Overview of Aromatic Plants Precision Agriculture with the use of UAV

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Abstract. While precision agriculture has been present for many years and lately massively spread through the agricultural and scientific community, little to nothing has been published for smart farming and agriculture in aromatic and herbal plants. In this article we search and review publications regarding aromatic plants' crop management, the use of state of the art techniques while recording most common UAVs, special thermal and multispectral cameras for the raw data acquisition and aerial imagery post - processing software used. We also discuss common methodologies and indices used for this specific segment of agriculture and point out the hidden potential of more efficient, in many ways, crop management in the use of UAVs.

Keywords: UAV; Precision Agriculture; Photogrammetry; Aromatic & Herbal Plants; Overview; Vegetation Index.

1 Introduction

The majority of people living in developed countries have become really selective when it comes to the quality of their everyday nutrition. Along with frequent exercise, quality food is a must for both Generation X and Millennials. A large number of people in developing countries have traditionally depended on products derived from plants, especially from forests, for curing human and livestock ailments. Additionally, several aromatic plants are popular for domestic and commercial uses and collectively they are called medicinal and aromatic plants (MAPs) (M.R. Rao, 2004). Nutrition quality of the modern family is one of the main reasons that medicinal and aromatic plants consumption and -therefore- cultivation have continuously been on the rise for many years as well as being relatively inexpensive to cultivate but with a respectable profit margin.

At the same time, vast progress has been made in Remote Sensing and Geographical Information Systems (GIS) while rising technologies such as Internet of Things (IoT) alongside Machine Learning and Artificial Intelligence (AI) broaden their scope of application each year. All of the aforementioned, combined with the ease of use of the latest Unmanned Aerial Vehicles (UAV) –which have almost

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become part of our everyday lives- and their relatively low cost in initial purchase and maintenance, pave the way for better and more efficient crop management of aromatic plants through constant monitoring· to name a few, UAVs can be used in crop mapping and soil analysis with the use of specific sensors and software, fertilizer spot spraying, seed planting.

UAV designs include many different forms, features, and functions (Vergouw, 2016). The four primary types of drones are fixed-wing, single-rotor, multi-rotor, and hybrid; all of these types have certain advantages and disadvantages and they have been widely used for research in various fields. They feature simple controls, require low costs, and are highly mobile with the ability to take off anywhere (Chen, 2020) and by employing UAVs, the corresponding spatial resolution can be increased to much less than a meter (Prem Chandra Pandey, 2020).

Aromatic and herbal plants can be divided into groups based on how they are used as:

- Raw materials for essential oil extraction; a major use of these plants.
- Culinary spices; the non-leafy parts are used as a flavoring or seasoning.
- Culinary herbs; the leafy or soft flowering parts are used as a flavoring or seasoning.
- Medicinal group; the development of natural or semi-synthetic medicine
- Miscellaneous group: MAPs and their extracts become components of cosmetics, dyes, air fresheners, disinfectants, botanical pesticides, insect repellents, etc. (Solomou, 2016)

Most commonly cultivated medicinal and aromatic plant species in Greece are (Solomou, 2016);

Sideritis sp.
Pimbinella anisum
Origanum sp.
Origanum dictamus
Crocus sp.
Hyssopus officinalis
Salvia sp.
Origanum majorana
Jasminum officinalis
Lavandula spica
Sinapis sp.
Matricaria chamomila
Hypericum perforatum
Urtica sp.
Aloysia citriodora
Crithmum maritimum
Mentha viridis
Coriandrum sativum
Mentha sp.
Salvia sp.
Lepidium sp.
Crocus sp.
Phacelia tanacetifolia
Phoeniculum vulgare
Rosmarinus officinalis
Thymus sp.
Glycirrhiza glabra
Cuminum cyminum
Ocimum basilicum

2 Literature Review

2.1 Respective Aromatic and Herbal Plant papers

Systematic and thorough literature search was conducted with searches only in the English language in the following scientific databases;

Web of Science, MDPI, PubMed, ScienceDirect, ResearchGate, Elsevier and Google Scholar by using search terms such as “medicinal plant UAV” “aromatic plant UAV” “herbal plant UAV” along with keyword combinations (e.g. “Multispectral Imaging”, “remote sensing”, “Vegetation Index” and “cultivation practice”) in order to find the relevant published papers and complete the literature review.

Our aim and focus in using multispectral –as well as thermal- cameras will be mainly in aromatic and herbal plants that are cultivated in Greece and particularly within the Western Macedonia Prefecture in order to find ways to enhance the crops’ cultivation and help ease the consequences from the violent decarbonization of the area. Specifically, Rosemary (*Salvia rosmarinus*), Oregano (*Origanum vulgare*) (Olmedo, 2013), Sage (*Salvia officinalis*) and Lavender (*Lavandula angustifolia*).

The use of Remote Sensing Data and GIS Technologies for Monitoring Stocks of Medicinal Plants, was examined in 2019 with the necessity of a digital terrain model along with multispectral and plain photography data as the outcome (Fadeev, 2019)

By monitoring the effect of different levels of irrigation in the cultivation of oregano with the use of GIS and a 4 band multispectral camera, the NDVI vegetation index was not proved particularly reliable and further research using other growth indicators was recommended (Lontou, 2020).

By investigating correlation between salt stress in rosemary and NDVI with remote sensing technique, significant relationship between salt stress and reflection values in the plant was highlighted. The findings show that the reflectance values could be used to estimate the salt-stress level in plants (Atun, 2020) even though earlier studies show that there is no direct relationship between NDVI and chlorophyll content (Hernandez et al., 2014).

Hyperspectral Imaging (HSI) is a non-destructive, time-saving versatile and environmentally friendly technique with potential application for on-line quality monitoring (Shikanga, 2013), mostly used in the absence of organic solvents (Tripathi and Mishra, 2009). It offers new possibilities by combining spectral and visual data, researchers and producers can employ this tool for mapping distributions of compounds, adulteration, and contamination in aromatic and medicinal plant products as well as derivatives such as spices (Sajad, 2018).

In 2019, a study proved that a fusion of multispectral and Structure from Motion (SfM)-derived vertical information significantly improves the accuracies of classification of shrubland vegetation (and conclusively herb plants) to the level of individual species, without the need to invest in (expensive) LiDAR sensor equipment (Prošek, 2019)

Mapping rosemary cover results established that not any vegetation index is useful for classification, but there are combinations to find for well training the supervised classification while indices as NDVI, MCARI and BI are forming the best combination (Chafik, 2020).

2.2 Respective Basic Vegetation Indices for Aromatic and Herbal Plants

According to a 1991 research (Jackson, 1991), Vegetation Indices (VI) classify into two major groups, slope-based and distance-based; slope-based VIs are combinations of the visible red and the near infrared bands and are widely used to generate vegetation indices and distance-based VIs have as main objective to cancel the effect of soil brightness in cases where vegetation is sparse and pixels contain a mixture of green vegetation and soil background (Silleos, 2006).

A recent study of the Vegetation Indices, reviewing their developments and applications over the years recorded significant increase in used and implemented indices calculated from multispectral as well as hyperspectral information (Xue. 2017).

NDVI, as normalized ratio between the red and near infrared bands is the Normalized Difference Vegetation Index (Karnieli, 2010) and may perhaps be the widely known one but there are many more although it is very difficult to indicate which would be the best approach without knowing the details of the desired application; there are too many factors that can influence the decision (costs, spatial resolution, area coverage, type of image to be used, type of feature of index to be calculated, etc.) (Barbedo, 2019).

3 Discussion and Conclusion

According to the aforementioned literature review, proper and thorough research of various vegetation indices in aromatic and herbal plants has to be made, especially for those species that are mostly cultivated in Greece and specifically in Western Macedonia Prefectures' climate which may be traditionally Greek through the summers but is particularly rough through autumn and winter given that it is in the northern part of the country (Figure 1).

Fig. 1. Western Macedonia Perfecture in Greece, its‘ major cities and Area of Interest within the Public Power Corporations‘ (PPC SA) old deposits of the lignite mines.

Therefore, an area of 26 acres has been chosen for the cultivation of 4 different herbal species from scratch, within accordingly formed area in an old deposits area from the lignite mines that dominated the area in previous years, as can be seen in the corresponding Figure 2:

- Rosemary (Salvia rosmarinus), 4 acres
- Oregano (Origanum vulgare), 12 acres
- Sage (Salvia officinalis), 3 acres
- Lavender (Lavandula angustifolia), 7 acres

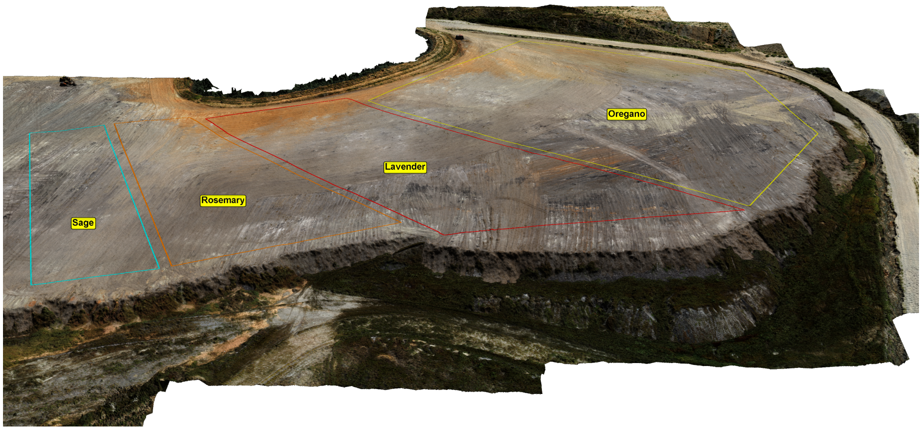

Fig. 2. The four different species of aromatic and herbal plants that will constitute our research area over the Vegetation Indices used on them with the use of a UAV carrying a multispectral and a thermal camera.

There is striking potential to be analyzed in terms of research, some of the areas that we intend to emphasize are the following;

- Comparison of the lignite mine old deposits sites' ground with an area away from the mines in terms of moisture etc.
- Comparison of the lignite mines' old deposits site ground -using of multispectral and thermal camera- with the outcome from soil testing bore holes
- Research over various vegetation indices in all four herbal and aromatic species throughout the cultivation stages, crop growth and yield with the use of a four-band multispectral camera as well as a radiometric thermal camera
- Research for the output produced by using a rotary wing drone vs a fixed wing Unmanned Aerial Vehicle
- Evaluation of the level of influence different heights or/and different flight plans/use of Digital Surface Model of the UAVs used

Conflicts of Interest. The authors declare no conflict of interest.

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