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Improving remote sensing research and education in developing countries: Approaches and recommendations

Barry Haack[a,*], Robert Ryerson[b]

[a] George Mason University, 4400 University Drive, Fairfax, VA 22030, USA
[b] Kim Geomatics Corporation, Box 1125, Manotick, Ontario K4M 1A9, Canada

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ABSTRACT

Since the 1970s, a number of different models have been used to develop basic and applied science capacities of remote sensing in developing countries. Those efforts have had varied levels of success. One of the more effective capacity building efforts is extended training workshops held within the targeted developing country institution with existing resources. The extending training format requires participant teams to complete a remote sensing project for their country in their organization. The basic science activity of developing country scientists was documented by a review of six remote sensing journals which determined that a very small percentage of remote sensing manuscript authors are from developing countries. Many developing countries have established internal remote sensing capacities but many others have not. Given the potential importance of remote sensing for natural resource assessment and monitoring as well as economic decision making, more attention must be given to assisting those countries in hardware, software, internet capacity and technical assistance.

1. Introduction

Spaceborne remote sensing and associated mapping technologies have long been recognized as well-suited to resource exploration, resource monitoring and change detection in development (Brandenberger, 1968; NAS, 1977), as well as a potential contributor to the development process (Ryerson and Samson, 2011). More recently, increased importance has been accorded these technologies when the United Nations (UN) adopted a motion that geospatial information including earth observation data were as important a part of a national infrastructure as education, transportation, health and energy, inasmuch as one could not plan for any of the other infrastructure elements without such data (United Nations, 1999).

The rapid increase in the availability of spaceborne remote sensing data coupled with the increasing need for accurate and timely earth surface information especially in developing countries has accelerated the demand for and provision of technology transfer of remote sensing by many organizations and governments. Much of this increase is related to concerns for global climate change. Under the mandate of the United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC), there are multiple efforts to create national land use and land cover maps at two year intervals for carbon reporting. These requirements have often included the technology transfer and use of remote sensing to developing countries.

There are many other similar activities by FAO, World Bank, other UN organizations and individual countries. The United States Agency for International Development (USAID) has several relevant programs including SERVIR and SilvaCarbon.

The Group on Earth Observations (GEO) is a voluntary partnership organization founded in 2005 following the Earth Observation Summit called in July 2003 by US President Bush. GEO was created to coordinate Earth observations and information for primarily environmental topics. GEO Member governments include 96 nations and the European Commission, and 87 participating organizations comprised of international bodies with a mandate in Earth observations. Together, the GEO community is creating a Global Earth Observation System of Systems (GEOSS) that will link Earth observation resources world-wide across multiple societal benefit areas – agriculture, biodiversity, climate, disasters, ecosystems, energy, health, water and weather – and make those resources available for better informed decision-making. This mandate has resulted in multiple activities in or for developing countries.

One of the issues in international assistance is the varying use of terminology including the definition of what constitutes a

* Corresponding author. Fax.: 703 993 1216.
E-mail addresses: bhaack@gmu.edu (B. Haack), bryerson@kimgeomatics.com (R. Ryerson).

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developing country. There have been various terms for developing countries including emerging economies, less developed and third world among others. In this manuscript, the term developing countries is accepted. There is also no uniform definition or list of developing countries. The World Bank uses gross national income per capita of under $1045 US as a definition of low income and lists 31countries for the 2016 fiscal year. The United Nations lists 48 countries as least developed. There is also a human development index and a gross national happiness list that attempt to identify these countries.

In the context of this discussion, remote sensing research is basic science that would be published in peer reviewed manuscripts rather than the operational use of remote sensing. Training is education on remote sensing availability of data and methods for information extraction for specific or multiple disciplines. These training activities could be conducted over multiple time frames but typically workshops of one or several weeks. Capacity building extends beyond training to include improved infrastructure often including hardware and software as well as budgetary support and vehicles.

This paper examines a number of the approaches that have been employed to improve both remote sensing education and research capacity in developing countries. The assessments provide are based on the author's collective experience over their careers in more than forty countries in Asia, Africa and South America. That experience includes serving as advisors and workshop instructors (in-country both long and short term), supervision of graduate students and post-doctoral fellows (both in-country and in North America), as well as in evaluating and creating programs to improve developing country capacity in both remote sensing research and education. Admittedly, the content of this manuscript is primarily qualitative and subjective. While some of the approaches seem to have worked in some places and not in others, there do seem to be some lessons that can be learned to assist in more effective remote sensing capacity building in the future. The following sections describe technology transfer approaches to remote sensing education and research with a short commentary on their relative strengths and weaknesses.

2. Building remote sensing education in developing countries

Each of the following subsections identifies a different approach to building education in remote sensing and are summarized in Table 1. The first column identifies the approach, while the second column suggests benefits and the third presents limitations.

2.1. Send students abroad for education

There are different levels of education included in these activities including undergraduate or more frequently university based graduate degrees, technical programs and post-doctoral positions. While these three educational levels have differences, they are generally similar in benefits and limitations and therefore combined in Table 1. They are, however, discussed independently in the following sections.

2.1.1. Graduate degrees

This approach has been widely used with examples of both success and failure. Success has come from the return of graduates to their home countries with the education, experience and contacts gained while studying abroad that allow them to either create an educational program at home or mentor others from their countries.

Failures come from several situations. First, the students may not return, either to remain where they studied or accept positions in international organizations such as the UN or development banks or contract opportunities in other countries. A second failure is when the student works on a thesis or research topic of little or no relevance to the home country. While this is less of an issue today that it was some years ago, it can still be an issue. A third problem is that a highly trained scientist returns to a home institution where the available resources (equipment, data, finances) do not allow continuation or instruction of the newly acquired competences. The fourth failure can occur when an individual returns with a graduate degree only to have that degree propel him or her to more senior positions that do not involve remote sensing. One way to ensure the return home of a student is to have a firm contract that stipulates that the student will return. It is not clear how one can limit the advancement of returning students so that they remain in a position where their remote sensing education is of benefit.

2.1.2. Post graduate technical training

There are advanced college-level post-graduate diploma programs in remote sensing and geographic information systems in developed countries. Such programs are seeing an increase in students from developing countries as the lack of practical technical knowledge is seen as a limitation. Often spatial education in developing countries is more academic and theoretical than applied because of limited resources. Typically the students from developing countries are from government agencies. Participants taking these applied courses are more likely to return to their home country than do those enrolled in post-graduate degree programs. While such people are often heavily recruited on their return to leave government to join the private sector, they often do remain in their country where they can contribute. One lesson is to have a clear contract as to how and when a trainee can leave the sponsoring agency.

2.1.3. Post-doctoral education

Scientists from developing countries doing Post-doctoral fellowships suffer from the same issues as those following post-graduate degree programs: they do not always return, or they return for a higher position or to universities without the resources to use the newly acquired skills.

2.2. Bring foreign nationals to local universities

This approach has been widely used with some success. One of the most prominent programs but not limited to the spatial sciences is the United States Fulbright Program. While the terms are typically short, the period of a sabbatical for example, they do build lasting relationships that benefit both the visiting faculty member and the host country's academic institution. However, unless the terms are longer than one year, or unless there is a continuous flow of competent visiting faculty, there can be issues of continuity. Simply stated, the visiting periods are shorter than the typical term of a degree, whether the first degree or an advanced degree, thus limiting mentoring by visiting academics. The lack of available resources in the developing countries host institutions can also be a serious limitation.

2.3. Bring in foreign experts to provide advanced training in specialized workshops

This was a common approach by the United Nations and other international agencies beginning shortly after the first Landsat in 1972 and is still ongoing. The concept of bringing in experts for short term training and education was and is an efficient approach to technology transfer. These workshops can be several days to several weeks. Problems can occur if the people attending the workshop