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# APLICATION OF UNMANNED AERIAL VEHICLES (UAV) FOR PRECISION AGRICULTURE, IN SELECTED WHEAT FIELDS OF RAJANPUR

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## ABSTRACT

Precision agriculture is an innovative approach of agricultural management, that incorporates latest technology to monitor the crop production process and taking measures to optimize agricultural production. Winter wheat is a significant crop planted in the arid region of Rajanpur district, Punjab, Pakistan, whose 83% of the total population is rural based and relies on agriculture as their main source of living. This study aims to perform the comparative analysis of biomass levels using UAV and Landsat imagery and to explore possibility of application of drone technology in assessing wheat crop stress in winter wheat fields lying in different desertification vulnerability zones of Rajanpur. Landsat 8 imagery of 30 m resolution and DJI Phantom 3 captured imagery with 12 MP (8.6m) resolution were the data sets used in this study. The images were captured during field survey in February 2019. The results concluded that the UAV captured imagery provided detailed biomass variance, through NDVI analysis of the farms under study, as compared to the generalized NDVI results obtained through Landsat 8 images. Also, the results of the wheat crop stress analysis calculated through UAV imagery, concluded that Fatehpur UC, suffered greatest wheat crop stress of 34.83%, the wheat filed in Asni UC, suffered second highest wheat crop stress with a value of 8.41% and finally, the wheat field in Kot Mithan UC suffered least wheat crop stress of 4.76%, thus affirming that UAV proved efficient tool in demarcating the exact regions in small fields, suffering from crop stress. Such timely knowledge can lead to efficient measures to be taken by the farmers in a timely manner to save the crop from economic failure. Future studies can be focused on precise monitoring of crops that could lead us towards precision agriculture.

**KEY WORDS:** Unmanned Aerial Vehicles (UAV), Landsat 8, Crop stress, NDVI, desertification vulnerability

## INTRODUCTION

As the population explosion continues, the world continues to face the constant threat of food insecurity and resultant advancement in agricultural sector remains indispensable. Agricultural development has socio-economic benefits, as it boosts agricultural yields, provides occupation opportunities, and reduces imbalance between rural urban employments *(Norasma et al.,* 2019). Precision agriculture is an innovative approach of agricultural management, that incorporates latest technology to monitor the crop production process and taking measures to optimize agricultural production (Trivelli *et al.,* 2019) and is one of the top agricultural revolutions (Mulla, 2013). It can be defined as “an agricultural system in which the management practice is performed at the right place, with the right intensity, and at the right time” (Maes and Steppe, 2019). Development in Unmanned Aerial Vehicles (UAV) have recently provided a boom to the precision agriculture, as this technology combines with image data analytics to provide solutions to issues posed by climate change, lack of potential available arable lands, and demand of freshwater (Radoglou-Grammatikis, Sarigiannidis, Lagkas, and Moscholios, 2020).

Assessing vegetation health through the remote sensing techniques is one of the main PA applications, however, access to satellite images is very expensive and their resolution and resultant quality is not satisfactory. The satellite images may be affected from cloud cover and other distortions. However, UAV or drones provide economical and practical solution to field monitoring (Radoglou-Grammatikis *et al.,* 2020), by providing high quality images and enabling crop monitoring in different stages of crop development. Similarly, UAVs can generate images of higher spatial resolution (<1m) at a temporal frequency that enables timely response in accordance to field status (Elarab, Ticlavilca, Torres-Rua, Maslova, and McKee, 2015). They offer the opportunity for various images to be captured of the same field using multiple camera filters, which provide detailed information regarding the crop health and helps in pin pointing the areas of field that require specific attention, of particular type (Norasma *et al.,* 2019).

According to Maes and Steppe (2019) UAV technology has proved to be a ‘game changer’ in precision agriculture. UAVs can be used in various ways for precision agriculture, e.g. crop monitoring, estimation of crop height, pesticide spraying, soil analysis etc. (Mogili and Deepak, 2018). Similarly, the UAV captured imagery is even used for early detection of crop diseases (Albetis *et al.,* 2017). Thus, through UAV use, precision agriculture can be efficiently practiced as, the cost of use of pesticides; fertilizers, water can be reduced, and can be provided to particularly those areas of field where they are actually needed.

UAV captured imagery is used by the farmers to assess the stresses and variabilities their crops go through. This is achieved by calculating vegetation indices through the captured images. NDVI can easily be calculated thorough UAV imagery, and it provides valuable information regarding the biomass levels, which in turn help in reaching meaningful conclusions regarding crop diseases, pest infestation, water stress, deficiency of particular nutrients and other factors that might affect crop productivity (Radoglou-Grammatikis *et al.,* 2020; Xue and Su, 2017). The RGB imagery in winter wheat fields is particularly important for the early weed detection and lodging detection (Maes and Steppe, 2019).

Winter wheat is a significant crop planted in the arid region of Rajanpur district, Punjab, Pakistan. 83.10% of its population is rural and relies on livestock herding and agriculture for their living (GoP, 2017). The district has an arid type of climate with rainfall concentrated in monsoon months. The district has a high population growth rate of 3.16 for the period of 1998-2017 (GoP). According to NDMA (NDMA, 2017) , this district has highly food insecure population. The variations in the wheat yield, or crop failure in case of acute water shortage, can lead to economic and health disaster for the locals who highly depend on agriculture as the main source of earning.

The aim of this study was to perform the comparative analysis of biomass levels using UAV and Landsat imagery and to explore possibility of application of drone technology in assessing wheat crop stress in winter wheat fields lying in different desertification vulnerability zones of Rajanpur, as an effort to strive for the goal of precision agriculture in the district.

## MATERIAL AND METHODS

### Study area

Its lies within 29.2080° north and 70.2408°east longitude (Google Earth) spatial coordinates. The district is divided into 3 tehsils which are further subdivided into 69 union councils (GoP, 2013). Three sample wheat fields, from three different union councils of Rajanpur district were selected, randomly, from each of the Desertification Vulnerability Indexed Zones as identified in the study by (Mazhar, Shirazi, and Javid, 2018).

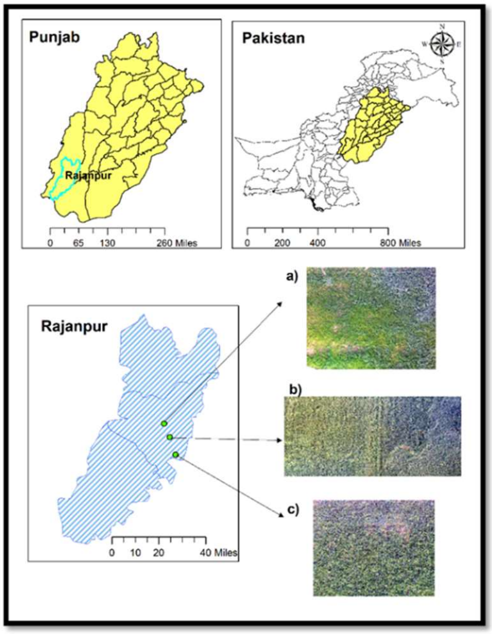


**Figure 1:** Study area map with orthomosaic images processed through UAV captured images a) Fatehpur b) Asni and c) Kot Mithan

**UAV Survey**

The survey was conducted using DJI Phantom III Standard quadcopter, in Rajanpur, Punjab, Pakistan from 25-27 February, 2019. DJI Phantom 3, has a built in 2.7K camera. It's Gimbal is 3-axis and is capable of capturing 12 MP still images. Its 12 MP resolution is equal to 8.6m. GPS is used by this UAV for positioning outdoors. The month of February was selected for the survey as the wheat crop of Punjab, usually reaches the flowering stage in this month. Water deficiency in this stage can lead to reduced yields (Naheed and Mahmood, 2009).

A single flight of UAV was performed over each sample field, at midday. The UAV was flown at 15m height above the ground, and the images captured had a resolution of 30.48ppi. The images were in RGB, having a pixel depth of 16 Bit. Before the survey, waypoint routes were generated for the sample fields in *djigo* app. Nadir view angle was chosen for the survey under clear sky conditions. The images obtained through UAV were uploaded on djigo app and the orthomosaics were obtained, and later Agremo app was used to generate the crop stress report.

**Landsat 8 imagery**

The Landsat 8 images of 30m resolution, OLI/TRIS images were obtained from USGS earth explorer, for the same year and same month. The study area covered four tiles, and the path and rows of the tiles that covered the study area were, 151-39, 151-40, 152-39, 152-40. The georeferenced and atmospherically corrected images were requested and later downloaded from USGS. The images obtained were cloud free.

Normalized Difference Vegetation Index (NDVI) (1)provides a reliable estimation of greenery in a region, presents a meaningful combination of bands associated with the transmission, reflection and assimilation of vegetation (Mazhar et al., 2018). NDVI was calculated from Landsat 8 image, using ERDAS Imagine 2015 software, using the equation provided by Epiphanio and Huete (1995):

$$NDVI = (NIR-R) / (NIR+R) \quad (1)$$

## RESULTS AND DISCUSSION

The NDVI results of Landsat image (figure 2), present More than 50% of the district under low NDVI values of -0.495. The entire eastern strip of Rajanpur, is lying under moderate NDVI, while some high NDVI values can be spotted in north eastern and eastern Rajanpur. On the western border of the district lie the Suleiman mountains which justify the low NDVI values for this zone.

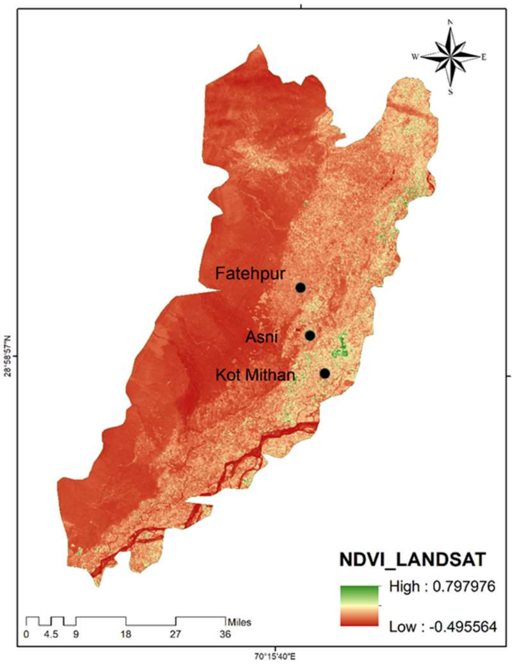


**Figure 2:** NDVI calculated from Landsat 8 imagery, for Rajanpur District

In figure 3 the comparison of NDVI calculated for wheat field of Fatehpur becomes apparent. The inset maps in a) and b) present zoomed versions of the NDVI value as extracted from the Landsat 8 image, and the result declares entire Fatehpur wheat field, lying in high DVI zone, to be suffering from low NDVI. Whereas figure c) presents the NDVI calculated from the UAV captured image, and shows variation in the NDVI values, ranging from a low NDVI value of -0.740741 in the central patches of the field, to a high NDVI value of 0.196319 in the eastern and western patches of the field.

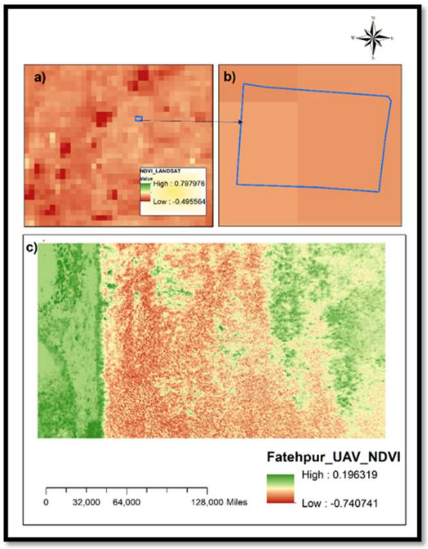


**Figure 3:** Comparative NDVI for wheat field in Fatehpur UC: a) and b) zoomed NDVI views calculated from Landsat 8 image: c) NDVI obtained from UAV captured image

Figure 4 presents the NDVI comparative maps calculated through Landsat and UAV captured imagery, for wheat field in Asni, a union council which lies in moderate DVI zone. According to b) inset map, the Landsat calculated NDVI present entire Asni field to experience low NDVI of -0.495564, while great variation in this NDVI is visible in the NDVI calculated from the UAV captured image. Almost entire field has vertical zones of low NDVI, having a value of -0.768116, with patches of moderate NDVI in between. Only in the southern small patch of the field, high DVI with a value of 0.158209 can be spotted.

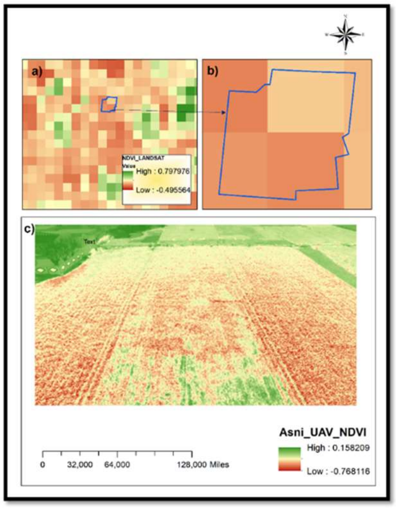


**Figure 4:** Comparative NDVI for wheat field in Asni UC: a) and b) zoomed NDVI views calculated from Landsat 8 image: c) NDVI obtained from UAV captured image

Figure 5 presents the variation in NDVI calculated for Kot Mithan's wheat field, which was located in the low DVI zone. The inset maps, a) and b) present the zoomed version of the Landsat calculated NDVI, with low NDVI values of -0.495564 covering approximately one fourth of the field, while the remaining field was having moderate NDVI. On the contrary, c) show the UAV based calculated NDVI, with high NDVI of 0.125683 covering almost 70 of the field, and low NDVI with a value of -0.544304 covering small area in the center of the field. Results clearly indicate greater variation visible through UAV captured imagery.

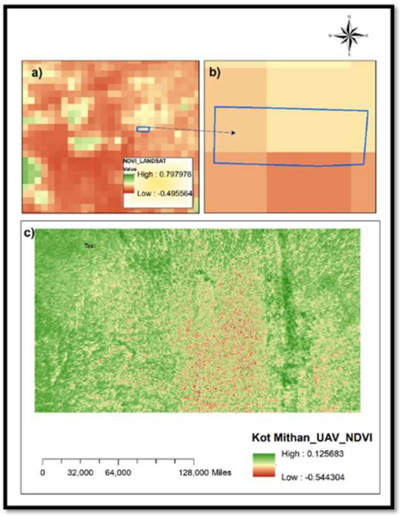

**Figure 5:** Comparative NDVI for wheat field in Kot Mithan UC: a) and b) zoomed NDVI views calculated from Landsat 8 image: c) NDVI obtained from UAV captured image

Figure 6 presents the results of the crop stress calculated using the orthomosaic images captured using UAV in the sample fields, lying in randomly selected union councils, of each of the DVI zones, in Rajanpur District.

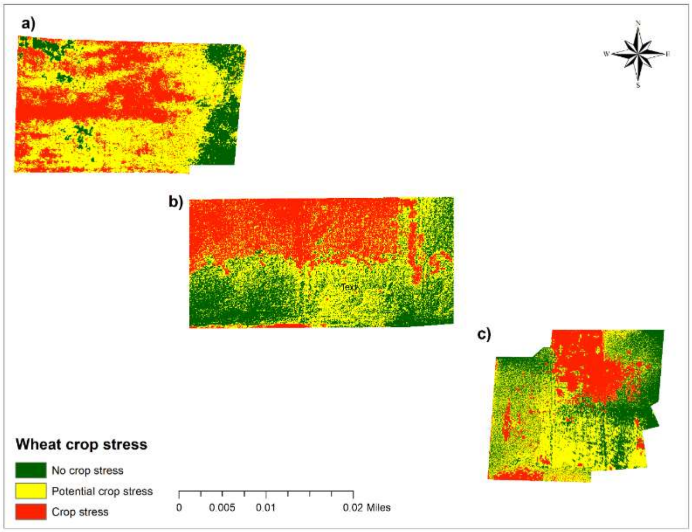


**Figure 6:** UAV image-based wheat crop stress analysis for Rajanpur District's selected wheat farms a) Fatehpur b) Asni c) Kot Mithan

Table 1 presents the interesting finding that in Fatehpur UC, 34.83% of the wheat field was under crop stress, while a further 51.16% was under potential crop stress. Since this field is located in the high DVI zone, the crop stress analysis further affirms the findings of Mazhar *et al.*, (2018), that the high DVI zone wheat farms are witnessing higher rates of crop stress. Only 13.95% of the sample wheat field in Fatehpur UC was witnessing no stress.

Sample wheat farm in Asni UC experienced 8.41% of crop and 14.48% of potential crop stress, on the contrary much of the farm, i.e. 77.10% was experiencing no crop stress, again affirming the findings of Mazhar et al. (2018), since Asni UC is located in the medium DVI zone.

| District | Union Council | DVI Zone | No crop stress (ha) | % No crop stress | Potential crop Stress (ha) | % Potential crop Stress | Crop Stress (ha) | % Crop Stress |
|---|---|---|---|---|---|---|---|---|
| Rajanpur | Fatehpur | High | 0.01 | 13.95 | 0.04 | 51.16 | 0.03 | 34.83 |
| | Asni | Medium | 0.16 | 77.10 | 0.03 | 14.48 | 0.01 | 8.41 |
| | Kot Mithan | Low | 0.06 | 63.80 | 0.03 | 31.42 | 0.00 | 4.76 |

**Table 1.** Crop stress in selected winter wheat fields of Rajanpur district

Kot Mithan UC lying in the low DVI zone (Mazhar *et al.,* 2018) witnessed a meagre 4.76% of crop stress, while another 31.42% was found to under the potential crop stress category. However, 63.80% of the wheat field in Kot Mithan was found to be experiencing no crop stress.

Similar application of UAV imagery for analyzing the health of winter wheat crop was performed in a study by Christiansen, Laursen, Jørgensen, Skovsen, and Gislum (2017) and Rasmussen, Nielsen, Garcia-Ruiz, Christensen, and Streibig (2013). The findings of similar studies affirm that the variation in the vegetation health at micro level, for e.g. one acre, can only be captured through UAVs, because they have advantage of better resolution and ease of use as compared to satellite data.

## CONCLUSION

UAVs can be efficiently used in agriculture sector of Punjab Pakistan, for promoting the precision agriculture, which would result in reducing food insecurity in the country. The current study presented comparative NDVI analysis result of three one acre, winter wheat fields, selected in different Desertification Vulnerability Indexed (DVI) zones in Rajanpur district, Punjab Pakistan. The results presented that variations in results as the Landsat 8, NDVI calculated on the 30m resolution images presented highly generalized results, without giving any detailed information about the biomass levels in different parts of small fields. Whereas the 12 MP UAV captured imagery presented NDVI values with detailed clear variation on the one acre wheat fields, under study. The results would help the farmers to take necessary action in the areas with low biomass levels and prevent reduced crop yields, or even in worst case, crop failures. The results of the wheat crop stress analysis presented the interesting finding that the wheat field in Fatehpur UC, lying in high DVI zone of Rajanpur, suffered greatest wheat crop stress of 34.83%, the wheat filed in Asni UC, lying in moderate DVI zone, suffered second highest wheat crop stress with a value of 8.41%. Finally, the wheat field in Kot Mithan UC, lying in the low DVI zone suffered least wheat crop stress of 4.76%, this affirming that UAV proved efficient tool in demarcating the exact regions in small fields, suffering from crop stress. Such timely knowledge can lead to efficient measures to be taken by the farmers in a timely manner to save the crop from economic failure. Future studies can be focused on precise monitoring of weed attacks, pest infestations, water stress, and soil properties analysis using UAV on small scale, so that the dream of precision agriculture can be fulfilled even in remote areas of Pakistan.

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