Innovative Satellite Data Applications
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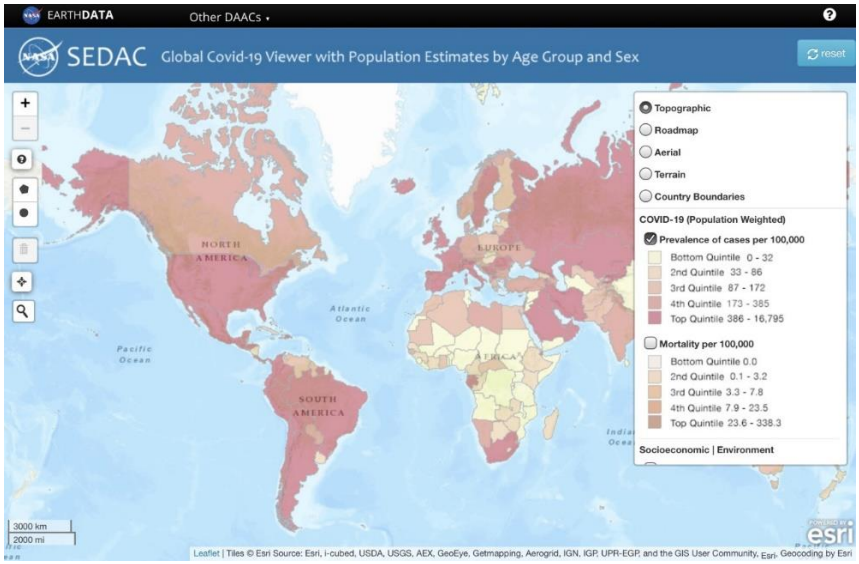
Introduction

The increased use of satellite imagery and data in recent years has led to expansions in multiple fields of research.[1] The utilization of satellites has developed beyond just the tracking of weather patterns. Satellites are now used in the study of land cover and vegetation growth to support agricultural production. Images can even assist in assessing damage caused by war and tracking the movements of refugees during a humanitarian crisis.[2] Today, satellite data are used to aid in the achievement of multiple Sustainable Development Goals (SDGs), which were developed by the United Nations to help create a better, more sustainable future for everyone on Earth.[3] These goals were designed to address many global challenges, including health, peace, and economic growth.

Health

Society is currently experiencing a global health crisis with the COVID-19 pandemic. However, satellite data can deliver useful information to assist in tracking the impact and spread of the disease. The Socioeconomic Data and Applications Center (SEDAC) at the National Aeronautics and Space Administration (NASA) is one organization that combines Earth data from satellites with socioeconomic information.[4] In response to the pandemic, SEDAC has developed the *Global Covid-19 Viewer,* which is a no cost, interactive mapping tool that compares Coronavirus information from Johns Hopkins University with global age and sex data.[5] The dashboard provides information to health officials, policymakers, and the public on where the virus is spreading geographically and which population groups are being infected.[6]



Occurrences of COVID-19 cases worldwide. Data obtained on 8/27/2020 from the SEDAC *Global Covid-19 Viewer*.
Image/Data Source: NASA SEDAC

In an attempt to contain the virus, many countries shutdown, halting business and issuing stay-at-home orders for citizens. The effects of the shutdown have been wide in scope and have impacted not only worldwide industry, but also the environment. In an effort to combine information on these effects, several international space agencies, including the European Space Agency (ESA), the Japanese Aerospace Exploration Agency (JAXA) and NASA, have partnered together to create the *Earth Observing Dashboard* for COVID-19 impacts.[7] The dashboard is another no cost, interactive tool that

uses multiple satellite data records to track changes in air and water quality, climate change, economic activity, and agriculture and help us better understand these issues that impact humanity and global health.[8] Information viewed through the *Earth Observing Dashboard* reveals that air and water quality improved in many parts of the world as a result of reduced transportation during the shutdown.[9] Unfortunately, global economic activity also declined and some countries experienced disruptions in their food supply chains. However, the dashboard can be used to identify which areas throughout the world are experiencing problems so that appropriate resources and support can be dispatched to those locations.

In addition to tracking the spread and effects of global diseases, space data also assist in the administration of vaccines. The Bill and Melinda Gates Foundation uses geospatial data to make population estimates to aid in vaccine delivery.[10] While disease eradication requires careful planning and execution, obtaining accurate population estimates from census data can be difficult due to cost, delays, and potential political corruption. However, satellite images, with the use of computer algorithms that analyze buildings and neighborhoods, can produce population estimates that are free from interference.[11] For example, the Bill and Melinda Gates Foundation used population estimates from satellite data to determine the number of polio vaccines needed in Nigeria in 2014.[12] The campaign was so successful that the country was certified free of polio in 2019.[13] Successes like these that support global health initiatives are why many view this type of satellite data as a public good. In the future, accurate population estimates will be crucial in the worldwide delivery of COVID-19 vaccines and the eradication of the virus.

Peace and Justice

Satellite data can also be used to analyze human conflict and humanitarian crises. Satellite Analysis and Applied Research (UNOSAT) at the United Nations Institute for Training and Research (UNITAR) is responsible for satellite analysis and capacity development.[14] UNOSAT uses satellite images for multiple objectives, including the evaluation of physical destruction, the search for unexploded devices, the mapping out of refugee camps, and even as evidence in international criminal courts.[15]

Image taken from the Landsat 7 satellite showing deforestation in Rwanda as a result of refugees clearing the area for farming.
Image Source: NASA Landsat

Satellites are especially valuable in the assessment of damage caused by conflict.[16] Many Earth observation satellites, such as NASA's Landsat satellites and the National Centre for Space Studies' (CNES) Pléiades satellites, are capable of taking the type of detailed images used for the study of human conflict.[17] These satellite images are utilized for both short-term and long-term analysis. In the short-term,

the images display changes in the landscape. For example, satellite images showed the tracks of Israeli vehicles moving in and out of Gaza during an altercation in 2014. However, over a long period of time, the satellite data can reveal long-term or repeat effects, such as the repeated targeting of medical facilities in Aleppo, Syria during the Syrian civil war.

These images offer many benefits to government officials and policymakers.[18] Most importantly, data from satellites provide objective information since images from multiple satellites operated by different countries can be used for analysis. These images are often high quality and can cover inaccessible areas from above in near real-time. Satellite data also deliver a continuous historical record that can be used to evaluate and mitigate the effects of war and humanitarian disasters for years to come.

Employment and Economic Growth

Satellite data can also be an avenue for economic growth and can provide jobs in countries around the world. Green Keeper Africa is a nonprofit organization founded in 2014 with the mission of contributing to economic activity and social welfare in Benin.[19] The organization developed an innovative solution to manage water hyacinth, an invasive plant that grows seasonally in Lake Nokoué and interrupts fishing and transportation. Green Keeper Africa works with local communities and provides training and employment for the harvesting of the water hyacinth.[20] The harvested plant is then turned into a sorbent called GKSORB that is designed to soak up oil spills and is sold worldwide. The nonprofit works with the research group, Space Enabled, and uses satellite images to track the plant growth throughout the year and measure the chemical makeup of the water, which allows for more efficient harvesting. Since its creation, Green Keeper Africa's harvesting network has grown to nearly 1,200 employed individuals, with 85% of those being women.[21]

Natural laboratories offer another opportunity for growth and additional employment. These locations have distinct geographical characteristics that make them advantageous to scientific and technological development.[22] For example, the Atacama Desert in Chile is a dry, mountainous region that offers exceptionally good conditions for making astronomical observations with telescopes.[23] The knowledge and information gained can be used to create jobs and foster growth in that region. Those in developing countries who see the economic potential of these natural laboratories can use them as mechanisms for learning, training, and capacity building. They also act as a gateway into international science communities by providing opportunities for collaborations with experts from around the world.

The data science involved in both space and Earth observation are similar in these two closely-related fields.[24] This presents an opportunity for Earth and space sciences to converge and progress datacentric activities. However, there is a need for additional support structures to integrate the data and make it available to all. With the appropriate institutions in place, the information and knowledge available can be transformed into jobs and economic growth.

Conclusion: Moving Forward

Despite the recent expanded use of satellite information in support of the SDGs, challenges still remain that inhibit further applications of the data. Although much of it is open source, the availability of data and the ability to access it are barriers to many, especially those in developing countries.[25] Training is also necessary as highly-skilled people are needed to properly interpret the satellite data and conduct meaningful analyses.[26] Finally, satellite imagery and data are only useful if people know about them and their potential.[27] Raising awareness on the availability and value of satellite data across multiple public and private sectors will ensure that the field progresses into the future.

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