

GIS and Remote Sensing in Agriculture

Precision Farming is one of the latest developments in managing returns from farm assets. However, is this all-encompassing? Are there ways we can improve our decisions? With the combination of remotely sensed data (satellite imagery, aerial photography, plus others) and GIS, decisions on farm management can be made to maximise returns and reduce costs.

Imagery can be used to determine the health and vigor of crops and assist in determining growth rates. Informed decisions can then be made on the productivity of various parcels. Action can be taken to improve areas that are not performing. Yield returns can be calculated and risk assessments made for the viability of any parcel of land. Long-term strategies can be formed with confidence that the information being used is the

best available. With the information determined from imagery the harvest could be planned to maximise yields over the entire farm. Remote sensing and GIS has emerged as an effective tool for the macro and micro level mapping of natural resources.

Hilly states with highly diversified terrain ranging from low hills to high mountain ranges has provided a challenge in the agriculture from further enhancing and utilising the latest technologies as compared to the rest of the states of the country.

Many technological developments occurred in 20th century led to the development of the concept of precision farming. The success of the precision farming system relies on the integration of these technologies into a single

system that can be operated at farm level with sustainable effort.

Precision farming is very vital in the mountainous terrain as it becomes more site specific as compared to the rest of the flat agricultural fields. In order to manage the agriculture at such small site specific crop areas it becomes very important to actually identify the each field location.

The precision agriculture can thus be implemented by improvising the traditional farming practices to maximum benefits to these small site specific locations.

GIS and Remote Sensing(RS) plays a very significant role in implementing and monitoring farm practices at this scale. Use of GPS devices whether in built with smart phones or hand held devices leads to actual mapping of the fields and

farmers can actually get site specific and more precise solutions for their problems.

With the help of GIS and Remote sensing not only the field mapping is carried out but if spatial content is related to the other web based application it provides a very powerful tool which can be used to monitor the crop stages, disease management, yield estimation, soil mapping, weeds mapping, hotspots for disease incidences.

Use of GIS and RS in the field of agriculture is increasing day by day and the applications vary from Spatial Decision support system (SDSS), yield estimation, food and security analysis, Crop simulation models, Pest management, Livestock mapping, potential sites identification etc. are some of the most commonly used ones.

Today's necessity has also raised a need to share the information over internet and thus many online web based real-time applications have replaced the traditional stand-alone applications.

This article profiles some of the major players in this industry and gives a detailed overview of their product offering.

1. Earth Observation Data for Agricultural Crop Estimates

The ability of Earth Observation satellites to record data regularly over vast regions makes it a very useful and efficient mechanism to monitor large areas of natural resources, environmental phenomena and agriculture cultivation.

Satellite images recorded by Earth Observation satellites have several bands (electromagnetic wavelengths) that are sensitive to and collect information on vegetation stage and condition. Technological advances in Earth Observation technology have resulted in a continuous increase in the number of satellites launched, and subsequently recording imagery at shorter intervals.

These regular recordings, combined with satellite sensor capabilities to detect information on vegetation makes Earth Observation systems ideal to provide information on cultivation patterns and crop condition.

Agriculture was one of the first applications where Earth Observation data was utilised extensively, and today agricultural crop monitoring by means of satellite imagery is a common practice throughout the world. One of the most important applications of Earth Observation data in agriculture is to monitor grain production in order to gather information on food security.

Food security at a national scale is often linked to the production of grain, which is a function of the total area planted and the yield (ton/ha) harvested for a specific crop in that country. Crop areas estimates, based on satellite imagery is a well-known and vital technique to quantify the area planted of a specific grain crop in a certain district province or country.

The methodology to estimate area cultivated of a specific grain crop by means of satellite image is firstly based on the identification and demarcation of agricultural fields in preparation for surveys, and secondly on performing a crop type classification.

The demarcation (stratification) process aims to identify the geographic areas of cultivation by using existing maps (such as land cover) or by mapping areas of cultivation from satellite imagery. GeoTerraImage has implemented such a mapping process in South Africa as part of the NCSC (National Crop Statistics Consortium).

This field boundary mapping exercise was initially based on mapping from the Spot 5 satellite at 2,5 m resolution and a scale of 1:10 000 scale. The launch of the Spot 6 and 7 satellites with identical spectral characteristics made it possible to map at 1,5m resolution since 2015, thereby improving mapping accuracy.

A comparable data set has been developed for Zambia, by mapping individual centre pivot irrigation fields, commercial rainfed fields as well as grouping small holder fields together as clusters of cultivated fields.

The national field boundary data layer contains a polygon for each individual commercial agriculture field with an attribute of the area in



GeoTerraImage, Agriculture Product Director - Mr Fanie Ferreira

hectare for each field. Fields that are irrigated by means of a centre pivots were also labelled accordingly, while small scale farming fields were grouped together as clusters of cultivation.

The field boundaries are updated annually and used as a statistical framework for the PICES (Producer Independent Crop Estimate System) survey which identifies crop types on selected fields in South Africa. The information from the PICES surveys is used primarily for a statistical calculation of a specific crop area per province, as well as ground referencing information for the crop type classification.

The crop type classification is based on monthly satellite imagery such as Sentinel 2 and Landsat 8 which is recorded during the crop growth season. Information from the PICES survey is used to calibrate satellite imagery in order to perform the crop type classification. This process assigns a crop such as maize, sunflower, soyabeans, groundnuts or wheat to each field. This information allows the calculation of area cultivated per district for a specific crop. As an example, GeoTerraImage has been providing crop type classifications for the summer grain provinces in South Africa to the Crop Estimates Committee (CEC) in support of their monthly crop estimates meetings to determine national production.

The availability of monthly satellite imagery during the growing season has also allowed GeoTerraImage to develop algorithms and techniques that can monitor crop growth stages and track harvesting activity on a month by month schedule. This information, along with the crop area estimate information can assist decision makers to understand agricultural activity in a region, and gain valuable insight into cropping patterns and trends.

2. ST Group

Founded in 1994, the ST Group operates from its head office in Midrand, Johannesburg and is the African distributor for leading software companies, Pitney Bowes, Dynamic Design and Basarsoft, offering solutions and expertise in Asset and Infrastructure Management together with Location Intelligence and GIS.

Together, these products focus on enabling strategic and operational activities across a broad spectrum of industry, particularly in the Utilities and Telecommunications industries throughout Africa.

Location Intelligence, Data and Resource Management.

Relating business value to location is called Location Intelligence, and the MapInfo brand is the leader in the delivery of that business value. For business value to be realised from Location Intelligence, it is not sufficient to only use software tools. These must be related to data sets to provide insight. We supply a wide range of applicable data, both topographical and business-related.

We are focused on providing tools and insight into the effective management of telecommunications, power, water and gas networks. Planning and effective operational management of these resources provide real business value to our clients. We assist our clients to capitalise on these benefits by training them, assisting in the deployment of the solution and supporting them for the continued benefits of operation of the system.

The Products.

ConnectMaster

ConnectMaster is an off the shelf, scalable and open software solution for the comprehensive design and management of telecom networks

and inventory using the geospatial location intelligence of MapInfo. ConnectMaster supports key business tasks for both domains – physical inventory management and logical resource management within one integrated product.

ConnectMaster supports the end-to-end engineering and management of fibre optic networks. In addition, it will generate a range of reports to enable more efficient design and operation of fibre optic networks. ConnectMaster FTTx Rapid Network Planner automates the entire process, from rough planning to the preparation of construction documents and work orders, including detailed specification of costs for individual building projects.

The Maestro suite

This is an easy-to-use software environment that makes the management of electric, gas, water and wastewater infrastructure more effective. It defines topology of the network components such as feeder lines, transmission lines and transformers so that areas fed by these can be displayed on a map, analyzed, and presented in reports. The Maestro products are GIS-based, so subscriber Information, network status, and network inventory are all digitally integrated for easier monitoring. This knowledge effectively guides procedures such as network maintenance and meter installation and defines exactly which subscribers are affected.

Location Intelligence

MapInfo Pro

MapInfo Professional is an industry leading location intelligence desktop solution used for creating, editing, visualizing and analyzing customer and business data in the context of location.

Spectrum

Spectrum Spatial is an enterprise location platform designed to provide organizations with a suite of broadly applicable location capabilities that solve a wide variety of business problems. Spectrum Spatial provides organizations with a way to centrally manage location capabilities and apply those capabilities across departments and applications. Using standards-based Web Services technology, Spectrum Spatial is able to deliver precise and reusable functionality in a

scalable, high-performance package.

SiteMarker

SiteMarker Professional allows analysts to determine the best markets and the optimal number of sites within those markets in order to maximise their network, whether that means building new stores, consolidating branches or filling gaps that exhibit high potential.

MapMarker

If you and your organisation need to locate and visualise your customers for market analysis and improved business intelligence, MapInfo MapMarker provides you with an industry leading solution for pinpoint geo-coding. MapMarker includes address cleaning to ensure accurate, consistent address data and enables you to make the most of your data.

3. Supergeo Technologies Inc.

Supergeo Technologies Inc. is the global leading GIS software provider that develops and sales SuperGIS series products to meet various professional's demand for over a decade. Also, onsite and online GIS training, product customization, and consultancy services are provided upon request.

Key Products of Supergeo:

Mobile GIS Series

SuperSurv 10

- Operating on Android, SuperSurv is a mobile app integrating advanced GIS and GNSS technologies. Its core functions include spatial data collection, displaying, editing & querying, real-time GNSS positioning, and waypoint management.

Key Features:

- Capture point, line, and polygon field data efficiently.
- Add additional info in WMS, WMTS & WFS standards.
- Export the result of field survey in printable designs.
- View and edit data even in the offline environment.
- Reach decimeter GNSS accuracy through NTRIP service.
- Upload data to Google Drive or Dropbox with ease.

SuperGIS Desktop 10



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SuperPad 10

Similar to SuperSurv, SuperPad is a mobile app equipped with advanced GIS and GNSS technologies but works on Windows & Windows Mobile OS. Since it is developed earlier than SuperSurv, SuperPad can achieve more with its more powerful functions.

Key Features:

- Collect precise spatial data in the field via NTRIP service.
- Integrate online maps in WMS, WMTS & WFS standards.
- Access, manage, and share layers through Google Drive and Dropbox.
- Add extensions like BirdView, CADLayer, etc. to meet distinct needs.
- Overlay maps even in different coordinate systems.
- Define or import a custom Quick Project to finish field works rapidly.

Benefits of Using Mobile GIS in Agriculture:

For farm management, field workers can use mobile GIS to build up the basic spatial data as

well as to check and update the condition of crops in real-time.

Desktop GIS & Extensions

SuperGIS Desktop 10

SuperGIS Desktop is powerful and reliable desktop GIS software that enables users to visualize, process, edit, query, analyze, and manage different kinds of geographic data with its abundant tools.

Key Features:

- Visualize spatial data to understand the distribution of geographic features.
- Create useful maps and insert professional analytical charts.
- Access geo-databases and manage various kinds of spatial data.
- Develop custom models by connecting suitable geo-processing tools.
- Augment the capability for analyzing geo-data with various extensions.

Benefits of Using Desktop GIS in Agriculture:

With this excellent Desktop GIS product & extensions, users may easily process a large amount of spatial data, find the hidden patterns, and make smarter decisions. For example, combining the functions of Spatial Analyst and Image Analyzer, it becomes easier for the farm manager to discover the growth condition of crops and its relationship with irrigation and fertilization.

Server GIS

SuperGIS Server 3.3

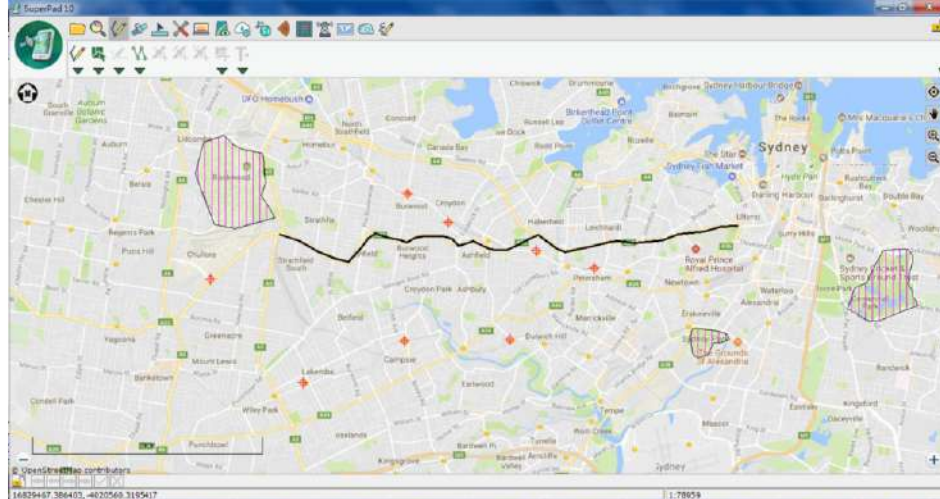
SuperGIS Server helps users integrate, manage, and publish diverse spatial data and geo-processing tools via the internet and intranet. By publishing data or tools over the internet, users may deliver your valuable results of GIS projects to anyone, anytime, anywhere.

Key Features:

- Share spatial data efficiently over the internet or intranet.
- Integrate various GIS services seamlessly.
- Manage a large amount of data in central geo-databases.
- Customize applications with rich SuperGIS Server APIs.
- Extend advanced GIS techs to multiple client-side applications.

Benefits of Using Server GIS in Agriculture:

The highly scalable design of SuperGIS Server would help farm managers create multifunctional GIS web applications with ease, distribute real-time monitoring data, and share to multiple clients, including mobile, desktop, and web applications. Therefore, various users can receive the map they need over the internet anytime, anywhere.





4. ArcGIS technology solutions.

Discover why Agricultural Farmers are using Geospatial technologies as a Farming

Management Tool

Farm Management poses numerous challenges in an ever-changing environment. To maximize profits and optimize yield, you need to dedicate the right crops and equipment to the places where they can flourish.

Due to rapidly enhanced sensor technologies, more powerful computers and improvements in spatial applications, Geographic Information Systems (GIS) is becoming the platform of choice for combining and analysing huge streams of data. The ability to analyse those data streams and display results visually on maps has engendered several new applications across various fields.

Boost your seasonal production and your profitability by intelligently assigning your resources. With intelligent maps and spatial analysis, you can optimize your operations and logistics to cut your fertilizer, fuel, seed, labour, and transportation costs. Avoid costly maintenance repairs by tracking and managing your assets to keep your farm operating at peak efficiency.

Geographic information system (GIS) technology is used throughout the agricultural

industry to manage resources, increase yields, reduce input costs, predict outcomes, improve business practices, and more. The capability of GIS to visualize agricultural environments and workflows has proved to be very beneficial to those involved in farming. The powerful analytical capabilities of the technology is used to examine farm conditions and measure and monitor the effects of farm management practices.

From collecting data in the field with mobile GIS to the analysis of remote-sensing data at the farm manager's office, GIS is playing an increasing role in agriculture production throughout the world by helping farmers expand production, reduce costs, and manage their land more efficiently.

Visualize

Visualize your data and perform spatial analysis that can help you better understand risks to operations. Model what-if scenarios to better understand the potential impacts of threats from both pests and the climate

Analyze

Determine how much water is available in a specified area, what yield you can expect from the water that is available for crops, and how efficiently water is used. This will enable farmers to produce more food in a sustainable way

Collect

Go into your fields to take detailed observations that can refine crop forecasts and planning.

Monitor

Track extreme weather events and man-made disruptions. Assemble the information you need to respond at a moment's notice. With Esri technology, you can monitor the health of individual crops in your fields and spatially analyse the differences in soil types, sunlight, and slope to name a few. The tool can accurately estimate variable yields across any field and maximize crop production, through vegetation health monitoring and comparing crop yields.

Benefits of using Spatial Technology

- Factor in every variable that affects your crop and find the best places to plant
- Go into your fields to take detailed observations that can refine crop forecasts and planning
- Map individual variations in your fields to better understand them and get a clear picture of your operations
- Understand insect and animal behaviour. Plan and assess measures to mitigate the impact of pests on your operations
- Track extreme weather events and man-made disruptions. Assemble the information you need to respond at a moment's notice
- Combine live weather information with pest and crop data into a common view to get the complete picture
- Determine the best location to plant a crop to enable maintenance of soil nutrition levels to best benefit the crop

The adoption of spatial technology to manage farm processes will create new opportunities and increase profits. The time is now to Take the guesswork out of agricultural production and manage land more efficiently with ArcGIS technology solutions.



5. Hexagon Geospatial

Hexagon Geospatial helps agricultural companies of all sizes make sense of the dynamically changing world. We enable you to envision, experience and communicate geographic information. Our technology provides you the form to design, develop and deliver solutions that solve complex, real-world challenges.

Our software provides tools and maps that help growers, agronomists, suppliers, and other decision makers stay on top of their fields and operations. By enabling two-way, cloud-based sharing of critical farm data, our solutions support sustainable practices in the farming community and provide the tools to analyze factors such as moisture, soil type, slope, and sun position to inform planting, maintenance, and harvest. They also can accurately identify and measure the impact of drought, pestilence, and other threats.

A Strong Legacy in Remote Sensing and GIS

Hexagon Geospatial has a long heritage in the Remote Sensing and GIS fields for agriculture and natural resources management.

ERDAS IMAGINE, originally designed as an earth resources data analysis tool, has grown into the world's most widely used remote sensing software. Across the globe, agriculture, forestry, and natural resources companies rely on ERDAS

IMAGINE every day. Apart from image processing tools designed for crop, field, and agricultural analysis, ERDAS IMAGINE is designed to work with data from a variety of sources – including satellite, aerial photo and even UAV/drone imagery.

GeoMedia, our GIS desktop software, also benefits from a long legacy of working with agricultural customers. GeoMedia is a full-service GIS package, with powerful dynamic modelling and analysis tools. Like our other software packages, GeoMedia is designed to connect to a variety of data, empowering agricultural customers to analyse their data without costly data conversions.

We also offer other platforms for data management (ERDAS APOLLO), compression (ECW), web-based distribution (GeoMedia WebMap) and field work (GeoMedia Smart Client and Mobile MapWorks).

The Map of the Future Isn't a Map, It's a Smart M.App

The agriculture industry in Africa is vital to the health and sustenance of people across the globe, and timely information is critical to success. Traditional maps can take weeks or months to build and distribute, and the data is out of date before the map is even finished. This is why Hexagon Geospatial created the Hexagon Smart M.App.

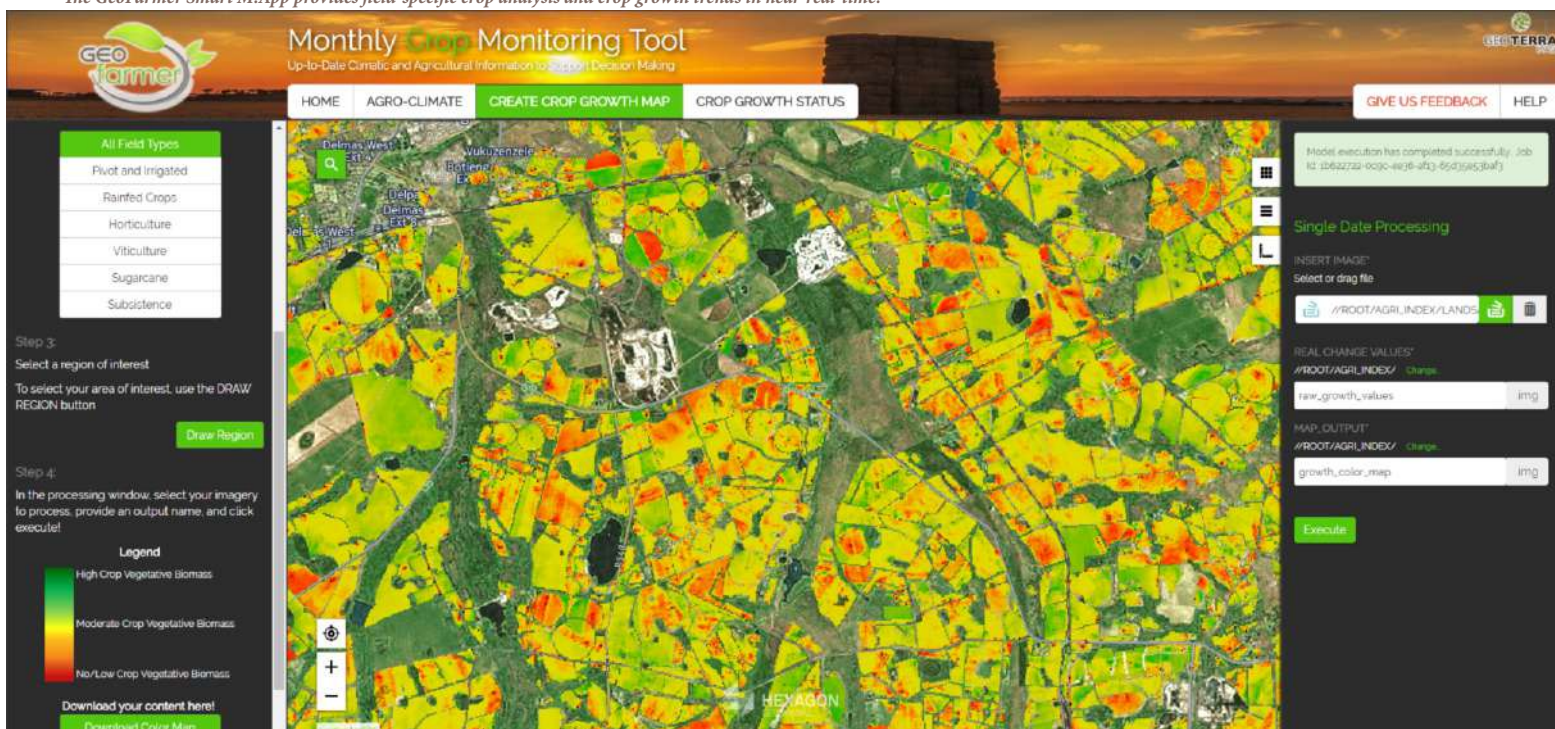
A Smart M.App isn't a map, it is a dynamic information service. It combines geospatial data analysis and agricultural workflows with dynamic information streams. Building on the methods and techniques learned from our Remote Sensing and GIS tools, we created a new paradigm in mapping and analysis. This analysis can then be placed in an intuitive dashboard so growers, agronomists, suppliers, and other decision makers have access to the information they need to make informed choices based on their unique situations.

Smart M.Apps are streamlined tools that build on our remote sensing and GIS legacy to provide targeted answers to specific questions that can help manage agriculture projects. When should I water or apply fertilizer and insecticides? Solutions can be quickly prototyped and connected to dynamic data sources, providing up-to-date insight to decision makers without embroiling them in the details of geospatial mechanics.

The Hexagon Advantage

Hexagon Geospatial is part of Hexagon AB, the leading global provider of information technologies that drive productivity across geospatial and industrial enterprise applications. Together with our other Hexagon brands like Hexagon Agriculture, Hexagon Geosystems, and Hexagon Safety & Infrastructure, we offer the full end-to-end sensor-to-information data lifecycle.

The GeoFarmer Smart M.App provides field-specific crop analysis and crop growth trends in near-real-time.



6. Geospatial Integration Solutions

Farmers have always looked for early indicators of crop health. Roses are planted at the ends of vineyards to indicate mildew and aphids. Nitrogen deficiency is indicated by yellow leaf tips, and reddish hues show a phosphorus (P) deficiency or BRIX indicators for sugar levels. For farmers, these are the clues that indicate the possibility of low crop yields, pest attacks and the health of their plants.

Traditionally this was achieved through long walks through the fields with random tests combined with verbal feedback from staff working the fields.

Then, based on years of experience and a gut feel, additional costly resources such as fertilizer or intensive spraying would be deployed to the whole field to preempt crop failure - not a very scientific or profitable approach.

Now with the dawn of unmanned aerial vehicles (UAV's), it has become a simple exercise to collect big data of the field in both the visible and invisible spectrum of light, which is supposed to tell us how to improve the yield. How do we translate the "Big Data" captured into actionable intelligence that will save money?

Welcome to GIS and remote sensing. GIS is not software or hardware, it is a system and tool set to allow us to interpret aerial maps and deploy the correct resources to those parts of the field that are ailing.

GIS is the link that takes us from asking questions about farming, to acting in an efficient way to improve yields. By digitally combining various data sets, we can use spatial analysis and see patterns emerge, and together with farming experience allocate corrective solutions to only the affected areas.

GIS allows for the compilation of aerial data easily collected by UAV, combined with "gut feel" experience to precisely allocate the necessary resources for the betterment of the farming operation.

Much has been written lately about the benefits of UAV's in agriculture to collect airborne data, and how simple and cost effective it is to measure crop health. UAV technology has reached a point

where the level of accuracy and quality of the data is now more affordable than ever, with certain providers supplying specific UAV Agricultural packages.

GIS and remote sensing have made incredible advances in recent times allowing for easier, more affordable access to highly accurate remotely sensed data which has increased the feasibility for using GIS and Remote Sensing for agricultural applications.

GIS can be applied to agriculture long before a farm is even acquired which can aid decision-making and planning to improve efficiency and profit once agricultural activity begins. GIS can be used to analyze potential and existing farms to examine the terrain in both slope gradients and aspect; access to transport routes; access to water; upstream catchment area of rivers and to analyze the vegetation content of the land.

During the planning phase, GIS can be used to optimize the farm layout, maximizing field area while minimizing on farm transport routes. Irrigation and other infrastructure can also be optimized, in order to maximize efficiency.

Photo synthesis is the conversion of absorbed blue and green light into energy. Plants are green, as they reflect green light. Similarly, near infra-red light is reflected by healthy plants. By comparing the ratio of red light absorbed and near infra-red light reflected, we obtain a graphical index referred to as normalized difference vegetation index (NDVI) of Chlorophyll content, which indicates plant health. GIS allows us to take the image and, on a map, see where plants are unhealthy or stressed and which areas of the field are healthy. Then, as we are working with a map, we can extract the position of the stressed areas, and find those exact areas using simple GPS or even a smartphone. Now we can focus on this part of the field only, saving both time and money.

A similar analysis using other wavelengths can be used to derive an index of water content in leaves, known as the Normalized Difference Water Index (NDWI). The water index can be used to optimize irrigation and identify possible areas which need more, or less water - which is vital in times of drought to optimize the use of water to get maximum benefit for your crops.

The water index also conversely can be applied to identify fire risk areas and, by combining this with other data such as roads and access, can aid the combat of large fires and identify the effectiveness of fire breaks.

The benefits of UAV applications are that they are more cost effective over satellite or traditional aerial imagery and, by focusing the area, the resolution and accuracy is increased giving better results. Due to far lower costs, multiple flights throughout the year can be repeated, in order to successfully track the progress of crops and irrigation methods.

Analysis like this can be done regularly to monitor crops and plantations and give estimates on crop yields. The main advantage of utilizing Drones to collect data and it's analysis using GIS, is that it can be done at a regular interval allowing for quick reaction times and an understanding of the corrective interventions.

Visual applications of UAV technology can also be highly beneficial to agricultural industry from plant counts to infrared imaging for tracking and identifying vermin populations and doing game counts.

In South Louisiana, drones are successfully being used to track the wild pigs that are ruining crops. For game farmers and hunting lodges, UAV's can be used to track injured animals by covering larger areas and rough terrain faster with thermal and infrared cameras not being limited by light conditions.

Michael Mazur from PWC has identified four areas that can benefit from combining GIS analysis with aerial drone mapping that can benefit agriculture. These are:

Soil and field analysis: At the start of the crop cycle, precise 3D maps can be used for soil analysis and determining optimal planting patterns, nitrogen feed levels and irrigation programs. Automated planters can then be deployed on planting patterns using GPS and the maps derived from the GIS analysis.

Crop monitoring and health assessment: Traditionally, only satellite imagery was available to indicate plant health. The simple ongoing deployment of Drones, together with GIS for data

interpolation, allows for time sequences showing crop growth and early indicators of stress. GIS can be used to overlay weekly images of crop growth and the emerging patterns quickly show where remedial action is required.

Irrigation: Drones with hyperspectral, multispectral, or thermal sensors can identify which parts of a field are dry. This data can be combine with a thermal heat index and irrigation programs can be modified. The internet will soon allow for individual irrigation sprinklers in a field to be programmed switched on and off and, as the IS mapping is indicting which areas are in need of water, only these specific sprinklers need to be turned on. The color spectrum of imagery can further be analyzed to show how much water is required.

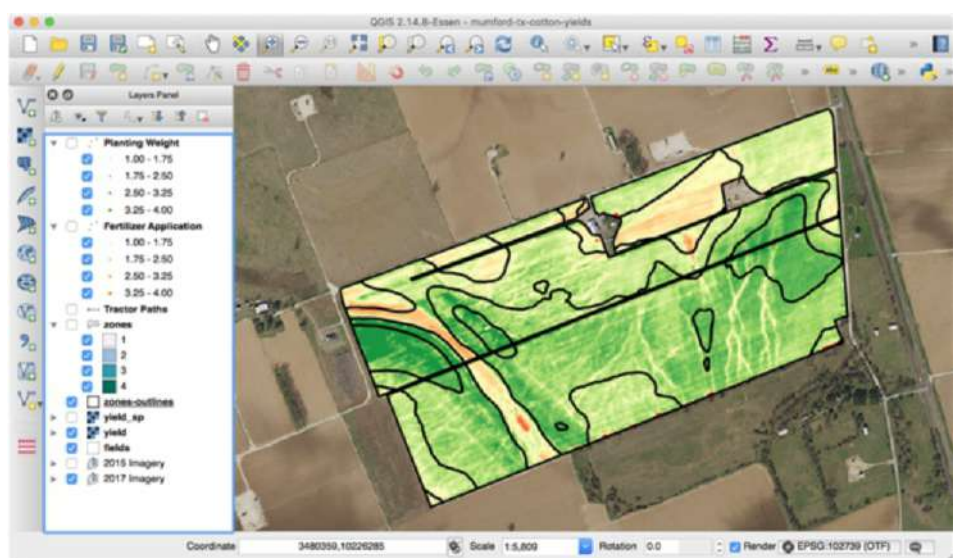
Crop Spraying : Larger drones can now be deployed using GPS to specific sections of field to spray nutrients or remedies.

With the cost of UAV hardware and software both dropping and the ease of use increasing, it is clear to see that GIS and remote sensing are set to play a bigger and bigger role in agriculture by helping increase efficiency and aiding decision making.

7. The Boundless Product Suite

Boundless offers an open GIS ecosystem through a unique combination of technology, products and experts that gives organizations deeper intelligence and insights using their location-based data. The Boundless platform is built upon open source technology and open APIs that generate actionable location intelligence across third-party apps, content services and plugins for enterprise applications.

Boundless' open design lets agricultural organizations scale their technology as needed and provides the ability to integrate location-based data into an existing farm IT environment. When not locked into a single GIS vendor, the farm staff can gain flexibility and attain well-rounded expertise by becoming proficient in more than one type of software. The farm can additionally swap out technology as needed for newer, more cost-effective, or more full-featured systems – and the staff can migrate to the new technology without extensive retraining. An open source approach to precision agriculture allows farmers to choose the best geospatial tools



for their jobs, change or update those tools at will, and integrate their GIS with other technology tools.

Boundless Desktop

Boundless Desktop is a full-featured, professional desktop GIS that supports the management, analysis, visualization and dissemination of geospatial data. Powered by QGIS, a proven open source geospatial software, Desktop combines innovative open source projects with premier support, certification and security, giving organizations the control and tools necessary to unlock the power of location-based data for maximum bottom-line impact.

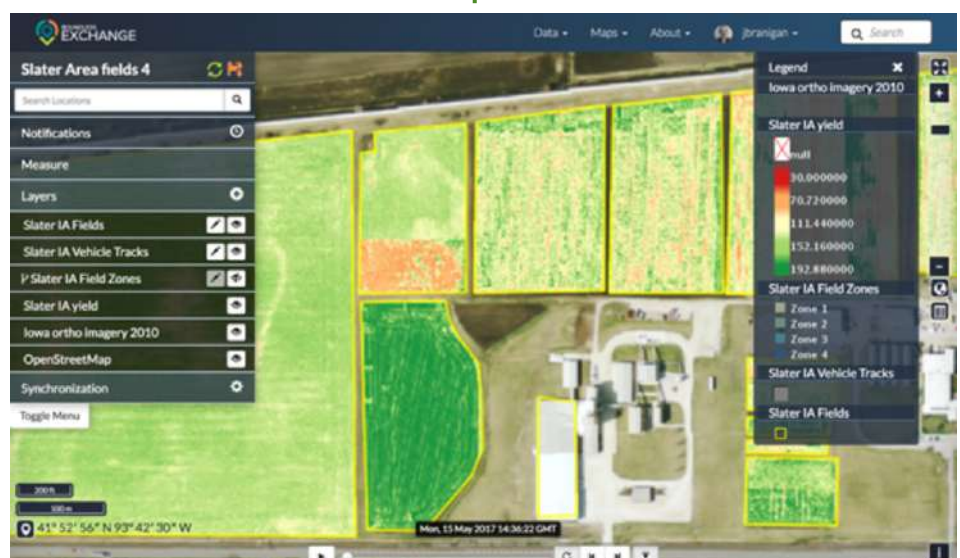
- **Features include:**
- Subscription service model scales without penalty to unlimited users.
- 600+ plugins including: Boundless Lessons & WebAppBuilder.
- Access to Boundless Connect online platform.

- Build and manage geographic data.
- Native cross-platform workspace.
- Automate workflows, export and share effortlessly.
- Access to Premium Imagery and Basemaps.

Boundless Exchange

Boundless Exchange lets users search and discover content. Open by design, Exchange easily integrates with any existing GIS enterprise system, or serves as a standalone solution for targeted projects. Exchange includes intuitive tools help organizations turn their geospatial data into actionable business decisions.

- **Features include:**
- Completely customizable.
- Extensible architecture integration.
- Proven performance & scalability.
- Critical technology integrations.
- Interoperable & OGC-compliant.
- Dynamic, interactive, communal collaboration.



- Basemaps from top providers: Mapbox, Planet and more.
- Discoverability - search & retrieve ALL geospatial services.

Boundless Suite

Boundless Suite is a full package of supported open source geospatial software that represents the fastest and easiest way to publish geospatial information on the web. Pre-configured and bundled together, the Boundless Suite combines the power of open source with the reliability and support of a single, stable vendor, providing a full stack of software.

- **Features include:**
- Support on the CentOS 7 operating system, giving users outside of the Windows ecosystem access to the most comprehensive open GIS solution.
- Leverage modern symbology styles with Mapbox Styles, a modern way to style data that is designed to work across the entire Boundless product platform. This update lets users style applications quickly and consistently across desktop, web and mobile.
- Designed to work in modern IT architectures, including virtual machines, elastic DevOps architectures and the cloud, allowing customers to maximize their GIS investment and lower total ownership costs.

8. Swift Geospatial Agricultural

Swift Geospatial Agriculture services Remote sensing technologies have proved to be great technological aids in the agricultural sector.

Swift Geospatial has brought together a range of technologies that can operate in isolation or together as a package that deliver valuable insight into crop health, yield prediction, planting, harvesting and many other important aspects of modern farming.

Both active and passive sensors can be utilised to produce remote sensing products for agriculture. Active sensors include technologies such as RADAR and LiDAR, which both emit energy and measure the

returning energy to produce a 3D model of the ground.

This can be useful for land assessment and planning.

Passive sensors include multispectral satellite imagery that can be collected at various wavelengths for different applications.

Swift Geospatial has a variety of Geospatial technologies for agriculture, which include: UAVs (drones) and satellite data

The most accessible remote sensing technologies that can bring the greatest immediate benefit are UAVs (drones) and satellite data.

Swift Geospatial offer UAV sales, flight services and associated processing and analytics. Our UAVs are designed to operate in the African environment, and can be custom specified to meet individual requirements.

The units can accommodate a variety of sensors, including infrared and thermal. We offer processing and hosting capabilities, meaning that if you have a drone, or purchase one from us, we can process the data and host the outputs



on a secure online platform, so the user can easily and quickly log on to retrieve the results, as well as value added analytics like crop health, crop health deviation from last year, harvested acreage and many more.

Satellite Technology

Satellite technology has been used in agriculture for over 50 years. Today, the technology is advanced enough to capture crop health data every single day, and it can be used to predict yields, determine problem areas and define optimum planting and harvesting regimes.

Swift Geospatial offer all of these services utilising the highest resolution satellite constellation (DigitalGlobe) and the highest frequency satellite constellation (Planet), to provide the most advanced solution available today. With the data from these satellites, multiple analyses can be performed and combined with ultra-high resolution UAV data to produce invaluable crop intelligence.



9. GIS Cloud

GIS Cloud is one of the first cloud-based GIS solutions in the market, which offers a complete map-based solution for different workflows in a wide range of industries: from tree inventory to utility inspection, to remote sensing and precision agriculture.

In agriculture, mapping technology can be used for farm management, allowing a greater understanding of the spatial distribution of crops, interpreting environmental data, and also to do wide-scale projects that can increase visibility and awareness of local farming production, as well as variables affecting it, such as droughts, pests or land values.

GIS Cloud offers a real-time mapping solution for the entire workflow in farm management - from collecting data on crops to making reports and creating interactive maps for a wider community. It helps agriculture workers to improve their efficiency and decision-making by creating a perfect environment for collaboration on a map.

With GIS Cloud Mobile Data Collection (MDC), you can do field inspections using mobile phones and tablets, with unique custom forms, which means you can have as many items as you want and you can structure the form according to your needs.



For instance, you can collect data about crops such as height, grain quality, potential pest infections, etc. or take photos and make audio recordings, directly linked to a point on a map. Forms can be updated at any time and synced on all devices. Data is sent on a map in real-time, instantly visualised and can be further analyzed or edited. This means that people in other locations can monitor and guide the data collection process as well as coordinate workers in the field.

If there is no network coverage in the field, data will be kept in a queue and sent to a map once the device is online again. MDC requires no additional training and you can deploy it within minutes. Also, it allows you to create reports on the go for an overview of work done in the field.

In Map Editor, you can view collected data and go even further. Maps can be created, edited, styled, overlaid with layers of other data (such as land values, risks for droughts etc.), and shared privately to users with different privileges. This is a perfect tool to collaborate with colleagues on a map, to analyze data, export it, and create reports.

You can also publish maps created in GIS Cloud and share it with the public via interactive and fully customizable Map Portal. This app allows you to add your branding, logo, custom interface, and a separate domain. Some of the options include the ability to search for various types of data (e.g. soil, crops, pests, etc.), visualise and switch layers on a map, filter results, and export data.

Some of the uses of GIS Cloud in farming are:

- Collecting crop data in the field in-real time and coordinating workers in the field
- Visualisation and analysis of collected data for various purposes such as crop monitoring, visualising distribution of





As a platform, GIS Cloud offers opportunity for various integrations, with desktop-based GIS solutions, as well as with hardware, such as humidity sensors and other equipment that sends data in real-time. You can also build your own unique agriculture and farm management apps on top of GIS Cloud.

GS Cloud supports raster and vector data formats, and it is built on the fastest map engine out there, which provides great performance in rendering even very large amounts of data, like drone imagery.

pesticides, crop forecasting, evaluating the damage from environmental factors (droughts, floods, wildfires...)

- Raising awareness of local farm production, land use, or potential dangers (floods and others) through public map portals
- Crowdsourcing spatial data from

farmers or community members, who can submit reports (manually approved by administrators) as anonymous users via branded mobile and web apps

- Visualising and sharing remote sensing and precision agriculture data

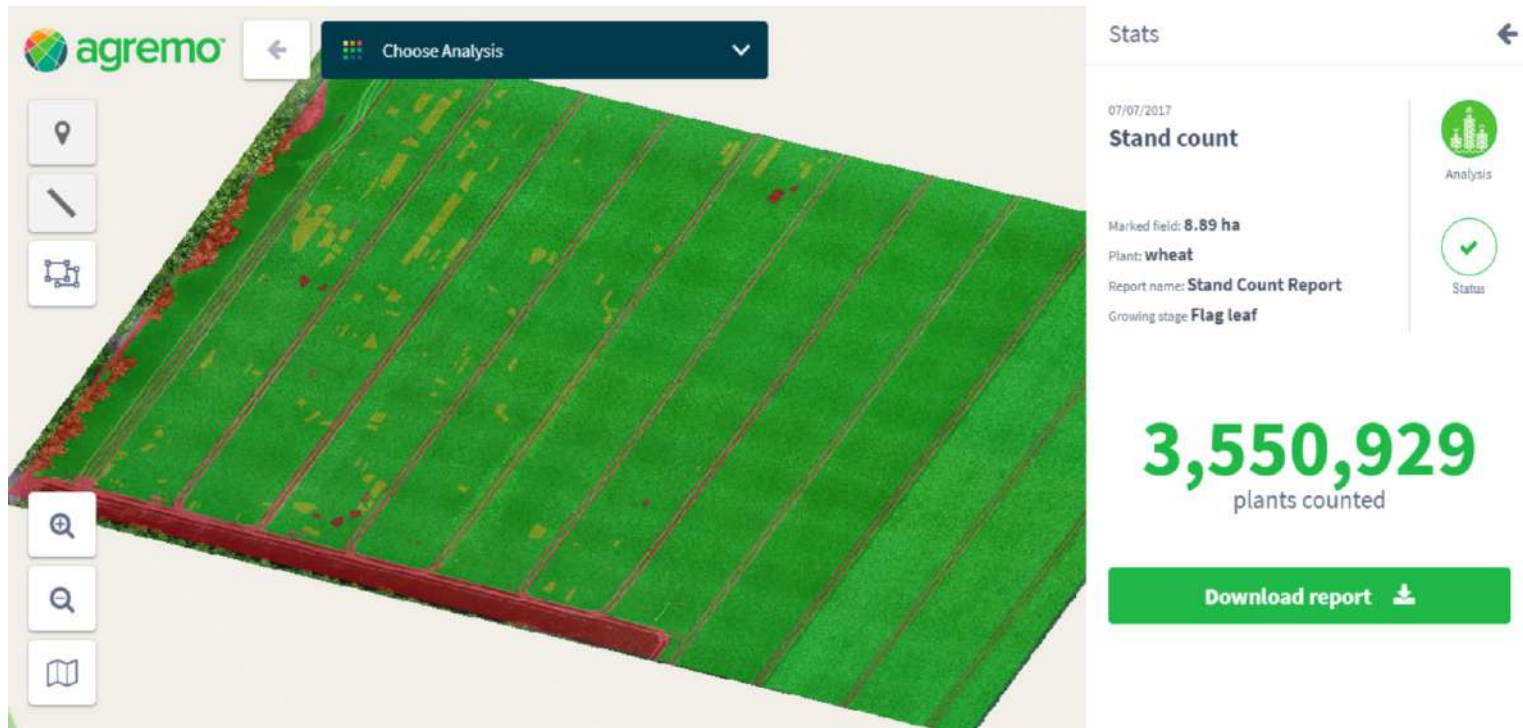


Find issues on your farm sooner with our drone & satellite maps

Nitrogen deficiency

Moths

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Go to www.droneclouds.com today



10. Agremo Plant

Agremo Plant Insights, formerly known as AgriSens, is a cloud-based software platform which uses insights extracted from drone-collected imagery to improve agricultural processes.

With Agremo, farmers, agricultural consultants, drone operators and insurance companies are able to successfully plan, monitor and analyze

agricultural activities and find out what is happening on their field at any given moment throughout the growing season.

How Agremo works

The process itself is simple: the users create a map of his field, uploads it to Agremo (www.agremo.com) and requests one of our analysis (Agremo analyses).

Agremo believes that good performances and good decisions come from careful and professional analyses.

That's why Agremo was developed in close collaboration with academic institutions and agricultural experts. Thanks to this unique blend of technology and agriculture, you get results that are accurate, understandable and easy to implement.■

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