FOR THOUGHT FOOD

Estimation and mapping of croplands at global and regional scales is of prime significance in ensuring food security while managing land and water resources, and global sustainability. **By Anusuya Datta**

Around 805 million people in the world suffer from chronic undernourishment. That's about one in nine people of the 7.3 billion global population. Almost all the hungry people — 791 million — live in developing countries. In other words, 13.5% of the population of developing countries doesn't get enough to eat on a daily basis. Meanwhile, there are 11 million undernourished people in the developed world.

That is the United Nations Food and Agriculture Organization (FAO) data for you.

This number is likely to increase as the population grows to 9 billion by 2050. To feed the world, food production must double, even as the land under agriculture gets drastically reduced owing to fast-paced development and urbanization. Then there are other worrisome factors, such as, unpredictable rains, increased droughts, natural disasters, high input prices and depletion of natural resources. In such a scenario, food security becomes an increasingly difficult challenge in the agricultural context.

Role of agriculture

The current ongoing volatility in commodity prices, recurring food crises around the world and unabated malnutrition in the developing world bring to light the

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people in the world suffer from chronic undernourishment

vulnerability of the global food system more than ever. Like in other businesses, population growth and urbanization are the primary driving factors for agriculture too. Add climate change, depleting water resources and degrading soil quality, and we have a lethal cocktail in hand. Feeding the global population of 9.1 billion in 2050 would require raising food production by around 70% between 2007 and 2050, says FAO. With 69% of the global population expected to be urban by 2050, the land under agriculture is shrinking at a faster rate.

Agriculture plays the most important role in providing food security. Accurate agricultural information is a prerequisite in understanding sustainable agricultural development and food security. "Whether it is through increasing

spatial precision at a sub-field level, or increasing temporal precision at a global level, geospatial technology is like the 'eye' that surveys the global status of crop production at all times and delivers that message across a diverse set of stakeholders," says Susana Crespo, Agriculture Industry Manager at Esri.

Understanding spatial variability is the principal challenge for policymakers to target appropriate and effective interventions. Geospatial technology plays a critical role in determining the right seed for the right location, and the right management practices to optimize production, while minimizing inputs, Crespo adds.

Geospatial information supplies analysts, governments and aid organizations with insights on agricultural lands, cultivated areas, crop health and crop diversity. "Mapping, of course, is the basis and GIS allows to combine different types of layers for farmers and governments," avers Tamme van der Wal, Partner, AeroVision B.V.

Further, accurate geoinformation helps realize required food production and ensures those foods are diverse and nutritious, and that they reach the targeted communities. For instance, while reviewing the food security framework review policy for Sabah, Malaysia, besides taking the GIS map and the local statistics, the department also used strategic environmental assessment to scope the different components. "To our surprise, we learnt that the food basket we think is essential for all the people is actually different for the rural and urban population," says Doria

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of the population of developing countries doesn't get enough to eat

Tai Yun Tyng, Principal Assistant Director, Lands and Surveys Department, Sabah. The team also realised that urban poverty was more severe than rural poverty because of the high rate of migration from rural to urban areas.

The ever-increasing global population and increased demand for food and industrial needs has put tremendous pressure on the planet's resources, such as, land and water.

Because agriculture is the fundamental driver of environmental change and food production, agriculture-related data can provide valuable insights into sustainability issues, including land use, biodiversity, and food security, for both researchers and applied users, claims SEDAC, NASA's Socioeconomic Data and Applications Center. Without accurate crop inventories, global development actors will always be reacting to crises instead of anticipating and preventing them.

Geoinformation for farming

The launch of the Earth Resources Technology Satellite in 1972 (later renamed Landsat) ushered in the modern era of global land observations and monitoring, and since then remote sensing has been an integral part of agriculture and food security programs of governments and agencies around the world. There has been a fast progress in application of remotely sensed data to the mapping and measurement of the Earth's characteristics. The last 35 years have seen amazing improvements in sensor technologies, incredible advances in computing, and impressive innovations in analytical procedures.

Rapid technological advancements in earth observation capabilities, coupled with advances in IT, cloud computing, GNSS, mobile technologies and the smartphone revolution, have created a unique opportunity for implementing
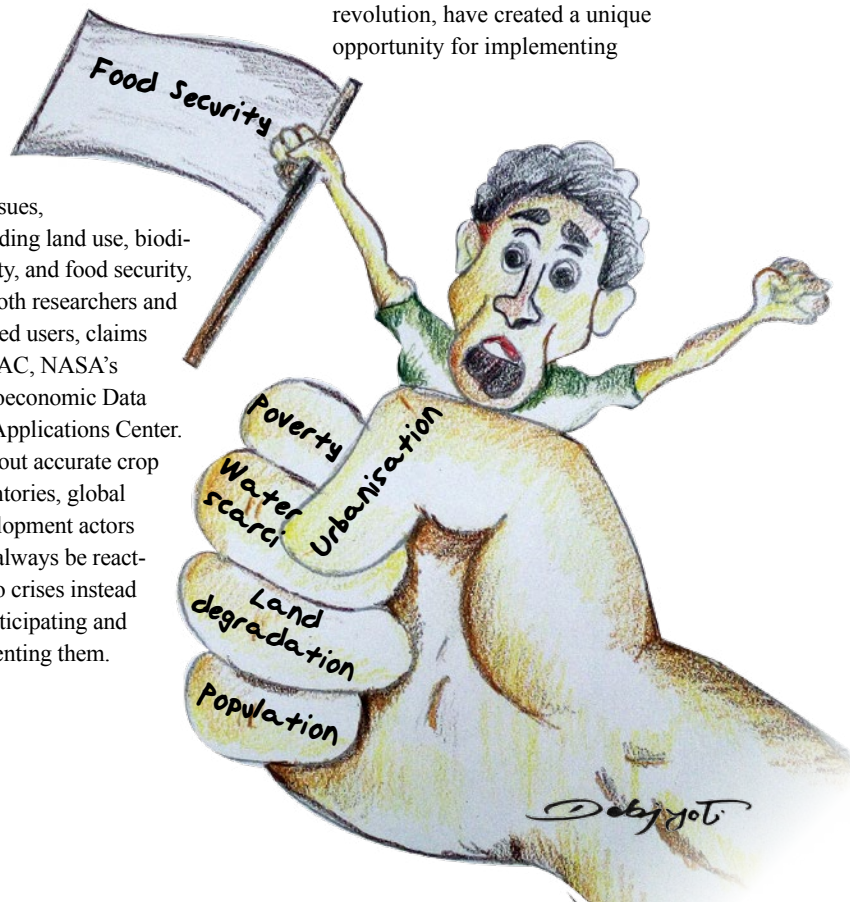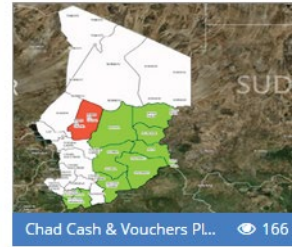
School Feeding in Egypt 👁 94 | CAR Operational OverVie... 👁 330 | WFP Presence by Region... 👁 350 | Chad Cash & Vouchers PL... 👁 166

Explore Data
Click to search for geospatial data from our corporate SDI or published by other users, organizations and public sources.

Explore Maps
Data is available for browsing, aggregating and styling to generate maps which can be shared publicly or restricted to specific users only.

Upload Data
GeoNode allows registered users for easily upload geospatial data in several formats including shapefile, GeoTiff and KML.

World Food Programme

The World Food Programme of the United Nations uses geospatial data and technologies for assessing crop vulnerability. WFP also runs GeoNode, a Web application for creating and sharing geospatial data and maps designed for non-GIS experts. *(See Page 36)*

smarter solutions for the agriculture sector globally.

Of late, multilateral agencies, such as United Nations, FAO, World Bank and Asian Develop-

NASS for You

The USDA's National Agricultural Statistics Service (NASS) provides timely, accurate, and useful statistics for the country's agriculture sector. NASS conducts hundreds of surveys every year and prepares reports covering virtually every aspect of US agriculture. Production and supplies of food and fiber, prices paid and received by farmers, farm labor and wages, farm finances, chemical use, and changes in the demographics of US producers are only a few examples.

ment Bank (ADB) and others have taken up a more focussed approach toward the use of spatial technologies and information for ensuring food security *(See Page 28)*.
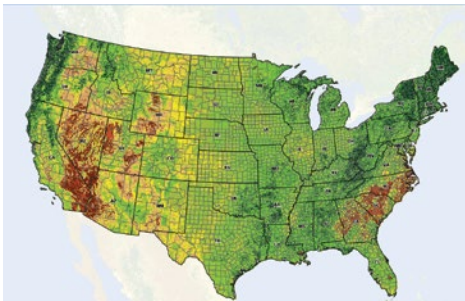
The UN organisations are promoting Global Geospatial Information Management (GGIM), points out van der Wal. "The thought is that land ownership or tenure, etc., require a good land administration, which is not only the basis for more responsible and sustainable farming practices, but also for access to loans and investments. The UK Ordnance Survey and the Dutch Cadastre are promoting that a lot.

"There are a lot of initiatives that not only do some kind of 'wall-to-wall' mapping of agricultural productivity using moderate-resolution Imaging Spectroradiometer and other satellite data, but also measure rainfall — like the 'old' ARTEMIS program of FAO," he adds.

Geospatial information has always been there (soil maps, vegetation maps, etc.), but, in

recent years, the ability to take that geo-referenced information in to orchards or fields have given us the ability to make real-time decisions that have drastically increased the sustainability and profitability of the fruit industry globally, points out C.H. Fraenkel, CEO of Agri-motion, a company working in the area of sustainable solutions for soil management and fruit production.

The Western Cape Department of Agriculture (South Africa) has pushed the geospatial initiative through various projects. "The one that we use a lot is FruitLook. It has provided fruit farmers with the ability to spatially monitor their orchards on a weekly basis," Fraenkel reveals. The project monitors various parameters like NDVI, increase in biomass, evaporation deficits, etc., and the results have ensured reductions in over-irrigation, over-fertilizing, etc. The same initiative needs be put in place in the rest of South Africa as well. "If it makes a difference for smaller

farmers, you can imagine that the benefit to commercial farmers will be exponential. This will not only ensure food security, but will also secure and protect valuable resources, such as, soil and water, for generations to come."

How G-tech can help

Enormous efforts are underway throughout the world to gather data and information on crops, range, land, livestock and other related agricultural resources and their production mechanisms. Such information or data are often used in many global and regional scale models to assess status or trends at the landscape level or even larger units. However, at these scales, such data may fail to reflect ground realities that are often very different from information or data collected at larger scales, and therefore, fail to capture the complex nature of agro-ecosystems. This is especially the case in the developing world, where landholdings are fragmented, and production systems are highly diverse and complex. The complexity ranges from factors such as crops that are produced, soils, land quality, water availability, elevation, weather, poverty, infrastructure, migration, local policies on land tenure, market access, conflict, etc.

At the macro level, accurate location information equips governments about the volume and location of various crops across vast agricultural areas. This helps the governments to anticipate harvests. Accordingly, appropriate trade policies can be selected and areas of surplus produce can be mobilized to supply areas of deficit, preventing

food shortages and hunger. Private sector insurance, re-insurance, commodity traders, all would benefit from monthly snapshots of the status of global crop production. Willis Re and Thomson Reuters are two potential sources of demand for GEOGLAM data (*See Page 29*).

Besides, there are a number of other areas where geospatial technologies play a key role.

Digital terrain database generation: Geoinformation technologies play a crucial role in development of digital terrain database in replacing the qualitative and nominal characterization of topography. The availability of remote sensing-based topographic datasets has opened new venues for hydrologic and geomorphologic studies, including analysis of surface morphology.

Soil analysis: Location technologies play a critical role in the generation of spatial data layers and their integration to estimate soil loss by adopting suitable models. "The role of soil in food security has been underestimated. A good soil reduces risks, retains nutrients, etc.," echoes van der Wal. "And although this seems very logical, it is only now that farmers in Europe are trying to preserve the soil," he says, while adding that his company is working on an agricultural program for soil preservation and restoration. "I think our MISTRALE project — where we design a drone for soil moisture measurements — is quite interesting. Of course, the drone is only one of the means of measuring soil moisture, but soil moisture is a variable that is very important in managing irrigation and water productivity, and it is often poorly estimated."

Dry land productivity: There are few innovative and well-demonstrated remote sensing-based operational projects in dryland areas, such as, integrated land and water resources management, cropping system analysis, etc. The International Center for Agricultural Research in Dry Areas
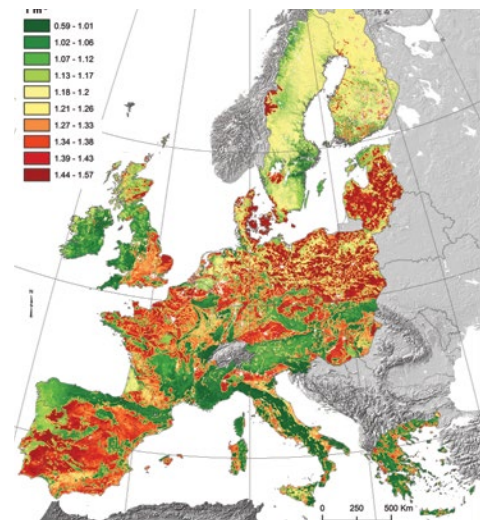
The MARS Mission

The MARS Unit of the European Commission provides timely forecasts, early assessments and the scientific underpinning for efficient monitoring and control systems via its initiatives AGRI4CAST, GeoCAP and FOODSEC. The work serves the agriculture and food policies of the European Union, lists their impact on rural economies and on the environment, encompassing the global issues of food security and climate change. The AGRI4CAST system, also known as the MARS Crop Yield Forecasting System (MCYFS), is made by remote sensing and meteorological observations, agro-meteorological modelling (Crop Growth Monitoring System) and statistical analysis tools. The CAP is a common policy for all the member states of the European Union. It is managed and funded at European level from the resources of the EU annual budget.

REMOTE SENSING   SATELLITE

CAPTURE AND PROCESS DATA
- PLOT BOUNDARIES
- CROP TYPE
- CROP QUALITY
- CROP VOLUME

UAV

FARMER

FIELD TECHNICIANS

INFORM BETTER DECISIONS, ENABLE BETTER PRODUCTIVITY

Reaching for the STARS

The STARS (Spurring a Transformation for Agriculture through Remote Sensing) project explores the uses and opportunities of both established and new remote sensing based technologies and tools as a pathway for the monitoring of agriculture for food security. Funded by the Bill and Melinda Gates Foundation, it is a collaborative effort by various research institutions. The significant spatial and technical challenges present in Sub-Saharan Africa and Southern Asia have prevented the use of remote sensing technology in many areas. The STARS project aims to bridge this gap.

(ICARDA) is one of the research centers of the Consultative Group on International Agricultural Research (CGIAR). ICARDA works closely with national agricultural research programs and partners worldwide to develop new technological solutions to improve dryland agriculture and productivity to provide food security while protecting fragile ecosystems in those countries. It also leads the CGIAR Research Program (CRP) on Dryland Systems, which targets the poor and highly vulnerable populations of the dry areas.

Crop forecasting: Accurate information on crop acreages, timely forecasts and yield estimates are important for various downstream and upstream activities. Satellite data is analyzed with ground-based information on agro-meteorology, and market economics to estimate crop acreage and production much

before the harvest. Multiple, on-time information can bridge the crop production and post-harvest technology gap, and empower authorities for decision making on policy, pricing, procurements, etc.

Cropping system analysis: Satellite data provides the much-needed information for cropping system analysis, including crop area, pattern, rotation, the crop calendar, soil type, etc. The cropping patterns and crop rotation maps are utilized to assess the crop diversity (number of crops occupying a particular area) and cropping intensity (how many crops in succession are grown in a year in a single field).

Restoration of land: Land degradation implies temporary or permanent recession of land through deterioration of physical, chemical and biological aspects. Remote sensing techniques can help identify the 'hot spot' areas, which are un-

dergoing fast degradation, diagnose the potential and constraints of the land and suggest suitable remedial measures for developing these degraded lands.

Increasing acreage: According to a 2010 World Bank report, 37.7% of the world's total land area was considered agricultural land, while approximately 10.6% was considered arable. Management of wastelands is of strategic importance for enhancing agricultural productivity, improving ecology, poverty alleviation and environmental protection. Remote sensing-based mapping and monitoring of wastelands helps in diversification and intensification of agricultural activities, especially in rain-fed areas.

Water resource management: Today, agriculture uses 70% of all freshwater withdrawals worldwide, and up to 95% in several developing countries. Growing scarcity of

water is a major threat to the future food security and poverty alleviation, especially in rural areas. As is with all natural resources, the combined use of remote sensing, GNSS and GIS can monitor, measure, model and manage water resources from the local to the global scale. FAO is developing a publicly accessible near real-time database using satellite data that will allow monitoring of agricultural water productivity. This database can be used to propose solutions to reduce water productivity gaps while taking into account ecosystems services and the equitable use of water resources.

New technologies

There is no debate that climate change is real. Water and land resources are getting scarce. Yield reliability will decrease with greater susceptibility to weeds and diseases, and lesser predictability in the weather. Furthermore, many crops have been neglected because of the high cost it takes to get a trait to market. Diversification may not be easy, but, it is necessary.

"Today, we are dealing with a very disturbing issue called climate change and the mismatch between land and crops is becoming more evident than ever," says Siva Balasubramaniam, Associate Professor, Department of Agriculture, University Putra Malaysia. "Therefore, having the right information about the right location and having the right technologies that can enable further productivity is always an added advantage."

Greenhouse gas emissions from agriculture have increased by 17% since 1990, driven by livestock manure management systems, soil management practices and the environmental burden that fertilizers impose on farming fields. To hedge against decreasing reliability, the world must find new ways to understand soil health and composition. There is also a need to create transparency around seed performance to optimize decisions like what to plant and how to grow it, while working on better R&D methods to develop new seeds, traits and integrated solutions for underserved markets.

This is where precision agriculture comes in — GNSS guided machines, skyscraper vertical farms, and sensor-studded fields overseen by drones. "The possibilities are limitless because geospatial technologies are the backbone of precision agriculture," exhorts Balasubramaniam. "Precision agriculture is the new way of farming which is not only productivity-driven, but also cares for sustainable environment and ecology."

From an economic perspective, farming is getting expensive. Seeds, fertilizers and herbicides comprise a lion's share of the total costs in farm production. This scenario has only worsened due to herbicide tolerance, seed-pricing dynamics and the increasing cost of labor.

"Guidance is the success story of precision agriculture — helping farmers to optimise their field use. Sensing is the most difficult of all. Of course, many tools and techniques can 'extend the farmers eyes' in observing crops and fields, but,
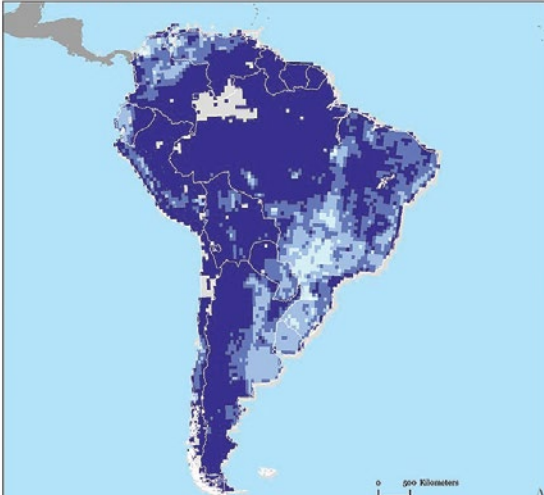

Satellite Power

DigitalGlobe is partnering on a two-year initiative to demonstrate the efficacy of very high-resolution satellite imagery and derived information in monitoring the nature and condition of smallholder farms. This would enable farmers to increase crop yields through enhanced precision agriculture, facilitate improved access to land, and make smallholder farmers aware of better policy choices.
DigitalGlobe's very high-resolution, super-spectral imagery provides many key agricultural data points, such as, water availability, the nitrogen content of plants, crop vigor, and evidence of continued care of the land over time that could be used for collateral.
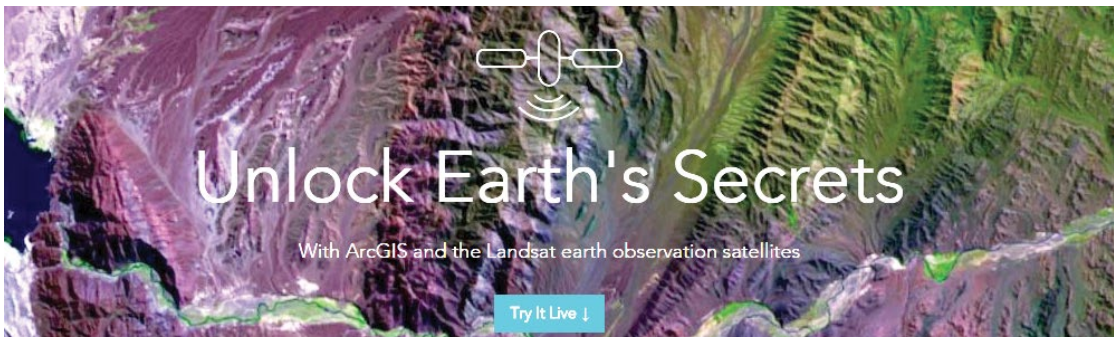
NASA's SEDAC

NASA's Socioeconomic Data and Applications Center (SEDAC) offers a variety of interdisciplinary data and related resources grouped under socioeconomic and Earth science themes. The agriculture and food security theme spans global data holdings and resources that touch on the proportion of cropland and pasture, the extent of poverty, biodiversity, environmental indicators, and human consumption measures. The SEDAC portal provides access to several global agriculture-related data sets, including global agricultural lands that show the proportion of land area used as cropland and pasture, global fertilizer and manure application rates, and effects of climate change on global food production.

the translation of measurements to decisions or even activities is still an unpaved road," says van der Wal.

To reduce the net environmental footprint of agriculture in livestock and crop production, there is an urgent need to better manage the production cycle and move toward automation of the whole process — planting, input application and harvesting — for leveraging existing resources more effectively. Precision agricultural information management system equips farmers with various tools that not only estimate the best harvest time, operate the machinery efficiently, and optimize the farming work, but also generate solutions and/or advice for farmers on how to use fertilizers or agricultural chemicals.

Further, as Crespo points out, there are additional areas beyond farming and crop production where geospatial technology supports food security. Let us not forget, about 30% of the food produced every year gets lost or wasted, amounting to roughly $680 billion in industrialized countries and $310 billion in developing nations. In medium- and high-income countries, food is wasted and lost mainly at later stages in the supply chain, which is the result of lack of coordination between the actors in the supply chain.

"Developing infrastructure and transportation networks that facilitate distribution have multiple

When FEWS means Lots

FEWS NET, the Famine Early Warning Systems Network, is a leading provider of early warning and analysis on acute food insecurity. Created in 1985 by the US Agency for International Development (USAID) after devastating famines in East and West Africa, FEWS NET provides objective, evidence-based analysis to help government decision-makers and relief agencies plan for and respond to humanitarian crises. FEWS NET analysts, spread in more than 35 countries, continuously gather evidence of the current food security situation in areas of concern. They collect data from a variety of sources, including US science agencies, national ministries of trade and agriculture, international organizations, and NGOs. The network has 20 "presence" countries, where locally-based analysts work full-time from a national office. In addition, they monitor 16 countries remotely, typically from a nearby country office. In these "non-presence" countries, the analysis centers on identifying anomalies and spotlighting deteriorating conditions.

benefits throughout the value chain, such as, increasing market access, decreasing food loss and waste, and closing the gap between producer and consumer. There is also a lot to gain in the post-harvest part in terms of logistics, storage, market prices, etc. Some mention that 50% of the harvest is lost before it is used as food or feed... This is a very relevant issue," concurs van der Wal. One other thing that might be of interest is the issue of getting food to or near mega-cities. Alterra is working on these agri-production parks, which are set-up to provide meat and milk in huge urban areas.

The scope is immense

While there have been a lot of initiatives at the global scale, are governments doing enough at the country level to encourage the use of location technology for ensuring food security?

"I think it's still evolving. There is tremendous interest from the community on location technologies like GPS, GIS, remote sensing, etc.," says Balasubramaniam. "We need more trained hands to get these going and I think a great start would be to have more awareness on the benefits of geospatial technologies toward ensuring a sustainable planet."

Yun Tyng believes governments should be setting the policies and giving the directions to ensure there are sufficient and good quality land resources set aside for agriculture. "But beyond that, the initiative must really come from the private sector, the farmers and those involved in the marketing of food products. They are the ones who should be making it happen at the ground level."

For such initiatives to be rolled out to remote places in Africa and beyond, organisations like the

FAO will need to fund projects to make geospatial information more affordable and readily available for the end user. "Making farmers more aware of the benefits of using geospatial information may be the best starting point," stresses Fraenkel.

As open-access policies for sharing geospatial information and technology become an integral part of solving the food security equation, geospatial technologies, such as, remote sensing, GNSS and GIS will keep expanding to provide powerful tools in almost every aspect of food security.

Feeding a population of 9 billion by 2050 will not be easy, but robust monitoring programs with timely, reliable information will certainly be the biggest asset here.

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