# MULTISPECTRAL IMAGING DRONES FOR AGRICULTURE

Crop Health Data at Your Disposal

*Agriculture is our wisest pursuit, because it will, in the end, contribute most to real wealth, good morals, and happiness.*
**- Thomas Jefferson**

Nothing makes a farmer proud like a healthy harvest. You take pride in feeding people with your hard work, but you also grapple with razor-thin margins and operate your business at the whims of mother nature.

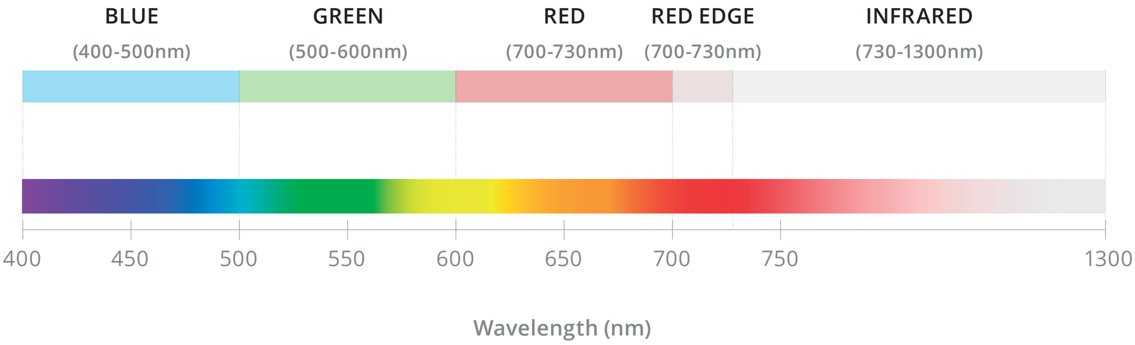
Fortunately, there are more technologies and tools available than ever before for farmers to protect, nurture, and maximize the productivity and health of their farms. In particular, precision agriculture practices like remote sensing have enabled farmers to identify issues early, act with assurance, and eliminate guesswork. As remote sensing data becomes more accessible, the wisest of farmers and agronomists are eagerly integrating this information into their decision-making processes to stabilize income while minimizing impact on the environment.

This eBook will delve into multispectral imaging — a major domain of remote sensing — and its benefits to crop farming, specifically the use of a multispectral drone to generate actionable insights in the form of vegetation index maps.

## LOOKING FOR LIGHT UNTIL ... IT DAWNED ON ME

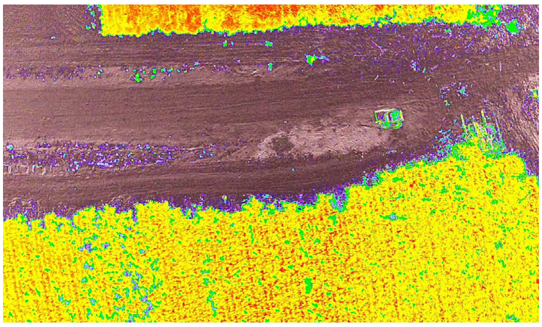
***Light is the fastest thing in the universe. That we know of, at least.***

Light, or visible light, is just one part of the broader electromagnetic spectrum. Our eyes can detect wavelengths of light between 400-700nm, but there are wavelengths on either side which are much shorter, and also much longer.

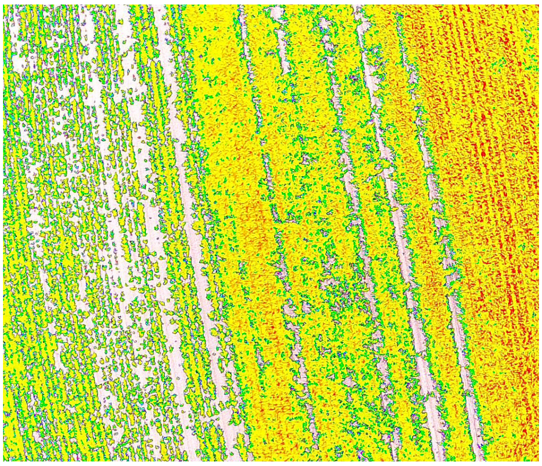



When electromagnetic radiation is emitted by the sun, it flies through outer space at close to $3x10^8$ meters per second and collides with the Earth. Fortunately for us, our atmosphere includes ozone molecules which absorb ultraviolet light, which could otherwise cause damage.

In addition to absorption, like in the case of ozone and UV light, electromagnetic radiation can also be reflected off of or transmitted through objects it encounters. Our sky is blue because blue wavelength light is scattered or reflected off the molecules that make up our atmosphere.



The combination of light absorbed by, transmitted through, and reflected by an object is referred to its spectral signature, and is responsible for the colors that we see. Every object has its own spectral signature, and most of it is invisible to the human eye outside the visible light spectrum. Changes in health conditions that living organisms experience can register as changes in this spectral signature while not having any visible effect.



## MULTISPECTRAL IMAGING AND YOUR FARM

Multispectral imaging relies on capturing multiple specific wavelengths of light, including bands from beyond the visible spectrum. When it comes to remote sensing, we can use multispectral cameras to detect the spectral signatures of different crops and plants, even identifying weeds and other unwanted plants based on these differences. The spectral signature of each individual plant can change depending on many things, including but not limited to the current stage of its growth cycle, the level of water stress it's experiencing, or whether it's suffering a nutrient deficiency.

For example, the green leaves we see absorb light in the red wavelengths and reflect green and near-infrared (NIR) light. Healthy plants can appear greener than unhealthy plants. While the color change might be noticeable, nuanced changes in NIR reflections are invisible to the human eye and can happen before visible color changes in the plants. This is where multispectral sensors come in handy.


The Color We Perceive is the Band that is Reflected

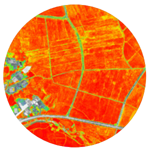
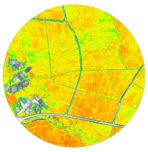
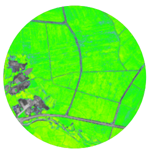
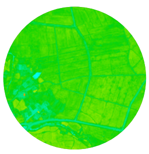
### VEGETATION INDICES

Having quick access to vegetation health data is an indispensable complement to observations in the field, and the results can make or break a harvest. Although an aerial overview alone could help farmers visualize potential problems in their plots, tapping into analyses based on multispectral imagery can be much more helpful in understanding variability in the field throughout different growing seasons.

Vegetation indices (VI) have been around for many decades. They are algorithms that compare the proportions of light captured across different spectral bands of the electromagnetic spectrum. VIs were first conceived of by scientists as a tool to measure reflectance from the earth's surface in satellite images, and farmers have been using them to gain an aerial perspective of their fields. There are many different VIs that are calculated in different ways, each providing different insights into different aspects of your farm.

Today, large numbers of multispectral images can be stitched together to form VI maps where each pixel on the map is assigned values depending on their spectral signature. VI maps can help reveal critical information about plant health, soil conditions, and irrigation.

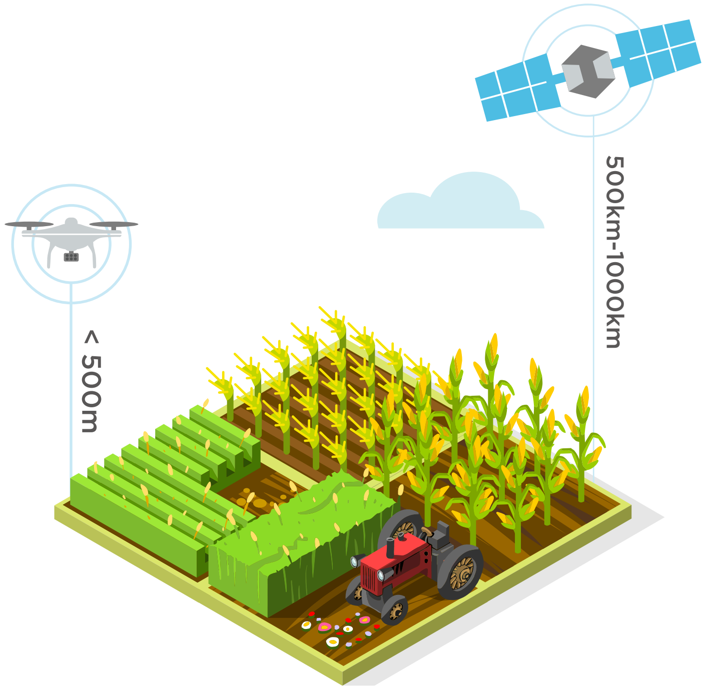
Some common vegetation indices:

| INDEX NAME | FORMULA | WHAT IT TELLS YOU |
|---|---|---|
| Visible Atmospherically Resistant Index (**VARI**)  | $\frac{Green - Red}{Green + Red - Blue}$ | VARI was designed and tested to work with RGB data rather than near-infrared (NIR) data. It is a measure of “how green” an image is. VARI is not intended as a substitute for a NIR camera, but it is meaningful when working with non-NDVI imagery. It was developed on a measurement of corn and soybean crops in the Midwestern United States. |
| Normalized Difference Vegetation Index (**NDVI**)  | $\frac{NIR - Red}{NIR + Red}$ | NDVI is the most commonly-used vegetation index and gives insight into the chlorophyll content of plants. It accounts for variations in soil background brightness and moisture conditions, especially in areas of low vegetation cover, and is also sensitive to atmospheric effects of aerosols. |
| Green Normalized Difference Vegetation Index (**GNDVI**)  | $\frac{NIR - Green}{NIR + Green}$ | This index uses the green wave to calculate chlorophyll content instead of red in NDVI, and has been shown in research to be more stable than the NDVI index. It has almost the same sensitivity and minimizes the influence of green reflection in the picture |
| Optimized Soil Adjusted Vegetation Index (**OSAVI**)  | $\frac{NIR - Red}{NIR + Red + 0.16}$ | This index takes soil condition into consideration, and is a good indicator of chlorophyll content of crops in their early growth stages. |
| Normalized Difference Red Edge Index (**NDRE**)  | $\frac{NIR - RE}{NIR + RE}$ | This index gives insight into chlorophyll content in mid to late season crops. It is sensitive to chlorophyll content in leaves, variability in leaf area, and soil background effects. |

## AERIAL PERSPECTIVES ARE NOT CREATED EQUAL

While traditional agriculture service providers often incorporate satellite-based vegetation health data into the overall assessment, the availability of usable data is completely dependent on the type of professional services that the farm has access to, and favorable weather conditions: clear skies only for the satellite data to be usable. Drones provide a flexible alternative to acquiring multispectral data that is not only of a much higher resolution but is also more consistent across growing seasons.

It's also important to keep in mind the accuracy of your aerial maps, which is often described using Ground Sample Distance, or GSD – the distance between the centers of two consecutive pixels on a map. The smaller the GSD the higher the resolution and accuracy. A commercial satellite can have a GSD of around 30 m/pixel, while a drone can produce a GSD as small as 3 cm/pixel. Read more on GSD in our **guide to choosing the right tools for surveying**.




Commercial satellites that provide imagery for agricultural purposes usually orbit at 500-1000 km, and orbital altitude influences the spatial coverage and resolution of the resulting image. In the context of remote sensing for the field, the higher the satellite is, the lower the image resolution, and the more likely it is affected by variables like weather. A satellite that's far away in orbit will not be able to provide data that helps you pinpoint issues in the field for targeted decisions to be made in time.

Drones, on the other hand, let you decide the resolution of imagery you get as you can control how high to fly the drone. For quick scouting missions, fly higher to cover large amounts of land efficiently; for detailed missions that help determine how much chemicals to apply to a particular area of the field, fly lower to maximize map resolution.

| | SATELLITE-BASED | DRONE-BASED |
|---|---|---|
| Image Resolution and Data Quality | 3-5 m, shows you that there are issues in the field. Could be affected by weather, and data could be unusable if there are heavy clouds. | 3-5 cm at a flight altitude of <100 m, with a GSD of around 5 cm, shows you exactly where the issue is and what the nature of the issue might be. Get consistent data adjusted for sunlight levels every time you fly. |
| Accessibility | Whenever the weather permits, usually comes with a subscription to an agronomy or precision agriculture service. Also an option - use free satellite images from sources like **USGS EarthExplorer**, input into software programs like ArcGis to view vegetation index maps. | Data on-demand - once you learn how to operate and render the types of maps you need, you have full access. |
| Frequency | Regular access to satellite images, monthly or quarterly paperwork, depending on the type of service subscription. | Set up routine flights that can be repeated daily/ weekly, or as frequently as you need. |
| Cost | $1.5 -$10 (US) per acre, or around $1200 per year depending on the agronomy service provider and the subscription plan. | A one-time investment in a multispectral imaging drone + a subscription to a software solution. |

**A Typical Drone-Powered Workflow**

1. Identify the area that you want to map
2. Create a flight plan
3. Fly and capture data
4. Create RGB and VI maps
5. Identify areas of concern and apply chemicals or other treatments accordingly
6. Repeat as you need

## IMPORTANT THINGS TO CONSIDER BEFORE BUYING YOUR FIRST MULTISPECTRAL DRONE

If you've made it this far into the eBook, you might be eager to get a multispectral drone to start optimizing inputs and improving your crop yields today. Here are some things that you need to think about when choosing your new tool:

### HARDWARE: THE SENSOR ITSELF

1. **Image resolution and mapping efficiency.** A high-resolution sensor can cover a large farm in a few short flight missions.

2. **Spectral bands for VI maps.** Choose a sensor that captures data from the spectral bands that you need to create VI maps most relevant to your crops.

3. **Data consistency.** You will likely be flying your drone to cover the same area on different days in different lighting conditions. To ensure that the data you capture is consistent regardless of cloud cover or time of the day so that you can make meaningful comparisons, it is important to have an additional sensor that accounts for sunlight.

### SOFTWARE: HOW YOU PROCESS AND ACCESS THE DATA

1. **Crop type and VI maps.** Different vegetation indices might reveal different things about different crops, it is up to you to choose the most appropriate VI map to examine during a particular growing season. This is why choosing a software program that gives you options to create a variety of maps will be ideal.

2. **Compatibility with other smart farming software.** Some software options can integrate drone maps and plant health data with farming equipment apps so you can execute treatments based on insights from drones.

### EASE OF USE

Though there are many multispectral sensors in the market designed for drones, many of them aren't "plug-and-play" as they require more work than a "ready-out-of-the-box" drone to be fully integrated into your existing workflows.

i. Multispectral sensors and integration kits for drones: **Sentera, Slantrange, MicaSense**

ii. All-in-one multispectral drone: **DJI P4 Multispectral.**

## DON'T WORK ANOTHER DAY WITHOUT AERIAL INSIGHTS

Drones are a logical addition to a farmer's toolkit and will soon become a standard piece of farm equipment. The value of informed planning and data-driven decision making cannot be overstated. Drones for your farm are easier than ever to use, have immediate utility, and allow you to operate with precision and certainty.

We hope this ebook has helped you understand the benefits of multispectral imaging for your farm.

To learn more about the roles a drone plays on the farm, read **Could a Drone Help Your Farm?**

For more information on choosing a drone for your farm, read our guide: **Choose the Right Ag Solution**.

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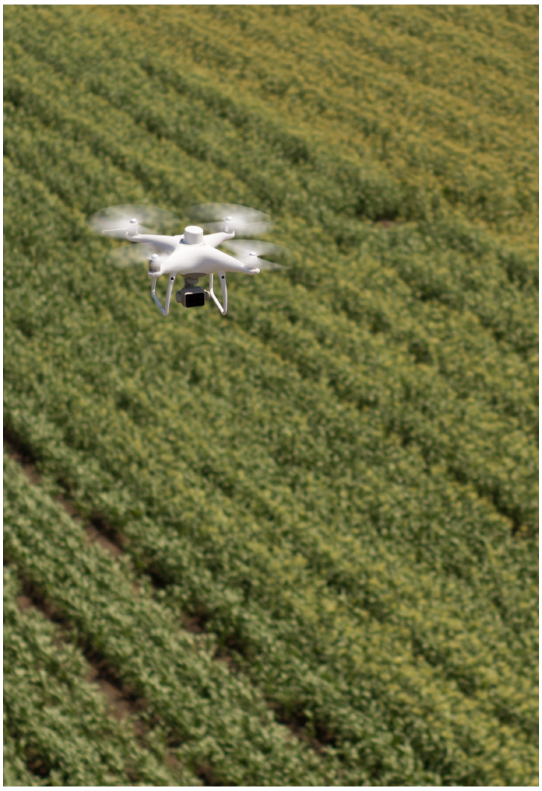


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