CALCULATION AND LONG TERM PREDICTION OF CARBON STOCKS FOR THE ARABLE LANDS OF KARCAG

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Abstract

Agriculture is in direct relation with environment so it has strong effect on it and in parallel the state of nature basically determines the characteristic and efficiency of agricultural activities. Intensity and impact areas of process resulted environmental changes have wide range spatial and time variability (Kreybig, 1946). Agri-environmental schemes has key role in agriculture related environmental activities by the motivation of farmers to implement sustainable and good agricultural practice. To detect these effects, use of indicators and indices are required. In 1994 OECD set up DPSIR model (Driving forces-Pressure-State-Impact-Response) which helps to analyse and highlight anthropogenic originated environmental cause-and-effect relationships. This is confirmed by official statement of European Commission that highlighted the role of environmental indicators in communication (Smeets és Weterings, 1999).

GIS evaluation works, predictions based on IPCC method and Corine CLC surface cover vector database 2006 in Karcag area.

State indicators were used to get information about positive or negative effects of Land use categories. Based on both IPCC method and Agrotopo map database, soil reference carbon stock was estimated at Karcag area. Agri-environmental friendly solution and prediction were made on agricultural practice and how to change land use.

Consequently it is recommended at Karcag area the conversion of one part of arable land with conventional tillage into energy saving conservation systems affects carbon stocks. In addition application of mulch technology and (or) supplemental organic matter are necessary as well. On poor areas with solonec soil a recommendation to change land use was given.

Key words: (maximum 6): land use, carbon stock, IPCC method, agri-environmantal indicators

INTRODUCTION

Agriculture is in direct interaction with environment as the part of a natural system. So it has strong effects on nature. However, the characteristic and efficiency of agricultural activities are entirely determined by elements and state of nature. Agricultural plant production has plenty of environmental pollution and at the same time, it could contribute to agriculture environmental protection.

The most important reserve of C in agricultural ecosystems is held in soil organic matter (Janzen, 2004). However, the importance of organic matter is not only related to its nature of “C source” and “C sink”, but also it influences many ecosystem functions such as water retention, resistance to degradation and erosion, nutrient provision for plants and regulation of soil biological activity (Martinez et al., 2008; Powlson et al., 2011). Hence, the increase of soil organic carbon (SOC) levels in agricultural systems generates "win-win" situations because its imultaneously reduces CO_2 levels and enhances fertility, productivity and resilience of soil (Freibauer et al., 2004; Ogle et al., 2004; Paustian et al., 2004).

Soil organic carbon (SOC) represents the largest terrestrial organic C pool and globally contains over 1550 Pg C (A Pg is equal to 1015 g or 1000 million metric tons) (Lal, 2008). Conversion of natural ecosystems to agriculture is known to cause large losses of SOC (Lal, 2005; Van der Werf et al., 2009; Yan et al., 2012). Globally, 24% of the SOC stock has been lost through the conversion of forest to cropland (Murty et al., 2002) and 59% through the conversion of pasture to cropland (Guo & Gifford, 2002).

There is limited understanding of the interplay between land management and C cycling, and more specifically between management practices, agricultural yield and net C balance (Smith et al., 2010).

However, the SOC losses also depends on tillage and cropping practices (Dolan et al., 2006; Li et al., 2012). However, management decisions that reduce tillage intensity, rise input level, have all been suggested to increase SOC stocks (Hermle et al., 2008, Zinn et al., 2005).

MATERIAL AND METHOD

Landscape level soil carbon stock and change based on IPCC method

The amount of carbon stored in and emitted or removed from permanent cropland basically depends on the crop type, the management practices, the soil variables and the climate variables. The calculation method we used is based on the default factors given in IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry (LULUCF 2003). According to this method, the existing carbon stock (from the native soil type and the climate characteristics) and the land use factor (from the land use type, management and input features) must be determined.

The soil type was categorised as High Activity Clay Mineral Soil (HAC) on the base of AGROTOPO data base. In addition soil organic content determination based on Agrotopo database (code nr. 1. soil type, code nr. 3. soil physical type, code nr. 7. soil organic content t ha^{-1}) as well in Karcag area. The following soil types occurring at the investigated plot: meadow chernozem 35.65 %, meadow chernozem solonetzic in the deeper layers 9.8 %, meadow soil 25.07 %, meadow solonec 22.24 %, 2.2 % solonec meadow soil 5.46%.

Determination of the rate of arable land on different soil types at Karcag region was made by Corine CLC surface cover vector database 2006

(Figure 1.). This harmonisation process was made by IDRISI Selva software.

To choose the input factor that representing the agricultural practice of the region, the characteristics of crop rotations were taken into consideration. According to the IPCC Good Practice Guidance for LULUCF (2003), the input factors represent the effect of changing carbon input to the soil, as a function of crop residue yield, bare-fallow frequency, cropping intensity, or applying amendments. Therefore Low Input category for conventional tillage, while Medium Input category for reduced tillage were applied for the calculations.

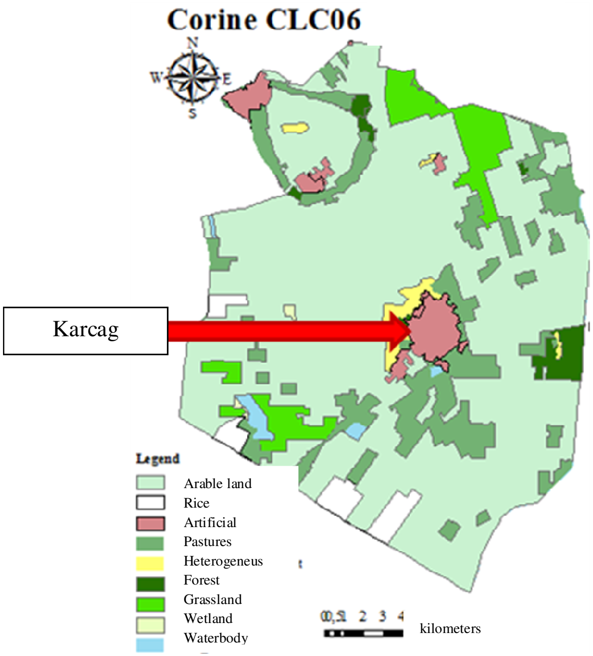

Fig. 1. Investigated area by Corine CLC 2006

According to the estimation method described in the IPCC Good Practice Guidance for LULUCF (2003) – based on AGROTOPO map data base harmonisation – first the soil organic C stocks (SOC_{ref} in t ha^{-1}) were estimated with default stock change factors (F_{LU}, F_{MG}, F_I) for the beginning. Inventory time period: 20 years.

RESULTS AND DISCUSSION

The change in soil organic C stocks in mineral soils was calculated by subtracting the C stock in the last year of an inventory time period (SOC_0) from the C stock at the beginning of the inventory time period ($SOC_{(0-T)}$).

According to Schmidt (2003) indices were used which were converted to Hu %. These are the following:

1. 100-200 t ha^{-1} organic material content: 1.3-2.6 Hu %,
2. 200-300 t ha^{-1} organic material content: 2.6-3.9 Hu%
3. 300-400 t ha^{-1} organic material content: 3.9-5.3 Hu%.

Carbon content of Hu% is 58%. Calculated soil depth is 30 cm (*1. table*).

According to the estimation method described in the IPCC Good Practice Guidance for LULUCF (2003), first the soil organic C stocks (SOC) were estimated for the beginning and end of the inventory time period using the default stock change factors (F_{LU}, F_{MG}, F_I). In 2006 the estimated C stock at research area is 2 693 790.34 t. In the case of conventional tillage system, input level is low and plant residue is taken away from the field (Table 1.). This results Carbon loss. The annual increase of the carbon stock can be up to 0.2 t ha^{-1} if the conversion to reduced tillage system takes place.

Table 1

Predicted and calculated SOC t ha^{-1} in 2006

Tillage system	**Input**	**SOC**	$F_{LU(0)}$	$F_{MG(0)}$	**SOC (t ha^{-1})**	**2006. Area (ha)**	**Sum. SOC (t)**
conventional	low	53.94 $_{(c)}$	0.82	1	44.23	1663.47	73576.61
conventional	low	89.91 $_{(c)}$	0.82	1	73.73	8759.86	645831.19
conventional	low	127.26 (c)	0.82	1	104.35	18914.6	1973796.95
conventional	low	89.08 $_{(c.)}$	0.82	1	73.05	3.21	234.48
reduced	medium	38 $_{(ref)}$	0.82	1.03	32.09	10.94	351.12

On arable lands, which based on conventional tillage, it is recommended to do nutrient supplement by plants demand and soil analyses. Instead of using only N or NKP fertilizers, macro and micro elements could contribute to higher yields with appropriate quality. However, alternative solutions such as manure, green manures and/or mulch technology contribute to management practices which build up soil C by increasing the input of organic matter to soil and/or decrease soil organic matter decomposition rates.

When soil surface is covered by plant residues (mulch) erosion is avoid and organic matters are kept into the soil. As organic matters have significant affect on soil structure, buffer capacity, water retention ability, biological activity and nutrient equilibrium it is recommended to use this technology widely in practice.

There is a strange difference between calculated (c) and reference (ref) SOC values. However IPCC method is suitable for highlighting the rate of changes.

Based on calculated SOC t ha^{-1} in 2006 he following changes are necessary to achieve C stock change in a 20 year time period at this area (Table 2.):

1. At Karcag area the conversion of half part of arable land with conventional tillage into energy saving conservation systems affects higher carbon stocks.
2. The annual increase of the carbon stock can be up to 0.55 t ha^{-1} if the conversion to reduced tillage practice is combined with a higher input of organic matters e.g. annual cropping with cereals where all crop residues are returned to the field. This is recommended at 15 % of reduced tillage area.
3. Lowland area's characteristic soil type is solonec soil (1663.47 ha). Parts of these are arable land. It could be an environmental solution to change their land use to grassland. In addition these are long term solutions to increase C stock of the soil in Karcag area. Based on these recommendation on 29 352.06 ha, in 20 years time, 35 330.42 t soil C stock rising is realizable. This is confirmed by Guo and Gifford (2002), they concluded that soil C stocks significantly increased when cropland was converted to pasture which confirm
4. In the case of conventional tillage system it is sustainable solution to implement mulch technology. If residues are removed then supplemental organic matter (e.g. manure, green manure) is recommended to add. However, green manure practice is not so popular because of drought summers resulted risks on water supplement of crops in dry tillage systems. A recommendation is given for (experimental) planting green manure e.g. winter rye/winter wheat with vetch (Lathyrus L.) or Lathyrus sativus.
5. In the case of conventional tillage system added manure, fermented manure products can contribute to stop carbon loss. In this way farmers start to use manure as well (not only fertilizer) and this results a medium input level.

Carbon stocks in soils can be significant and changes in stocks can occur in conjunction with most management practices, including crop type and rotation, tillage, drainage, residue management and organic amendments.

The differences are considerable, hence all farmers who still follow conventional soil tillage should think over whether the sustainability of crop production would not requires the conversion into a soil protective, energy- and soil carbon stock saving management practice.

Table 2

Predicted SOC t ha^{-1} in 2026

Tillage system	Input	SOC	$F_{LU(0)}$	$F_{MG(0)}$	SOC (t ha^{-1})	2026. Area (ha)	Sum. SOC (t)
conventional	medium	89.08 $_{(c)}$	0.82	1.03	75.24	3.21	241.51
reduced	medium	89.08 $_{(c)}$	0.82	1.03	75.24	10.94	823.09
conventional	medium	127.26 $_{(c)}$	0.82	1	104.35	14676.03	1531490.69
reduced	medium	127.26 $_{(c)}$	0.82	1.03	107.48	4238.55	455575.44
reduced	medium	89.91 $_{(c)}$	0.82	1.03	75.94	6559.28	498098.51
reduced	manure	89.91$_{(c)}$	0.82	1.03	75.94	2200.58	167107.61
improved grassland	medium	53.94 $_{(ref)}$	0.82	1.03	45.56	1663.47	75783.91

Studying the effect of different soil utilisation/cultivation methods on the carbon stocks based on both IPCC method and Agrotopo map database are competent to use their results as state indicators.

CONCLUSIONS

Corine land use database, Agrotopo map database were integrated and used during agri-environmental oriented calculations and prediction at Karcag area. These evaluation are useful for decision support processes by environmental oriented program planning and monitoring activities.

Consequently it is recommended at Karcag area the conversion of one part of arable land with conventional tillage into energy saving conservation systems affects carbon stocks. In addition application of mulch technology and (or) supplemental organic matter are necessary as well. On poor areas with solonec soil I gave a recommendation to change land use to improved grassland and get subventions in the frame of SAPS and Agri-Environmental Program by European Union.

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