Sensing Progress

Space Solutions for Food & Water Security

Executive Summary

Southern Hemisphere Space Studies Program

2016

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Introduction

Adequate food and fresh water are essential for life, and access to sufficient quantities of both is essential to human health. Nevertheless, due to a variety of underlying causes including ineffective policies and programs, inadequate infrastructure, and political or economic reasons, not everyone in the world has adequate access to these resources.

Regardless of the underlying reason, the need for action is clear. The world community needs to make affordable, healthy food, and make it accessible to all. Accessibility will require improved and more effective management of the world's agricultural resources and the policies to address them.

We also need to find ways to provide and maintain sufficient fresh water for human consumption and for growing crops. Because of the strong connection between water availability and food production, the international community should balance the need to supply water for human consumption and the demand for food. Space technologies can help address these needs.

In this paper, the term 'Global South' collectively refers to the countries that lie on or below the Tropic of Cancer. This represents the four main regions of the Southern Hemisphere: Africa, Asia, Oceania, and Central and South America, and includes approximately two-thirds of the nations of the world.

These regions lack commonality in the degree of economic development, climatic and environmental conditions, politics, language and culture; nevertheless, climate change, population growth, and extreme weather events constitute three key common threats to food and water security.

The respective nations of each region require individualized resource management plans to meet the challenges associated with ensuring food and water security. Such strategies will include innovative and technological solutions.

Our goal is to outline information about the role that space-based information can play in the development and implementation of cross-sector strategies. These strategies are designed to enhance local and regional food and water security in the face of the key challenges we have identified. In particular we explore the use of some space-based applications in combination with terrestrial resources.

For the nations of the Global South, providing access to sufficient, safe, and nutritious food for their entire populations is an ongoing local and regional challenge. While it is unrealistic to try to find a single solution to solve this problem across all nations, it is useful to bring to bear all available resources, including those linked to space technologies.

"Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (World Food Summit, 1996).

Mission Statement:

To propose internationally cooperative methods to countries of the Global South for developing and strengthening food and water security strategies using a combination of space-based and terrestrial resources.

"Water security is defined as the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining livelihoods, human well-being and socio-economic development" (UN-Water, 2013).

This White Paper provides recommendations to assist decision-makers in formulating cross-sector strategies to strengthen international capacity building, cooperation, and expansion toward enhancing food and water security in the Global South.

Key challenges to food and water security include urbanization and population growth, climate change and flooding & drought.

Urbanization and Population Growth

The proportion of the global population located in cities currently stands at 54% and is expected to rise to 66% by 2050 (United Nations, 2014). As city populations grow, demand on existing water sources increases, interrupting the natural water cycle and decreasing water security in urban areas (WWAP, 2015).

Growth and industrialization generate significant quantities of pollutants, such as black carbon, nitrogen oxides, ozone, and sulphur dioxide. These substances have been demonstrated to have a wide range of harmful effects on crops, including starving plants of sunlight, and exposing them to toxicity. Studies have shown that crops exposed to air pollution in this way have much lower yields than those which are not (Mina et al., 2013; Burney and Ramanathan, 2014).

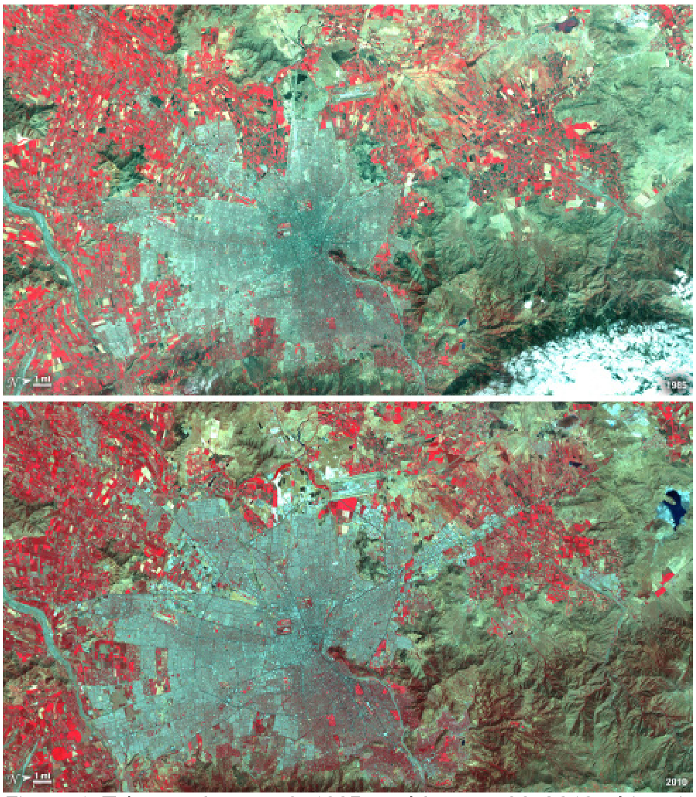

Figure 1: Taken on January 9, 1985, and January 30, 2010, this pair of images from the Landsat 5 satellite illustrates the population growth of Santiago, Chile. The images were made with infrared and visible light so that plant-covered land is red. Bare or sparsely vegetated land is tan, and the city is dark silver. Credit NASA.

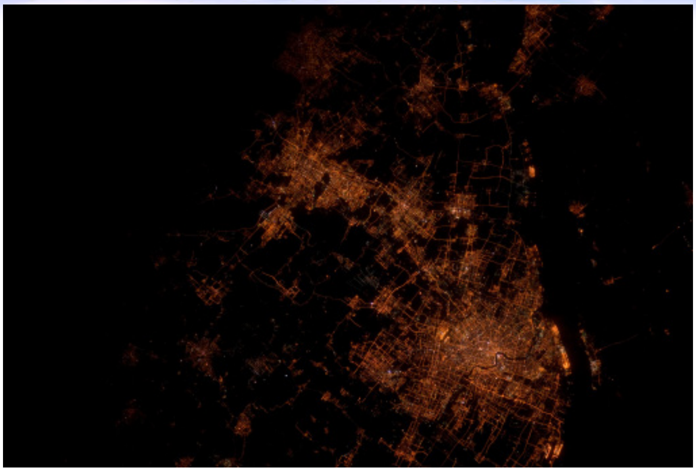

Figure 2: A nighttime view of Shanghai is featured in this image photographed by an Expedition 30 crew member on the International Space Station. The city of Shanghai's population increased by 28% from 2000 (16.4 million) to 2010 (23 million). Credit NASA.

Increasing urbanization decreases the availability of arable land (Matuschke, 2009). This is particularly apparent in the areas surrounding the Nile delta, where urban encroachment risks consuming the total available arable land within 200 years (Al Tarawneh, 2014). Urban encroachment threatens other agricultural areas across the Global South including in China, Indonesia and Chile (Matuschke, 2009). Urbanization further affects agriculture by reducing the availability and quality of water for agricultural and domestic applications.

Space-based solutions, such as remote sensing systems, are cost effective methods to inform urban planning and management decisions. For example, they can monitor the effects that present levels of urbanization have on water quality and availability. Remote sensing techniques have been proposed for detecting suspended particulate matter in bodies of water, a prominent source of pollution (Usali and Ismail, 2010). By combining remote sensing systems with terrestrial sensor networks, it may be possible to detect air and water pollution events in near-real time and act quickly to mitigate an incident as it happens.

Furthermore, Earth observation systems play a role in validating hydrological models that are used as part of urban planning. By reducing the number of impermeable surfaces it is possible to minimize the effects of urbanization on the water cycle (Kite and Pietroniro, 1996).

Climate Change

The last 150 years have seen a steady increase in the average global temperature of just under two degrees Celsius (IPCC, 2014). Scientists believe that this temperature increase has resulted in widespread environmental consequences including droughts, storms, floods, and rising sea levels. All of these effects, collectively known as climate change, present challenges, especially to agriculture and its associated water requirements.

Figure 3: "There is no way out, no loopholes. The Great Barrier Reef will be over within 20 years or so. Once carbon dioxide had hit the levels predicted for between 2030 and 2060, all coral reefs were doomed to extinction. They would be the world's first global ecosystem to collapse. I have the backing of every coral reef scientist, every research organization. I've spoken to them all. This is critical. This is reality." Charlie Veron, former chief scientist of the Australian Institute of Marine Science. Satellite image of the Great Barrier Reef. Credit NASA.

As weather becomes increasingly unpredictable, farmers are more challenged to plan for the future. Crop failures become increasingly common occurrences and overall food yields subsequently diminish. As a result, farmers in affected areas are adjusting their traditional agricultural practices in order to adapt to warmer seasonal temperatures.

Space-based technologies such as Earth observation and communication satellites, enable the effective remote monitoring of these

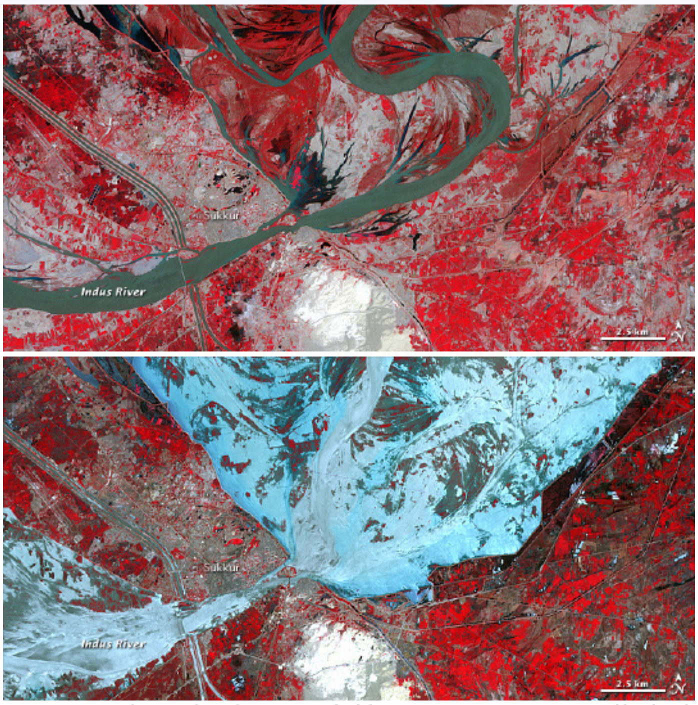

Figure 4: The Indus River at Sukkur was at exceptionally high levels on August 18, 2010, when the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on NASA's Terra satellite captured the top false-color image. The lower image shows the Sukkur region on August 13, 2001. Credit NASA.

environmental changes. In an effort to achieve such data capture and dissemination from remote monitoring, the intergovernmental Group on Earth Observations (GEO) is coordinating efforts to build a Global Earth Observation System of Systems (GEOSS). As a partnership of 80 governments and 52 international organizations, GEOSS links Earth observation, information and processing systems to improve monitoring of the state of our planet. Data obtained through GEO can be used to improve both farming practices and inform policymakers.

Figure 5: This astronaut photograph illustrates slash-and-burn forest clearing along the Rio Xingu (Xingu River) in the state of Matto Grasso, Brazil. This photo was taken aboard the International Space Station on the 17th of September, 2011. Credit NASA.

Flooding & Drought

Floods and droughts represent serious threats to food and water security, especially in the countries of the Global South. Flooding has taken its toll on agriculture and food supplies and resulted in water contamination, and destruction of infrastructure, thus exacerbating malnutrition problems in the Global South (UNISDR, 2015). Topsoil can also be washed away during flooding, causing damage to arable land. Many countries of the Global South are especially vulnerable to flooding (UNISDR, 2015).

Droughts crucially impact agricultural production and water supply. Decreasing crop yields have direct impacts on food prices, and affect global markets and consumer demand. Reductions in river flows may have consequences for water supply and limit the potential for hydroelectric generation. Poor quality water can have significant negative health outcomes for affected populations.

Current space-based solutions rely heavily on information derived from remote sensing satellites, which are used to monitor water levels, inundation, soil moisture, and crop health. Hydrological models interfaced with Geographic Information System (GIS) data sets provide a 3D map of the terrain to evaluate potential drainage issues. The amount of moisture contained in soil can be detected by satellites and used to ascertain drainage efficency in flooding situations, as well as to predict crop yields in drought conditions (Doorenbos et al., 1979). Space-based multi-spectral remote sensing provides a near-global field of view for prediction of crop yield (such as via the GEO Global Agricultural Monitoring (GEOGLAM) portal). This is especially valuable in areas where ground-based measurements are difficult or costly to implement, and allows further determination of at-risk areas.

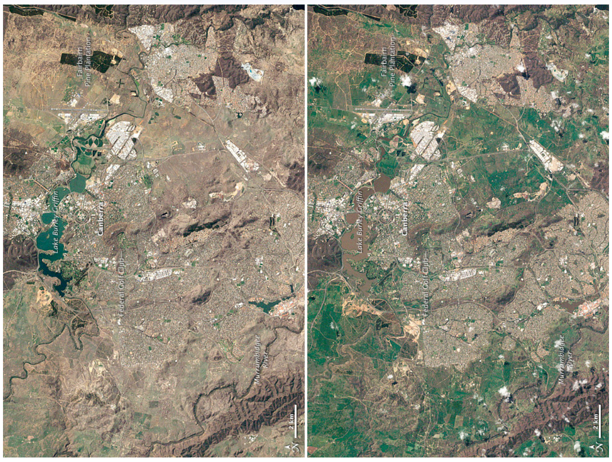

Figure 7: In September 2008, Australia's capital city of Canberra was parched. The Thematic Mapper on the Landsat 5 satellite acquired the left image on September 24, 2008, and the right image on October 19, 2010. These natural-color images show the stark difference that rainfall makes. Credit NASA.

It is necessary to have information and management systems in place to handle data, and deliver the appropriate responses. For example, Remote Sensing-based Information and Insurance for Crops in Emerging Economies (RIICE) is an active program in Southeast Asia that collates data on rice crops to provide assessments of crop yield and quantifiable losses of crops resulting from natural disasters (ASEAN SAS, 2014).

Figure 6: This series of images from the Landsat satellites documents the changes to the northern half of the Aral Sea from 1989 (left) to 2014 (right). The Aral Sea was once the fourth largest lake in the world. However irrigation north of the Aral Sea, which is used to transform the desert into farms for cotton and other crops, has devastated the lake and surrounding area.

Recommendations

In 2016, the International Space University and the University of South Australia entered the fifth session of the Southern Hemisphere Space Studies Program. This program brought together industry professionals and academics from eleven different countries to examine the issue of food and water security. In addressing the Mission Statement, the team makes the following recommendations:

Recommendation 1: International Data Sharing

We recommend the open and timely sharing of Earth observation data, experience and other information resources among nations and peoples. This tangible exchange will foster broader bilateral and multilateral cooperation enhancing food and water security.

International collaboration should focus on the actual exchange of space-derived data and sharing of analysis systems and techniques. Adequately feeding and hydrating all the people of our planet necessitates sharing our collective capabilities and tools. This requires the sharing of data, experience, and other information resources. Much of this relevant information is obtained from space-based assets such as Earth observation satellites. Improved information sharing at the international level also enables governments and institutions to directly advise farmers on the ground.

Recommendation 2: Capacity Building

We recommend that governments in the Global South invest in capacity building by funding Earth observation and remote sensing education and outreach programs. These programs should be supported by well developed communications infrastructure and access to relevant hardware and software platforms. These programs should be accompanied by setting measurable goals to assess performance.

Earth observation data is freely available from the internet. Nevertheless, some of the people who would benefit the most from this data are unable to access and interpret it to obtain meaningful information.

We recommend that governments in the Global South expand current agricultural education programs to include training in the use and benefits of remote sensing systems, and how to convert raw data into useful information. In countries where no agricultural education programs exist, we call for governments to initiate such initiatives. However, education by itself is not enough. Governments must create communications infrastructure to ensure individuals have access to Earth observation data.

Recommendation 3: Expansion

Expand current Earth observation programs by establishing multisectoral policies and programs focused on strengthening food and water security within States where such schemes are already prevalent, and to States where such schemes would greatly improve the quality of life. In particular, successful programs such as Remote Sensing-based Information and Insurance for Crops in Emerging Economies (RIICE) and Famine Early Warning System (FEWS) should be expanded to cover a greater number of countries.

Food and water insecurity are multifaceted issues that are interlinked to a great extent, and caused by a variety of factors. We propose that by establishing multisectoral policies and programs, current Earth observation schemes can be expanded to address the issues of food and water security in a holistic manner.

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