RATING ACADEMY

JOURNAL OF SCIENTIFIC PERSPECTIVES JSP

Journal of Scientific Perspectives

Volume **4,** Issue **2,** Year **2020**, pp. **123-136**
E - ISSN: **2587-3008**
URL: https://ratingacademy.com.tr/ojs/index.php/jsp
DOİ: https://doi.org/10.26900/jsp.4.010
Research Article

SMART FARMING- PRECISION AGRICULTURE TECHNOLOGIES AND PRACTICES [1]

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Received: 14 January 2020, Accepted: 17 April 2020

ABSTRACT

According to the current increase rate of the world population it is expected to reach 10 billion people in 2050. In addition, agricultural production area and agricultural labor force is constantly decreasing with the migration of rural population to the city with the use of agricultural areas for residential and industrial purposes. Therefore, it is a necessity to develop and disseminate systematic and efficient production techniques that will provide sufficient nutrition for humanity.

The agricultural sector also benefits greatly from what Industry 4.0 brings. IoT (Internet of Things), AI (Artificial Intelligence), Remote Sensing & ImP (Remote Sensing and Image Processing) techniques have been integrated with GIS (Geographic Information Systems) and have been actively used in agriculture in recent years. In addition to the soil characteristic and meteorological data collected by sensors, high resolution multi-band images taken from satellite systems and unmanned aerial vehicles are transferred to decision support platforms and artificial intelligence support can be used to determine the stress factors of crops and propose instant solution alternatives.

Within the scope of this paper, in a study carried out by HEKTAŞ R & D Center which develops innovation projects in the agricultural sector with the motto of "Pioneer of smart agriculture" general information will be given on the practical use of some of the above mentioned precision agricultural techniques during phenological growth stages of the wheat in Thrace region.

Keywords: *Precision Agriculture, IoT, Spectral analysis, UAV, Artificial Intelligence, Remote sensing*

[1] This study is the revised form of the manuscript, presented at "3rd International Conference on Awareness" on 5 - 7 December 2019, Çanakkale / TURKEY

1. INTRODUCTION

Hektaş is a Turkish company which is provider of fertilizer, seed and crop protection products for agriculture sector since 1956 and is a subsidary company of OYAK group. "The doctor of agriculture" slogan which is used by Hektaş along years has turned to "pioneer of smart agriculture" motto by innovative investment. Within this scope, projects were developed in the R & D Center established within the framework of the vision of taking part in all areas that create added value to the agricultural sector.

The aim of this study is to determine the factors that cause stress on plant growth at early stage and to provide optimal solution through the geographic information system based decision support platform that established within the scope of precision agricultural practices project. There is a necessity to create a spectral library of crops for Turkey's natural planting conditions. It can be done on selected cultivated area by remote sensing and image processing techniques using drones which are equipped with spectral cameras. At Hektaş Research and Development Center, data is collected and analyzed by aforementioned techniques. This library could be reference for further research and practices.

Precision agriculture techniques that allow effective timing and optimized application of inputs have the ability to protect crop health, protect soil and environment, improve efficiency, life quality and sustainability.

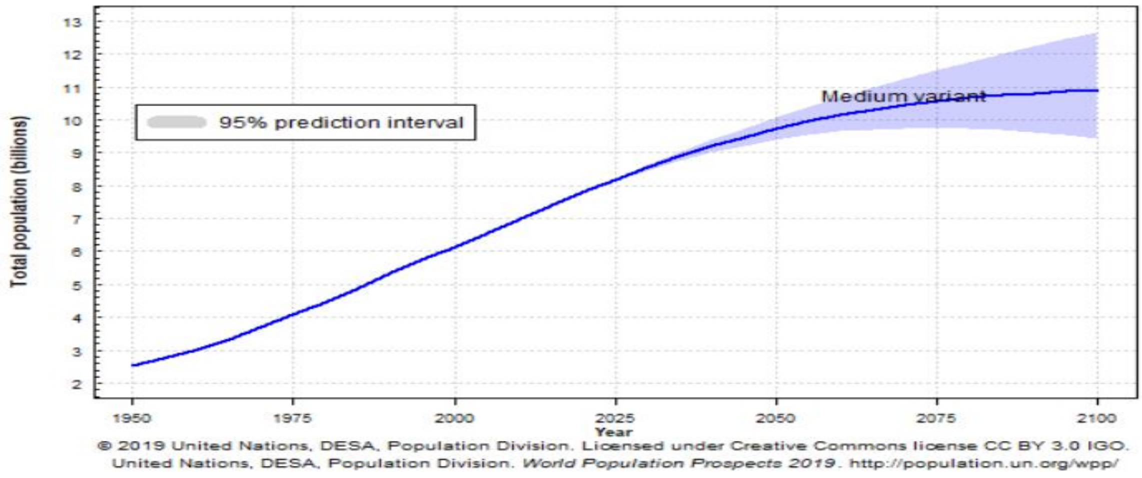
Due to the increasing population and problems to feed them, wheat has been the subject of research as a strategic product. Turkey and world wheat production figures will be mentioned below.

2. WORLD POPULATION AND NUTRITION PROBLEMS

The Food and Agriculture Organization of the United Nations (FAO), World Health Organization (WHO) draws attention to the current situation in its studies and publications and makes predictions about the problems that await us in the future.

Indicators shows that by 2050, we do not have the agricultural production infrastructure to feed the population of 10 billion people worldwide. According to the United Nations Food Safety and Nutrition Report 2019, more than 820 million people are currently under threat of hunger, while 670 million adults and 120 million children are fighting obesity. Along with this unbalanced distribution, it is known that approximately one third of the food is lost or wasted due to various reasons from the beginning of production to consumption.

Graph 1. World population projection



Due to climate change, water resources that are potable and suitable for agriculture are reducing, while natural disasters also increase losses in arable areas.

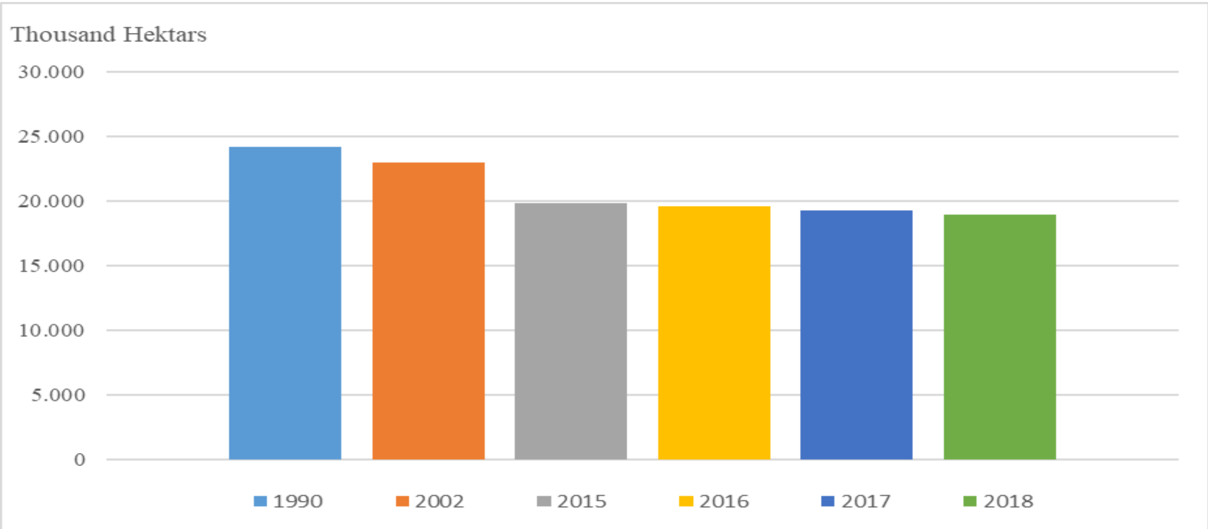
Desertification has become one of the most important environmental problems of today with the impact of climate change, unsustainable fresh water use and land management, which consume resources significantly. 4 billion hectares, which constitute 25% of terrestrial land in the world, directly affect the lives of 1.5 billion people in 193 countries. Every year 12 million hectares of agricultural land is degraded. Agricultural production is expected to decrease by 2% in the next decade. Observations over the past five years show that on average 5.2 million hectares of forest land is decreasing each year. The effect of erosion on the decrease of land productivity in Turkey still stands out as the foremost problem. 59% of agricultural land, 64% of pasture, 54% of forest land are exposed to erosion. Non-agricultural uses (industrial, urbanization, tourism, mining and transportation for public investment) are among the causes of land destruction as well as erosion.

Table 1. Agricultural Land in Turkey

Agricultural land (Thousand hektars)	**1990**	**2002**	**2015**	**2016**	**2017**	**2018**
Sown area of cereal and other crops	18.868	17.935	15.723	15.575	15.498	15.421
Fallow land	5.324	5.040	4.114	3.998	3.697	3.513
Area of vegetable gardens	635	930	808	804	798	784
Area of fruits, beverage and spice crops	3.019	2.674	3.284	3.329	3.343	3.462
Area of ornamental plants	0	0	5	5	5	5
Total utilized agricultural land	**27.846**	**26.579**	**23.934**	**23.711**	**23.341**	**23.185**

Source: Turkish Statistical Institute

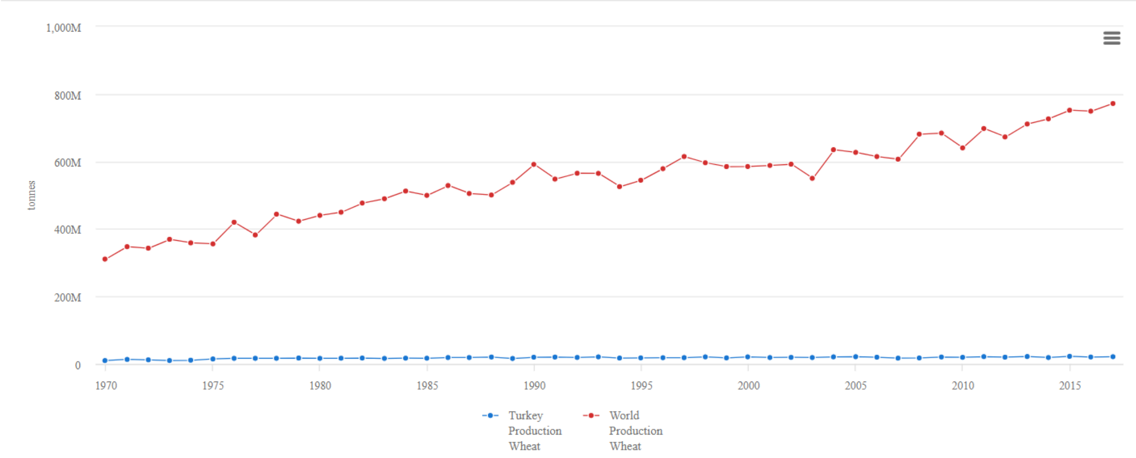
Graph 2. Agricultural Land (cereal&other crops and fallow land) in Turkey by years



Source: Turkish Statistical Institute

The total of sown and fallow area for crop production has decreased by 21.6% in the last 28 years.

Graph 3. Wheat Production of Turkey and World (1970-2017)



Source: Food and Agriculture Organization of United Nation

3. THE FOURTH INDUSTRY REVOLUTION; DIGITALIZATION PROCESS: FROM INDUSTRY 4.0 TO AGRICULTURE 4.0

What do we understand when it comes to industry 4.0?

Mechanical production systems that use water and steam power to assist workers in large-scale manufacturing of products since the late 18th century are called industry 1.0. Industry 1.0 can be considered the beginning of a business culture that focuses on efficiency, quality and scale.

In the early 20th century, electricity was widely used in mass production and adopted as Industry 2.0.

The widespread use of computers and the use of information technologies, electronics and automation systems in 1970 and later are expressed as Industry 3.0.

The concept of Industry 4.0, which covers the concept of "Internet of Things", was used for the first time in 2011 in Hannover Fair. Basically Industry 4.0 Cyber-Physical Systems (a combination of physical and virtual worlds) is based on the Internet of Things and the Internet of Services. Industry 4.0 includes intelligent robots, fully autonomous systems, driverless cars, driverless trucks, captainless ships, pilotless planes, virtual reality, etc. It is the name given to the total digital transformation covering many areas.

Industry 4.0 defines the Fourth Industrial Revolution, a new level in the organization and management of the entire value chain in the life cycle of products and production systems. This cycle focuses on personalized customer demands and includes the entire chain in the product development and production order, from the idea stage to the distribution and recycling of a product to the end user. The effects of Industry 4.0 on the business world are presented in three main areas. These are the integration and digitization of vertical and horizontal value chains, digitalization of products and services, and the creation of a digital business model and customer relationships (Guban & Kovacs, 2017: 113).

The application of developing technology in agriculture was not delayed. The data obtained from the sensors can be analyzed with artificial intelligence and deep learning methods, and crop protection and nutrition programs can be made. Suggestions made with decision support platforms have started to be adopted by the farmer. Pesticides, herbicides, fertilizers and water can be applied autonomously by the smart agricultural machine or drones only to the area where the stressed plant is located instead of the whole area.

Agriculture 4.0; Data collection methods have been developed with remote sensing, image processing, GPS technology, IoT technologies with sensors. These smart devices and robotic systems and precision agriculture make farms more profitable, productive, safe and environmentally friendly.

4. SMART AGRICULTURE TECHNOLOGIES

Factors that cannot be controlled by the impact of climate change increase the loss of on-farm food in agricultural production. Common causes of losses include restrictions on the use of resources in production practices, improper harvesting techniques, and post-harvest handling and storage. Traditional production methods of farmer cannot provide professional monitoring of plant growth.

Regarding the future of agriculture, a number of adjustment measures should be taken regarding agricultural practices such as sowing, harvesting and irrigation, fertilization of existing plants, seed selection, use of different varieties, diversification of crops and innovative management practices. In digital monitoring methods data collected from channels such as satellite images, ground-based optical sensors, aerial imagery are stored systematically and location-based. The interrelation of the data can be analyzed using various algorithms and ready-to-use information can be transmitted by mobile phones within seconds. Digital technologies that entered our lives with Industry 4.0 serve as intermediaries that provide data to decision support platforms.

The Internet of Things (IoT): It is an internet-based network system where smart devices that communicate with each other by sensors can activate some operations using this information. IoT is quickly accepted in many industries when combined with other technologies due to its real-time, highly sensitive digital information flow and its benefits in process and service management. It is considered that 20 billion devices in many areas such as smart houses, cities, energy systems, communication, logistics, agriculture, health, industry are connected with IoT technology. It is thought to be combined with blockchain technology against security problems.

GIS (Geographical Information Systems) : GIS is described as systems of data that managed based on locations. With GIS that which includes location-based data collection, management and analysis; lots of data could related easily and provide a more in-depth perspective and insights by maps that visualized data.

Artificial intelligence (AI): Artificial intelligence has many definitions, it basically defines a simulation system designed by human and mimicking mind actions. It consists of teaching the system with various algorithms, providing a kind of reasoning ability and increasing the reliability of the output by using the comparison data by continuously feeding the system with an integrated approach. Although the limits of human intelligence are unknown, it needs machine support in multiple, complex and large amount of data processing, and it can use the technology and information system for its purposes. With these systems, decision making mechanism is developed and accelerated.

Hektaş Smart Assistant (AA) mobile application uses artificial intelligence technology to diagnose plant disease by photograph and offer suggestions related to the disease in seconds. AA aplication is the winner of Growtech Agricultural Innovation Awards in the category of

"Agricultural Informatics" in Growtech Eurasia 2019 - 19th International Greenhouse, Agricultural Technologies and Livestock Equipment Fair.

Remote sensing is expressed as the science and art of learning and analyzing information about the earth and its objects, measured by instruments placed on any platform, at a certain distance, in the atmosphere or on the satellite, without physical contact. It is technically the process of detecting and monitoring the physical properties of regions such as cities, forests, agricultural areas by measuring the reflected and emitted radiation with sensors on planes, satellites and drones.

Image processing is a method of performing some operations on the image to combine many images with the help of appropriate software, make them meaningful and to reach appropriate information. The processed image results can be expressed visually, numerically and graphically after corrections.

5. RESEARCH METHODS AND MATERIALS

5.1. Methodology

Widespread wheat varieties produced in Thrace region, were monitored by remote sensing in approximately 500 hectares in 3 different regions from planting to harvest during the stages of growth and development. The captured images were processed, image analyzes were performed and classified.

5.2. Materials and other requirements

- Unmanned Aerial vehicles; DJI, 2 units (UAV 0 and UAV 1) within the framework of the regulations and permits of the General Directorate of Civil Aviation, are used with the appropriate pilot license.
- Cameras and devices; 4 cameras (multispectral, thermal) and spectroradiometers were used.
- Geographic Information System based decision support platform and various specific software

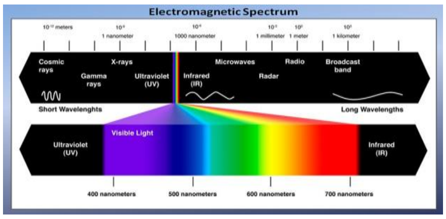
5.3. Remote sensing and image processing

It is possible to obtain information about the development and health of plants by looking at the reflection values at various wavelengths. Images are captured under optimum sunlight condition and flight level using a UAV equipped with a spectral camera.

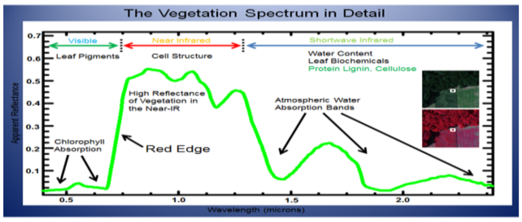
One of the aims of this research is to determine the unhealthy plant area using spectral images obtained from drones and provide detailed information about the health of the crop, the area covered by the stressed crop and its geographical location.

In this study, a combination of spectral vegetation index techniques was used to produce a comprehensive solution for precision agriculture using image processing.

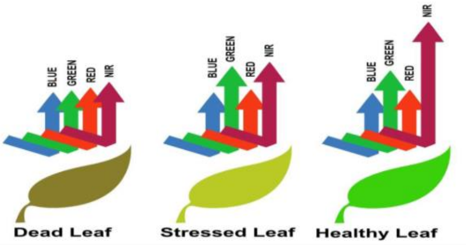
Figure 1. Spectral analysis fundamentals for agriculture



The Electromagnetic Spectrum. Source: Zami, Zuly.



Details of an example vegetation spectral signature. Source: Mark Elowitz



Source: https://agribotix.com/wp-content/uploads/2016/04/WhatFarmersNeedToKnow_web.pdf

5.3.1. Remote Sensing and Image processing applications in precision agriculture

- Hydrological Evaluations
- Image interpretation: variety identification
- Image interpretation: plant stress detection
- Image interpretation: weed detection
- Determination of yield

5.3.2. Measurable benefits of remote sensing / image processing applications in agriculture

- Provide information to make better management decision
- Reduce chemical and fertilizer costs through more efficient application
- Improve crop yield and profit margine
- Preserve natural resources, reduce pollution
- Food Safety

5.3.3. Commercial use opportunities

- Agricultural products with high economic and strategic value for the country and products with large chronic yields and quality losses
- Products and areas that cannot be used efficiently due to unconscious production practices
- Agricultural areas that difficult to manage.

Figure 2. Flow chart of plant protection studies by remote sensing and image processing

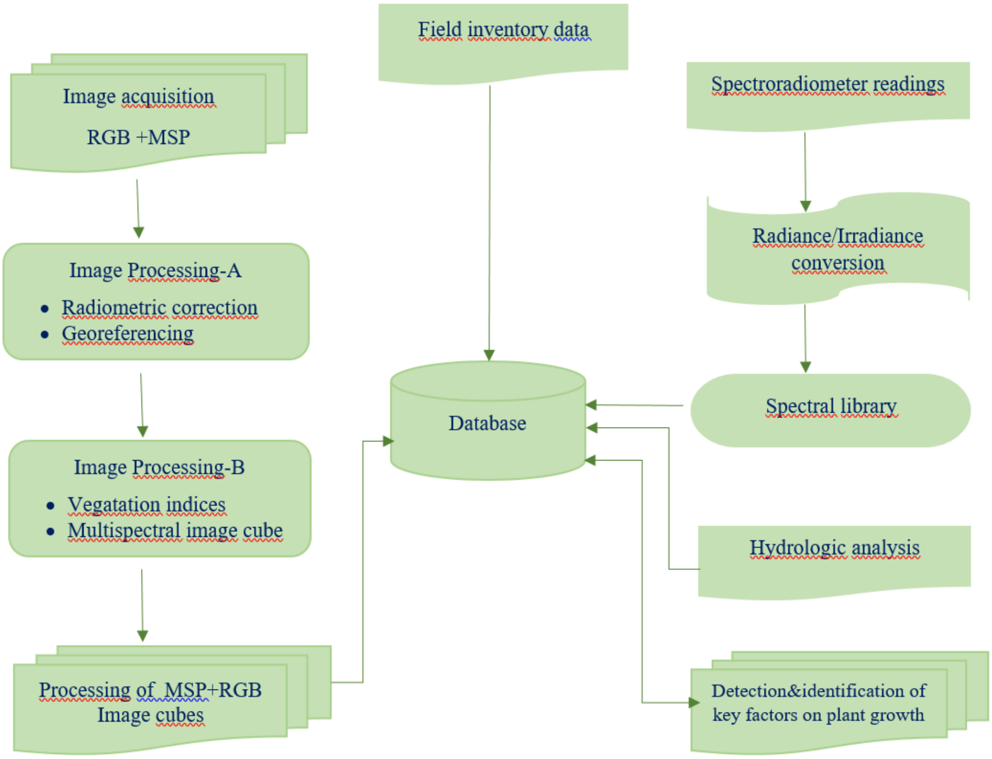


Figure 3. Image Processing of RGB + MSP

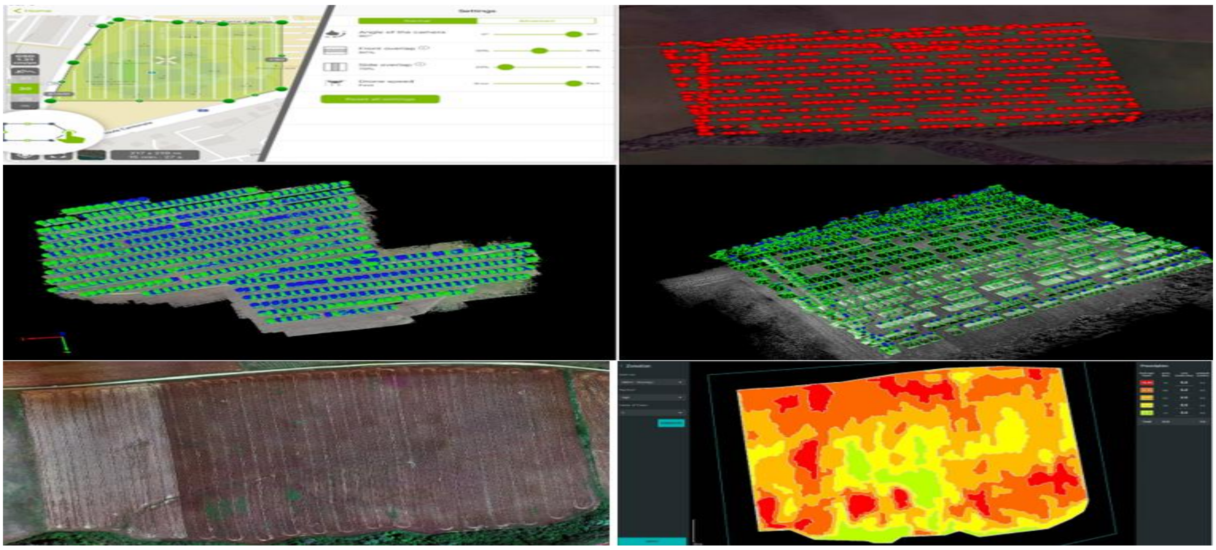


Figure 4. Hydrological evaluations (Digital Elevation and Digital Surface model images)

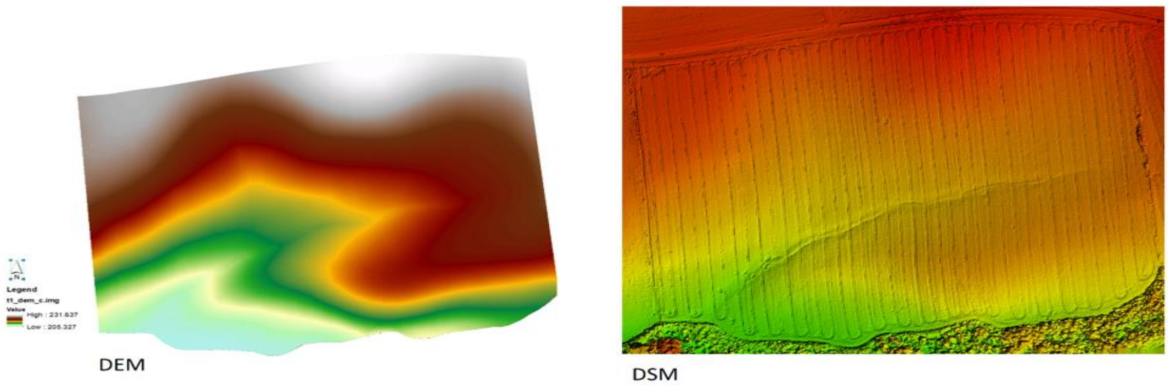
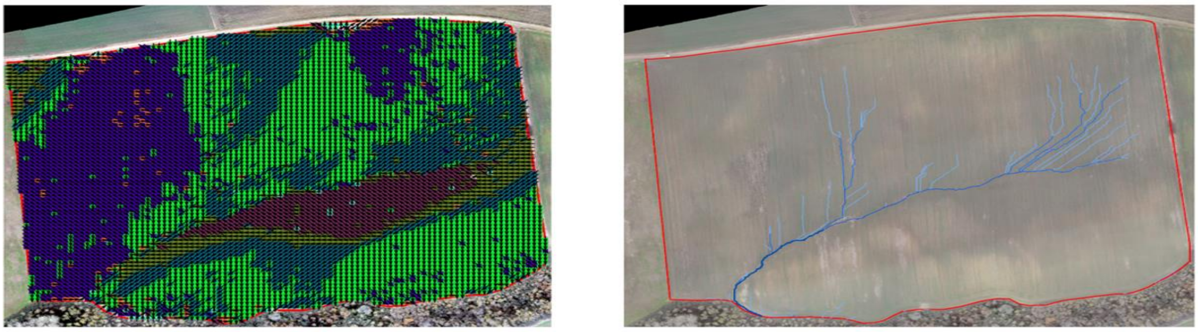


Figure 5. Hydrological Prosessing Results (Drainage and water flow images)

Flow direction　　　　Main drainage line



The presence of water-borne stress conditions can be evaluated and solutions can be offered.

Figure 6. Image interpretation: variety identification

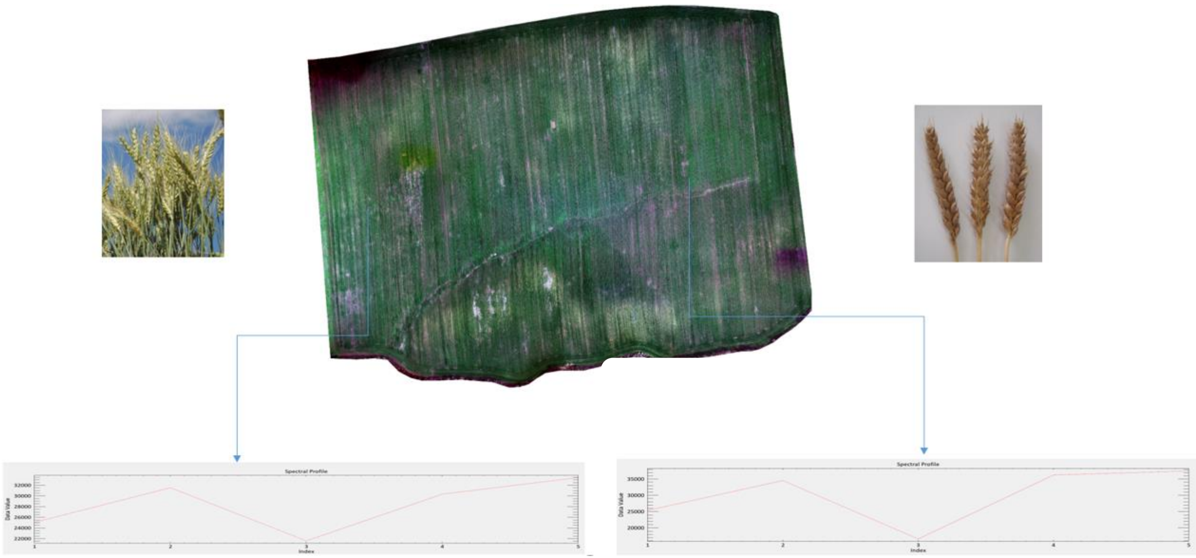
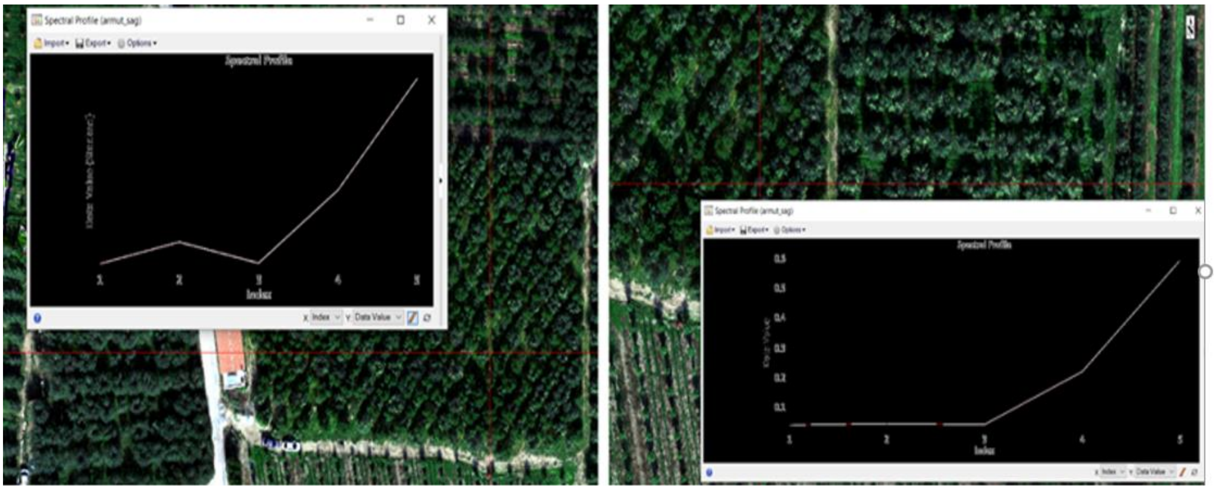
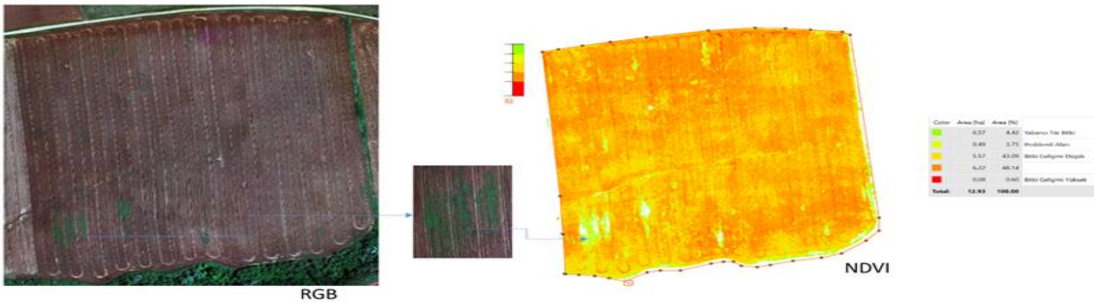


Figure 7. Image interpretation: plant stress detection



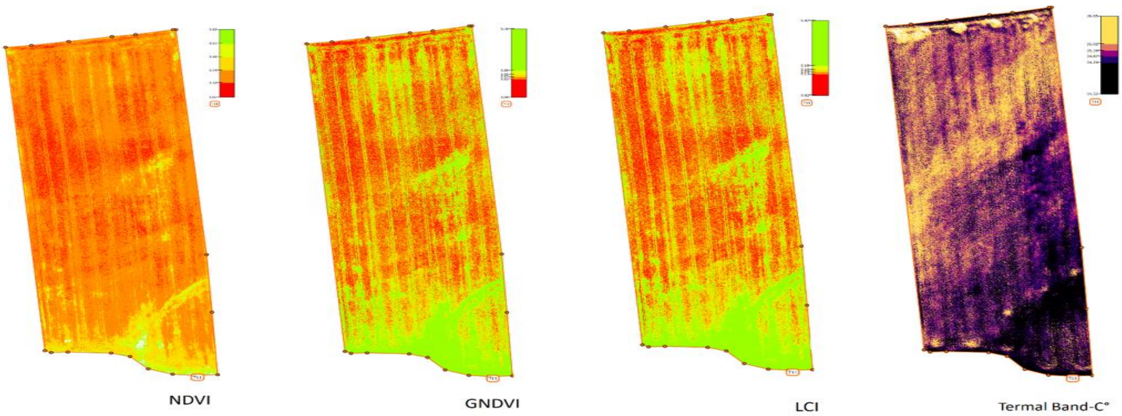
Healthy plant   Stressed plant

Figure 8. Image interpretation, weed detection



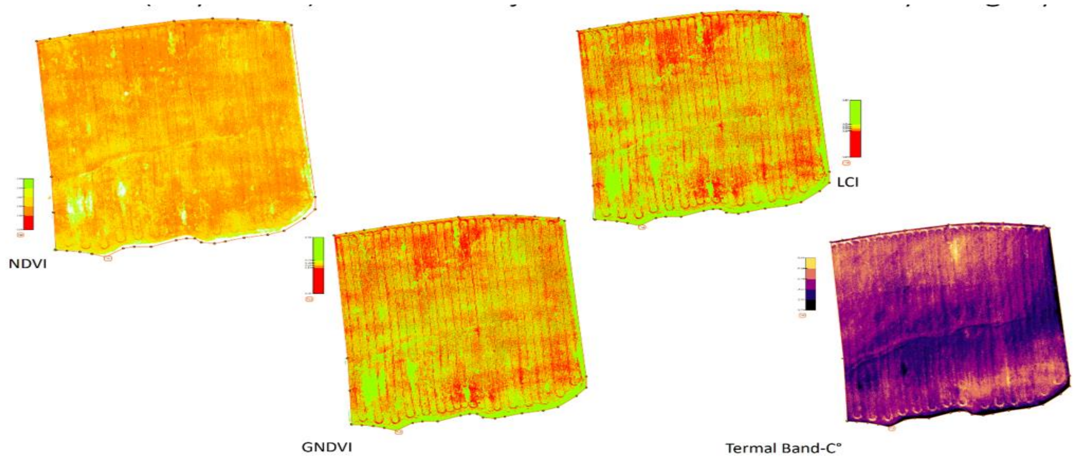
When thousands of images are processed and analyzed, weeds can be detected and location based programming can be done for disposal.

Figure 9. Image interpretation: Field 1- Variety A



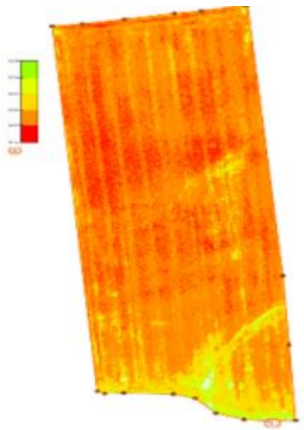
Reflectance value varies depending on the variety of plant.

Figure 10. Image interpretation: Field 2- Variety B



Reflectance value varies depending on the variety of plant.

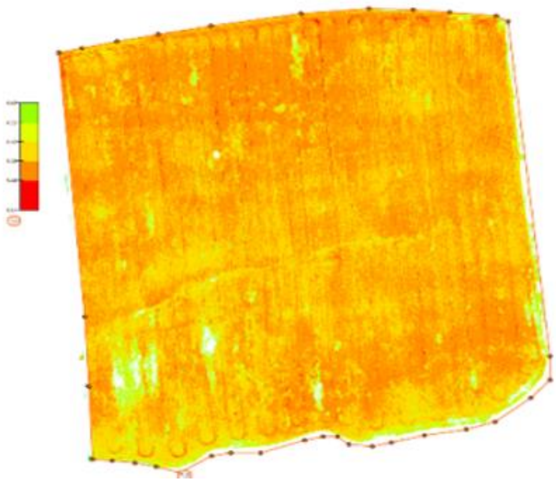
Figure 11. Determination of yield



T11

Color	Area [ha]	Area [%]	Rate	Quantity	Comment
	0.04	1.03	0.00	0.00	Zayıf
	0.10	2.60	1000.00	97.42	
	0.49	13.01	4210.00	2050.19	Orta
	2.71	72.43	5480.00	14852.35	
	0.41	10.92	6680.00	2728.81	Yüksek
Total:	**3.74**	**100.00**		**19728.78**	

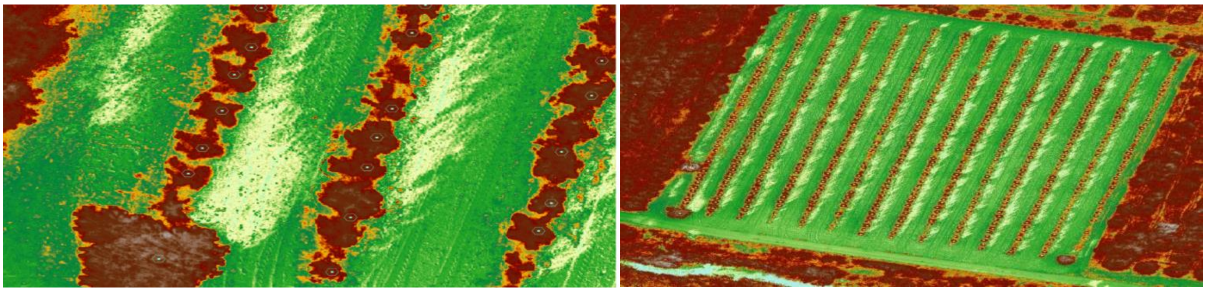
NDVI



T12

Color	Area [ha]	Area [%]	Rate	Quantity	Comment
	0.57	4.42	0.00	0.00	Zayıf
	0.49	3.75	2602.00	1262.52	
	5.57	43.09	4450.00	24790.70	Orta
	6.22	48.14	6740.00	41953.35	
	0.08	0.60	0.00	0.00	Yüksek
Total:	**12.93**	**100.00**		**68006.58**	

Figure 12. Tree count: 598 pieces



6.CONCLUSION

As a result of this study, the spectral analysis of the wheat plant was made and the spectral library archive started to be created. Parameters affecting plant growth have been added to the location-based database and an information store has been created for analysis to be conducted with deep learning techniques and artificial intelligence support.

Practises are ongoing to create a spectral library of other crops that are grown in different climatic conditions of the country. The research is deepened by establishing an infrastructure to monitor the changes in the biochemical structure of plants under controlled conditions by spectral analysis.

Despite the borders of the countries, the world's natural resources are used by all living things. Optimum use of resources is required for the sustainability of new generations. In the above study, it is clearly seen that the developing technology provides an advantage in the agricultural sector. Its use should be expanded immediately.

Turkey has a unique geographical location. The farming and grain production of the world began in Turkey. The world's first agricultural community lived in Gobeklitepe 12,000 years ago. For this reason, it is essential to implement and pioneer technological development in agriculture.

One of the most important warnings to be considered in the COVID-19 pandemic is that investment and development in the agricultural sector is a priority. Similarly, it is clear that blockchain-like technology infrastructure studies should be added to food safety policies for possible foodborne outbreaks.

REFERENCES

ABERSFELDER, S., BOGNER, E., HEYDER, A., FRANKEL, J., 2016, *Application and validation of an existing Industry 4.0 guideline for the development of specific recommendations for implementation*, Advanced Materials Research, 1140, 465-472.

Akıllı Tarım Platformu, 2019, *Türkiye'de Akıllı Tarımın Mevcut Durum Raporu*.

ALBERS, A. & B. GLADYSZ & T. PINNER & V. BUTENKO & T. STURMLINGER, 2016, P*rocedure for defining the system of objectives in the initial phase of an industry 4.0 project focusing on intelligent quality control systems*, Procedia CIRP, (52), 262-267.

ALMADA-LOBO, F., 2015, *The Industry 4.0 revolution and the future of Manufacturing Execution Systems (MES)*, Journal of Innovation Management, 3(4), 16-21.

BANERJEE, M., CHOO, K. R., LEE, J., 2018, *A blockchain future for internet of things security: a position paper*, Digital Communications and Networks, 4 (3):149-160.

BARNES, A.P., SOTO, I., EOPRY, V., BARBERO, M.G., 2019, *Exploring the adoption of precision agricultural technologies: A cross regional study of EU farmers*, Land Use Policy 80:163-174.

CHEN, Z., GU, X., HUANG, Y., Yu, T., 2018, *Agricultural remote sensing big data: Management and applications*, Journal of Integrative Agriculture, (179), 1915–1931.

CLIMATE DIPLOMACY, 2019, Explainer: 'Desertification' and the role of climate change [online], Intergovernmental Panel on Climate Change (IPCC), https://www.climate-diplomacy.org/news/explainer-%E2%80%98desertification%E2%80%99-and-role-climate-change, [Date Accessed: 7 October 2019].

ELOWITZ, M.R., *What is Imaging Spectroscopy (Hyperspectral Imaging)?*, www.markelowitz.com/Hyperspectral.html, [Data Accessed:11 November 2018].

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS, FAOSTAT, 2019, Food and Agriculture Data, http://www.fao.org/faostat/en/#data/QC, [Data Accessed:19 November 2019].

FORESIGHT, 2011, *The Future of Food and Farming*, Foresight Programme, Govt Office for Science, London.

GEBBERS, R. and ADAMCHUK, V.I., 2010, *Precision Agriculture and Food Security*, Science Vol. 327 no. 5967, pp. 828-831.

GENTNER, S., 2016, *Industry 4.0: Reality, Future or just Science Fiction? How to Convince Today's Management to Invest in Tomorrow's Future! Successful Strategies for Industry 4.0 and Manufacturing IT*, Chimia, 70 (9): 628-633.

GRIFFIN, T., BONGIOVANNI, R., LOWEBERG-DEBOER, J., 2010, Worldwide Adoption of Precision Agriculture Technology: The 2010 Update, 1*0th International Conference of Precision Agriculture*, July 18–21, 2010, Denver, Colorado, USA.

GUBÁN, M. and KOVÁCS G., 2017, *Industry 4.0 Conception*, Acta Technica Corviniensis Bulletin of Engineering, 10(1), 111.

INAN, M., 2004, Orman Varlığının Saptanmasında Uzaktan Algılama Verileri, Doktora, İstanbul Üniversitesi.

KOCA, K.C., 2018, *Sanayi 4.0: Türkiye Açısından Fırsatlar ve Tehditler*, Sosyoekonomi, Vol. 26(36), 245-252.

LU, Y., 2017, *Industry 4.0: A survey on technologies, applications and open research issues,* Journal of Industrial Information Integration, (6), 1-10.

L3HARRIS GEOSPATIAL, 2013, *Vegetation Analysis: Using Vegetation Indices in ENVI,* https://www.harrisgeospatial.com/Learn/Whitepapers/Whitepaper-Detail/ArtMID/17811/ArticleID/16162/, [Date Accessed: 10 November 2018].

McKINNON, T., 2016, *Agricultural Drones; What Farmers Need to Know,* https://agribotix.com/wp-content/uploads/2016/04/WhatFarmersNeedToKnow_web.pdf, [Data Accessed:13 November 2018].

PIERPAOLA, E., CARLIA, G., PIGNATTIA E. et al., 2013, *Drivers of Precision Agriculture*

PREUVENEERS, D., & ILIE-ZUDOR, E., 2017, *The intelligent industry of the future: A survey on emerging trends, research challenges and opportunities in Industry 4.0,* Journal of Ambient Intelligence and Smart Environments, 9(3):287-298.

PRICE WATERHOUSE COOPERS INTERNATIONAL LIMITED COMPANY, 2016, 2016 Global Industry 4.0 Survey: Industry 4.0: Building the digital enterprise, https://www.pwc.com/gx/en/industries/industries4.0/landing-page/industry-4.0-building-your-digitalenterprise-april-2016.pdf, [Data Accessed:25 November 2019].

TEKE ve diğ., 2016, Akıllı Tarım Fizibilite Projesi: Hassas Tarım Uygulamaları İçin Havadan Ve Yerden Veri Toplanması, İşlenmesi Ve Analizi, *6. Uzaktan Algılama-Cbs Sempozyumu (Uzal-Cbs 2016),* 5-7 Ekim 2016, Adana.

TEMA VAKFI, 2019, Toprağımız için elele, http://www.tema.org.tr/web_14966-2_1/entitialfocus.aspx?primary_id=2179&target=categorial1&type=2&detail=single, [Date Accessed: 21 July 2019].

TRAKYA KALKINMA AJANSI Planlama, Programlama ve Koordinasyon Birimi, 2014, *Çiftçi Algısı Analizi,* Kalitatif Rapor Çiftçi Odak Grup Toplantıları, Edirne, https://www.trakyaka.org.tr/upload/Node/33084/xfiles/Ciftci_Algisi_Analizi_Kalitatif_Rapor2.pdf, [Date Accessed: 3 November 2018]

TURKISH STATISTICAL INSTITUTE, 2019, Statistic by Theme, Agriculture, http://www.tuik.gov.tr/UstMenu.do?metod=kategorist, [Data Accessed:26 October 2019].

UNITED NATIONS, DESA, 2019, Population Division, World Population Prospects 2019, https://population.un.org/wpp/Graphs/Probabilistic/POP/TOT/900, [Data Accessed:12 November 2019].