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GIS - BASED MAPPING OF GRASSLANDS AND OILSEED RAPES FOR ECOLOGICAL DATA MANAGEMENT - CASE IN BULGARIA

Zhulieta ARNAUDOVA, Tatyana BILEVA, Dimka HAYTOVA

Agricultural University of Plovdiv, 12 Mendeleev Blvd., Plovdiv, Bulgaria

Corresponding author email: julieta_arnaudova@abv.bg

Abstract

The purpose of STACCATO project (SusTaining AgriCultural ChAnge Through ecological engineering and Optimal use of natural resources) is to investigate the interactions between annual crops and surrounding landscapes in the light of ecological engineering as a tool for eco-functional intensification. Geographical Information system (GIS) was used in this study to map habitat types of indicator species according of the project protocol around semi-natural grasslands and oilseed rapes in Bulgaria target field sites. Recording system of habitats and the database is performed as outlined and reclassified the available areas and objects in polygon, linear and point elements. The permanent land use categories or type of vegetation has been recorded by EUNIS habitat classification or redefined in accordance with the proposed method.

Key words*: ecological management, GIS, grassland, habitat mapping, oilseed rape.*

INTRODUCTION

In order to advance long-term sustainable development of land use systems, against risks arising from multiple aspects of global change, STACCATO project (SusTaining AgriCultural ChAnge Through ecological engineering and Optimal use of natural resources) aims to quantify the dependence of ecosystem functions (ESF) and the services (ESS) they generate on environmental pressures in representative agriculturally dominated landscapes in Europe. The focus is on local and regional land use intensity (including the socio-economic background) and biodiversity, and the potential impacts of future climate and land use change.

Action 5 of the EU Biodiversity Strategy to 2020 called Member States to map and assess the state of ecosystems and their services in their national territory with the assistance of the European Commission. The results of this mapping and assessment should support the maintenance and restoration of ecosystems and their services (Maes, J. et al., 2013).

The field site network (FSN) was established, based on the selection of paired sites with different land use intensity (crop dominated vs. high shares of semi-natural sites) across Europe.

Case study regions for the assessment of the interactions between annual crops and semi-natural grasslands and surrounding landscapes for ecological engineering are from the participating countries: Germany (Saxony), Switzerland, Sweden (Uppsala), Romania (Transylvania), Bulgaria (South Bulgaria).

Design of field site network

In each country, the field site network was identified of 10 **F**ield **S**ites (FS). Each site consists in pair of one semi-natural grassland field (grazed or mown, depending on what is most common in the region) and one field with autumn-sown oilseed rape. Project team defined semi-natural grasslands as grasslands that are permanently (minimum estimated age 30 years) not fertilized, not tilled and not improved by sowing. The grasslands can have a more or less dense cover of shrubs and trees. The maximum distance between the grassland and the oilseed rape field should be 500 m and the minimum distance should be 100 m.

The 10 sites are situated along a gradient from low (0%) to high (~20%) semi-natural habitats in the surrounding landscape, here defined as a buffer of 500 m from the edge of the focal grasslands and crop field. The minimum distance between sites should be 2 km (Figure 1).

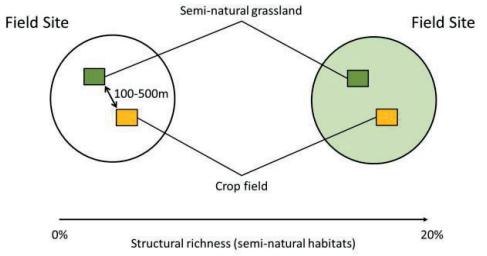

Figure 1. Design of field sites network

General characterisation of the FSN:

Abiotic parameters

FS: Landscape structure: based upon aerial photography and/or remote sensing data, both contemporary and historical, to assess urbanisation and soil loss trends; Data collection about geology, relief, climate and soils from available sources; Small-scale climate data: based upon statistical downscaling methods.

TF: Landscape structure: 50-200 m radius around TF; field mapping of crops (i.e. recording what crops are actually grown within certain radii around the TF).

Questionnaires on socio-economic frame conditions

FS: Household/family/production structure, yields, agricultural inputs and outputs including pesticide and fertiliser use, land ownership/use rights structure, competing/complementary land uses, market integration, income sources and level, land use intensity, landscape value criteria

TF: Income sources and expenditures, agricultural input expenditures, income structure and level, spending priorities, dominant sources of information, aspirations/priorities for change and for conservation, decision driving forces (tradition, state regulation, religion, gender roles), future development plans (some elements are repeated in FS and TF as more general data on the FS level can be used as basis for the information on the surrounding conditions) (http://staccato-project.net/).

The purpose of this study's to present habitat types selection and mapping according of project protocol around grassland and oilseed rape in Bulgaria by Geographical Information system (GIS).

MATERIALS AND METHODS

Study area

According to the field protocol, ten field sites were selected in 2 regions (Plovdiv and Haskovo) from South Bulgaria - Dobrich, Kostievo, Malak Cherdak, Momino selo, Radinovo, Stalevo, Stryama and Zelenikovo (Figure 2)

These sites represent the semi-natural grassland gradient in surrounding landscape.

For the purposes of this study, the timing of the habitat mapping is not linked to growth stages of oilseed rape. The data for land cover (LC) and land use (LU) are generated from land classification according to Bulgarian cadastral register and filed identification.

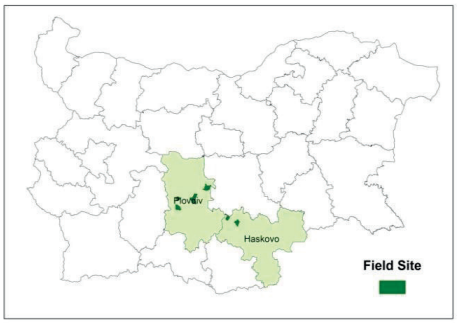

Figure 2. Selected field sites in Bulgaria

For the field database recording were used GNSS Trimble JUNOSB with a portable version ArcPad 10.0 and ArcGIS 10.0.

The sites data layer was overlaid into the Web-based satellite ArcGIS World Imagery by ESRI.(ESRI World Imagery)

Techniques for generating a land classification from raw data bottom-up approach can draw on existing methods used in geographical disciplines and allow flexibility in adapting the land classification to the specific research question (Hahs & McDonnell, 2006; Owen et al., 2006; Samuelson & Leadbeater, 2018).

The protocol involves manual generation of a land cover map based on visual inspection and using existing data layers to increase flexibility in selecting resolution, allow later combination with ground survey data.

Cadastral maps of the selected regions and field sites regions were used.

It was used European Terrestrial Reference System 1989 (ETRS89, EPSG:4258) as coordinate system following the "INSPIRE Data Specification on Population Distribution - TechnicalGuidelinesguideline" (http://spatialreference.org/), (http://inspire.ec.europa.eu/id/document/tg/pd).

Habitat mapping and Land Cover (LC)

The mapping protocol was inspired by the guidelines for habitat mapping and recording developed by the "European Biodiversity Observation Network" (EBONE) but it was simplified and adjusted for the needs of the project (Bunce R.G.H. et al., 2011).

The key concept is as follows:

• The habitats of the surrounding and connecting landscape of pair the oil-seed rape field and the grassland are mapped in a buffer of 500 m surrounding the oilseed rape and the grassland (Figure 3).

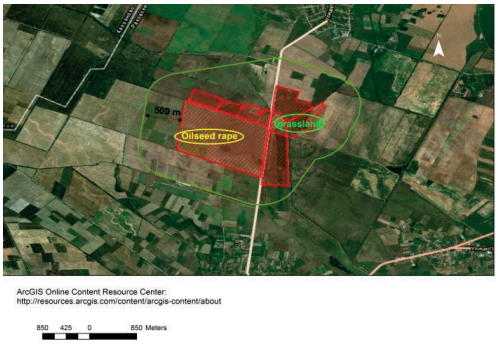

Figure 3. Illustration the steps of land cover for 500 m radii around the field sites

• In order to have a consistent vegetation classification, it should be follow the classification of habitats from the European Nature Information System (EUNIS) down to the third level of classification (EEA Habitat types, EEA, 2017).

• LU classification system and type of vegetation in Bulgaria, which can be used at the recording state as long as each local vegetation type can be assigned a EUNIS habitat.

Record the habitat type of:

Areal elements with an area > 400 m^2 with a minimum dimensions of 5 x 80 m (elements that smaller in extent, and/or are less than 5 m wide are recorded as linear or point elements);

Linear elements longer than 30 m and wider than 1 m according to the predefined list:

- lines of trees (LTR);
- hedges (HED);
- species Rich Hedge (SRH);
- lines of scrub (LSC);
- dry stone wall (DSW);
- water edges (WAT);
- herbaceous strips (HST);
- grass strips (GST);
- annual strip (ANN);
- walls (WAL);
- banks (BAN);
- tracks (TRA);
- roads, sealed compared to tracks (ROA);
- lines of sparse vegetation (LSV).

Point elements if landscape elements do not fulfil the areal or linear requirement (i.e., are smaller than 400 m^2, shorter than 30 m, or less than 1 m wide) following the EUNIS habitat types and the list of linear elements.

The protocol to map habitat types consists of three phases (Figure 4).

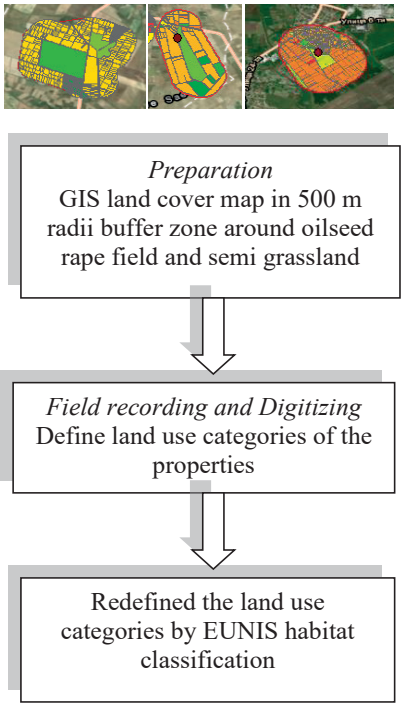

Figure 4. Phases of habitat mapping

RESULTS AND DISCUSSIONS

Selecting of the research field sites

The start of data acquisition from Bulgarian field sites started in Spring 2018.The reason was that in Bulgaria, autumn 2016 and spring 2017 were exceptionally dry, which hampered the successful establishment of oilseed rape plants.

New surveys have been made with cooperation the Municipal agricultural services in South Bulgaria to selected other study field sites like a pair - crop field (oilseed rapes) and semi-natural grasslands. Unfortunately, it was impossible to locate all of the research fields according to proposed methodology. The reason was the poor communication and information of the local agricultural services with landowners.

Table 1. Field sites in South Bulgaria

FS	LU	Villages	Coordinates	Gradient
1	grassland	Kostievo	N 42°10'28.6" E 24°36' 49.7"	5%
	rape	Kostievo	N 42°10'19.0" E 24°36' 48.3"	
2	grassland	Zelenikovo	N 42°22'50.1" E 25°04' 43.4"	5%
	rape	Zelenikovo	N 42°22'44.8" E 25°04' 48.1"	
3	garssland	Dobrich	N 42°01'09.3" E 25°32' 08.1"	5%
	rape	Dobrich	N 42°01'24.3" E 25°32' 08.2"	
4	grassland	Stryma	N 42°14'56.6" E 24°51' 02.3"	10%
	rape	Stryma	N 42°15'14.8" E 24°50' 53.5"	
5	garssland	Zelenikovo	N 42°23'49.4" E 25°03'08.7"	10%
	rape	Zelenikovo	N 42°23'47.0" E 25°02' 57.5"	
6	garssland	Momino Selo	N 42°17'39.7" E 24°52' 59.3"	20%
	rape	Momino Selo	N 42°17'30.8" E 24°52' 50.8"	
7	grassland	Malak chardak	N 42°16'53.2" E 24°37' 52.8"	20%
	rape	Malak chardak	N 42°16'47.1" E 24°37' 31.9"	
8	garssland	Stalevo	N 42°03'22.7" E 25°23' 25.5"	20%
	rape	Stalevo	N 42°03'15.2" E 25°23' 28.9"	
9	grassland	Radinovo	N 42°11'12.7" E 24°38' 22.4"	100%
10	Rape	Malak chardak	N 42°16'45.4" E 24°38' 47.4"	0%

Eight of the new field sites were selected to meet the requirements of the protocol and to be situated along a gradient from low (0%) to high (~20%) semi-natural habitats in the surrounding landscape (Table 1).

For the purpose of the project Bulgarian team selected two new field sites, only one TF with a gradient 0% (oilseed rape) and 100% grassland. Table 1 shows the name of villages, gradient and focal coordinates of the target fields.

Habitat mapping

In this study are indicated some of investigating field sites which are more specific and representative.

Region village Radinovo

Habitat mapping in this buffer zone is only determined by the presence of semi-natural grassland. One of main characteristic is proximity to two settlements - Radinovo and Kostievo. Total area for mapping is 160.3 ha. The area of the target grassland site is 11.2 ha.

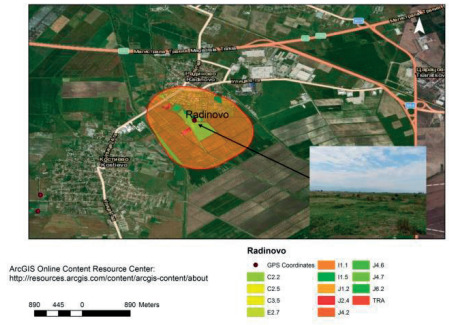

Figure 5. Map of habitats around field site villages Radinovo

Redefined land use and vegetation by EUNIS classification in the buffer zone (Figure5):

C2.2: Permanent non-tidal, fast, turbulent water courses;

C2.5: Temporary running waters;

C3.5: Periodically inundated shores with pioneer and ephemeral vegetations;

E2.7: Unmanaged mesic grassland;

I1.1: Intensive unmixed crops;

I1.5: Bare tilled, fallow or recently abandoned arable land;

J1.2: Residential buildings of villages and urban peripheries;

J2.4: Agricultural constructions;

J4.2: Road networks;

J4.6: Pavements and recreation areas;

J4.7: Constructed parts of cemeteries;
J6.2: Household waste and landfill sites;
TRA: Tracks.
As a result of classification 61% of total area is Intensive unmixed crops and 17.7% - Residential buildings of villages and urban peripheries.
Land surrounding the grassland sites in this buffer was dominated by arable agricultural fields and residential buildings in the immediate vicinity of the research area within a rural landscape.
Region village Kostievo
Habitat mapping in this buffer zone is determined by the presence of oil-seed rape and grassland with a gradient of 5%.
The target fields are very close to the village Kostievo. The area of grassland and oil-seed rape are respectively 24.5 ha and 21.3 ha. Total area for mapping is 367.8 ha.

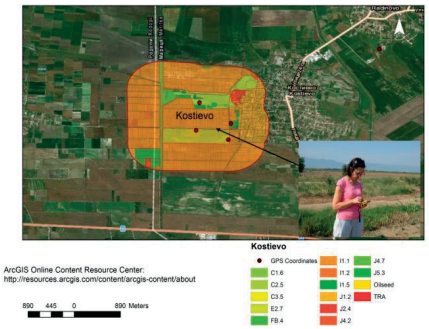

Figure 6. Map of habitats around field sites villages Kostievo

Redefined land use and vegetation by EUNIS classification (Figure 6):
C1.6: Temporary lakes, ponds and pools;
C2.5: Temporary running waters;
C3.5: Periodically inundated shores with pioneer ephemeral vegetations;
E2.7: Unmanaged mesic grassland;
FB.4: Vineyards;
I1.1: Intensive unmixed crops;
I1.2: Mixed crops of market gardens and horticulture;
I1.5: Bare tilled, fallow or recently abandoned arable land;
J1.2: Residential buildings of villages and urban peripheries;
J2.4: Agricultural constructions;
J4.2: Road networks;
J4.7: Constructed parts of cemeteries;
J5.3: Highly artificial non-saline standing waters;
TRA- Tracks.
Similar to the mapping in the previous field site in Radinovo, the largest percentage of the area was occupied of Intensive unmixed crops - 60.6%, Residential buildings of villages and urban peripheriesare 8.6% (Figure 7).
Region villages Momino selo

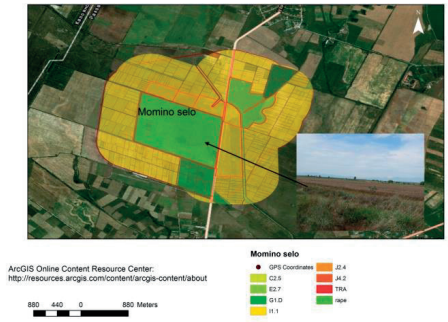

Figure 7. Map of habitats around field sites villages Momino selo

C2.5: Temporary running waters;
E2.7: Unmanaged mesic grassland;
G1.D: Fruit and nut tree orchards;
I1.1: Intensive unmixed crops;
J2.4: Agricultural constructions;
J4.2: Road networks;
Rape: oil-seed rape;
TRA: Tracks.
The region is characterised irrigated arable land and cereals crops.
Region villages Zelenikovo
In this region are selected two field sites. The area is a very interesting and specific with regard to vegetation and land use.
The village of Zelenikovo is located on the Southern slopes of the highest part of the Eastern Sredna Gora Mountain. It is part of Brezovo municipality. The terrain of the regions from flat to mountain. Total habitat mapping area for two researched fields sites are respectively 337.4 ha and 247.4 ha.
The following habitats were mapped and identified in the two regions (Figure 8):

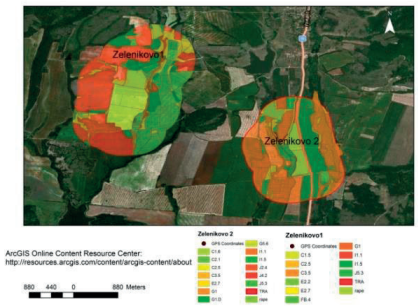

Figure 8. Map of habitats around field sites villages Zelenikovo

C2.1: Springs, spring brooks and geysers;
C2.5: Temporary running waters;
C3.5: Periodically inundated shores with pioneer and ephemeral vegetations;
E2.2: Low and medium altitude hay meadows;
E2.7: Unmanaged mesic grassland;
FB.4: Vineyards;
G1: Broad leaved deciduous woodland;
G1.D: Fruit and nut tree orchards;
G5.6: Early-stage natural and semi natural woodlands and regions;
I1.1: Intensive unmixed crops;
I1.5: Bare tilled, fallow or recently abandoned arable land;
J5.3: Highly artificial non-saline standing waters;
TRA: Tracks.

The analysis of the habitats in the two sites in Zelenikovo village presents a wide variety of vegetation and permanent land use. This is due to the proximity of the mountains to the field sites and the availability of forest vegetation.

The percent of the forest and perennials vegetation are 26.5% and 12.5% in the two zones. At the same time the percent of abandoned lands and early stage natural and semi natural vegetation are high.

This has a very positive impact on the habitats of indicator species.

CONCLUSIONS

Climate change and drought in the period from the start of the project adversely affect the development of the selected oil see drape, which has hampered the project work.

In 2018, 10 new field sites were selected in South Bulgaria. Analysis was performed for 5 of the selected field sites with specific and representative habitats.

The results of this mapping and evaluation should support the maintenance and restoration of ecosystems and their services for environmental management. This will help to analyze the dominant agricultural landscape and the potential impacts of future changes and land use.

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