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USING NDVI CONVERTER APPLICATION FOR ASSESSMENT OF THE VEGETATION INDEX IN WINTER CEREALS AND OILSEED RAPE

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Abstract

The purpose of the article was to describe the outcomes of an in-field evaluation of the NDVI Converter application, which was created to assess the normalized difference vegetation index (NDVI) using estimates of the percentage of green canopy cover. The study was carried out in 2023 on fields of winter wheat, winter barley, and winter oilseed rape in the phenological stages BBCH 21–32 and BBCH 18–39, respectively. The fraction of green canopy cover was estimated using the application Canopeo. By comparing the mean absolute percentage error and Pearson's correlation coefficient to the actual values of the spatial vegetation index, as determined by the platform OneSoil, the quality of the vegetation index evaluation was assessed. Thus, it has been established that NDVI Converter offers accurate vegetation index assessment for cereal crops, with mean absolute percentage error 16.23% and Pearson's correlation coefficient within 0.99, and reasonable quality for oilseed rape (statistical indicators of 46.61% and 0.99, respectively). After the adjustment, the accuracy score of the NDVI Converter increased up to 27.62% for oilseed rape, and 8.71% for winter cereals. Therefore, NDVI Converter could be recommended for practical use in case the spatial vegetation index is not provided by satellite imagery services.

Key words: *fraction of green canopy cover, NDVI, phenology, winter barley, winter oilseed rape, winter wheat*

INTRODUCTION

One of the major producers and exporters of grains worldwide is Ukraine [5]. Because of this, cereal crops benefit from significant attention paid to boosting output and lowering monitoring costs.
Current agricultural science and practice applies Normalized difference vegetation index (NDVI) to solve the tasks of remote crops conditions monitoring, crops mapping, crops productivity forecasting, phytosanitary monitoring, etc. [9, 12, 14, 15]. Therefore, the importance of this vegetation index for successful crop production is hardly to be overestimated.
However, not all crop producers have access to the platforms, which provide ready-to-use solutions for NDVI. Some of the products are expensive, and most free of charge services have strict limitations, e. g., limited areas or number of fields, limited time series of satellite imagery, and limited areas covered. That is why in some cases farmers cannot implement the latest scientific approaches for crop monitoring and yield simulation, where NDVI is utilized.
To solve this problem, NDVI Converter mobile application has been developed. Its main purpose is to provide crop producers with a simple tool for getting NDVI values for their fields using the fraction of green canopy cover (FGCC).
FGCC could be easily evaluated using Canopeo mobile application through photographing field plots on a smartphone's camera [16]. Then, a farmer can use the obtained FGCC value in NDVI Converter, and in several clicks, one gets the value of the vegetation index on a screen of a smartphone.
NDVI Converter mobile application is built up based on scientific research on the interaction and relationship between FGCC and NDVI, conducted for major crops, cultivated in the South of Ukraine [10, 11].
Therefore, the application seems to be robust and reliable tool. Although there is good

scientific evidence for the principles, laid up into the basis of the application, it is important to test its performance in real in-field conditions using the exterior data.

This study's primary objective was to assess the accuracy of the NDVI assessments made by the NDVI Converter on the winter cereals (namely barley and wheat) and winter oilseed rape crops grown in the southern Ukraine.

The evaluation was performed in the initial stages of the crops' growth and development, as on these stages the foundation for further productivity of the crops is laid, thus they require careful monitoring, which could be performed through the vegetation indices, in our case, NDVI [2, 18].

MATERIALS AND METHODS

The in-field fixation of the FGCC was carried out in 2023 on the fields of winter wheat, winter barley and winter oilseed rape, located in Odesa region, in the neighbourhood of Stavrove village. The fixation was performed using a smartphone's camera, with strict accordance to Canopeo mobile application guidelines [8]. The examples of the taken images of the crops are presented in Photos 1 and 2. All the photographs made were linked to geographical network and further allocated on the OneSoil platform to corresponding spatial NDVI values of moderate resolution (250 m), collected from the combined imagery of the satellites' sensors Sentinel-1 and Sentinel-2.

Photo 1. The image of winter cereals, processed in Canopeo application
Source: The authors' own study.

Photo 2. The example of the image for winter oilseed rape crops, used for processing in Canopeo
Source: The authors' own in-field research work.

The study was performed in the stages BBCH 21-32 (tillering – beginning of stem elongation) for winter cereals [21], and BBCH 18-39 (stem elongation) for winter oilseed rape [4].

To determine the values of the vegetation index, the FGCC values were entered into the corresponding cells of the NDVI Converter mobile application. In total, 72 pairs of input data (FGCC – NDVI) were analyzed.

Further, the modelled in the application and true values of NDVI, obtained at the OneSoil platform, were compared through the calculation of Pearson's correlation coefficient (R) and mean absolute percentage error (MAPE). Statistical computations, as well as graphical work, were performed in Microsoft Excel 365 through the standard algorithms [1, 13].

RESULTS AND DISCUSSIONS

As a result, the Table 1 was formed to present the outcomes of statistical comparison of the true and assessed in NDVI Converter values of the normalized difference vegetation index.

The fitting quality is quite high and that the simulated and genuine NDVI values coincide very well, with the correlation coefficient varying between 0.98 and 1.00. [17].

The accuracy of NDVI Converter mobile application differs by the studied crops, with the best accuracy provided for the cereals (MAPE is 16.23%), and the worse precision for the oilseed rape (MAPE is 46.61%). Generally, the values of MAPE for winter wheat and barley falls within the interval 10-

20%, so that it could be considered as a marker of good prediction [3]; while the MAPE 46.61% tells that the accuracy of NDVI modelling for oilseed rape is reasonable and should be used cautiously. The main reason of such an outcome could be in the difference of the crops' conditions at the moment of in-field screening: winter cereals had better winter resistance, therefore, their early-spring conditions were sufficiently better than of oilseed rape, which was partially damaged by frosts and diseases.

Table 1. Evaluation of NDVI Converter for assessment of the spatial vegetation index values

Crop name	R	R^2	MAPE (%)
Winter cereals	0.9949	0.9897	16.23
Winter oilseed rape	0.9853	0.9707	46.61

Source: The authors' own calculations.

Visualization of the comparison between the modelled and actual values of the NDVI revealed that the modelled index values tend to be less than the true ones (Figures 1 and 2).

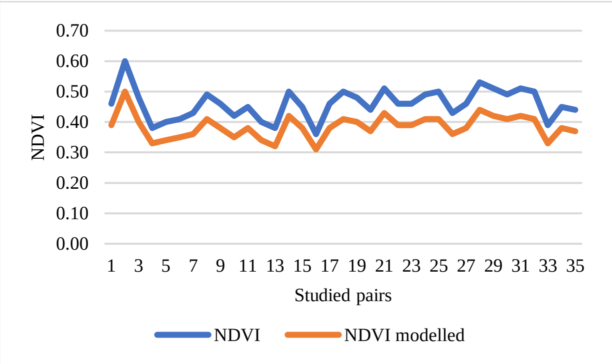

Fig. 1. Visual Evaluation of the NDVI Modelling Quality for Winter Cereals at the Stage BBCH 21-32
Source: The authors' own graphical work.

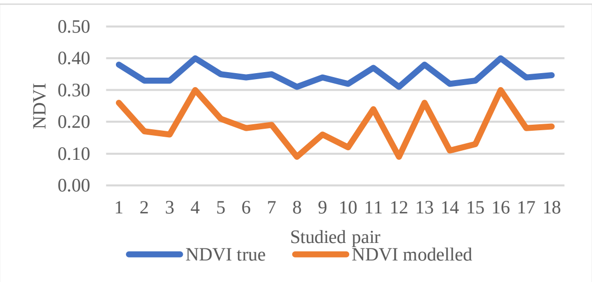

Fig. 2. Visual Evaluation of the NDVI Modelling Quality for Winter Oilseed Rape at the Stage BBCH 18-39
Source: The authors' own graphical work.

The greater discrepancy is observed for winter oilseed rape (the amplitude of the absolute error is 0.12), while the latter for winter cereals is slight (the amplitude is 0.05). The highest value of the absolute error for the oilseed rape crops was 0.22, and for the cereals – 0.10.

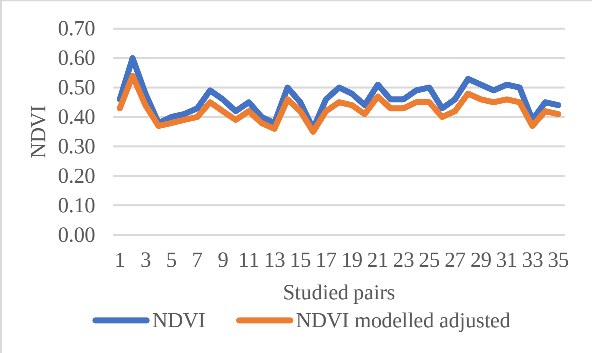

Fig. 3. Visual Evaluation of the NDVI Adjusted Modelling Quality for Winter Cereals at the Stage BBCH 21-3
Source: The authors' own graphical work.

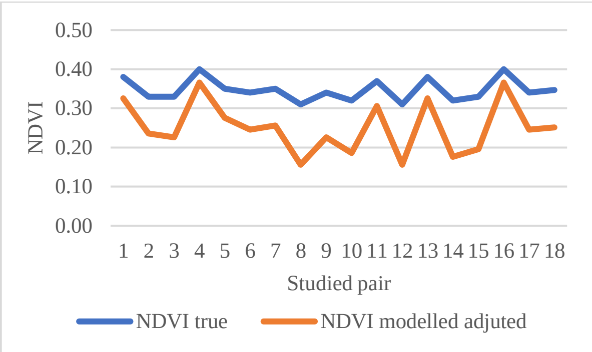

Fig. 4. Visual Evaluation of the NDVI Adjusted Modelling Quality for Winter Oilseed Rape at the Stage BBCH 18-39
Source: The authors' own graphical work.

Therefore, it should be noted that NDVI Converter's values of assessed vegetation index underestimate the real conditions of the crops' growth and development, and the adjustment for the estimation should be applied. In the intercourse of statistical estimation, it was established that the adjustment is to be performed by 0.07 NDVI score for oilseed rape, and by 0.04 – for winter cereals. After the adjustment, the precision of the modelled NDVI increased, and the MAPE changed to 27.62% for oilseed rape, and to 8.71% for winter cereals. The results of the visual evaluation of the adjusted models are provided in the Figures 3 and 4.

To sum up, the performance of NDVI Converter application seems to be good enough to provide reliable assessment of NDVI for the cropping areas, where for any reasons it is impossible to obtain direct ready-to-use spatial images.

The findings of the evaluation of the mobile NDVI Converter application are presented in our study for the first time. However, given the close relationship between the normalized difference vegetation index (NDVI) and crop yields, there are several studies in which writers endorse the idea of utilizing the fraction of green canopy cover (FGCC) as an input [7, 20]. It is interesting that some studies are devoted to the subject of reverse conversion between the green canopy cover percentage and NDVI, proving strong direct interconnection (determination index ≥75%) between the two indices [19]. However, some scientists claim that there is lack of evidence for using spatial index for canopy assessment and mapping, because of extremely low interconnection between them [6]. We believe that such a difference in the statements and scientific results could be put upon different methodological and technical approaches used, as well as different kind of vegetation, which has been put to evaluation in different studies.

To sum up, the NDVI Converter mobile application is an innovative and simple tool to assist current agricultural science and practice in reaping the benefits of crop modelling and monitoring through the mobile devices in geoinformation systems. It is free to use, as well as Canopeo mobile application, and requires no specific qualification or knowledge to be successfully implemented. Therefore, this mobile application may save costs and time of farmers, who are keen to try novel approaches in crop production with no economic risks and extra expenditures.

CONCLUSIONS

The results of the in-field testing of NDVI Converter mobile application revealed that the latter is a simple and reliable tool for the assessment of NDVI values at the fields, where this index cannot be obtained at spatial monitoring platforms and hubs. The fitting quality is very high, and the accuracy of the index estimation is good for winter cereals and reasonable for oilseed rape, so that to use it in the crop monitoring.

REFERENCES

[1]Akoglu, H., 2018, User's guide to correlation coefficients. Turkish Journal of Emergency Medicine, 18(3): 91-93.

[2]Anonymous, 2020, Oilseed Rape Growth Guide. AHDB Cereals & Oilseeds.

[3]Blasco, B.C., Moreno, J.J.M., Pol, A.P., Abad, A.S., 2013, Using the R-MAPE index as a resistant measure of forecast accuracy. Psicothema, 25(4): 500-506.

[4]Böttcher, U., Rampin, E., Hartmann, K., Zanetti, F., Flenet, F., Morison, M., Kage, H., 2016, A phenological model of winter oilseed rape according to the BBCH scale. Crop and Pasture Science, 67(4): 345-358.

[5]Fesenko, H., Averchev, O., Lavrenko, S., Avercheva, N., Lavrenko, N., 2022, Monitoring, assessment and development prospect of the cereal crop market in Ukraine, Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, Vol.22(2), 317-323.

[6]Ghorbani, A., Mossivand, A.M., Ouri, A.E., 2012, Utility of the Normalized Difference Vegetation Index (NDVI) for land/canopy cover mapping in Khalkhal County (Iran). Annals of Biological Research, 3(12): 5494-5503.

[7]Goodwin, A.W., Lindsey, L.E., Harrison, S.K., Paul, P.A., 2018, Estimating wheat yield with normalized difference vegetation index and fractional green canopy cover. Crop, Forage & Turfgrass Management, 4(1), 1-6.

[8]Jáuregui, J.M., Delbino, F.G., Bonvini, M.I.B., Berhongaray, G., 2019, Determining yield of forage crops using the Canopeo mobile phone app. Journal of New Zealand Grasslands, 81: 41-46.

[9]Lykhovyd, P.V., 2021, Forecasting oil crops yields on the regional scale using normalized difference vegetation index. Journal of Ecological Engineering, 22(3): 53-57.

[10]Lykhovyd, P.V., Vozhehova, R.A., Lavrenko, S.O., Lavrenko, N.M., 2022, The study on the relationship between normalized difference vegetation index and fractional green canopy cover in five selected crops. The Scientific World Journal, 2022, 8479424.

[11]Lykhovyd, P., Vozhehova, R., Lavrenko, S., 2022, Annual NDVI dynamics observed in industrial tomato grown in the South of Ukraine. Modern Phytomorphology, 16: 160-164.

[12]Mazzetto, F., Calcante, A., Mena, A., Vercesi, A., 2010, Integration of optical and analogue sensors for monitoring canopy health and vigour in precision viticulture. Precision Agriculture, 11: 636-649.

[13]Millar, N., 2001, Biology statistics made simple using Excel. School Science Review, 83: 23-34.
[14]Osinnii, O., Averchev, O., Lavrenko, S., Lykhovyd, P., 2022, Cost-effective and time saving method of phenological monitoring using satellite imagery in drip-irrigated rice. Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development, 22(4): 511-515.
[15]Pan, Z., Huang, J., Zhou, Q., Wang, L., Cheng, Y., Zhang, H., Blackburn, G.A., Yan, J., Liu, J., 2015, Mapping crop phenology using NDVI time-series derived from HJ-1 A/B data. International Journal of Applied Earth Observation and Geoinformation, 34: 188-197.
[16]Patrignani, A., Ochsner, T.E., 2015, Canopeo: A powerful new tool for measuring fractional green canopy cover. Agronomy Journal, 107(6): 2312-2320.
[17]Saigal, S., Mehrotra, D., 2012, Performance comparison of time series data using predictive data mining techniques. Advances in Information Mining, 4(1): 57-66.
[18]Satorre, E.H., Slafer, G.A., 1999, Wheat: Ecology and Physiology of Yield Determination. CRC Press.
[19]Tenreiro, T.R., García-Vila, M., Gómez, J.A., Jiménez-Berni, J.A., Fereres, E., 2021, Using NDVI for the assessment of canopy cover in agricultural crops within modelling research. Computers and Electronics in Agriculture, 182: 106038.
[20]Trout, T.J., Johnson, L.F., Gartung, J., 2008, Remote sensing of canopy cover in horticultural crops. HortScience, 43(2): 333-337.
[21]Ventura, F., Marletto, V., Traini, S., Tomei, F., Botarelli, L., Rossi, P., 2009, Validation of development models for winter cereals and maize with independent agrophenological observations in the BBCH scale. Rivista Italiana Di Agrometeorologia, 14: 17-26.