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Introduction

Conducting land consolidation within an area where agricultural land has the largest share is of great importance. Current practice of enforcing land consolidation was focused upon achieving favorable conditions for agricultural production, simultaneously leading to negative effects related to the environment, wildlife and native species. The aim of land consolidation is achieving favorable conditions for agricultural production, which can be obtained through the grouping of properties and the formation of larger plots of proper shape. In order to accomplish these effects, barriers which might interfere with agricultural operations (e.g. forest vegetation and non-functional amelioration canals) must often be removed. Especially drastic measures of clearing the terrain are required if mobile equipment for irrigation is planned on new plots. However, in the context of the integral land consolidation both effects can be achieved, i.e. improved conditions for agricultural production, as well as positive effects related to the environment.

Vojvodina is a northern province of Serbia where 76% of arable land is exploited in agriculture, while forested areas cover only - about 6% (Marković and Tatalović, 1995). The implementation of land consolidation, in most of cases led to even more reduced presence of non-forest vegetation within the area. During implementation of the measures, the regulation was mainly done by removing non-forest vegetation. Compensation for non-forest vegetation, or segregation area for afforestation, in most cases has not been included in the project design. During the second half of the last century, more than 56% of the territory in Vojvodina has been regulated by applying land consolidation measures (Damjanović and Benka, 1994). Unfortunately, the implementation of land consolidation measures was focused mostly upon establishing favorable conditions for intensive agricultural production and often led to reduction of non-forest vegetation. Nowadays, forested areas within arable land, where intensive agricultural production is applied, cover only 1.5 % (Letić et al., 2001).

Due to unilateral approach of land consolidation, later efforts were focused upon improving environment by planning implementation of subsequent measures - raising windshield forest belts. The paper presents the results of the

analysis of spatial representation, distribution and interconnectivity of non-forest vegetation within an area where land consolidation was performed. Outcome of these measures was compared to the situation after introducing windshield forest belts.

Background

Non-forest vegetation, within the area where intensive agricultural production is applied, significantly improves biodiversity. Fragmentation generally results in a landscape that consists of remnant areas of native vegetation surrounded by a matrix of agricultural or other land (Saunders et al., 1991). In the area where presence of agricultural land is high, field margins, other uncultivated areas, small water bodies covered with natural vegetation, together with windshield shelterbelts and other forms of non-forest vegetation present oases of wildlife. Their survival on agricultural land is threatened especially on a large complex of agricultural land; where various agrochemicals are used for cultivated plants, while other plant species are considered weeds and animal pest species.

Areas under non-forest vegetation can be of point, line or surface type. Point structures such as single tree or very small areas under trees or shrubs are generally of no great significance, except they contribute mostly to the breakage of the monotonous visual outlook of landscape. Surface structures such as areas under the trees, bushes and water usually have the greatest ecological importance, but these are poorly represented within the area where intensive agricultural production exists. Within an agricultural area the most common type of non-forest vegetation are lined structures, such as vegetated boundaries and field margins, windshield belts and green areas surrounding the water bodies. The presence of non-forest vegetation within an area with a high percentage of arable land provides many benefits such as: soil protection from harmful effects of wind and water erosion; protection of soil from excessive drying and microclimate regulation; protection from dust and noise; shelter for other plant and animal species and biodiversity support and contribution to the visual appearance of the landscape, etc.

As linear features, field margins are also thought to act as corridors for the movement of fauna and possibly flora (Marshall and Moonen, 2002). Connectivity of habitat patches within a landscape has therefore become a key issue in the conservation of biodiversity (Davies and Pullin, 2007). Although the implementation of land consolidation is primarily intended for the improvement of conditions for agricultural production, some areas might be planned simultaneously for non-forest vegetation. Areas under non-forest

vegetation can be integrated into a network of green corridors, which could mitigate the effects on the environment caused by the intensive agricultural production, use of pesticides, monocultures covering large surfaces, etc.

Goals and objectives

The aim of this study was to examine the representation, spatial distribution and connectivity of non-forest vegetation within the area where the process of land consolidation has been completed. In the case of land consolidation in the municipality of Ada the objective was to perform the grouping of agricultural parcels and the formation of large plots of land, free of obstacles and suitable for the installation of the irrigation system. However, the project of land consolidation did not take into consideration distribution and representation of non-forest vegetation. After the implementation of the project, negative effects began to emerge, which were in relation to the absence of non-forest vegetation. Therefore, afforestation was partly conducted, but with no satisfying results. In order to solve the problem, a new project for windshield shelterbelts was prepared, but it has not been realized. This paper examines a potential beneficial effect of raising windshield shelterbelts according to the proposed project. Another objective is to emphasize that the potentials of land consolidation were not utilized enough. Method of land consolidation is suitable for solving complex problems in a particular area, including the presence of non-forest vegetation and creation of green corridors, simultaneously with achievement of other objectives such as the grouping of parcels, implementation of drainage, irrigation, etc.

Method

In the area with a large percentage of agricultural land, the areas under non-forest vegetation are very valuable. Areas vegetated with vegetation may include forests, alleys and windbreaks, field margins covered with native plants, grassy areas, water bodies, i.e. drainage canals and their banks. However, forested areas are the most important. Besides, even vineyards and orchards, which are not cultivated intensively, could be considered as non-forest vegetation. Problem of representation of non-forest vegetation can be analyzed in several ways. The simplest way is to identify areas that can be assumed as non-forest vegetation and to find the ratio of the total surface of non-forest vegetation and the total surface of other utilization patterns including the agricultural one. This relationship represents the so-called quantitative index of ecological stability (Klementova, 2005; Rybarsky, 1985). Since none of the existing forms of non-forest vegetation contributes equally to the overall ecological stability of the area, the presence of non-forest vegetation can be assessed taking into account the type of vegetation and using

appropriate index. According to Klementova (2005), observed area is divided into smaller parts with different patterns of utilization. In addition, the area of every part is multiplied by the index defined for such pattern of land use. The natural forms of landscape have the highest value of the index, while urban and arable lands have the lowest values. Although these methods for evaluation of non-forest vegetation spreading can provide some general idea, neither the distribution of these areas, nor the present forms of non-forest vegetation can be determined. Besides, they do not give information about their interconnectivity.

The existence of parts, within the study area, without non-forest vegetation is possible to determine by measuring distances between certain parts of the area and the nearest area covered with non-forest vegetation. Using geographic information system (GIS) during the planning of spatial distribution of windshield shelterbelts, it is possible to arrange them within the area and to satisfy the request of being at certain distances from already existing non-forest vegetation. Areas under non-forest vegetation, with respect to their geometrical characteristics, can be classified as point, line or surface structure. Within agricultural areas, surface structures are the most valuable, but they cover the smallest surface. Line structures are much more common in agricultural areas. Using GIS, based on the geometric characteristics, the mentioned small areas can be designated as point structures. Areas with high value of diversity index (Patton, 1975) can be extracted as lined structures.

If the structures of the non-forest vegetation are predominantly of lined and surface type, it is preferable for them to be connected into a network of green corridors. Interconnectivity of the structures can also be determined using GIS, by measuring the distance to the nearest structure of non-forest vegetation.

Results and discussion

The paper examines a striking example of land consolidation and removing barriers in Ada municipality during the 70s in the past century. During the process of planning, irrigation system was established covering 3000 ha. Prior to the construction of the irrigation system a complete clearing of the area has been performed. Shortly after the implementation of these measures negative effects began to emerge: microclimate changes - increased drying out of land and the occurrence of wind erosion, reduced wildlife, devastated landscape, etc. Due to the perceived problems during the 90s reforestation of selected areas was carried out. Unfortunately, reforestation was not carried out within the area under irrigation system. In order to comprehensively address the lack of non-forest vegetation, a new project was proposed for raising agri-protection forest belts in 2006.

This project represents an attempt to solve the problems of lack of non-forest vegetation in the area where the land consolidation was already performed. Concerning the fact that prior to composing of the new project the land consolidation was already performed, in the preparation of the project there were some limitations, e.g. the routes of existing field roads, along which are designed windshield shelterbelts. Unfortunately, an opportunity was missed related to planning of a network of windshield shelterbelts within the project of land consolidation, where the routes of windshield belts could have been implemented in the most optimal locations. Unfortunately, the project of raising non-forest vegetation has not been realized so far.

In this article a spatial analysis of the presence of non-forest vegetation has been performed in Ada municipality. The current state of non-forest vegetation after partial reforestation has been examined and compared to the situation proposed by the project of raising windshield forest belts. Spatial analysis included: coverage of the investigated area with non-forest vegetation; coverage according to the type of structures of non-forest vegetation; the interconnection of structures and uniformity of spreading within the area. Besides, consequences of raising agricultural protective networks have been considered regarding effectivity of soil tillage. A GIS tool has been used for spatial analysis. Necessary data for analysis were taken from satellite imagery, cadastral plans and the project for raising the windshield forest belts.

Spatial analyses conducted on investigated area showed a small coverage under non-forest vegetation of 5.04% (Table 1). Mainly point, line and surface structures have been indentified (Table 1) which are loosely coupled and unevenly distributed within the area, while within the area under irrigation system these structures are completely missing (Figure 1, Table 1).

Such coverage, uneven distribution and poor interconnectivity of non-forest green structures can be linked by the above mentioned negative phenomena within this area (land drainage, the occurrence of wind erosion, reduced wildlife, etc.). These effects are still present despite the partial reforestation conducted in 90s during the last century, because afforestation was not conducted on the entire territory of the municipality.

The results are showing that in the case of realization of the project of raising agricultural protection forest belts, the presence of primarily lined structures of non-forest vegetation would significantly increase up to 8.8% (Table 1).

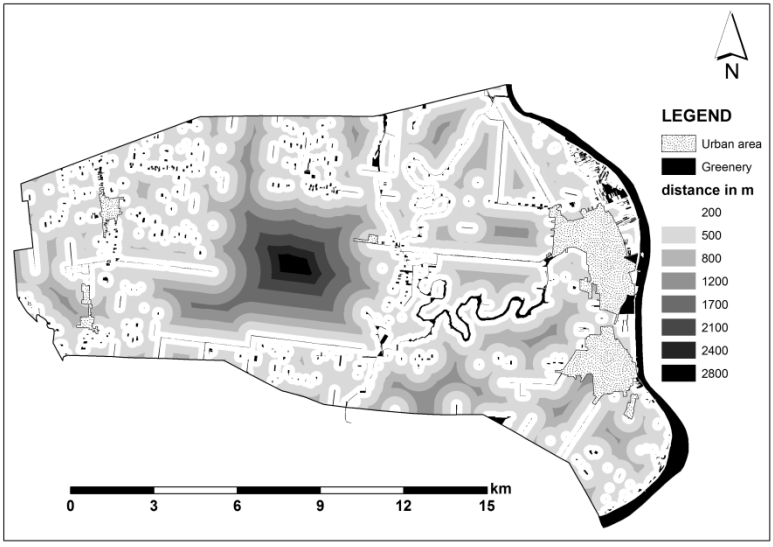

Figure 1. Uneven distribution of non-forest vegetation in Ada municipality

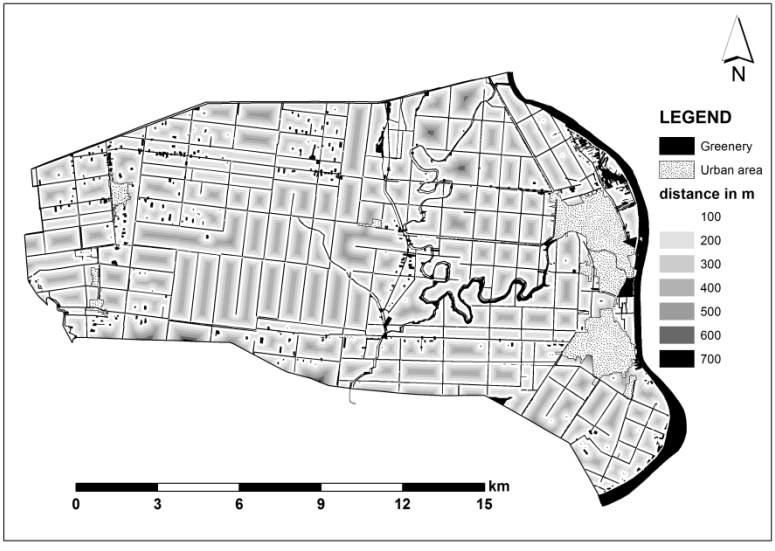

Figure 2: Distribution of non-forest vegetation according to the project of windshield forest belts

Besides, the structures would be better connected and more evenly distributed across the area, representing a network of green corridors (Figure 2, Table 1). However, the implementation of the project of agri-protection forest belts would reduce effects caused by the land consolidation. Impairing effects would

be reflected in the difficulty of access to plots, because of setting vegetation along field roads. Furthermore, a certain arable area would have to be reduced in favor of setting new vegetative structures. Planning of agri-protection networks after completing the land consolidation process leaves only space along field roads which is not always perpendicular to the direction of the dominant wind. Finally, distances between vegetation are not always optimally adjusted in order to protect all agricultural land between two belts.

Table 1. Present state of non-forest vegetation (A) and the situation in case of implementing the project of raising agri-protective belts (B)

	A - Present state	B –potential state
Total area of non-forest vegetation	1132 ha (5.04%)	1823 ha (8.11%)
Quantitative index ecological stability	0.039	0.098
Qualitative index ecological stability	0.176	0.217
Maximum distance from non-forest vegetation	2800 m	800 m
% of area with more than 500 m distance to non-forest vegetation	28.4%	0.01%
Number of point / linear / surface structure	112 / 212 / 602	111 / 599 / 621
Total area of point / linear / surface structure in ha	0.6 / 833 / 298	0.6 / 1520 / 300
Number of isolated structures (over 100 m to next structure)	182	66
Total area of isolated structures (over 100 m to next structure)	75 ha	2.3 ha

During the process of land consolidation an opportunity was missed to integrate a network of agricultural shelterbelts. I this case in a comprehensive manner a network of windshield belts areas could have been harmonized with a network of field roads, drainage canals and other facilities in the area, in order to achieve optimal effects for all the measures envisaged.

Conclusion

Land consolidation is a powerful measure that regulates and improves conditions for agricultural production, but may negatively reflect to the wildlife within the area, if it requires loss of any kind of native vegetation. The paper examines all negative effects and obstacles which may arise in situations when green corridors are planned apart from land consolidation, which was the

case in Ada municipality. Application of GIS and spatial analysis for distribution of non-forest vegetation allows a comparison of the situation before the implementation of the land consolidation and after its completion. Besides, it enables comparison of the effects of multiple variants in order to choose the most optimal one and therefore, to integrate non-forest vegetation in the land consolidation process.

In that way, benefit would reflect on stability and sustainability of agricultural landscape and production, and at the same time, the improved conditions for sustaining wildlife and biodiversity would be achieved. Mutual co-ordination of the envisaged measures, as opposed to the subsequent implementation of partial measures, in the process of land consolidation can result in optimal effects.

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