AUTOMATION, WEB PUBLISHING AND BIG DATA MANIPULATION OF NDVI, NDWI, PRECIPITATION AND TEMPERATURE ALONG WITH OTHER INFORMATION FOR FARMING AND CROP MONITORING LIKE GNSS SENSORS AND LIDAR/UAV DATA – PRECISE AGRICULTURE

AUTOMATIZAREA, WEB PUBLISHING ŞI MANIPULAREA INFORMAȚIILOR BIG DATA A DATELOR NDVI, NDWI, PRECIPITAȚII ŞI TEMPERATURĂ CORELATE CU ALTE INFORMAȚII PENTRU AGRICULTURĂ ŞI MONITORIZAREA CULTURILOR FOLOSIND SENZORI GNSS, DATE UAV ŞI LIDAR – AGRICULTURĂ DE PRECIZIE

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Abstract. *The study aimed to present the research and conclusions of process automation, web publishing, Big Data manipulation of some indices used in agricultural environment like NDVI, NDWI, precipitation and temperature along with GNSS Sensors with RTK data (precise position) and UAV with LIDAR and Multispectral. It is based on the data obtained using open source information from different satellites, UAV's. The data was processed using multiple OS environments and multiple programming solutions (Python, PHP, PostgreSQL). All the information must be assembled in to one simple solutions (web-based) along with other information like graphical display of crops, plots in lease and plots in property and other topographical information. The solutions was planned because in present day in Romania are multiple modules to get specific data and none to assemble all information in one place*

Key words: NDVI, NDWI, Temperature, precipitation, agriculture, crops.

Rezumat. *Prin acest studiu se doreşte prezentarea cercetărilor şi concluziile privin automatizarea anumitor procese, web publishing şi manipularea datelor mari (Big Data) a indicilor folosiți în agricultura de precizie precum NDVI, NDWI, precipitații, temperatură în corelare cu senzorii GNSS (folosind date RTK pentru poziție precisă) şi date UAV LIDAR sau multispectrale. Pentru obținerea datelor s-au folosit informații de tip open-source de la diferiți sateliți şi UAV-uri. Datele au fost procesate folosind multiple sisteme de operare (Windows şi Linux) precum şi folosind mai multe limbaje de programare (Python, PHP, PostgreSQL). Toate informațiile trebuie asamblate într-o soluție simplă (web-based) în strictă legătură cu informații grafice despre cultură, parcele în arendă şi în proprietate precum şi cu alte informații topografice. Soluția a fost gândită deoarece în România există multiple module dezvoltate*

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pentru diferite operații din agricultură dar nicio soluție nu leagă toate informațiile într-un singur mediu.

Cuvinte cheie: NDVI, NDWI, temperatură, precipitații, agricultură, culturi

INTRODUCTION

NDVI, NDWI, temperature and precipitation data are important indices in agricultural industry. These indices combined can be used in multiple departments or processes in a farm. From reducing the cost with fertilizer by variable application in field, to on spot disease identification, a farmer can monitor the crop in real time monitoring and can take decision a lot faster and in important moments of crop development. One of the big problem in Romania is the projection system used and projection system used by satellite data. In Romania is used Stereographic 70 projection system and satellite data from LANDSAT for example is WGS84 or UTM35. Another step is to manipulate the data. Satellite data are coming in spectral information (different bands with different wavelength) in brut (unprocessed) image formats. In present there is no web-based application to combine all important information in one place. According to world economic data, and agricultural data there is a massive request for crop analysis. Although not all farmers in Romania for example are not open minded to new digital technology or agricultural technology and they are not investing in maximizing crop production per ha. That's why Romania had in 2018 very low production per ha because of drought. Many farmers are still using Excel for keeping evidence, information about the crops, land plots in lease or in property. Even though they are using Excel for keeping track of data many of them are not using the full potential of functions in Excel and for example they can't even create a pivot data from a table because of the format of table structure. Using specific software for plots/crop management and tracking (textual and graphical) and using crop analysis tools a farmer can reduce costs in all departments of a farm and a farmer can distribute a human resource in another specific processing point in farm to gain value.

Using GNSS Sensors a farmer is able to use it on agricultural machines for automated machine control with high precision (1-2 cm). Using this system covering the whole country a farmer can implement auto-steering devices with high precision GPS and also can use it for variable fertilizer machines. The GNSS Sensors are capable to send RTK data correction to GPS mounted on agricultural or other type of machines.

Using LIDAR data along with UAV data the volume of information can be comprehensive to analyses a crop and make on time decisions. In this context this paper presents some solutions for farmers they can use. The paper explains the process used (automations, solutions used) to gain the results of NDVI, NDWI, temperature, precipitation, web mapping, plot management, RTK corrections or precise positioning system.

MATERIALS AND METHOD

In order to achieve results a identifications of solutions was needed. Based on the data from satellites (Landsat 8, Sentinel 2, MODIS) and UAV's a solutions was needed to process it and web publishing with a low time cost (time of processing and publishing) (Carlson and Ripley, 1997). Beside of a powerful server a solution for web publishing was found using OpenLayers, Geoserver and PostgreSQL (Peters *et al.*, 2002).

Also a discussions with famers was made for identifying the needs and requests for implementing land plot lease data and land plot property data.

The data was collected using open source web portals for search and download data from Sentinel, Landsat, MODIS.

Using GNSS Sensors a precise position was obtained with RTK correction data on spot identification in fields or even for measuring crops.

Using UAV with LIDAR or Multispectral cameras gain a plus in collecting data in various timeline of plant development. Also it complete the crop analysis because the satellite data (images) can be affected of clouds and a zone is collected by satellite 2 times a week or less.

RESULTS AND DISCUSSIONS

In order to obtain a web application for GIS Web in which to monitor crops and to manage a farm multiple processing steps and automated operations were made. For achieving results various programming languages were used (PHP, Python, VBA, Postgresql) and different OS were used (Windows, Linux, Jupyter Notebook).

Searching / Downloading / Processing NDVI, NDWI, temperature and precipitation data was partial automated. The principle or the process starts from the data uploaded by a farmer (SHP file with the geometry of the crop). Based on this information a Windows PHP algorithm starts to search in open source web portal (https://finder.creodias.eu/) for satellite data from Sentinel and Landsat by eliminating images that are over 20% cloud covered. MODIS (precipitation and temperature) are searched and downloaded from https://neo.sci.gsfc.nasa.gov/view.php?datasetId=MOD_LSTD_M. After the data is downloaded using Postgresql for database and PHP along with Python the satellite images are processed using the metadata of each image (azimuth, sun reflectance etc.). After the image was processed the NDVI and NDWI indices are calculated and uploaded as a TIFF raster in Postgresql. Processing time is smaller if the PC is more powerful and queries on server on TIFF raster for NDVI and NDWI are a lot faster if the images are uploaded with a 200x200 tile constraint. Querying a Raster with 200x200 tile is generating a faster results then other type of queries. A test was made by converting a TIFF raster with NDVI data to a polygon or point feature but the processing / uploading data was very slow and querying vector features was very slow. For a 50 ha crop the time needed to publish data to web map (fig. 1) was ~10 minutes and for a TIFF Raster is reduced to matter of seconds (fig. 2).

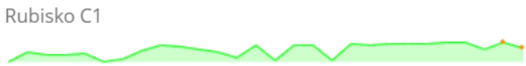

Fig. 1 Summary view of NDVI of a crop

Fig. 2 View of NDVI of a crop in map (green is good, yellow is medium)

Farm Management data (digital – textual and graphic) it could be used in tracking contracts or plots (leased or in property) (fig. 3). The lack of digitalization in agricultural sector or the lack knowledge in IT domain for farmers is a throwback for them. The implementation using PHP and Postgresql for plot management (web map) and contracts management (textual) was made using information from farmers and see what they are missing.

Fig. 3 View of crops on map (colorized by type of crop)

The ability for the farmer to get fast to all data for crop monitoring (fig. 4) with real time decisions or on time decisions can reduce costs and improve production per ha. The farmer can fertilize variable on all field or can go on spot to identify the problems in a crop (fig. 5).

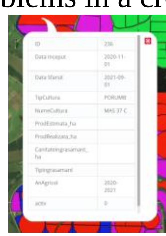

Fig. 4 View of information about a crop by clicking it on map

Fig. 5 View of NDVI/NDWI/temperature/Precipitation data of a field

Combined with the ability to manage the contracts and see graphical plots along with other information can also reduce costs for searching data, view data, get data faster.

The processing time was reduced for a user can see his data in real time and faster. For a 232 ha plot the time of getting NDVI or NDWI data is reduced at matter of seconds: ~2 seconds for a number of more then 22.000 small polygons with value and colorized. To achieve this reduced time various of processing types were used (fig. 6).

lessage Result1

row_number	geom	ndvi_category
1	0103000020E61000000100000	0.7000 - 0.8000
2	0103000020E61000000100000	0.7000 - 0.8000
3	0103000020E61000000100000	0.8000 - 0.9000
4	0103000020E61000000100000	0.8000 - 0.9000
5	0103000020E61000000100000	0.7000 - 0.8000
6	0103000020E61000000100000	0.8000 - 0.9000
7	0103000020E61000000100000	0.8000 - 0.9000
8	0103000020E61000000100000	0.7000 - 0.8000
9	0103000020E61000000100000	0.8000 - 0.9000
10	0103000020E61000000100000	0.8000 - 0.9000
11	0103000020E61000000100000	0.8000 - 0.9000
12	0103000020E61000000100000	0.8000 - 0.9000
13	0103000020E61000000100000	0.8000 - 0.9000
14	0103000020E61000000100000	0.8000 - 0.9000
15	0103000020E61000000100000	0.8000 - 0.9000
16	0103000020E61000000100000	0.8000 - 0.9000
17	0103000020E61000000100000	0.7000 - 0.8000

ELECT row_number() OVER () AS row_number, (((foo.gv).geom)) AS geom, CASE WHEN ((foo.gv).val BETWEEN -1 AND 0.2) THEN '0.0000 - 0.2000' WHEN ((foo.gv).val BETWEEN 0.2 AND 0.4) THEN '0.2000 - Read Only Query time: 0.607s Record 1 of 22529

Fig. 6 Time of processing and number of results (rows) from a query

Using NDVI data a farmer cand view where the crop is healthy or affected by diseases or natural phenomena. By having this data he can go on spot to identify the problem (fig. 7).

Fig. 7 NDVI data on crop (red is bad, green is good)

Also, using NDWI data (indices of water inside a plant) he can see where the plant has optimal water or not inside a field. A user can see even if two different hybrids uses less or more water (same cereal but different hybrid) (fig. 8).

Fig. 8 NDWI data on crop (blue – water is more present, yellow/red – water is less present in plant)

In figure 9 a farmer can see in left the NDVI data where it is shown that some area is less developed but in the right picture the NDWI value shows that the crop has a homogeneous amount of water (optimal). Based on this data a farmer should go in field to check if a diseases is present or a natural phenomenon occurred (wind flattened the crop to the ground).

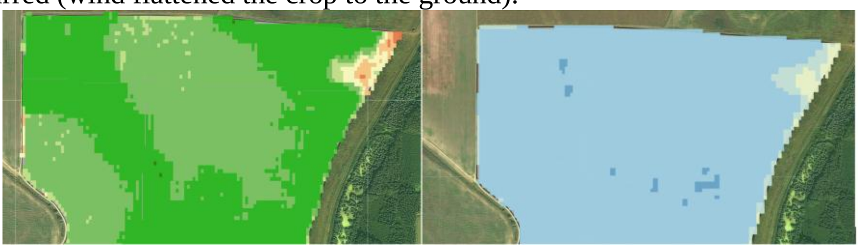

Fig. 9 NDVI and NDWI comparsion.

By using temperature and precipitation data along with cumulative temperature (cumulative temperature is calculated or summed only if the temperature is greater than 10 degrees) a farmer can make on time decisions and planning (he can increase the fertiliser capacity per ha or decrease) (fig. 10).

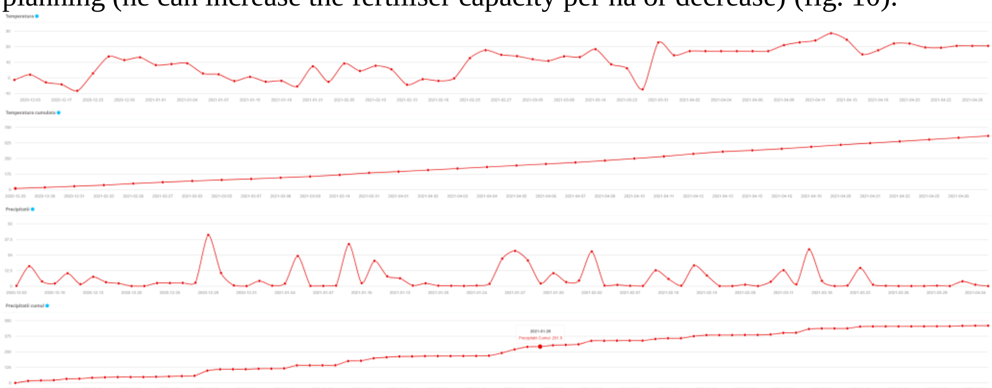

Fig. 10 Temperature / Precipitation data with cumulative information

After planning the day the farmer can input variable fertilisation data in his machine and using it with GNSS Sensor (fig. 11) RTK data can increase the position accuracy. Also the machine will be able with high accuracy to work on specific limits of field not wasting gas or fertiliser.

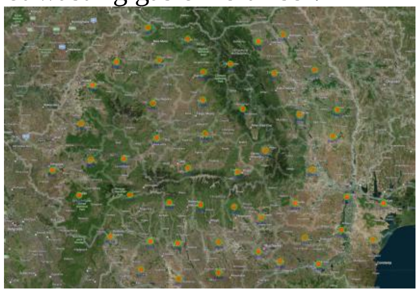

Fig. 11 GNSS Sensors Map

GNSS Sensors are installed in the whole country covering 95% of the working area. The software who process the data received from GNSS sensors is installed on a powerful server with high internet band connection. After processing the data it transmits the corrected RTK data to the user.

Name	Epoch ...	Epoch Number	Data Integrity	Receiving ...	Data delay
BARG-Prundu Barg...	14:00:10	36-403966-5951273-(32-G9-R7-...	100%-99%-98.8%	264(M)82136	146(ms)
VISE-Viseul de Jos				0(M)861	5983473(s
TILE-Tilecus Oradea	14:00:11	48-403980-5974997-(31-G9-R7-...	100%-99%-98.7%	62(M)183608	64(ms)
BOBO-Bobota	14:00:10	22-403964-5958875-(31-G9-R7-...	99%-99%-98.8%	140(M)36087	97(ms)
CERT-Certeze	14:00:10	27-400986-5960585-(31-G9-R7-...	99%-99%-98.8%	175(M)99353	62(ms)
VIMA-Vima Mica	14:00:10	35-403976-5767759-(30-G9-R7-...	99%-96%-98.4%	3599(M)13...	121(ms)

Fig. 12 GNSS Sensors Software

Connected via IP and port to GNSS Sensor server the GPS will get RTK correction data and the precision of the position will be around 1 or 2 cm.UAV data using LIDAR or multispectral data is highly useful because the Satellite data can be affected by clouds or the number of passing by (2 / week).

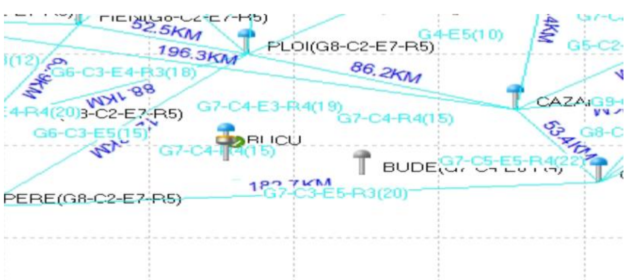

Fig. 13 GPS Position in map

This can be risky because it can have a whole month without satellite data which is very ineffective for a farmer. Using a UAV it means that the control is in operator of UAV.

He can go on field whenever is nice outside or when the farmer needs data in mandatory. Also the resolution obtained from multispectral camera or LIDAR can be 5 cm/ pixel which is more than 10 m / pixel from Sentinel who has the best resolution in present days for open source satellite data.

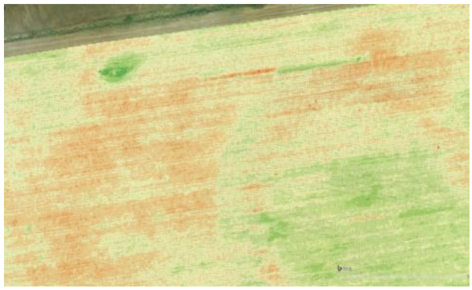

Fig. 14 UAV NDVI data

CONCLUSIONS

1. Developing and implementing all this solutions into one module or one application for precise farming / precise agriculture it's a plus for a farmer to develop itself. Because of the continuous digital development in agriculture mostly of farmers will stay behind and will think that farming is done on the field, watching the crop. Those farmers will disappear or will be taken by other farmers who invest in technology.

2. The cost per ha per year for implementing all these solutions will be significantly less then: fertilizing without a plan (variable), just to be sure the crop will be healthy; managing plots and contracts without automated or simpler data tables (search, view, keep tracking); not saving crops from diseases or natural phenomena by taking decisions in time and on time. The farmers will be more and more interested in UAV, LIDAR, Multispectral data from Satellite or drones

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