT-SDG Impact Assessment Framework* for mapping an organization's goals and efforts to the SDGs:

1. **Select goals and targets.**
2. **Analyze indicators.**
3. **Develop a theory of change.**
4. **Map solutions.**
5. **Assess impacts.**

Using this process, organizations can evaluate the viability of correlating the organization's ICT solutions to the targeted SDG(s).

2.1. Select goals and targets

With 169 targets it would be a daunting task to map at once the impact of an ICT solution to the entire breadth of SDGs. This would also be excessive as most will be little effected by any single ICT solution and thus can functionally be left out of the analysis. Here one can see the importance of utilizing this framework via an iterative process. For example, initially a dozen targets from three different goals are identified as potentially relevant. As one begins to work through the rest of steps, it will become evident that some targets should be dropped and eventually one will arrive at a reasonable group of targets with which to work.

For the purposes of this study we selected SDG 4 as discussed in section 1.1. See figure 8 for the full list of targets.

The ICT-SDG Impact Assessment Framework

SELECT GOALS + TARGETS
Identify target or set of targets to focus on

ANALYZE INDICATORS
Summarize, categorize and compare the selected targets

DEVELOP A THEORY OF CHANGE
Identify evidence of potential real-world impacts of proposed ICT solutions

MAP SOLUTIONS
Map the identified solutions to the SDG

ASSESS IMPACTS
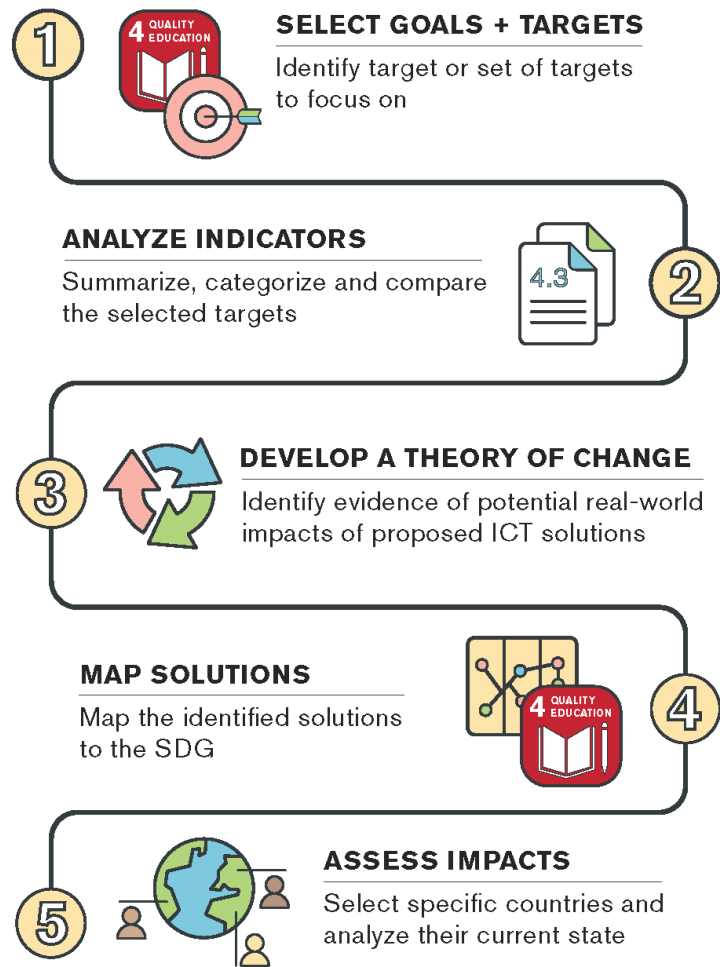Select specific countries and analyze their current state

Figure 7 The ICT-SDG Impact Assessment Framework

SDG 4: *Ensure inclusive and quality education for all and promote lifelong learning*

Targets:

4.1 *By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes*

4.2 *By 2030, ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education*

4.3 *By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university*

4.4 *By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship*

4.5 *By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations*

4.6 *By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy*

4.7 *By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development*

4.a *Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environments for all*

4.b *By 2020, substantially expand globally the number of scholarships available to developing countries, in particular least developed countries, small island developing States and African countries, for enrolment in higher education, including vocational training and information and communications technology, technical, engineering and scientific programmes, in developed countries and other developing countries*

4.c *By 2030, substantially increase the supply of qualified teachers, including through international cooperation for teacher training in developing countries, especially least developed countries and small island developing States*

Figure 8 SDG 4 and its Targets

2.2. Analyze Indicators

While the goals and targets capture the headlines, it is the indicators that are necessary for the hard work of measurement. For this step the objective is to summarize, categorize and compare the selected SDG target(s) and their proposed indicators to identify gaps between them, assess the availability of data and likely future developments. Overall the goal of analyzing the indicators is to assess their functionality for use in concretely mapping ICT solutions to the selected SDG targets.

2.2.1. Measuring the SDGs

Several studies have attempted to measure the status of the SDGs by picking what they determined were representative measurements. Some assessed the goals with a handful of data points (GeSI & Accenture Strategy, 2016; Sachs, Schmidt-Traub & Durand-Delacre, 2016) while another study looked specifically at 2 targets per SDG (Kroll, 2015). We did not find any published studies which attempted to use the same indicators and measurements that the UN has actually proposed for assessing progress on the SDGs (draft of which was made available in March 2016).

In setting the indicators the UN explicitly decided not to consider data availability (Dunning & Kalow, 2016). The result is that in their current state the indicators range widely from easily measurable right now to those that will require significant data collection infrastructure to be measured in a meaningful way before 2030. It is important to remember that these indicators are still under development. The MDG indicators took some years to be finalized and some were adjusted as more knowledge was gained about measurement.

2.2.2. Rating the Indicators and Data

Overall there is significant variability between targets for all of the aspects studied. Indicators could be quite different or quite similar to the target while there is good data for some indicators and no data for others. A traffic light style chart was created in order to capture the overall situation for the indicators and data of SDG 4. Each of the eleven indicators were rated as bad (red), okay (yellow), and good (green) for three criteria:

- **Indicator <-> Target**: How well does the indicator capture all of what the target describes?
- **Current Data**: how well does currently available public data match the proposed indicator?
- **Future Data**: How good do prospects look for data availability for measuring this indicator in the future (by ~2020)?

The justifications for these ratings can be found under each indicator in Appendix D.

Figure 9 Traffic Light Chart of Measuring SDG 4

Takeaways:
- *The UN will measure the progress on the SDGs with specific indicators.*
- *These indicators are in draft form and we did not find any published analysis which utilized them.*
- *Analysis of all ten targets for SDG 4 revealed a lot of variation in the alignment of the target and the indicator and whether there was good data available or not (in some cases no data is available).*
- *It is very likely that some indicators will never have good data and thus impossible to rigorously assess contributions to those targets.*
- *Because of these differences and variations, it is not sufficient to map solutions to the goals or the targets, the indicators themselves are essential.*

2.3. Develop a Theory of Change

In order to legitimately credit the activities of an organization for the improvement in any particular SDG, it is necessary to develop a robust theory of change which clearly demonstrates how said activities led to the measured change. The theory of change will be based on the indicators and their leverage points and evidence of potential real-world impacts of proposed ICT solutions. In step 3 of the framework one needs to focus on three separate pieces necessary for developing a theory of change which will be brought together for the actual mapping of ICT solutions onto the SDGs.

- Categorize the target/indicators as inputs, outputs or outcomes.
- Identify the most important leverage points for the targets independently of any specific solutions.
- Based on the leverage points specify the solutions/operations of interest for this analysis and gather evidence.

2.3.1. Categorizing the Targets and Indicators

One critique of the SDGs is that a large share of them actually measure inputs and outputs and not the outcomes and impacts that Agenda 2030 claims to be striving for. While many targets are ambitiously worded (i.e. outcome-oriented), the indicators proposed to measure them tend to be more conservatively oriented towards inputs and outputs. The inclusion of inputs and outputs is defended on the ground that these targets are seen as necessary intermediaries for achieving other more ambitious outcome- and impact-oriented targets. This dynamic is clear when studying the targets and indicators for SDG 4.

Target 4.a is input-oriented and includes various school infrastructure metrics including computers and internet. Quality school infrastructure is widely agreed upon as a necessary element for Target 4.1 of getting all youth through lower secondary education and both of those feed into Target 4.4 of creating an outcome where all youth have the needed ICT skills.
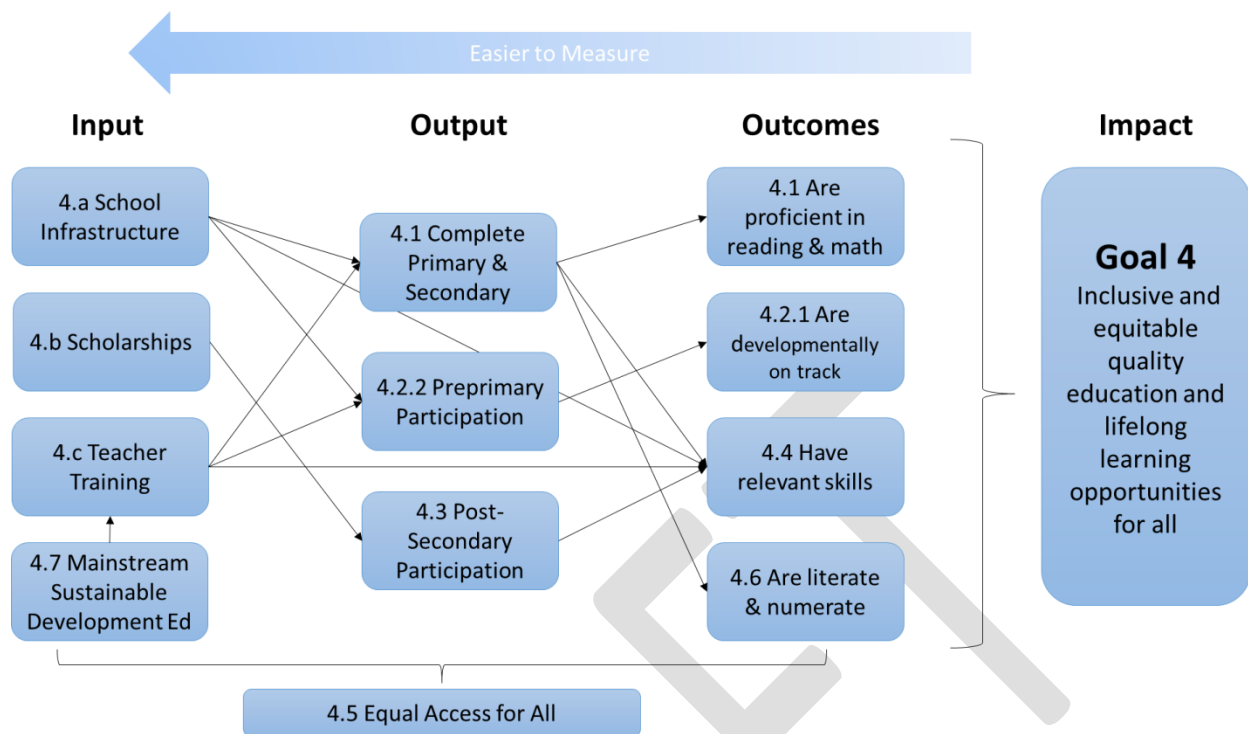
Figure 10. Categorization of SDG 4 Targets with Pathways Shown

For any entity looking to have an impact on the SDGs, the input based targets will be the easiest to measure and attribute responsibility for change to a particular project. For example if by building one hundred computer labs connected to the internet, 4.a is directly improved. By launching a first grade computer program to teach reading, how does it change the graduation rate of those students eight years later? How about change to their proficiency in reading and math at that point? Ultimately the input goals are the easiest to measure and achieve but also the least meaningful in terms of social outcomes.

2.3.2. Leverage Points

Research into the ten education targets should be conducted to reveal the most important leverage points for each one. In other words what are the critical issues, barriers and problems which are holding countries back from doing well on this target/indicator. Summary reports from the World Bank, UNESCO and other international agencies and review articles by academics were key sources of information on leverage points. When working in a particular country it is critical to tailor the target and indicator research to that particular context, as the most important leverage points will vary widely.

Some of the targets are actually leverage points for other targets as illustrated by the previous the example of computer labs. There will also certainly be interactions with the targets of other SDGs. The goal of the framework at this point is not to attempt to

capture the interactions between the SDGs just those within SDG 4. Researchers have begun to work on a framework for understanding these interactions (Nilsson, Griggs, Visbeck & Ringler, 2016) which ultimately will be essential to expanded efforts to fully map private sector activities to the SDGs. The leverage points for all SDG 4's targets are described in Appendix E.

2.3.3. ICT Solutions

A wide range of ICT solutions have been proposed and attempted to improve education. Many of these are variations on the same theme. The selection criteria for ICT solutions will depend on the interests of the organization. For this study a set of ICT solutions was selected based on the following criteria.

- Is the solution either a corporate activity of an ICT company or of the type typically supported by their foundations?
- Is the solution primarily ICT-based, or does ICT form an essential component?
- Is the solution intended to impact one or more of the SDG indicators?
- Does this solution show the potential to be scaled? Can it be applied in more than one country/region?
- Is there some high quality evidence of the real-world impact of the solution?

One of the principal constraints in selecting solutions is the paucity of evidence about their impact. Evidence was not evenly distributed across types of solutions; for example there are a lot of studies about computer labs but little about initiatives to teach girls programming. Additionally, SDG 4 targets only the attempt to measure some aspects of a high quality education and many of the solutions are only distantly related to the specific SDG targets and indicators. Appendix F has descriptions of all six case studies examined for this report.

Takeaways:
- *The SDG targets/indicators actually measure different points on the causal pathways; inputs, outputs and outcomes included.*
- *SDG indicators focused on inputs are much easier to measure and attribute credit for improvements than other types.*
- *Independently researching the leverage points for each target/indicator is an essential step in creating reliable causal maps.*
- *Relevant and quality impact data is one of the key constraints on rigorously assessing the impact of ICT solutions on the SDGs.*

2.4. Map Solutions

With the leverage points, descriptions, and evidence about the case studies, one is now able to complete the mapping, as seen in Figure 10. There are four ways that the case studies were mapped to the SDGs.

- **Directly measurable:** The impact of the ICT solution on the SDG indicator can be directly measured as part of the project. For example building computer labs in schools (Indicator 4.a).
- **Indirectly measureable:** Indirect links were mapped when the ICT solution impacted a relevant leverage point therefore having an indirect, but traceable and attributable impact on the SDG indicator. For example, providing electronic resources may improve classroom pedagogy, a leverage point for primary and secondary student graduation (Indicator 4.1).
- **Influence:** In these cases the ICT solution's impact cannot be traced via one of the leverage points and won't be attributable in a quantitative sense (at least with currently available data). For example providing online resources for girls to learn to code might increase the number that enroll in tertiary education (or at least those that enroll in computer science degrees) (Indicator 4.3).
- **Potential:** New opportunities for impact on the SDGs were identified which the ICT solutions examined here are currently not capitalizing upon.
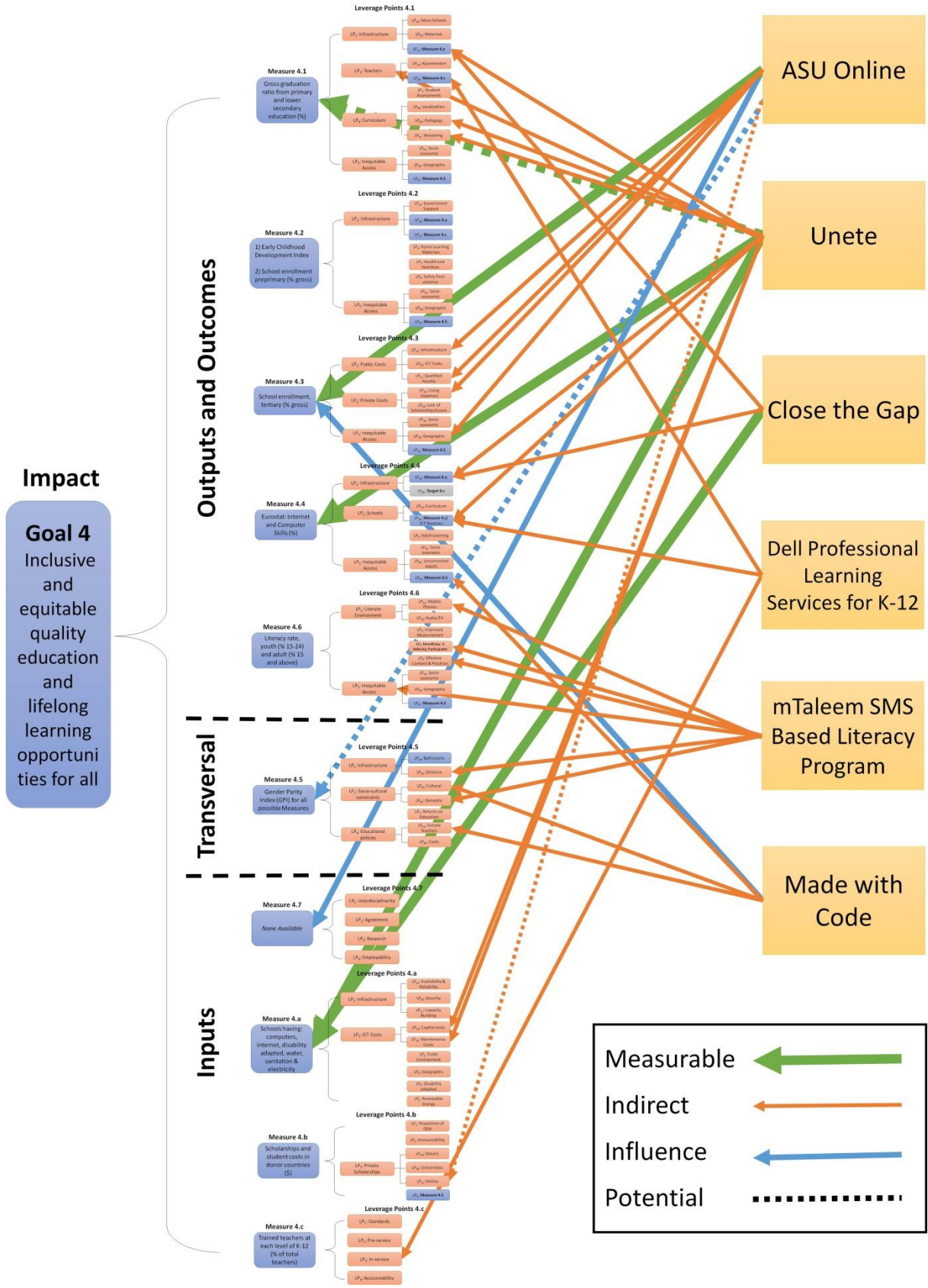
Figure 11 Mapping of six case studies to SDG 4 Targets/Indicators

This mapping exercise was done mapping the ICT solutions not to the targets themselves but to the way the proposed indicators can best be measured today. These measurements were determined as part of step 2. In total 95 leverage points were identified for SDG 4 targets, 14 of those being other targets. There were also 10 target-measures which could be directly mapped to. Of the 81 leverage points unrelated to other SDG targets, ¾ of them were not relevant to the 6 ICT solutions studied here. Analyzing additional solutions would touch on more of the leverage points but ultimately there are many for which ICT solutions are not relevant. The interconnections of the targets was very important, particularly 4.5—as eliminating disparities improves the overall situation. Finally, for some targets such as 4.2 (early childhood), ICT is unlikely to have much of an impact.

Given the current data sufficiency, data relevance and scientific evidence issues, quantifiable attributions or simple correlations cannot currently be made which fully link ICT solutions and the SDGs. For many solutions, some impacts can be quantified, as long as relevant data is reported. In other words, monitoring and evaluation of ICT solutions needs to link to the relevant SDG indicators so that impact can be assessed. It is worth noting that most ICT solutions are similar, so mapping the solutions to SDGs, targets, indicators and possibly leverage points will not need to be as extensive. Also, as more mapping is completed it will become clear which leverage points are most important.

> **Takeaways:**
> - *There are three ways that we mapped ICT solutions to the SDGs; measurable, indirect and influence.*
> - *The directness of the impact of an ICT solution on the SDGs and the availability of data and evidence will determine the ability to defensibly attribute successes to one particular entity.*
> - *Even with this small set of case studies patterns began to emerge on types of ICT solutions relevant for SDG 4, the key leverage points for ICT and where the potential is to have the biggest impact.*

2.5. Assess Impacts

In the final step one conducts an impact assessment by selecting specific countries and analyzing their current state, then using the links from the previous step to estimate the impacts on the SDG target. The exemplar countries selected for this case study cover the different levels of development as characterized by the Human Development Index: U.S. (very high), Mexico (high), India (medium) and Nigeria (low). This was illustrative because it showed that while there is great variability between countries in terms of both data and their specific needs, there is also much in common which could be leveraged

for global impact. An example of how an initial assessment of impact could be carried out will be demonstrated in the next section.

3. Applying the Framework to SDG 4.3

3.1. Select Goals and Target
For this example application of the ICT-SDG Impact Assessment Framework, SDG 4.3 was chosen.

Target 4.3: By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university.

3.2. Analyze Indicators
Indicator 4.3.1: Participation rate of youth and adults in formal and non-formal education and training in the last 12 months, by sex

The indicator proposed for target 4.3 captures much of its elements but does not mention affordability, accessibility or quality. These aspects are certainly difficult to measure given current information about post-secondary education but it is feasible.

Figure 12 Rating of Indicator 4.3.1

Measure: School enrollment, tertiary (% gross)

School enrollment in tertiary education is available for a large share of countries for most years, making it one of the better measures analyzed in this study. Yet it is much simpler than what the indicator calls for, in particular not being properly disaggregated by age group and by type of degree. These shortcomings are expected to be resolved in the next few years making it highly like that the full data for indicator 4.3.1 will be one of the best.

3.3. Develop a Theory of Change
Target 4.3 is an output type of target because it is not assessing what the students learned just that the system was able to output so many of them. Based on extensive research the following leverage points were identified:
- **Public Costs**: This refers to costs born by the higher education system and government. For low income countries it costs an average of 100% of GDP/capita to educate one student.

- o **Infrastructure**: Many of these countries have large and rapidly growing youth populations and a sudden influx of secondary graduates from improved K-12 systems. This is creating a demand which far outstrips the limited infrastructure which exists.
  - o **ICT costs**: While costs are generally lower in less developed countries, ICT costs are the same or higher than in developed countries. This means that as a proportion of university budgets, ICT capital expenditures and maintenance is quite large and is often delayed for too long.
  - o **Qualified Faculty:** To meet demand and this target, countries need to vastly grow their enrollments which does not just mean infrastructure but also qualified faculty to teach the classes. Many of these countries have too few PhD trained citizens and of those it can be difficult to convince them to live where new universities are being built (often in the middle of nowhere or in less cosmopolitan cities of the country).
- **Private Costs**: Even though many countries make higher education free or virtually so, families and students still have to bear significant costs to attend school. A reliance on private universities to expand enrollment worsens this
  - o **Living Expenses**: In many developing countries young people live with family until marriage (and sometimes after). The cost difference between living at home and on one's own is very large. In addition, new universities are often built on cheap land on the periphery of cities leading to significant transportation costs.
  - o **Lack of scholarships/loans**: Most low income countries have no system for students to get loans and especially when university is heavily subsidized, few scholarships are available. The advantage of these systems is they could be used to target low income families instead of free tuition being captured mostly by middle and upper income students. Also **4.b** (Appendix E)
- **Inequitable access**: Beyond being part SDG 4.5, inequitable access will be a barrier to raising participation rates because it means a portion of the population is not involved.
  - o **Socio-economic**: Middle and upper income students are overrepresented in higher education the world over. In addition certain indigenous and other social groups have been marginalized out of the system in many places.
  - o **Geographic**: Typically, national universities are located in the capitals of countries, leaving other parts of the country with much lower quality (or no) higher education institutions. This is a significant barrier for students from these regions.

Based on these leverage points, online higher education emerged as an obvious ICT solution which could have a big impact on SDG 4.3.
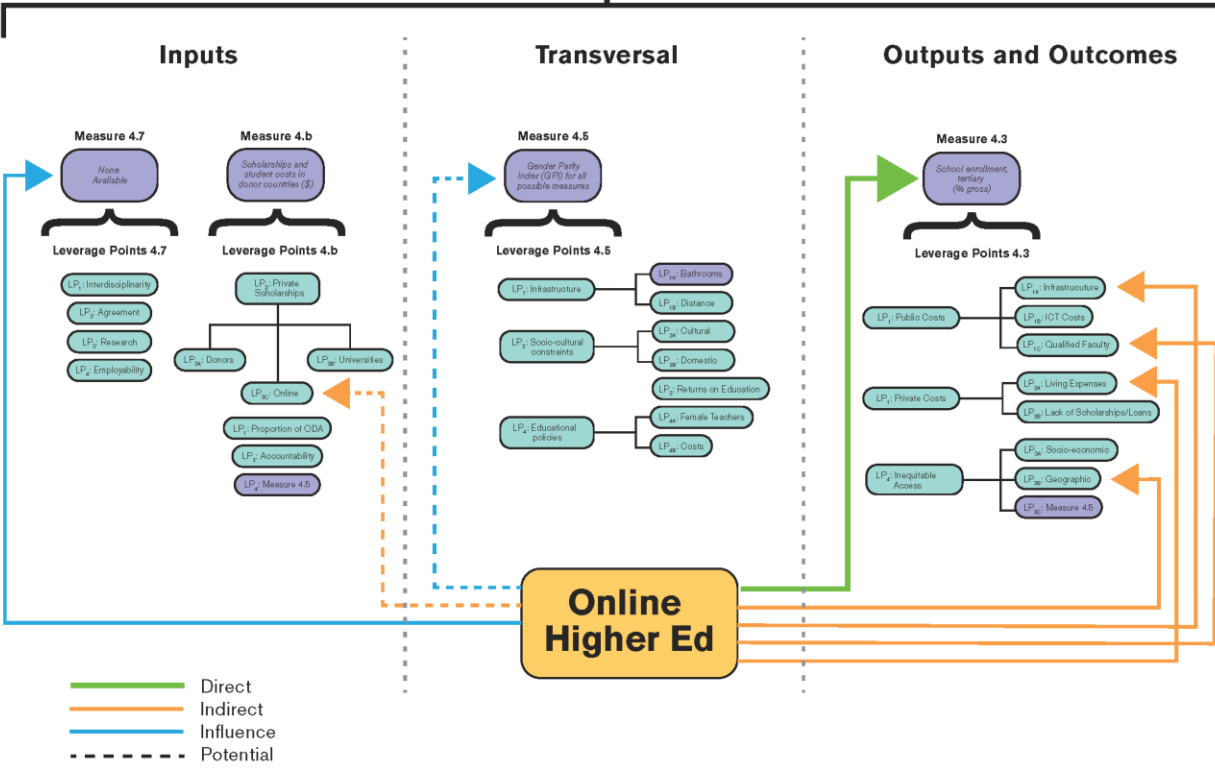

3.4. Map Solutions

Figure 13 Map of how Online Higher Ed Impacts SDG 4

3.5. Assess Impacts
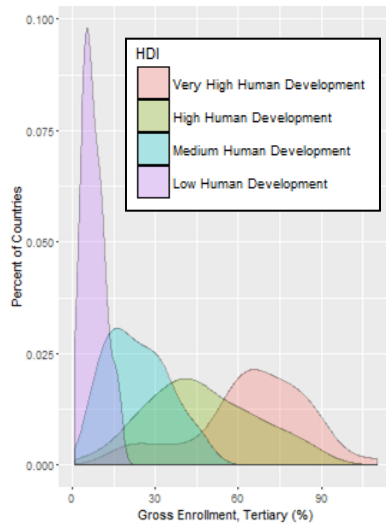
3.5.1. Current State

Figure 14 Histogram of Tertiary Enrollment

Figure 14 is a smoothed histogram of the tertiary enrollment level of all the countries in the world divided into four groups by HDI status. There is significant overlap between each of the groups, demonstrating that HDI level is not destiny when it comes to achieving high levels of post-secondary education. The main exception are the lowest HDI countries which average 7.5% enrollment versus 65% in the very high human development countries.

Figure 15 shows that in general countries with more internet users have higher enrollment rates but there is a wide dispersal around the average relationship.
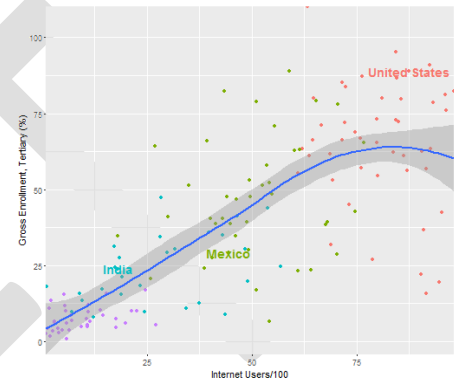

Figure 15 Plot of Internet Users versus Tertiary Enrollment Rates with Smoothed Average Line
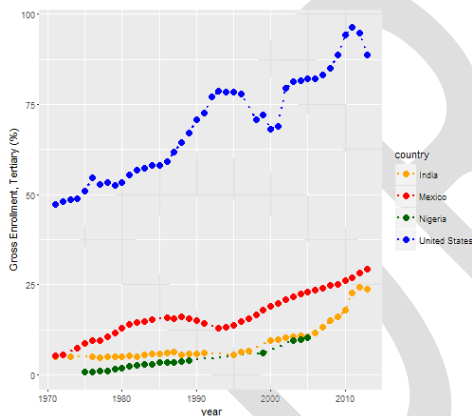

Figure 16 Tertiary Enrollment Rates over Time

Figure 16 plots the yearly enrollment rates for the four focus countries. Across the board there has been a growth in enrollment yet over the last forty years the US has actually grown the gap in enrollment between it and the rest of the countries. Overall it should be immediately apparent that without significant intervention, neither India, Mexico nor Nigeria are going to come close to achieving SDG 4.3 by 2030.

3.5.2. Impact Assessment

Nigeria has only 10% tertiary enrollment (in 2005) and yet 43% of its population online, making it a good candidate for online higher education. Current estimates note that at least one million students are applying to university who are unable to secure a seat anywhere (http://wenr.wes.org/2013/07/an-overview-of-education-in-nigeria/). An enormous expansion of university infrastructure has been proposed yet already 40% of faculty positions are currently unfilled. Of any African country, Nigeria sends the second most students overseas, as degrees from abroad are highly valued.

- **Cost**: $12 million/year for 1,000 students studying at a US online higher education program.
- **Measure 4.3**: This would only be an increase in enrollment of 0.07% but it would still be a direct and measurable improvement in the indicator.
- **Leverage Points 4.3:**
    - **Infrastructure:** The UNAM expansion in Mexico cost more than $100 million USD and currently enrolls slightly less than 1,000 students as a comparison of savings.
    - **Qualified Faculty:** The large Nigerian universities have ratios as high as 100 students per faculty so this project would reduce the need for 10 additional faculty.
    - **Living Expenses:** Would be difficult to calculate savings without additional data collection
    - **Geographic:** Program could be targeted at areas distant from currently existing universities
- **Leverage Points 4.b**: Donors are currently spending $3.8 billion on scholarships and student costs so this would represent just a 0.01% increase if the costs of enrollment were provided by scholarships. Would assume it to be much more cost effective.
- **Relevance for 4.4, 4.5 & 4.7:** By design this project could impact these additional targets in a meaningful way. Students could be required to take a programming course or major in STEM (4.4) or take Sustainability courses (4.7). A portion (or all) of the scholarships could go towards women (4.5) or other disadvantaged groups (ethnic minorities, rural, poor, etc).
- **Net positive benefits:** While these would need to be recalibrated to Nigeria, based on the previous study, one would estimate $130 million in yearly socio-economic benefits (starting in year 5 when students have graduated) and 7,000 tons of CO_2e emissions reduction.

4. Strategic Possibilities

If a business wants to move beyond reframing its current efforts in terms of the SDGs how does it even begin? There are 17 goals, 169 targets, 193 countries, hundreds of indicators and thousands of possible ICT solutions. While not the primary focus of this study, in the course of this research several opportunities for strategic approaches to impacting the SDGs were found and are presented here in brief.

4.1. Selecting Targets

In order to guide decision-making among the many targets a "traffic light diagram" can be a very useful tool. Figure 17 shows three evaluation criteria for each target in SDG 4 rated: bad (red), okay (yellow), and good (green). The basis for these structured qualitative judgements is elaborated more fully in Appendix F. In brief:

- **The Indicator & the Data**: This is an assessment of how well we can measure progress against this target with the proposed indicator and the available data sources (basis is discussed in section 2.1.2). This is essentially an aggregation of the assessment in Figure 5.
- **Relevancy of ICT**: Based on the leverage points for this target, how much potential is there for ICT solutions to make a difference to this target? Compare the role of ICT for kindergarteners versus college students for example.
- **Magnitude of ICT Impact**: Is there a transformative potential for ICT solutions in this sector, even if that solution does not exist yet? For example a computer program which successfully made every student a math prodigy would be transformational in terms of target 4.1.

Target	Short Name	The Indicator & the Data	Relevancy of ICT	Magnitude of ICT Impact
4.1	Proficiency of Primary and Secondary students	🟧	🟧	🟩
4.2	Early Childhood/ Preprimary Enrollment	🟩	🟥	🟥
4.3	Post- Secondary Education	🟩	🟩	🟩
4.4	ICT Skills	🟥	🟩	🟩
4.5	Equal access for all	🟩	🟧	🟧
4.6	Literacy	🟩	🟧	🟥
4.7	Sustainable Development Knowledge	🟥	🟧	🟧
4.a	School Infrastructure	🟧	🟧	🟧
4.b	Scholarships	🟧	🟧	🟧
4.c	Qualified Teachers	🟩	🟧	🟩

Figure 17 Target Selecting Diagram

4.2. Selecting Countries

One of the main disconnects between the SDGs and corporate sustainability reporting is the unit of interest. Businesses measure their impacts (and those of their suppliers)

from around the globe, aggregating results and impacts irrespective of location. The SDGs on the other hand are concerned with how well individual countries are doing. So when it comes to measuring progress on the SDGs it matters very much where the activities or impacts of interest are taking place. Reporting corporate sustainability activities by country is an essential step for alignment with the SDGs. A re-orientation towards countries presents much greater opportunities than just improved reporting. With a basic tool, one can quickly identify those countries with the best opportunity for the largest and most immediate impact on the SDGs.

This tool, the ICT Opportunity Index (IOI) was created to identify the best countries for deploying ICT solutions. It is calculated as follows for each indicator:

IOI = internet users / current state of the indicator of interest

Countries with a high score are considered to be the best opportunities because in these countries there is a large number of people who can use the ICT solution relative to the number of people who need such solutions. There will be a lot of other factors that determine the "best" country (supportive government, shared language, local partner, etc.), but the IOI narrows down the list and avoids, for example, deploying an online higher education degree program in a country where few people are online and lots of people are already getting immersive degrees anyway (such as Ukraine).

So after selecting a target (step 1), the IOI can be used to select an initial list of target countries. Figure 8 illustrates the results of calculating this index for indicator 4.3.1; additional results for SDG 4 and a more detailed explanation of the approach to calculating the IOI can be found in Appendix H. Immediately one can see that most of the best opportunities for online higher education programs to have a big impact on SDG 4.3 is in Africa where while enrollment is generally very low across the board, there are countries such as Kenya and Nigeria with a significant proportion of the population online.
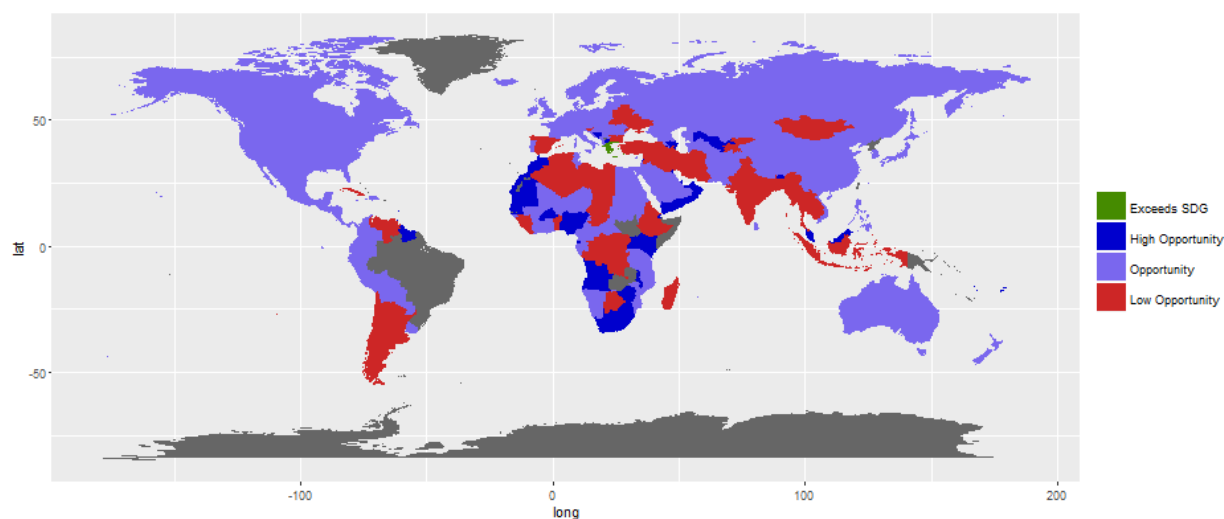
Figure 18. ICT Opportunity Index for Indicator 4.3.1 Gross Tertiary Enrollment (%)

Looking at all of the indicators for SDG 4 (where there is data) one can calculate a list of the countries which show the greatest potential for ICT to have an impact. Table 1 is a list of the top 15 countries along with their HDI level and Internet Access.

Table 1 Top 15 ICT Opportunity Index countries for SDG 4

Countries	HDI Level	Internet Access
Lebanon	High Human Development	74.7%
Malaysia	High Human Development	67.5%
Morocco	Medium Human Development	56.8%
Nigeria	Low Human Development	42.7%
Macedonia	High Human Development	68.1%
Azerbaijan	High Human Development	61.0%
Antigua and Barbuda	High Human Development	64.0%
Trinidad and Tobago	High Human Development	65.1%
Oman	High Human Development	70.2%
Kenya	Low Human Development	43.4%
Saint Vincent	High Human Development	56.5%
Dominica	High Human Development	62.9%
Mexico	High Human Development	44.4%
Palestine	Medium Human Development	53.7%
Yemen	Low Human Development	22.6%

> **Takeaways:**
> - *A strategic approach is essential in order to have projects with a meaningful and measurable impact on the SDGs.*
> - *The country is the level of measurement which matters for the SDGs.*
> - *Our tools can assist in strategically selecting targets and countries.*
> - *Mapping ICT solutions to the SDGs can help with project design and is essential for measuring impact.*

5. Conclusion

5.1. Key Considerations and Constraints

- **Targets and indicators are not necessarily aligned.** The U.N. will measure progress on the SDGs with specific indicators (currently still in draft form) that are sometimes aligned closely to their targets and sometimes not. In all cases the indicators are narrower in scope than their targets.
- **The targets fall on different points of the TOC model**. Those that are targeting inputs will be much easier to act on and measure but have the least impact while the SDG targets that are outputs and outcomes will be the reverse.
- **The major constraint is lack of good data.** Very few of the proposed SDG indicators have good data and almost none have thresholds. There are also few quality studies on the impact of ICT on relevant education outcomes.
- **Selecting targets and countries will get easier over the next few years.** As the coordinated global effort to achieve the SDGs ramps up, the process will get easier. More data will come online as countries and international agencies release reports.
- **For some SDG targets (and their indicators) a rigorous mapping will likely never be possible.** Some of the targets will never be measured sufficiently, in enough places and over long enough periods of time to meaningfully assess changes. For others, the connection to ICT is just too distant and/or weak. Finally, many possible ICT solutions will lack sufficient evidence about their relevant real-world impacts.
- **The SDGs are interlinked.** There are numerous links between the targets. Several other groups of researchers are currently working on systematically analyzing and mapping the links between all of the SDG targets, and taking advantage of their work will be critical in the future to conduct more holistic mapping.

5.2. Conclusions

Based on what is known today, ASU Global Sustainability Solutions Services can draw the following conclusions:

- **Mapping ICT solutions to the SDGs is possible in many cases.** Some cases are more direct and easier to map than others, but overall the process is currently very difficult.
- **Insufficient data is the primary barrier.** A lack of meaningful data about the specifics of the SDGs and the relevant impacts of ICT solutions are the main barriers to meaningful mapping and measurement.
- **The country is the level of measurement that matters for the SDGs.** To measure progress on the SDGs, solutions and their impacts must be studied on a country by country basis.
- **Evaluation of the leverage points independently of any specific solutions is critical.**
- **An unexpected and valuable result of the study was identification of the possibility of using a strategic approach to the SDGs.** This could be essential in order to have projects with meaningful and measurable impact on the SDGs. The tools developed in this study can assist in strategically selecting targets and countries.

5.3. Next Steps
5.3.1. Next steps for practitioners and researchers:
- Fully quantify the impact of one case study against all of the SDGs.
- Map the impact of all corporate activities of one ICT company against a selection (or all) of the SDGs.
- Expand the analysis on the impacts of the ICT sector on SDG-4 from this report to the impacts of the ICT sector on all 17 of the SDGs.

5.3.2. Next steps for the ICT sector:
- Gather and share better ICT data.
- Find evidence of the impact of ICT solutions on specific SDG goals, targets and especially indicators.
- Create sector-wide alliances to establish standards for mapping solutions to the SDGs, collect more reliable data and collaborate on having a greater impact.

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