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Lessons Learned from Capacity Building Efforts in Tropical Countries

Successful capacity building is hard to achieve in less developed countries. Over a period of years we have undertaken capacity building aimed at collaborating with countries and organizations to overcome the many challenges encountered. The following descriptions provide the background and then we detail the lessons learned from the last decade of working with SilvaCarbon and NASA-SERVIR, GOFC-GOLD and the World Bank in capacity building efforts.

Tropical deforestation and forest degradation have a wide variety of environmental and societal impacts including the release of carbon to the atmosphere following forest disturbance. Carbon concentration in the atmosphere is presently at record levels and the contribution by terrestrial carbon emissions is substantial and increasing. The international community has identified enhanced forest management in tropical countries incentivized by economic compensation as a feasible means to curb greenhouse gases.

REDD+, (*Reducing emissions from deforestation and forest degradation and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries*) was negotiated under the United Nations Framework Convention on Climate Change in 2005. Under REDD+ countries receive payments for evidence of emission reductions from deforestation and forest degradation and from enhancement and conservation of forest carbon. While fine in theory, the production of evidence of reductions that meet the criteria defined by the international research community is complex. The reporting criteria, defined by the Intergovernmental Panel on Climate Change, emphasize the lack of bias and quantification of uncertainty. This implies the use of sampling techniques and unbiased estimators in a statistical inference framework, not simply making maps and counting pixels (GFOI, 2016, p. 125).

Activities on the land surface that impact the terrestrial carbon budget (primarily deforestation, forest degradation and forest recovery) tend to be small relative to the total land area. Therefore, annual or biennial accurate maps of land cover and land cover change are needed to guide the sampling and to meet other needs related to land management. Obviously those responsible for producing results for payments must be proficient in remote sensing and statistics, as well as forestry and biogeosciences.

There are further complications. The annual areal extent of forest loss and gain is often very small relative to the entire study area (typically a country), even in countries with rampant deforestation. Estimating and mapping something very small is inherently complicated and uncertain. Furthermore uncertainty in carbon parameters can influence the final estimates of the carbon emissions/removals. Complicated institutional arrangements, understaffed and underfunded agencies, and difficulties recruiting and retaining talent are other common complicating factors. The result is a situation in which the production of estimates of emissions over time, with precision sufficient to determine that reductions have occurred -- and hence to receive result-based payments -- is very difficult.

The challenges are many and complex as are the potential solutions. The quality and quantity of relevant data, software and computing power have never been greater. After Landsat data were made available for free, other relevant satellite missions followed and adopted free data policies (e.g. Sentinel-2). New spaceborne lidar and radar instruments are or will collect data of great scientific value (ICESat-2, NISAR, BIOMASS, RCM, etc.). Powerful cloud computing platforms, such as Google Earth Engine, allow remote sensing analysts to access and process large quantities of data without downloading and preprocessing the data. Deciding how to best utilize these assets for the benefit of tropical forests and people is important for capacity building.

Lesson One—Research is Required

Assessing how to best monitor terrestrial carbon emissions needs research. Capacity building programs usually do not do or sponsor research but rely on the findings and deliverables of research programs. An example of the necessary synergy between capacity building and research is provided in Figure 1. Historically remote sensing data and interpretations assessed accuracies by comparing map labels

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with ground observations. They were rarely used to estimate area bias and uncertainty in area estimates, even though such information is often more important than the measures of map accuracy. Further, the reporting criteria under REDD+ stipulate that areas are estimated by sampling and unbiased estimators. The underlying statistical framework required to satisfy these criteria has been defined in the statistical literature (Cochran 1977; Särndal et al. 1992)[1]; Olofsson et al. (2014) was written to illustrate the use of such techniques in a remote sensing context[2]. Olofsson et al. (2014) was well received by the community and featured in capacity building efforts by SilvaCarbon, UN-FAO and others[3], and many countries have implemented the recommendations provided in the article[4]. Following implementation, many studies found that certain types of errors in the maps used for stratification purposes would introduce large uncertainty in area estimates[5]. The issue needed investigating and guidance to countries was needed -- with funding from the NASA Carbon Monitoring System[6], an article was written that provides additional guidance for how to mitigate the impact of omission errors (Olofsson et al., 2020)[7]. If this article in turn is used by the community[8, 9], new issues are likely to occur which need investigation[10]. This is just one example but it highlights the importance of research programs for assisting capacity building efforts. Many of the issues that countries are wrestling with are not static and experts are not in a position to simply provide a solution. Research funding and targeted investigations that engage in country-academics and governments are required.

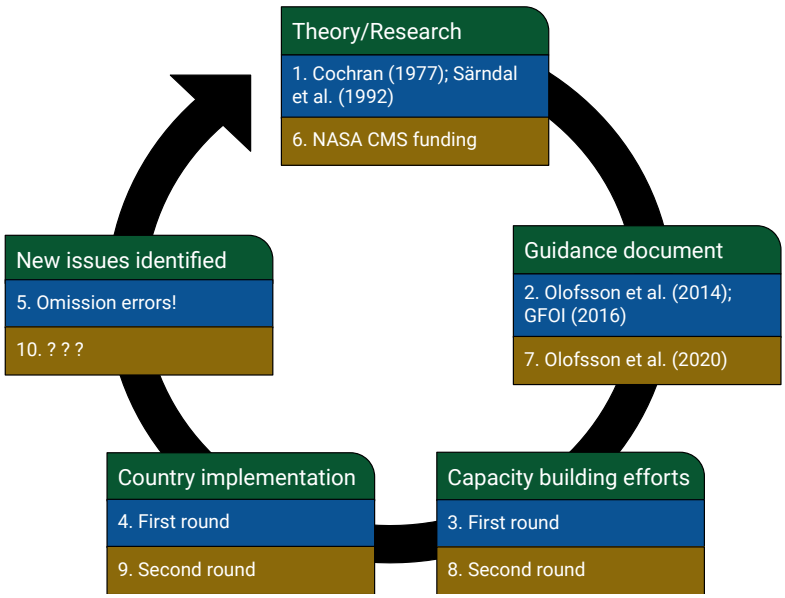

Figure 1. Example of the interdependence of capacity building efforts and research; the example shows the steps involved in popularizing sampling-based estimation of area and map accuracy.

Lesson Two—Open Source

This might be fairly obvious but unless the data and software featured in education and training sessions are available without restrictions, continuity is hard to achieve. Note that *open source* is not the same thing as *free*. The difference between open and free is best illustrated by a Government agency in charge of UNFCCC and REDD+ reporting in a tropical country in which we have been active. The agency maintains a high level of competency and has contributed to capacity building efforts in several other countries. An important reason behind the agency's ability to build and maintain talent is the re-coding of most of the software used in their national forest monitoring system. Knowledge, experience and expertise are created by coding their own versions of the software, which is greatly facilitated by keeping algorithms, tools and software open source and not just free of charge.

Lesson Three—Deliver Know-how, Not Products

We have seen that when practitioners are handed products (maps, estimates, sample data, etc.), regardless of sophistication and accuracy, maintaining continuity becomes more difficult. One-time efforts might fulfill important short-term requirements but are unlikely to build capacity. The desired outcome of capacity building is to improve the strength of the organization and enable local technical people to develop the necessary skills for sustainability. For example, if an institution or agency delivers a map product for use in forest monitoring to local practitioners, the product needs to be replicated for future monitoring which makes the process reliant on the map-making institution or agency. If the institution loses funding, changes staff, or redirects its interests, the people in charge of the local forest monitoring are back at square one. Instead, had the forest monitoring been implemented by local practitioners using open source software and data, the chances of achieving consistent monitoring would be greater. Capacity building efforts should focus on creating know-how by delivering training and educational materials while avoiding being distracted by competing methodologies, data and tools.

Lesson Four—Capacity Building Needs to be Customized for each Country

There is no global consensus on how best to conduct capacity building, although approaches that are successful in other countries are often applicable elsewhere. However, different countries present with different organization and societal structures, cultural practices, and gender roles, which in turn shape the way a country develops technical capacity. We have learned that what may work in one place or country may not work in another. Usually countries from the same geographical region share the same environmental and technical challenges but each country has their own land use priorities and land definitions. Capacity building must respond to each country's priorities and needs if capacity building is to be successful.

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In reading these stories, one senses the joy that comes from living a self-directed, value-driven life. In the words of Molly Burhans, founder of GoodLands, an organization that manages the conservation and land use of the Catholic Church's landholdings, "It is immensely fulfilling and enjoyable if you can align your career and life in such a way that you are surrounded by people who love what they do, and the best way to achieve that is to do what you love." She also says, "Never stop being in wonder of your work." The motto of Dr. Catherine Ball, leader of the World of Drones Congress and the founder of five start-up companies is, "She who dares, learns," and she states, "I am now more fearless than ever before."

This book includes many calls to action for its readers. In the words of Sylvia A. Earle, "We have the power to change the world – the way we look at the world, the way the world goes forward henceforth- if we just use the technologies and join together with our minds and our hearts and our commitment to make a difference." Shoreh Elhami implores, "We need to educate women about gender equality and their rights, and elect lawmakers who fight for them." Kristen Kurland, Carnegie Mellon University Professor, advises, "It's clear that the cost of higher education will soon exceed an amount that many can afford. Colleges and universities will need to reinvent how they educate students while still upholding academic rigor through research and scholarship." Kathryn Sullivan, the first woman to walk in space, expresses her hopes for the future by saying, "Our world needs more, not fewer, bright and energetic people to become scientists, both to advance the frontiers of knowledge and to connect science to society."

This book has achieved the goals established by its manager and publisher, Catherine Ortiz, to highlight the importance of science, technology, engineering and math (STEM) to change our world for the better and to underscore the key role that women have played and will continue to play in the application of STEM to our world's challenges. Women who are searching for a path to realize their potential and to make a difference in the world will find inspiration and guidance from the words of wisdom and the life examples provided in this book.

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