THE INFLUENCE OF CULTIVATION METHOD ON THE SOIL'S ORGANIC CARBON CONTENT CALCULATIONS (HUNGARIAN SOC REFERENCE VALUES *VS.* IPCC DEFAULTS)

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Abstract
In the majority of the IPCC (Intergovernmental Panel on Climate Change) studies the third most significant segment among the activities of the agricultural enterprises is the GHG emission from the soil. It is important to examine how this value could be reduced. Our research aims to find the modeling system which is able to provide us with accurate data regarding the difference of the several cultivation methods and easy to apply on the basis of the facts of practical. IPCC methodology has been applied in the calculation specified with the results of certain Hungarian studies. As an early outcome we have come to see that in comparison with the regular methodology our results showed more precise values. Where the IPCC demonstrates 1-2 t CO_{2e} we were able to witness 8-10 t CO_{2e} on soils with better humus content. Therefore we concluded that accurate values of the changes can only be calculated with the involvement of the local conditions.

Keywords: IPCC, Soil organic carbon (SOC), GHG calculation, anthropogenic activities, CO2 emission/saving

Introduction

The IPCC's research back from 2007 highlights the fact for us how much human activity contributes the growth of GHG emissions. We are able to witness every day the extreme weather changes and how frequent they have become. Nowadays we cannot talk about it, only the trap of heuristic thinking (Bazerman, Moore 2008), people from the world of science are more eager than ever to protest against the tendency of the negative effects. That is what makes it so important to be aware of how we can be more efficient towards the unfavorable environmental changes caused by human activity in the different economic systems. Unfortunately money is still a crucial decision factor in the world of business so we must find those systems that have interest and willing to contribute the activities which generate short-term disadvantage regarding their competitiveness (Fogarassy, 2012). What we should keep in mind that these are the answers for the opposing ones that have no vision for the future and any solution for our long-term problems. This study does not include economic examinations but aims to draw attention to the differences of certain methods which could be the ground for the ideal model.

Literature background

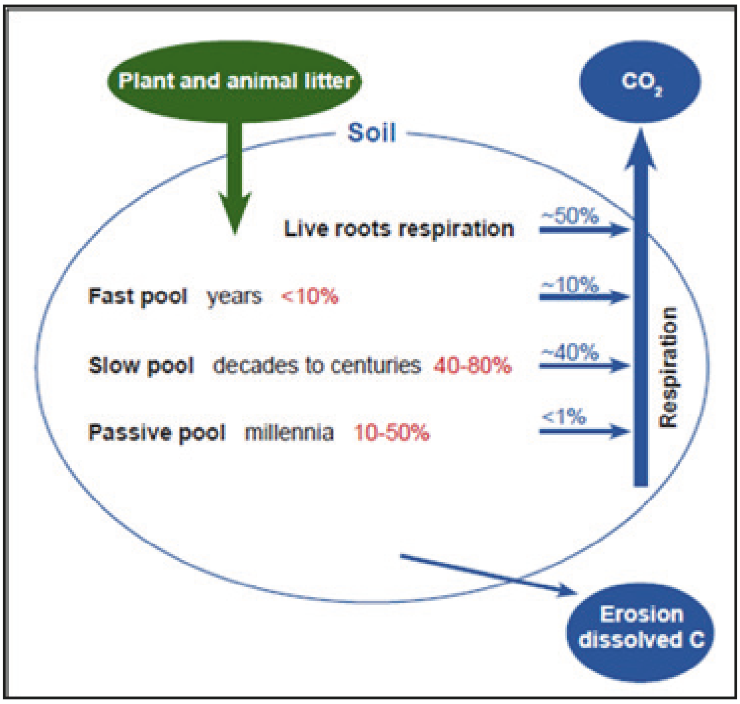
The CO_2 emissions and savings of the soil

The influence of the cultivation method on the soil's carbon content is mostly defined by the effect of the current process. (Paustian et al., 1997; Bruce et al., 1999; Ogle et al., 2005). The main aspects that determine the carbon assets of the soil regarding plant production are the followings: tillage, nutrient management (fertilizers and organic amendments), rotation and the intensity of the production, irrigation, various plant production systems and pasture, hay rotation sequences. Furthermore the drainage and the tillage of natural areas also decrease the carbon content of the soil (Armentano, Menges, 1986).

The soil's carbon turnover is mostly the impact of decomposition of the inorganic limestones. In this field stability and the lacking cycle of organic origin are recognized as general patterns so whenever it comes to the measurement of CO_2 emissions, most of the studies neglect them.

So in the rest of this study they will be ignored as well because the authors of this article find those cycles more important which are related to human activity. The CO_2 cycles of the soil are demonstrated on the first figure (Fig. 1.). The organic material of the fast pool is the easiest to increase but it also degrades really quick (for instance the carbon into the atmosphere). The slow pools are more important regarding binding the CO_2 but it is not that easy to implement them.

Figure 1. The CO_2 cycles of the soil



Source: Bureau of Rural Sciences, Dairy Australia, 2009.

The soil's carbon-absorbing capacity is based on a process which indicates carbon-dioxide binding plant material within the soil (mostly from dead plants and animal waste). The soil is a mixture organic compounds that are in the several phases of the decomposition. The organic carbon within the soil can be distributed into different „pools" according to it's nature of decomposition (like it is pictured on the first figure).

The following pools are:

- Fast pool: the added vegetable, animal and microorganism residues in the current year which decompose easily
- Slow pool: a stronger organic material, the humus. This pool is more or less stable, as long as it is not bothered by any human activities.
- Passive pool: the „oldest" phase. It resists to the further demolition and it is placed in the end of the decomposition process like becoming coal.

The amount of coal in the soil depends on several aspects and processes:

- The weather and the fertility of the soil: the fertile soils and wet zones (or highly irrigated), and the mixture of these two highly contributes the plant production so it is capable to get more organic material into the soil. The proportion of this organic material depends on the throughput, respiration of the living organisms which is also influenced by the temperature (higher temperature, more intense respiration) and the water content of the soil. So the weather and the soil determines the upper limit of the carbon sequestration.
- The system of agricultural production: usually more coal gets installed in the case of pastures than during the cultivation of cash crops.

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- Management: at plowed soils or at differently cultivated areas which were protected by microbial activities the carbon-dioxide emission increases. Those natural processes that stimulates the protective plant layer (for instance the stubble or the creation of th pasture) increase the soil's organic matter storage and eventually it's carbon sequestratuin but this modification is really slow.

So it can be concluded that the possibility of the human intervention is only possible in the case of production systems or management approaches because the climate or soil attributes cannot be changed.

Matherials and Methods

How to calculate the changes of carbon within the biomass

The calculation method examines the changes of land use and forestry in the case of land use and management mode modifications. Regarding the CO_2 emissions and savings we should put our focus on the following four important aspects:

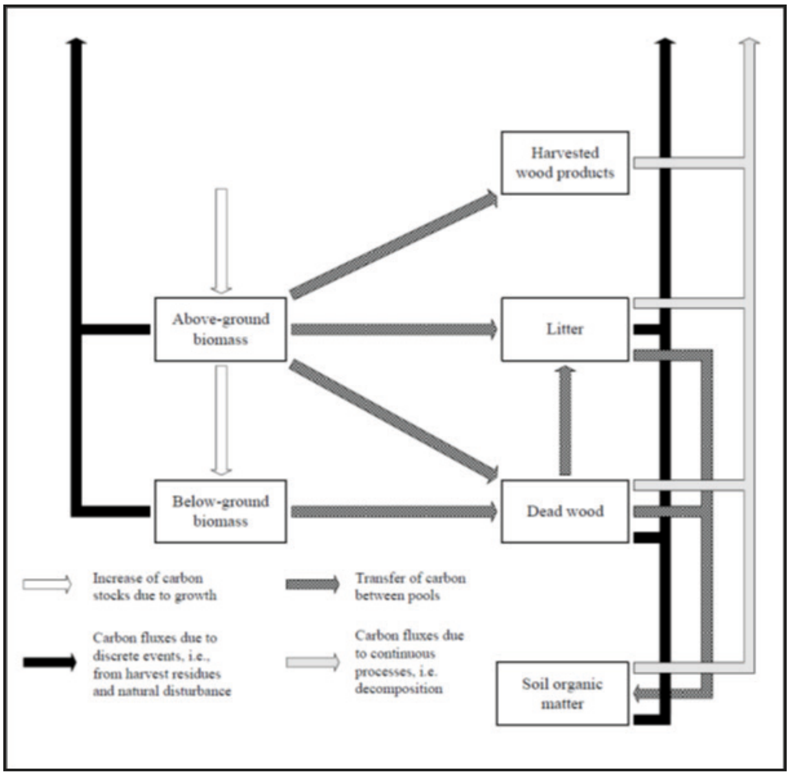
- changes within the woody biomass feedstock,
- cultivation changes,
- fields withdrawn from cultivation,
- the CO_2 emissions and savings of the soil

Basically the term „CO_2 savings" means a transformation from the atmosphere into a storage, meanwhile „CO_2 emissions" equals the opposite, when the atmosphere becomes polluted by the material of a storage. Not all of these transformations result in emissions or savings. Even though processing from a storage opportunity into another is considered as a reduction, for the receiving storage it still counts as a growth so it is not necessarily an emission.

Simplifications in the methodology

- The change of the *below-ground biomass stocks* equals 0.

Figure 2. The changes of carbon stocks between the different carbon storage systems in the perspective of the biomass turnover



Source: IPCC 2006 Volume 4.; Chapter 2., p. 8.

Table 1. Hungarian SOC values that differs from the numbers of the regular IPCC methodology (dimensionless)

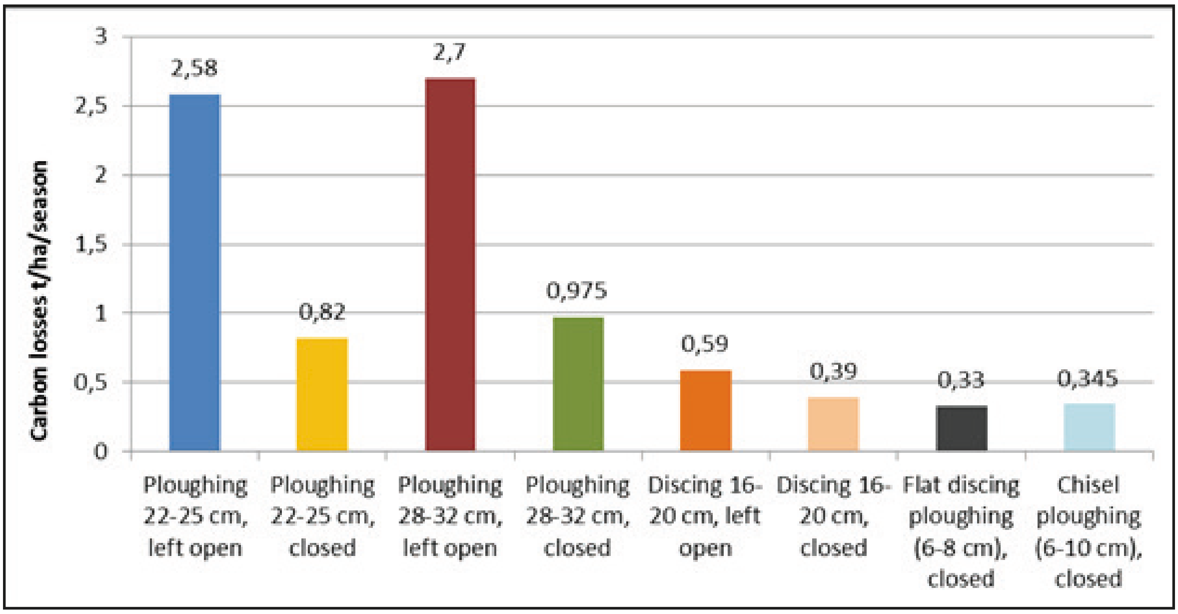
Fmg	Ploughing 28-32 cm	Ploughing 22-25 cm	Discing 16-20 cm	Flat discing ploughing 6-8 cm	Chisel ploughing 6-10 cm	Cultivation 30cm
Ploughing 28-32 cm	1.13	1.14	1.17	1.18	1.17	1.13
Ploughing 22-25 cm	1.12	1.13	1.16	1.17	1.17	1.13
Discing 16-20 cm	0.97	0.98	1.01	1.02	1.02	0.98
Flat discing ploughing 6-8 cm	0.97	0.98	1.01	1.02	1.02	0.98
Chisel ploughing 6-10 cm	0.97	0.98	1.01	1.02	1.02	0.98
Cultivation 30cm	0.93	0.94	0.97	0.98	0.97	0.93

Source: Authors' factor for F_{MG} (dimensionless) after the research of Birkás (2008)

- In this case the crop residue is usually classified as the part of the *plant-derived organic residues* category.
- The plant-derived organic residue aims to the 0 value in the case of the non-woody plants.

In the first place this method is based on the notion that in a long term perspective the annual plants produce no change according to their carbon balance. It concentrates more on the changes of the production intensity during the direct and indirect emissions of the soil. So it tries to measure the significance of the several cultivation forms in the CO_2 and non-CO_2 emissions. The schematic illustration (Fig. 2.) about the changes of the carbon stocks between the different carbon storage systems in the perspective of the biomass turnover.

Figure 3. Carbon losses during different soil preparation processes



Source: Birkás, 2008.

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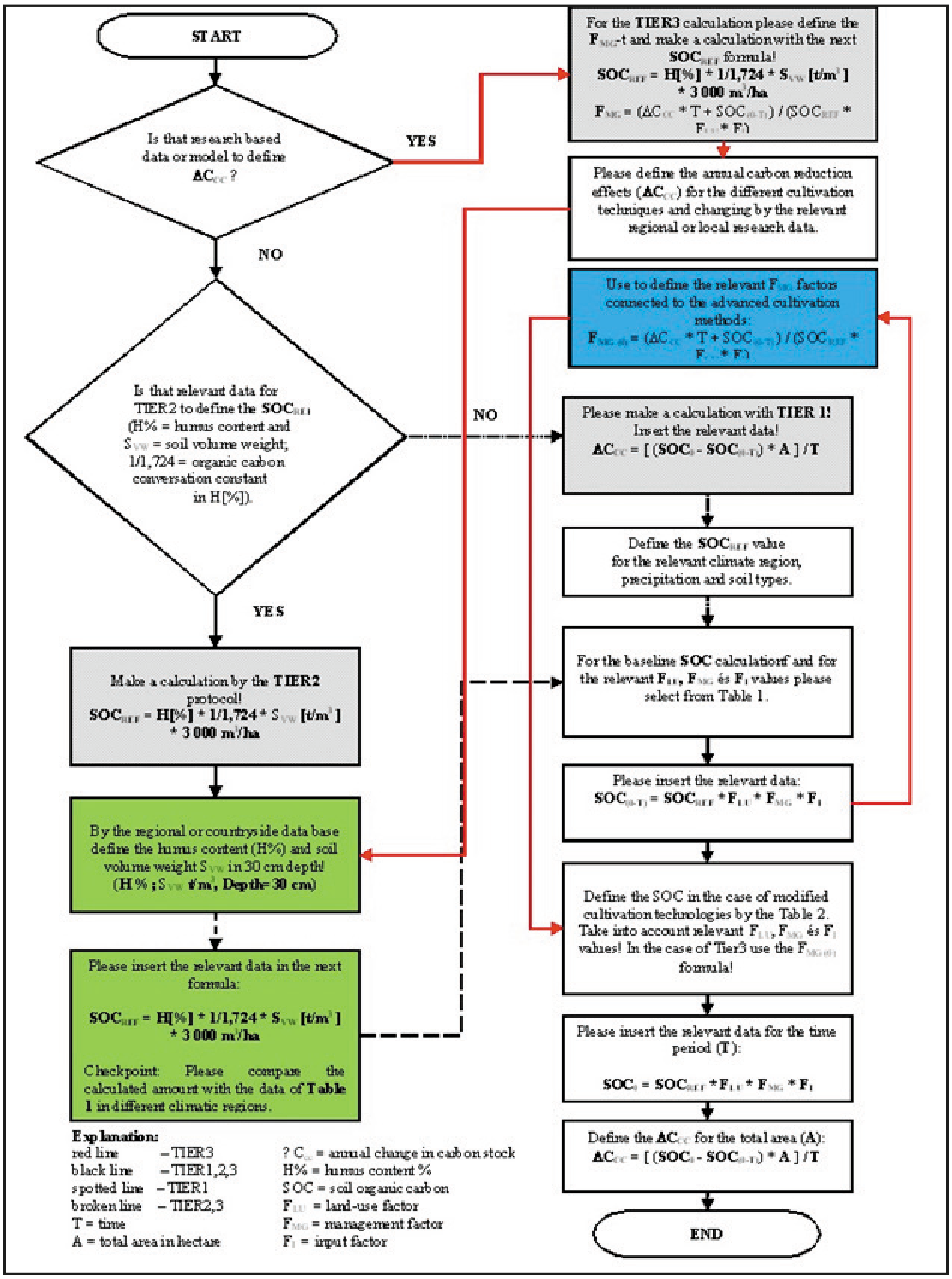
Figure 4. TIER Decision Tree



Source: Authors's graph after the Decision Tree of the IPCC

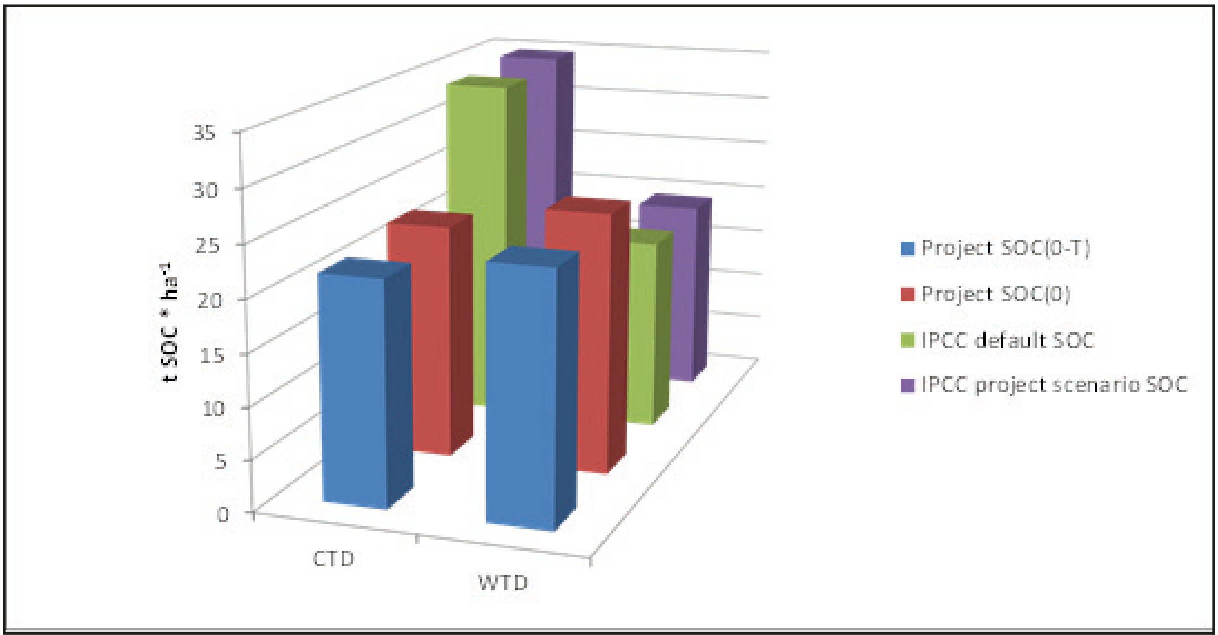
The calculation of the savings originated from the cultivation method

The examination results of BIRKÁS (Fig. 3.) about the soil loss caused by the different soil preparation processes. It shows that on one hectare of soil we would be able to reach almost a 2 t carbon saving which is 7,33 t CO_2/ha within the CO_2 balance (counting with 44/12 conversion factor). Her research points out the fact that the carbon saving happens only with the condition of not harvesting the crop residues. In case we gather the crop residues it causes a long term effect which is going to decrease the organic material puffering capacity of the soil. Eventually it also leads to crop yield losses within the next 2-3 years.

Besides the cultivation method we should associate a huge importance with the soil type as well. As the literature also highlights this point the real differences between countries will occur at their basic attribute: the land itself. Even though we included some calculations regarding the landuse and the management, we cannot forget about the quality of the soil. For this aspect we are going to use the help of the Debrecen University that already had a research about the several types of Hungarian soils and their humus content. They distribute the soils into „Cold" (CTD) and „Warm" (WTD) categories based on the country's temperature zones and from each group we picked out the six most important types (note: the different country level categories from Zsembeli at al. (2011) are not exacly suitable for the IPCC subcategories but green boxes mark the place of the calculations of the Debrecen University where we could use their research outcomes. The blue box is the part of this study where we were able to paste the previous data gathered by Birkás (2008) during her research at Experimental Farm of Józsefmajor. (It includes the results of her research which has been taking place at Experimental Farm of Józsefmajor from the year of 2002; Birkás, 2009).

The mentioned calculation (Table 1.) which takes place in the blue box presents the Hungarian SOC values that differs from the numbers of the regular IPCC methodology. We distributed the different carbon contents by the several cultivation methods and illustrated how they would change during shifting into another process.

Figure 5. The changes of the carbon content in „Arenosols (humus)" soil type according to IPCC and measured SOC data (SOC_{REF} Zsembeli et al., 2011)



Source: Authors' graph

these are not the most relevant factors in the SOC_{REF} calculations). What we learned from that study is the difference between the a basic IPCC carbon stock numbers and the real amount calculated in the mentioned soil types (Zsembeli et al., 2011). We made an own interpretation of the IPCC Tier decision tree (Fig. 4.) which is adapted to the Hungarian conditions. The two

The regular method of our calculations

In all the cases we modified the IPCC standards for Debrecen's calculated SOC_{REF} values during the examination of the three main factors: land use (F_{LU}), cultivation method (F_{MG}), the number and the amount of the certain inputs (F_I). The first step was to analyze the research data of

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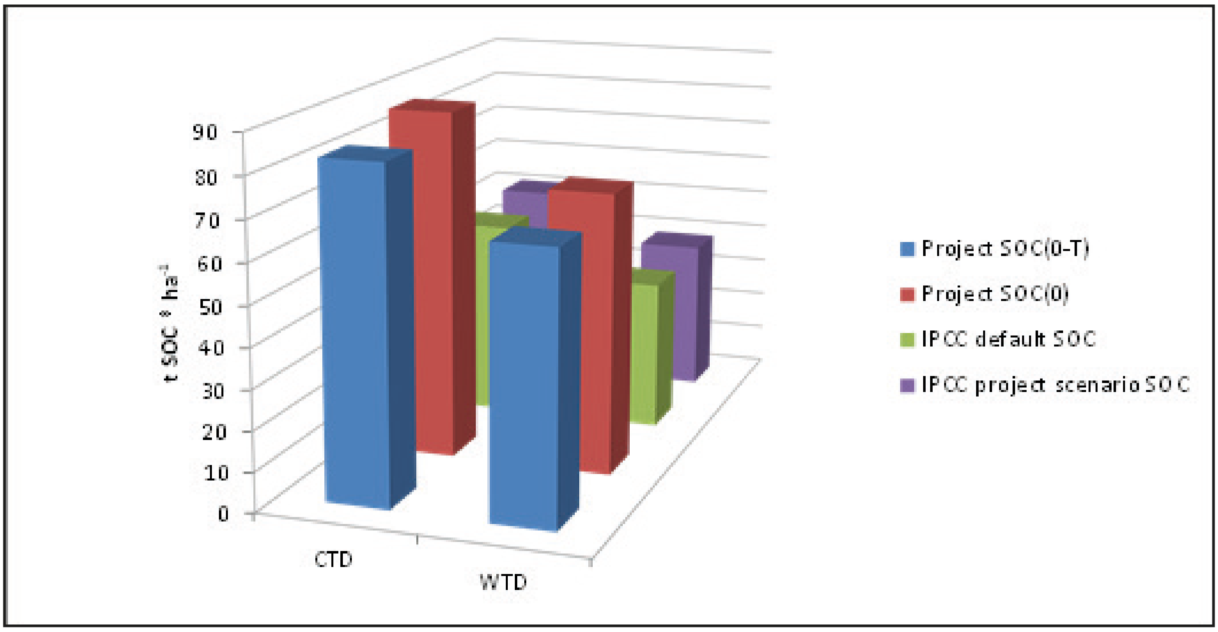
Figure 6. The changes of the carbon content in „Gleyosols" soil type according to IPCC and measured SOC data (SOC_{REF} Zsembeli et al., 2011)



Source: Autors's graph

the IPCC and the University of Debrecen than to translate their „CTD" and „WTD" (soils from cold and warm temperature zones) categories. After we have been able to measure the changes of the carbon content in the soil we calculated the difference between the IPCC and local results. Unfortunately we cannot illustrate our entire research outcomes for all of the soil types, cultivation methods and inputs so we selected only the most important and illustrious ones. From the previous studies of the IPCC we picked the two main categories (HAC - high activity clay- and SANDY) and in relation with the Hungarian background from both groups we involved the six most relevant soil types from each temperature zones. Eventually our results are going to present the carbon and CO_2 content changes of several soils using international and local calculations. Therefore the readers of this report will be able to see the difference between the methods.

Results and conclusions

On figure 5 and figure 6 we can see that the IPCC carbon content standards highly differ from the numbers of our research. In the case of the sandy soils the IPCC SOC_{REF} values are more favorable, meanwhile the HAC soils show better data in the local measures. After seeing the results of this table it is obvius that using our own SOC_{REF} database is more efficient because they turned to be the most accurate. But this difference also points out that the effect of the antrophogenic activity also diverges from the IPCC data because the landuse, the cultivation method and the inputs can also change in certain countries. For the characterization of this problem the technological-map might serve as the best solution which does tend to illustrate the application of the several method in a geographical perspective.

As another result of our research (Table 2. and Table 3.) we can see the changes of cultivation methods from medium left open into all the other examined closed processes that leave the organic materials entirely on the field. This outcome might be even more significant than the previous one because it shows the differences in comparison with the IPCC calculations in every single category. It is obvious to see that with our own method we are able to reach higher CO_{2e} savings than with the IPCC standards.

In the end of our research it can be concluded that even though the IPCC GHG calculation

Table 2. The changes of the CO_2 content in the certain soil types after a cultivation method modification from „Ploughing 28-32" into others (Cold temperature)

Δt CO_{2e} * ha^{-1}						
Temperature zone:	**CTD**					
IPCC classification:	**HAC**				**SANDY**	
Cultivation method/ soil type	Cambisols. Luvisols (Clay)	Cambisols. Luvisols (Ramann type)	Cambisols. Luvisols (Chernozem)	Gleyosols	Arenosols	Arenosols (Humus)
Cultivation 30cm	3.32	3.16	4.63	7.41	0.73	1.64
Chisel ploughing 6-10 cm	4.52	4.32	6.22	9.83	1.10	2.27
Flat discing ploughing 6-8 cm	4.56	4.35	6.26	9.90	1.11	2.29
Discing 16-20 cm	4.42	4.22	6.09	9.63	1.07	2.22
Ploughing 22-25 cm	3.46	3.30	4.82	7.70	0.77	1.71
Ploughing 28-32 cm	3.12	2.97	4.36	7.00	0.67	1.53
Average:	**3.90**	**3.72**	**5.40**	**8.58**	**0.91**	**1.94**

Source: Compiled by the authors (based on Kovacs-Bottlik, 2009)

provides a safe ground as a framework we still cannot rely on it's standards entirely. It might include the main intervention possibilities through a special model which makes sure that the certain data will not be multiplied but every model is just as good as the values they use during the function. Therefore our study pointed out the fact that we cannot implement any GHG reduction project based only on the IPCC system because we also need to be aware of the local conditions. It means everytime we would like to use this calculation method we must modify it first according to the attributes of the examined local soil.

Table 3. The changes of the CO_2 content in the certain soil types after a cultivation method modification from „Ploughing 28-32" into others (Warm temperature)

Δt CO_{2e} * ha^{-1}						
Temperature zone:	**WTD**					
IPCC classification:	**HAC**				**SANDY**	
Cultivation method/soil type	Cambisols, Luvisols (Clay)	Chernozems	Fluvisols	Gleyosols	Aernosols	Arenosols (Humus)
Cultivation 30cm	2.91	6.46	4.93	5.99	1.48	2.09
Chisel ploughing 6-10 cm	3.95	8.55	6.56	7.94	2.01	2.80
Flat discing ploughing 6-8 cm	3.98	8.61	6.61	7.99	2.02	2.82
Discing 16-20 cm	3.86	8.38	6.43	7.78	1.96	2.74
Ploughing 22-25 cm	3.04	6.72	5.13	6.23	1.54	2.18
Ploughing 28-32 cm	2.74	6.12	4.66	5.67	1.39	1.97
Average:	**3.41**	**7.47**	**5.72**	**6.93**	**1.73**	**2.43**

Source: Compiled by the authors

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