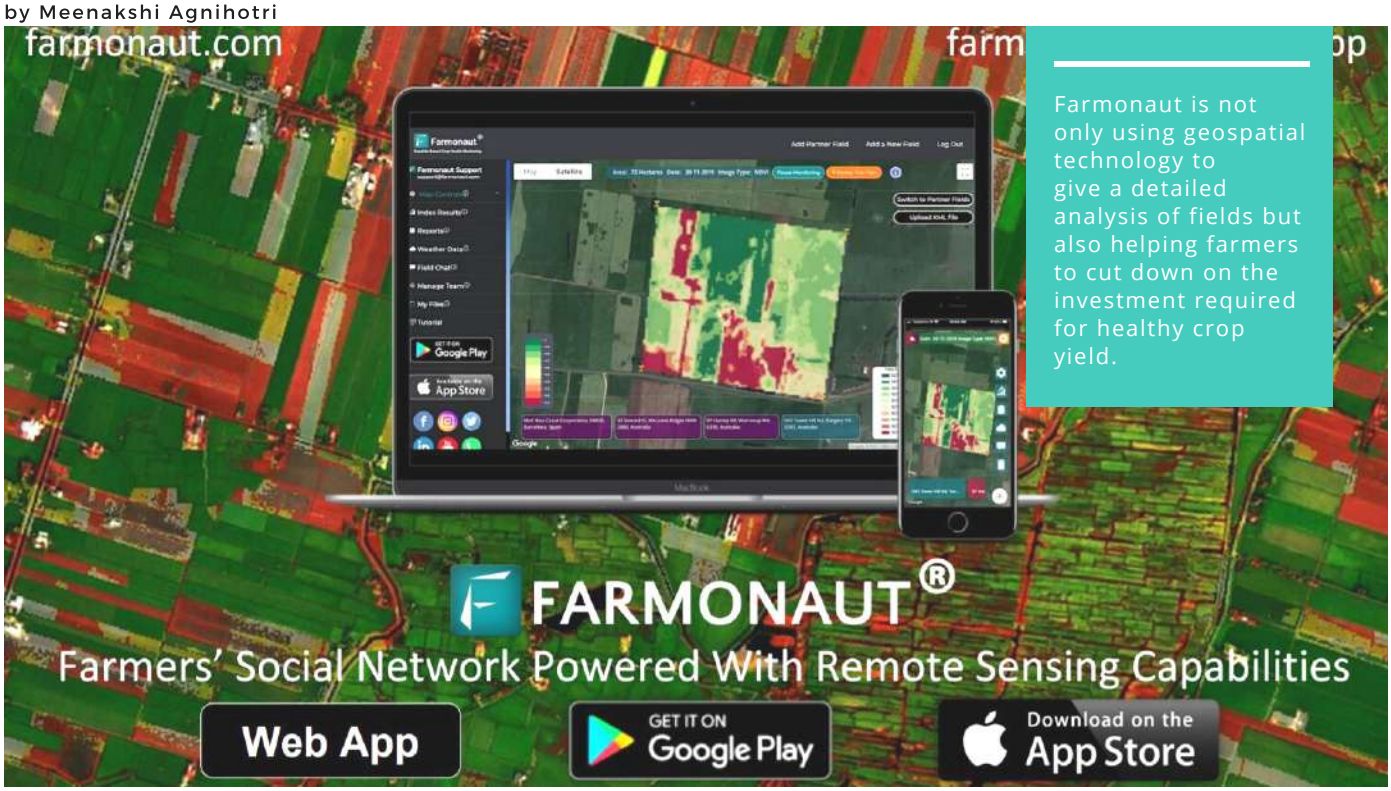
FARMONAUT®: GEOSPATIAL TECHNOLOGY FROM DATA TO INFORMATION

The biggest challenge in the Indian agriculture industry is the unawareness and inability to understand the complex technical concepts involved in the analysis. Farmonaut is bridging that very gap of unawareness by providing the farmers with a simpler solution.

by Meenakshi Agnihotri



Farmonaut is not only using geospatial technology to give a detailed analysis of fields but also helping farmers to cut down on the investment required for healthy crop yield.

With the digital revolution in India, there have been numerous technological advancements in the agriculture domain. Tech-savvies have taken up the responsibility to reform the most neglected field by providing our farmers with the most viable solutions. Geospatial technology is an evolving field that includes Geographic Information System (GIS), Remote sensing (RS), and Global positioning system (GPS). Geospatial technology is the need of the hour to ensure exponential growth in the agriculture domain. Farmonaut's Satellite Based Crop Health Monitoring System is built to put satellite technology in the hands of each and every farmer in the most economical way. Farmonaut's main objective is to break the cost barrier and help democratize remote sensing in the farming community by providing an on-the-go always ready platform for field monitoring through satellites. The system is accessible through our web, android as well as iOS apps.

About Author

Meenakshi Agnihotri

Email: *meenakshi.agnihotri22@gmail.com*

Farmonaut enables farmers to monitor their fields remotely through satellites by providing them with a detailed analysis of crop health, vegetation water stress, and soil organic carbon content.

Farmonaut is addressing one of the biggest challenges in the Indian agricultural ecosystem. Remote sensing is a widely used technology to monitor fields across the world, but in India, it couldn't be as popular due to the cost attached to it. Farmonaut has come up with the most cost-effective solution to the issue by helping farmers to identify crop-related issues without compromising on the quality and the depth of the data. Now even for a small farmer (field area less than 5 acre), the cost of 1 month of satellite monitoring is less than what 1 bottle of fertilizer/ chemical costs.

Available in 50+ languages, it is extending features like a social network of more than 10000 farmers, voice text-based plant issue identification, and Government approved farming database as well.

Importance of Remote Sensing in Agriculture (Precision Farming)

The entire agriculture industry has reformed with the incorporation of geospatial technology and the ability of systems converting data into useful information to increase yield.

Decades of research has proven that remote sensing can improve a farmer's productivity tremendously. By observing field changes through specialized sensors from space can reveal field information that is not perceivable through human eye and can help them take preventive actions and manage field related jobs in a much easier way. The easiest way to understand precision agriculture is to think of it as everything that makes the practice of farming more accurate and more defined when it comes to the growing of crops. One of the key components of this farm management approach is the use of information technology and a wide array of items such as GPS guidance, sensors, variable rate technology, GPS-based soil sampling and most importantly a software component to help unify all these components.

It can help us determine everything from what factors may be stressing a crop at a specific point to estimating the amount of moisture in the soil. This kind of data enriches decision-making on the farm.

Farmonaut is not only using geospatial technology to give a detailed analysis of fields but also helping farmers to cut down on the investment required for healthy crop yield. An Indian farmer, on an average, spends between Rs. 41500 (550 USD) to Rs. 332000 (4300 USD) annually on each hectare of arable land. By using highly processed remote sensing results on Farmonaut, a farmer can save approximately 30% of the expense on chemicals, insecticides, pesticides, plant growth regulators, etc.

Data to Information

Some of the concepts most commonly used for the high-level analysis by Farmonaut are NDVI, NDRE, EVI, VARI, SOC and NDWI.

Using the analysis of satellite data provided by Farmonaut in the form of comprehensible information, farmers can -

1. Reduce Chemical/Fertilizer consumption by applying it only at the locations where crop health is not good.
2. Reduce Labour costs by directing the labors only in those field areas where crop health is critical.
3. Reduce irrigation water wastage by applying proper irrigation only in those locations where plant water stress is low.
4. Increase the overall yield.
5. Maintain good nutrient composition post-harvest by getting the soil testing done on the locations where Farmonaut's SOC model has identified the level of soil organic carbon to below.

It can not only reduce and end the use of chemicals on the field but also increase the overall crop yield. It further prevents the deterioration of soil nutrient composition which might happen due to the prolonged usage of chemicals on the land.

Apart from the indices, Farmonaut also provides true color RGB images of the field.

TCI: TCI stands for True color Image. It is basically a raw image of the field captured by the satellite of a particular location completely unaltered. This is not an index image, but a RGB representation of how the field looked like in human perceivable colors upon its last visit.

ETCI: ETCI stands for Enhanced True Color Image. It is basically a TCI image processed by our own systems to enhance the land features which were not so explicitly visible in the raw TCI Image.

Normalized Difference Vegetation Index (NDVI)

NDVI stands for Normalized Difference Vegetation Index and is used as a measure to identify the state of plant health based on the light reflected by the plant at certain frequencies. Though we cannot perceive it with our eyes, everything around us (including plants) reflect wavelengths of light in visible and non-visible spectrum. Taking into account how much amount of a certain wavelength is reflected, we can access the current status of plants.

Case#1: The cotton farm displayed below belongs to one of our Israel based agricultural consultant. This farmland is spread across an area of approximately 15 hectares. The image displayed below is of NDVI index. The recorded satellite data is of 7-Sep-2020. As it is visible from the image, the field is mature and ready for defoliation. Defoliation at the right time helps farmers in maximizing their yield.

Case#2: The field image attached below is of the farmer Harikrushn from Surendranagar, Gujarat (Field Area: 6 Hectares). The image displayed on the map is NDVI captured by the satellite on 15 Feb 2020. In the posted image, as we can see, the top left portion of the field is completely barren, whereas the remaining field is in the yellowish green or green region. This indicates that the crop health of the farmer's field is pretty well. To cross-verify these results farmers can simply open GPS on their smartphones and can navigate through the field using this image.

Normalized Difference Red Edge (NDRE)

Normalized Difference Red Edge (NDRE) is a spectral index that helps in gathering the data at the later stages of a crop when chlorophyll content is relatively higher in the crop.

Case#1: The field displayed in the image below is of NDRE used for crop assessment in the stage of later growth from one of Farmonaut's exclusive farming hubs situated in Saharsa, Bihar. The colormap shows good conditions in the majority of the field. According to the information accessed in the image, the crop would be ready for harvesting in the coming weeks. After harvesting, Soil organic carbon (SOC) content of the bare land is captured to identify locations where SOC content might have gone down. Once locations with low SOC content are identified, a priority soil testing can be done to prepare the field further.

Case#2: The field image attached is of the farmer Paulo o (Ponta Pora - State of Mato Grosso do Sul, 79900-000, Brazil), (Field Area: 47 Hectares). The image displayed on the map is NDRE captured by the satellite. NDVI index is not ideal for the crops in their later stage of growth because in grasses, cereal crops, permanent crops and in certain row crops which are in their later growth stages, chlorophyll content reaches a point at which NDVI reaches a maximum value of 1.0 and hence saturates. Hence, any crop health issue is hard to detect with NDVI until any such problem becomes strong enough to reduce the NDVI value below 1.0. This may happen at a point at which damage has already occurred. By substituting NDVI's red band with NDRE's red edge band we can mitigate this issue of saturation discussed above. So, in conclusion, if the crops of observation are permanent or dense, you should use NDRE right away.

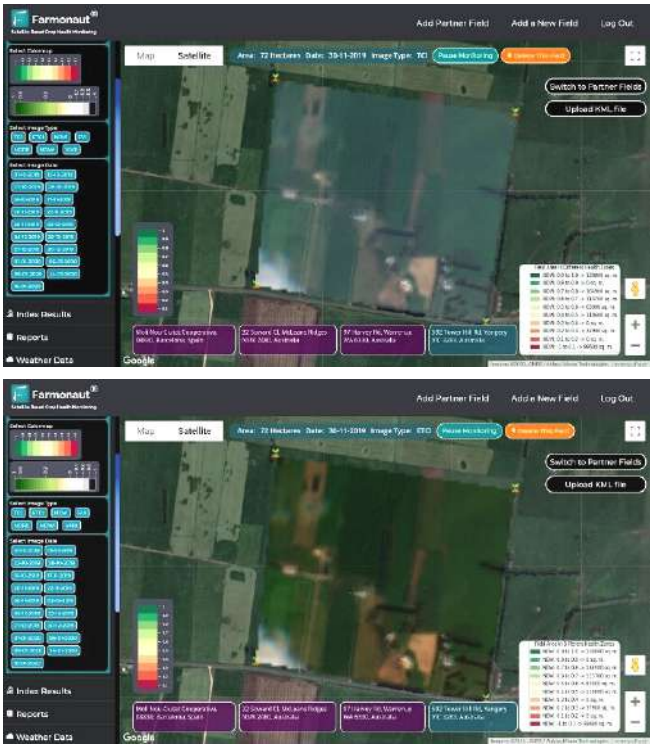


Figure 1 (top) and Figure 2 (bottom): True color image (TCI) and Enchanced true color image (ETCI)

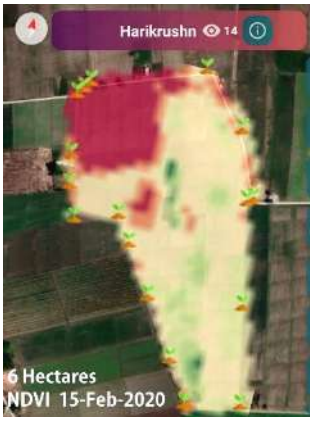


Figure 3 (left) and Figure 4 (right): NDVI values in Case#1 and Case#2 respectively.

Figure 5: NDRE values in Case#2.

Enhanced Vegetation Index (EVI)

EVI is further an optimized index designed to enhance the vegetation signal with improved sensitivity in high biomass regions and improved vegetation monitoring through a decoupling of the canopy background signal and a reduction in

atmosphere influences.

Case#1: These are a few fields added to Farmonaut for satellite monitoring by one of the users from Argentina. Both of these fields (96 Ha and 27 Ha) have maize and are in the early stage of growth. The images are of the EVI index. This is a side-by-side comparison of crop growth. The data is captured in the difference of 10 days by the satellites from 4th August 2020 to 14th August 2020. The data reveals that the crop is growing fine at the majority of the locations. At some locations wherever the EVI index is low, a field visit should be conducted on priority. Cropping needs to be performed again in case the crop has failed to grow at those locations. By having this piece of information, farmers can maximize their yield in the most effective way.

Case#2: The field displayed is of Prashant Amitbhai Hirapra and is approximately of area 4 hectares in Dhoraji taluka and district Rajkot, Gujarat. He has been monitoring blackgram and cotton in the farm. The displayed image is of EVI (Enhanced Vegetation Index). The top portion of the field is used for cotton whereas the bottom portion of the field is used for black gram. As is visible from the image above, the blackgram patch reached its maturity somewhere around 19-June-2020 and was harvested after that. Similarly, we can see that the cotton portion is still growing and is in a healthy state as per the data of 24-July-2020.

Watch video Testimonial:
https://www.youtube.com/watch?v=PJIMuDgZsDg

Case#3: The field displayed is of Ashish Vaishnav and is approximately of area 5 hectares in Dhoraji taluka and district Rajkot, Gujarat. He has been using Farmonaut app since last 2 months and has been monitoring groundnut in the farm. The displayed image is of EVI. The field transformation is visible through June to July which displays that the crop has reached the optimum maturity to be harvested. By having the crop maturity data, farmers can decide precisely when to harvest which region

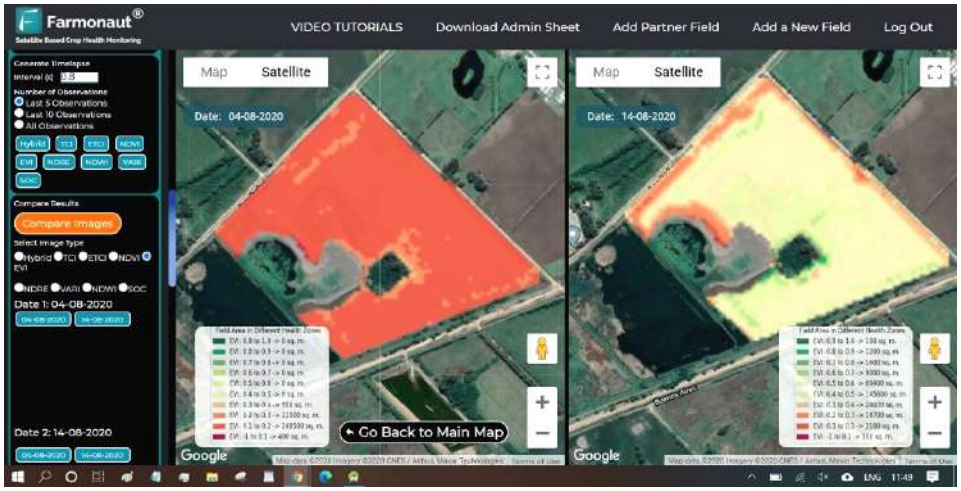


Figure 6: EVI of Case#1 - field added to Farmonaut for satellite monitoring by one of the users from Argentina.

of their field so as to get the maximum yield.

Watch video Testimonial:
https://www.youtube.com/watch?v=fdV20_WLJXA

Normalized Difference Water Index (NDWI)

NDWI stands for Normalized Difference Water Index. NDWI index can help us control irrigation, significantly improving agriculture, especially in areas where meeting the need for water is difficult. The high NDWI values correspond to high plant water content and coating of high plant fraction, whereas the low NDWI values correspond to low vegetation content and cover with low vegetation. NDWI rate will decrease during periods of water stress.

Hence, through NDWI, the early detection of water stress can prevent many of the negative impacts on crops

Case#1: The field image attached is of the farmer Gullapalli Sujatha (Viswamatha farms, Andhra Pradesh, one of the pioneers in Natural Farming in India), (Field Area: 26 Hectares). The image displayed on the map is NDWI (Normalized Difference Water Index) captured by the satellite.

In the posted image, as we can see, the top portion of the field shows pretty good water stress in the vegetation, whereas the remaining field is in the yellowish or red region. This indicates that the farmer needs to pay attention to irrigation in these highlighted regions. To cross-verify these results farmers can simply open GPS on their smartphones and can navigate through the field using this image.

Visible Atmospherically Resistant Index (VARI)

VARI stands for Visible Atmospherically Resistant Index. VARI is minimally resistant to atmospheric effects, allowing vegetation to be estimated in a wide variety of environment. Hence, it is ideally recommended to be used for farm level decision making if TCI and ETCI images show visible atmospheric distortion such as mild clouds or haze above the field.

Case#1: The field image attached is of the farmer Tafuma Fundira (Masvingo,

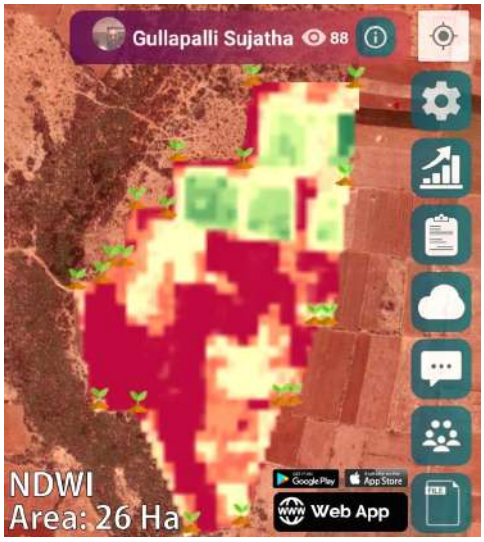


Figure 7: NDWI values in Case#1.

Zimbabwe), (Field Area: 2 Hectares). In the posted image, as we can see, the ETCI image seems to be distorted due to haze and clouds. In such cases vegetation indices like NDVI will not give correct observations. Thus, VARI is used in such cases. As we can see through the VARI image, a majority of the field is growing pretty well, with some barren regions shown in red. To cross-verify these results farmers can simply open GPS on their smartphones and can navigate through the field using this image.

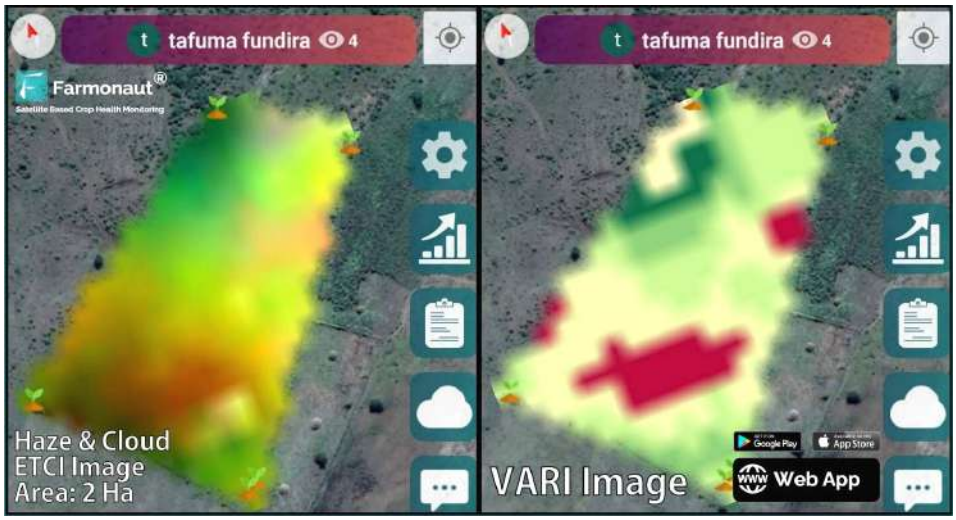


Figure 8: The image displayed on the map is ETCI (Enhanced True Color Image) on the left and VARI (Visible Atmospherically Resistant Index) image on the right.

HYBRID

All the examples cited above are supporting the fact that with the help of technology, data is processed to generate useful information for farmers. The biggest challenge in the Indian agriculture industry is the unawareness and inability to understand the complex technical concepts involved in the analysis. Farmonaut is bridging that very gap of unawareness by providing the farmers with a simpler solution. The field displayed below is entered by one of the farmers from Rattanpura, Rajasthan having cotton, guar, and moong currently under cultivation. The information in the image can be interpreted as follows:

1. (Green) Locations with good crop health and water stress
2. (Orange) Locations with bad crop health
3. (Purple) Locations with bad water stress
4. (White) Locations affected by clouds

Soil Organic Carbon (SOC)

Soil organic carbon is a measurable component of the soil organic matter that indicates the better health and yield of any land once the cultivation process ends. Remote sensing technology plays a vital role in enabling farmers to ensure high SOC content by taking the right measures at the right time and the right place. Farmonaut creates a SOC image with a color map of the percentage of organic matter present in the selected field. The monitored land appears green in the color map if the SOC content is more than 5% and red if the SOC content is less than 1%. Once the locations with lesser SOC levels are identified by Farmonaut, farmers can get the soil testing done on specific regions, and the required nutrients added to the identified land.

Prominent Long-term Example

Some of the prominent players in the agriculture industry have benefitted from the detailed analysis of satellite images provided by Farmonaut.

Viswamatha Farms: Viswamatha Farms are one of the popular names when it comes to natural farming. They had received SAKSHI EXCELLENCE AWARD in FARMING in 2017 for their contributions to natural farming. They majorly cultivate pulses, spices, groundnut, vegetables, and fruits in 26 ha land. Viswamatha Farms has been using Farmonaut's Satellite-Based Crop Health Monitoring System since September 2019.

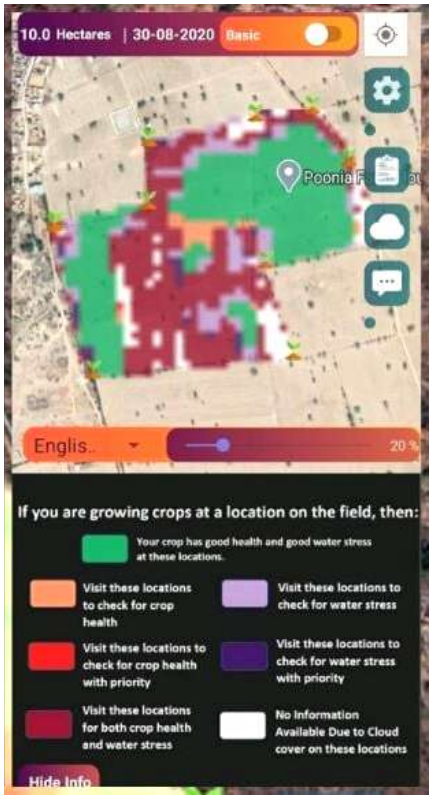


Figure 9: HYBRID - the complete information is collated to represent in a single image.

The farm is a healthy mix of agriculture, horticulture, floriculture and animal husbandary. Apart from their own farms, viswamatha farms has created natural farming farmers group to cater to the

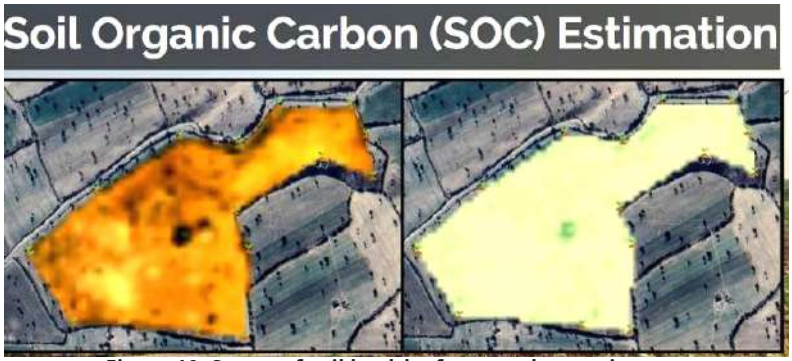


Figure 10: Status of soil health after crop harvesting.

requirement of quality products. Viswamatha farms enrich the soil nutrients by using Jeevamruth which is a fermented microbial culture. It provides nutrients but most importantly acts as catalytic agent that promotes the activities of micro-organism in the soil as well as increases earth worm's activity. During 48 hours of fermentation process the aerobic and anaerobic bacteria present in the cow dung and cow urine multiply as they eat up organic ingradient (pulse flour mixed in the jeevamruth) in the Jeevamruth. A handful of undisturbed soil from the field bunds also added to Jeevamruth as inoculate of native spices of microbes and organism.

Jeevamruth also helps to prevent fungal and bacterial plant diseases.

Insects and pests are managed by using specially prepared mixtures called as neemastram, agniastram, brahastram, dasaparni kashayam. These mixtures involve cow dung, cow urine, Neem leaves, Neem pulp, green chillies and other herbs as required to manage the pests and diseases. Remote sensing in combination with natural farming can do wonders for the agriculture sector. Below are a few examples of the same over the last one year of Farmonaut's working with Viswamatha Farms.

Several Other progressive farms such as Rahua Farm, Mill services, I Support Farming, Organic Foods Market, Agro Drone (Israel) are using the satellite data provided by Farmonaut. Rahua Farms is an agricultural company providing services for agricultural equipment used in sowing. It is currently monitoring more than 760+ hectares of land through Farmonaut.

Conclusion

Agriculture is one of the biggest and most important markets in India. 21% of the total Indian population that is, approximately 200 million lives are dependent on this occupation. To ease the hardships of farmers and enable them to withdraw the maximum benefit out of this domain, Farmonaut is all prepared to experiment further with the different aspects of Geospatial technology and come up with better solutions for the farming community.

With the upcoming advancements, apps like Farmonaut are certainly going to empower the farmers not just in India but across the world.

Figure 11 (left) and Figure 12 (right): (Left) Viswamatha Farms harvested their major crop Red Gram in the month of February, 2020. The image is of the red gram plants in the Viswamatha farms nearly after one month of harvesting. (Right) The image is of the farm nearby to Viswamatha farms which was using the contemporary methods of farming (not natural farming) and also harvested red gram from their field at the same.

Figure 12: The cultivation of the turmeric crop over an area of 1 acre recorded a return of 300 % in the last season.

Figure 13: Due to natural farming and PA (precision agriculture) tools, the crop is healthy with no diseases. Viswanatha Farms is one of the most progressive natural farms in South India.