Applied Studies in Agribusiness and Commerce – APSTRACT
Center-Print Publishing House, Debrecen
DOI: 10.19041/APSTRACT/2015/4/1

PROPOSALS FOR LOW-CARBON AGRICULTURE PRODUCTION STRATEGIES BETWEEN 2020 AND 2030 IN HUNGARY

Csaba Fogarassy[1] – Andras Nabradi[2]

[1] Associate professor, Faculty of Economics and Social Sciences, Climate Change Economic Research Centre, Szent István University, 1. Páter Károly Street, 2100 Gödöllő, Hungary
[2] Professor, Faculty of Economics and Business, Institute of Applied Economics, University of Debrecen Hungary, 138. Böszörményi Street, 4032 Debrecen, Hungary
E-mail: fogarassy.csaba@gtk.szie.hu, nabradi.andras@econ.unideb.hu

Abstract: *When viewed from the perspective of climate policy, agriculture as a separate sector is one of the most difficult development areas to assess. One of the reasons for this is the problem of the localization of greenhouse gas emitters, caused by the fact that production takes place in small or dispersed production units. The special circumstance that unit production takes place in complex interactive systems (food, feed, energy sources, main products, by-products, etc.) is yet another special factor, which in addition makes it significantly more difficult to measure and identify the GHGs they emit than if they were a uniform production plant. Additionally, there are few sectors outside agriculture where decision-makers encounter such strong opposition and lobby interests when developing limiting regulations. This stems from the fact that following World War II, European decision-makers and the Common Agricultural Policy elevated agriculture to a prominent role whose importance was indisputable. As a result, both climate policy and other measures that would result in any reduction of the priority of the sector are very difficult to implement, since the players involved always reason that limitations would restrict their competiveness and the security of their production. In addition, the uncertain nature of regulatory elements also poses a grave problem. As an example, the name of the sector itself – the LULUCF (Land Use, Land Use Change and Forestry) sector – shows that the strategy for reducing the greenhouse gasses emitted by the whole sector would be significantly different if these units were treated separately (agricultural land use, forest, not-cultivated areas). Taking the above into account, the present study aims to identify development directions that in turn allow those low-carbon development directions to be pinpointed within animal husbandry and plant production that have the greatest feasibility and can contribute to decreasing the GHG environmental load exerted by agriculture.*

Keywords: *cost benefit, analysis, low-carbon, emission reduction, green innovation, EU climate policy*
(JEL classification: Q16)

Introduction

Starting from 2020, the Emissions Trading System, which is presently applied in the EU and imposes certain GHG emission restrictions on the main climate greenhouse gas emitters, will be broadened in its scope to include other types of emissions. These include the transport sector, the energy sector, and the agriculture sector, the latter being one of the sectors most affected from an environmental perspective. In the interest of obtaining a clear picture of the sector's present situation and the possibilities for its climate policy developments, the costs of the possibilities for decreasing GHGs within the sector have to be clarified. As regards European agricultural production, it can be established that the sector's climate policy is one of the most difficult both to examine and to influence (Forster et al., 2012). This primarily stems from the difficulty in delineating the origins of its emissions and from the regulatory environment governing agricultural production, which is protectionist in several senses (Matthews, 2012). It should be known that the role played by the sector in affecting all joint European decision-making processes can be traced back to World War II; the EU's joint agriculture policy has existed since 1960. Even back in that early period, the primary - and also the most important - role of agriculture was determined as being the production of safe foods and the creation of food safety. The essence of the above is to produce a suitable amount of healthy foods that the largest possible number of people can obtain at suitable prices (Matthews, 2015). Thanks to this function, regulating agriculture has, not only from the climate policy perspective, but also from all other perspectives, proven to be a decades-old problem, as the first reaction of the parties involved is to declare that even the smallest of limitations could have grave effects on the sector's abilities to produce food and be competitive (Barry et al., 2010). However, this reaction can be understood when the economic background is taken into account, since the EU has devoted more than a third of its annual expenses to "sustainable growth" in agriculture, with a budget of EUR 58.809 billion in 2015. This results in it being very difficult to influence the sector from a climate policy intervention standpoint, and while marketplace instruments can be used to intervene in other systems not subject to the scope of the EU ETS with varying degrees of success, this proves to be especially complicated in the case of agriculture. The main reason is that in many cases, the EU CAP (Common Agricultural Policy) also affects environmental protection measures, causing the inherent performance of income compensation and other rural development functions to restructure the mechanisms for internalizing external factors: for example, it significantly impedes the endeavours of the agriculture sector to be energy self-sufficient (Fogarassy, 2012).

Agriculture not only has significant potential to decrease energy consumption and GHG emissions, it could also be used to produce and generate energy (Magda, 2011). Examples are the production of biomass or bio-fuels, which would allow it to provide energy for other sectors and help them generate climate-friendly consumption, or the production of low-carbon raw materials for the construction or chemical industries (Elbersen et al., 2012).

During the course of the present study, it was also important to examine additional possibilities, as these could result in climate-efficient developments based on sustainable production and consumption (Fonseca et al., 2010; Kiss, 2013). The present study aims at reviewing the possibilities for development in both plant production and animal husbandry that would be possible with direct intervention. This was the result of an attempt to sustain those principles that targeted objective developments at the project level, thus avoiding exaggerated numerical data resulting from the multiplier effect and overlaps between the sectors (i.e. agriculture and energy production).

Since the difference in emissions sources would have made it difficult to develop unequivocal points of connection between the two sectors, the analysis of GHG-reducing investments was basically separated into two areas: the plant production and the animal husbandry sectors. Due to the expected growth in production, restrictions cannot be included in the calculations (Kovács et al., 2014). Therefore, the scenarios presented attempted to increase the ratio of low-carbon approaches and technologies as much as possible. The aim of this approach was to find those directions within the framework in which - also taking into account cost-benefit indices - GHG emission reductions can be achieved in the most efficient way possible.

Methodology

Cost-benefit analysis (CBA) has become an accepted and widespread methodology; it is an essential pillar for defining future results when preparing any investments or decisions. Its fundamental aim is to be able to express all of the costs and benefits of measures taken in monetary terms and to make it possible to evaluate them before the actual measure is implemented. This allows it to contribute to facilitating not only the investment, but also the decisions that have to be made in the course of operations. This characteristic contains both the method's main strength and also its weakness: when it is applied, it can be observed that the advantages and disadvantages that are difficult to express in financial terms will end up having a smaller effect on investment decisions than the monetized factors (Leduc-Blomen, 2009).

Economics refers to elements that cannot be expressed in monetary terms as externalities. These do not form a part of the market, and if it is impossible to internalize them, it will also be impossible to obtain a clear picture of the systems examined. Without localizing the effects early on, the measures can also result in numerous negative processes in the implementation of the investment and during its subsequent lifecycle. Therefore, in the interest of avoiding faulty strategic planning, a specific framework system is required for all cost-benefit analyses, which allows the indicators that will be used later on to be developed depending on the present status and the objectives (Boros, 2014).

The unique features of the newly developed CBA model

Of the CBA models developed thus far for internalizing externalities, the methodology resulting from the work conducted by the COWI Group was used as the basis for the present work. This method was developed for the European Union's development projects and is therefore still considered a professionally accepted method for accounting costs and benefits. The main difference compared to general cost-benefit analyses is that in addition to the maximization of company profits, the COWI method also takes those indirect effects into account that can be important from the perspective of society and the environment (COWI, 2009).

Besides the various environmental and climate costs and benefits, the method also deals with external factors, which can be both positive and negative. Naturally, not all externalities can be monetized; however, estimations can be made to determine their present value. Fiscal corrections then have to be applied, which consist mainly of deducting indirect taxes, state subsidies, and transfer payments, as well as the correction of market prices (Kovacs et al., 2014). The study thus included an economic cost-benefit analysis that uses the COWI method to include external effects (significant mainly from the environmental perspective) in its calculations. Since the present case is fundamentally a climate policy study, the changes that the various projects bring about in the entire sector's GHG balance also had to be included in the calculations (Gohar-Shine, 2007). In the interest of the above, a business as usual (BAU) scenario was determined that mapped the future changes of the present system if no interventions are applied. This was then compared with a version that integrated the climate policy measures. The externalities were localized by analysing the BAU scenario and the GHG-reducing effects of the respective project. The CO_2 equivalent unit of measure was used to measure the differences in performance, which was monetized on the basis of the EU ETS quota price forecast (2030) (Point Carbon, 2015).

The fundamental objective of the study was to develop a CBA system that could also be used for the entire European Union to measure the effects of climate policy measures, especially those that are determined on the level of national economics. Therefore, the principle of multi-targeting was also applied, in addition to the CBA methodology. This means that of the targets to be reached, one is selected and the others are considered as having been attained. The results of the analysis performed under such conditions were saved; this practice was then applied to all of the selected objectives. The performance of the analyses led to a set of solutions: of these, the ones that best suited the purpose, that is the most cost effective solutions, could be selected.

In accordance with the above, the study is based on the following cost-benefit analysis equation (1) (Kovács, 2014):

$$AI_{pv} = -\underbrace{(IC - DI)}_{\text{Decision on development}} + \underbrace{(AS - AC}_{\text{Effects of operations}} \pm \underbrace{IE}_{\text{Indirect effects}} \pm GHG_i)_{pv} \quad (1)$$

where:

AI_{pv} = the present value of additional income

IC = the additional investment cost of the equipment to be purchased (HUF)

DI = possible support and discounts (HUF)

AS = the additional sales revenue resulting from the additional yield or increase in quality attributed to using the given technology (HUF/year)

AC = the balance of the given technology's additional costs and its possible savings (HUF/year)

IE = the indirect economic impacts (environmental effects, effects on society) of using the given technology and the value of GHG reduction (HUF/year)

GHGi = the indirect effects on emissions of using the given technology, based on the value of the decrease in GHGs as per the EU ETS quota forecast (HUF/year)

pv = present value

The novelty of the present model lies in the item referred to as "Indirect effects" at the end of the equation. It is at this point that an opportunity presented itself to add to the basic CBA method and monetize the externalities generated by the project. In respect to climate policy effects and social benefits, the benefits that result from the decrease in GHG emissions can be taken into account here. The quantification of this value is primarily based on the EU ETS quota price forecasts prepared until 2030 (based on Point Carbon, 2015). In order for the system to work perfectly, a fundamental technological structure that pertains to the sector has to be developed (BAU), compared to which it will be possible to examine the expansions and returns based on the various scenarios and technological interventions.

The model is comprised of the following main units:

- Historical datasets
- Scenarios
- Forecasts
- Cost-benefit tables
- Results and vulnerability studies

The database used in the study

The GHG data from the IPCC emissions registry pertaining to Hungary was used for the calculations in the agriculture sector climate policy study. Production costs retrieved from the Hungarian Research Institute of Agricultural Economics (AKI) Accountancy Data Network were then assigned to these.

Results

The authors assumed two fundamental cases in their scenarios: in one, processes continue as per the present political and support systems, which the literature refers to as "Business As Usual" (hereinafter BAU). In the other case, significant resources were allocated to the sector in the form of various large projects in the interest of achieving decreases in its GHG emissions. The development areas in the various scenarios were defined in a manner that ensured that they do not coincide with the EU Common Agricultural Policy's development targets; this means that only additional climate policy developments were taken into account, and not on condition that agriculture support is paid. Scenario 1 thus modelled the introduction of climate friendly farming systems and the options for expanding those. Scenario 2 was used to model performance in addition to obligations pertaining to manure treatment in animal farming, that is the development of enclosed manure treatment sites and the capture of methane and delivering it for use in energy production. Scenario 3 provides a presentation of the cost-effectiveness indices of introducing an awareness-increasing and consultancy program or service in connection with the introduction of a more climate friendly feed system, within the framework of a smaller experimental program.

SCENARIO 1: Increasing the low-carbon farming methods of cereals and oilseeds

According to the basic assumption made by the present study, conventional production methods will dominate the BAU scenario, since the fast paced development of the economy (Figure 1) prefers simple, traditional, and established production methods to new climate friendly technological methods that involve many risks. In 2010, the ratio of traditional production technologies (the use of tillage-based production) was 77%, with soil-friendly technologies (low-carbon[1], environment-friendly conservation tillage methods) amounting to only 11% (KSH, 2012).

The project's R+D+I requirements: HUF 13 billion.

The GHG decrease that can be attained with the project: 2,840,710 tons of CO_{2e} (decrease extrapolated over a 10-year period)

Explanation

R+D+I needs: The amount of the investment and/or

---

[1] (The low-carbon production trend in plant production: within the meaning applied by the present study, the low-carbon approach means the application of soil-friendly soil cultivation systems that use conservation tillage. The essence of this is to reduce the number of times the farmer travels over the field as compared to traditional soil cultivation methods, preferably by foregoing ploughing and rotary tilling. In this approach, the proportion of crop residue has to be at least 30%)

development cost required to attain the project's maximum GHG emission reduction (as compared to the BAU scenario).

GHG reduction: The GHG emissions decrease that can be attained with the project compared to the BAU scenario, calculated in $CO_{2e.}$

In the project (Scenario 1) tested by the present study, low-carbon production approaches receive greater importance: their size was doubled for 2020 from the forecast initial size of 400,000 hectares (11%) to 800,000 hectares. This is shown in the Project Version 2030 column in the following figure (Figure 2).

Figure 1: Production forecasts until 2030

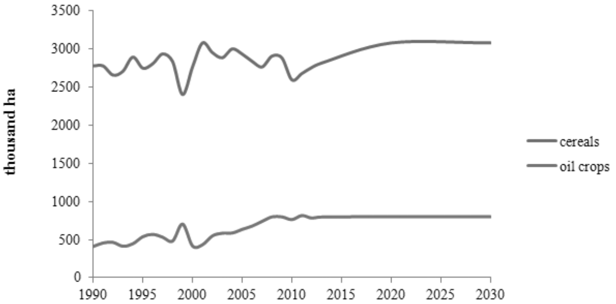
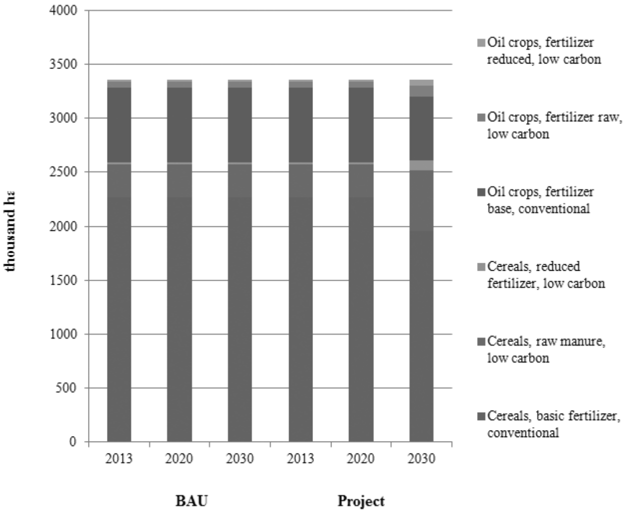


Figure 2: Changes in production structure until 2030



Carbon efficiency indices in Scenario 1

Figure 3 shows that the total emissions resulting from the production of cereals, oilseed rape, and sunflowers (11.26 million tons of CO_2e) decreases significantly in the accumulated balance (2,840 million CO_2e) after the area under low-carbon production is doubled from 400,000 to 800,000 hectares following 2021.

Figure 3: Total sectoral CO_2e changes until 2030

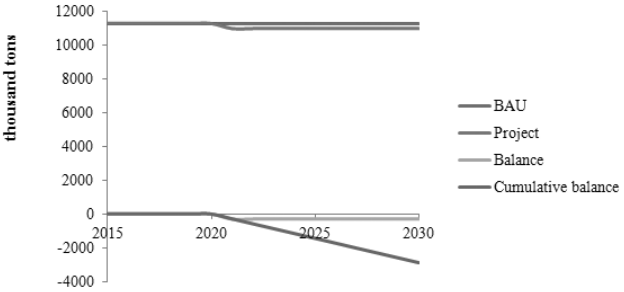


Figure 4 shows how CO_2e emissions per 1 hectare change between the two variants, extrapolated to total area. Thus, a decrease of 0.1 tons of CO_2e per hectare can be achieved over the entire area if an additional 400,000 hectares are included.

Figure 4: Changes in the average CO_2 efficiency of the sectors until 2030

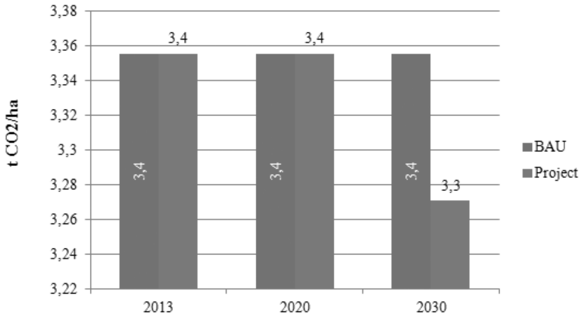
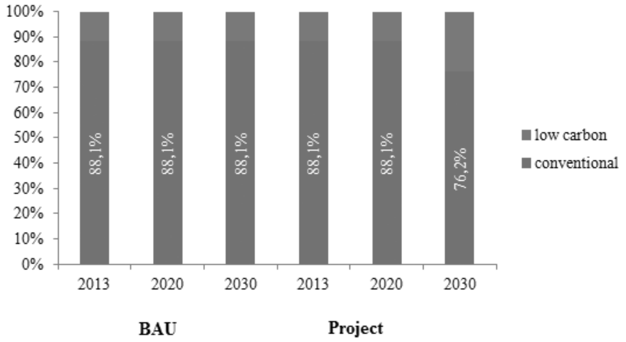


Figure 5 shows the distribution of the various soil cultivation procedures within the two development directions. The proportion of areas treated with „low-carbon" and „no tillage" (or direct seeding) technologies increased to 23.8% by 2030.

Figure 5: Changes in low-carbon soil cultivation ratios in the sectors until 2030

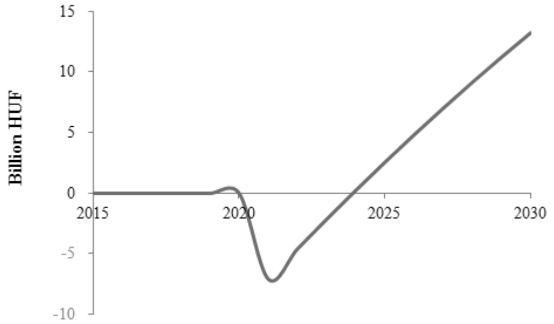


It is apparent from the carbon indices that the areas included in low-carbon soil cultivation lead to the same results as those assumed on the basis of the reduction potential. Both the decrease in absolute emissions and the increase in efficiency were found to be significant. In the future, the index values can be further augmented by gradually including increasing the amounts of land in the climate-friendly soil cultivation systems.

Financial return indices in Scenario 1

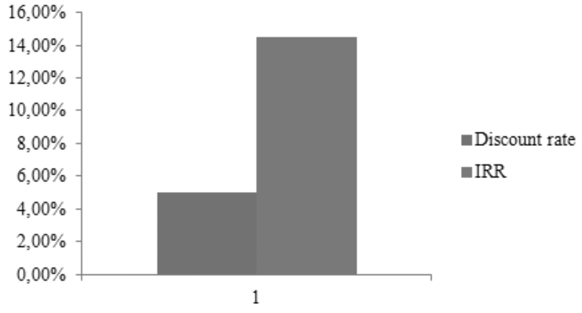
Figure 6 does not only illustrate the project's net present value (NPV) in the traditional sense; it also compares the cost-benefit systems of the BAU and Project variants. The project's investment requirements extend primarily to modern soil cultivation tools and equipment that are suitable for implementing the decreased number / closed cultivation technologies. As shown by the NPV, this investment can enjoy a return even over the short term, within 3-4 years, due to the decreased number of interventions required.

Figure 6: The additional income at present value in the project's cost-benefit calculation



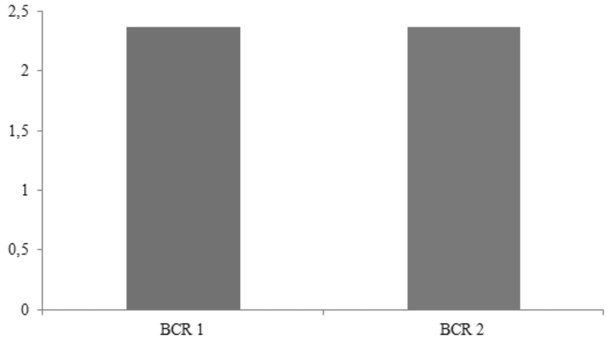
In addition to the discount rate, Figure 7 also shows the internal rate of return, which illustrates the probability that the project's investments will provide a return. The positive values unequivocally support the lessons learned from the NPV curve, which forecast advantageous financial processes.

Figure 7: The Project's Internal Rate of Return



The BCR1 displayed in Figure 8 provides an answer to the question of whether there will be a return (and how many times over the return will be realized) on the discounted total of the operating process and the ad hoc investment costs from the total of the revenues received during the entire term of the investment and the discounted residual value. The BCR2 index expresses whether there will be a return (and how many times over the return will be realized) on the investment's discounted ad hoc expenditure from the discounted amount of the results realized during the total term of the investment. In the present case, it is shown that this financial index also has a positive value.

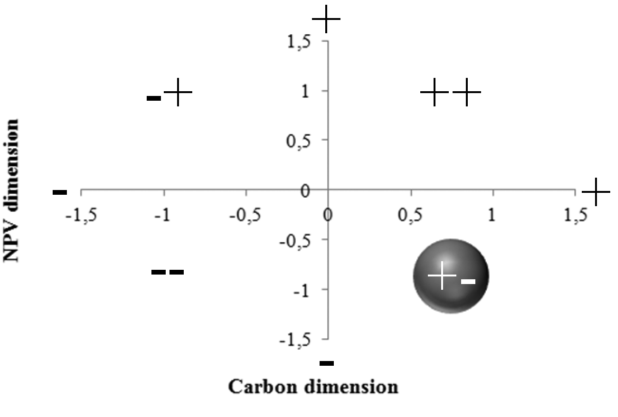
Figure 8: The Project's Benefit–Cost Ratios



Evaluation of Scenario 1

The carbon orientation matrix presents a summary of the study performed in Scenario 1. It unequivocally shows the processes that took place within the sector after project implementation, during the period studied. The placement of Scenario 1 is indicated by the blue bubble, which depends on the time the investment starts to give a return and whether the results led to a decrease in emissions or to a surplus within the sector. Taking into account the fact that both factors (GHG reduction and financial return) were fulfilled, the project was placed in the bottom right quartile, even if only a relatively smaller decrease was realized in emissions values. However, it must also be taken into consideration that this is a measure that is also acceptable from a financial perspective; its strength basically lies in the fact that it is a financially sound and also environment and climate-friendly investment.

Figure 9: Scenario 1 carbon orientation matrix



Explanation

(- +) A project is implemented that only serves to increase emissions and the investment does not provide a return within the lifecycle.

(+ +) A project where the invested costs show a tendency to provide a return, but the activity itself was not suitable for decreasing GHG emissions.

(- -) Emissions can only be decreased with high costs on which there will be no return.

(+ -) Acceptable scenarios that enable CO_2e decreases to be attained while also providing a return on investments within the lifecycle. (Investments that are recoverable even after their lifecycles, with externalities that can change in line with political preferences.)

SCENARIO 2: Low-carbon developments in dairy cow and pig feed and manure treatment

Similarly to Scenario 1, the basic objective in this case was to realize future GHG reductions by increasing the ratio of low-carbon (Al-Boainin et al., 2013; Fogarassy, Bakosne, 2014) measures used in the sector (concentrated mainly on the practices of manure treatment that decrease methane emissions) (Figure 10). In the framework of the project discussed, conventional livestock production involving slurry was decreased by 25% and was completely replaced by entirely closed low-carbon technologies. The resulting methane gas is captured and sold to gas service providers. However, the transition in the system is not immediate but is implemented gradually, which means ongoing investments will be necessary until 2030. In this case, the project lifecycle is 20 years, and the GHG savings and cost effectiveness were also calculated for this period.

The project's R+D+I requirements: HUF 18.447 billion.

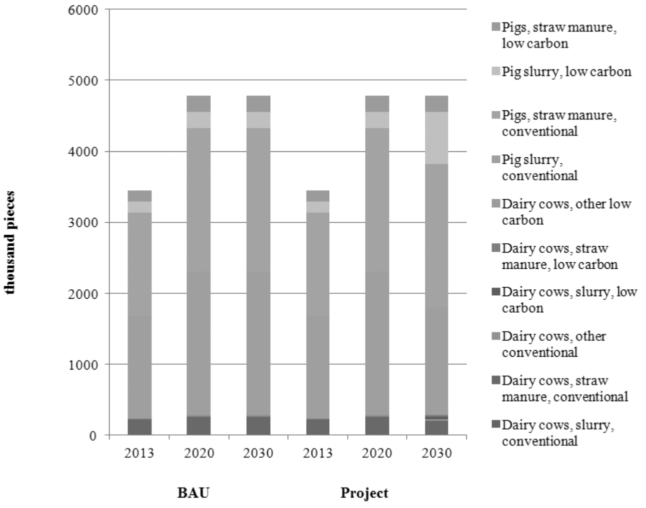
The GHG decrease that can be attained with the project: 4,421,700 tons of CO_2e (decrease extrapolated to a 20-year period)

Explanation

R+D+I needs: The amount of the investment and/or development costs required to attain the project's maximum GHG emission reduction (as compared to the BAU scenario).

GHG reduction: The GHG emissions decrease that can be attained with the project compared to the BAU scenario, calculated in CO_2e.

Figure 10: Developments in the structure of the dairy cow and pig production sector until 2030



Now, let us examine the GHG-reducing effects of Scenario 2.

Carbon efficiency indices in Scenario 2

In the case of the carbon indices (Figures 11, 12, and 13), the activity introduced can be considered successful in reducing $CO_{2e.}$ It can be seen that the absolute emissions of the sectors show a significant decrease after 2020 as a result of introducing the low-carbon measures. An even more important factor is improving efficiency: in this respect, the project was able to outdo even the BAU version, which itself showed improving values.

Figure 11: Developments in the industries' CO_2e emissions until 2030

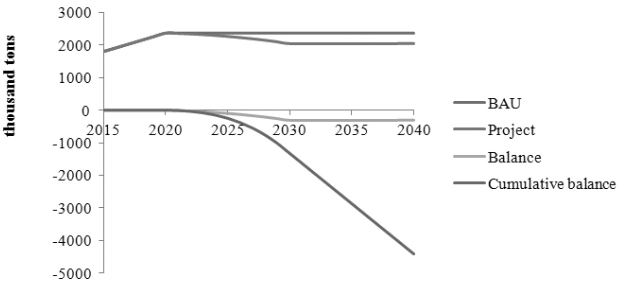


Figure 12: Developments in the industries' average CO_2e efficiency until 2030

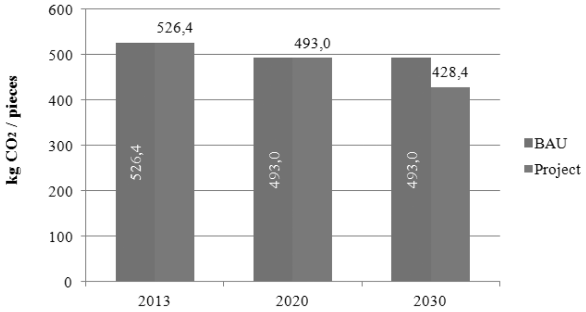
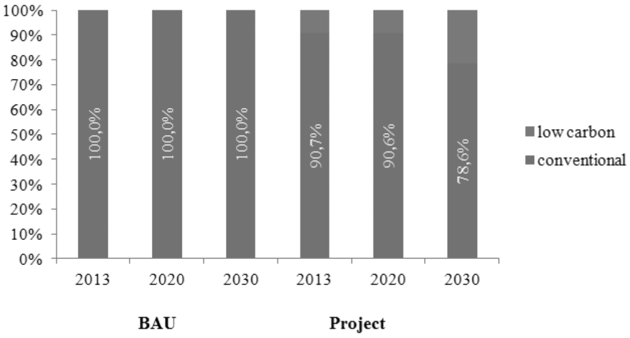


Figure 13: Changes in low-carbon technology ratios in the industries until 2030



Following the GHG reduction, let us also examine the returns on the project's expenditures.

Financial return indices in Scenario 2

Thanks to the continuous transition mentioned above, it can be seen that the NPV curve (Figure 14) will show a negative tendency until 2030, even though the investments will provide a return within 6-7 years after the investments are completed. Since this will not fully occur within the examined period of 2020-2030, the BCR index (Figure 15) also has quite a low value. This is precisely why taking BCR indices (Figure 16) into account is a good idea, as it indicates that the costs that have to be paid in the area of benefits remain manageable when social targets are factored in. At this BMR state (-6%), the possible social losses remain acceptable.

Figure 14: The additional income at present value in the project's cost-benefit calculation

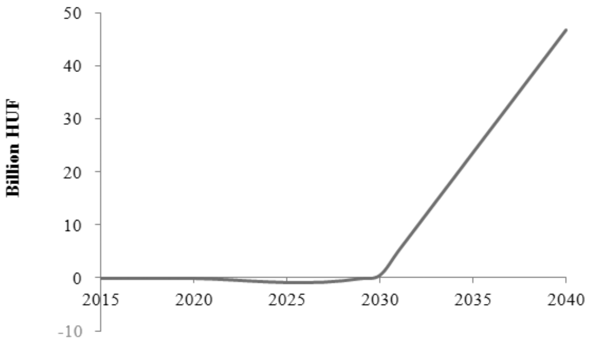


Figure 15: The Project's Benefit–Cost Ratios

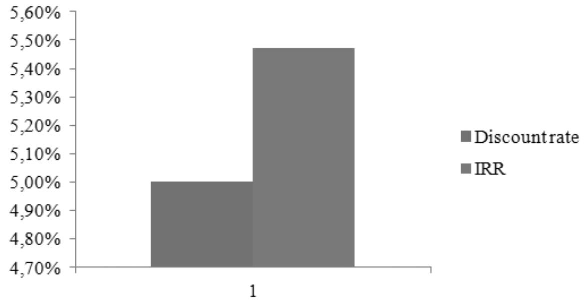
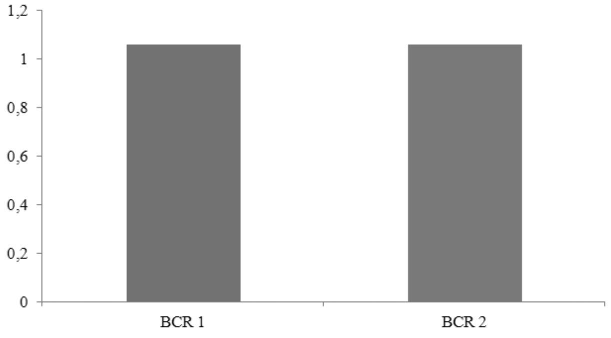


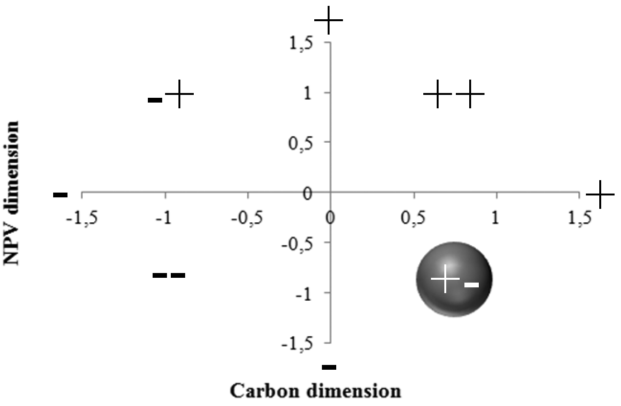
Figure 16: The Project's Internal Rate of Return



Evaluation of Scenario 2

As a summary of Scenario 2, it is worthwhile illustrating the results in a carbon orientation matrix, which shows that the project is again located in the ideal range (+, -), since it was capable of presenting a rate of return that showed a positive tendency over the long term, even with the given BAU emission reduction.

Figure 17: Scenario 2 carbon orientation matrix



SCENARIO 3: Dairy cow climate-friendly feed consultancy

The third Scenario involved the modelling of a pilot project that targeted the identification of the preparatory program which can enable the introduction of the low-carbon slurry and feed treatment developments presented in Scenario 2, which would thus increase the GHG efficiency and financial results of Scenario 2. Since this can be considered to be a model with a small number of samples, the emissions of the pig stock were not included in the model in addition to the dairy cow calculations. The previous examples have shown the positive effects on decreasing emissions of changing both feed and manure treatment; now, however, the objective is to assess what is possible by changing only feed methods by introducing a low-carbon consultancy program. In the case of the dairy cow stock, feed consultancy can also result in significant increases in the emissions factor. One of the factors influencing the emissions factor is the digestibility of the various feed types. The present study therefore recommends the introduction of a consultancy program in which the consultancy is used to optimize the composition of the available feeds in the product production process. Similarly to the previous cases, it was assumed that, contrary to the BAU scenario, the proportion of conventional livestock production would decrease by approximately 25% in favour of low-carbon methods by 2030 (Figure 18).

The project's R+D+I requirements: HUF 0.274 billion.

The GHG decrease that can be attained with the project: 74,863 thousand tons CO_{2e}

Explanation

R+D+I needs: The amount of the investment and/or development costs required to attain the project's maximum GHG emission reduction (as compared to the BAU scenario).

GHG reduction: The GHG emissions decrease that can be attained with the project compared to the BAU scenario, calculated in CO_2e.

Figure 18: Developments in the structure of the dairy cow production sector until 2030

Now, let us examine the scenario's effects on the GHG balance.

Carbon efficiency indices in Scenario 3

If we examine only the GHG indices (Figures 19, 20, and 21), it is apparent that this approach does not greatly impact the sector as a whole. The absolute value of CO_2e barely changed, similarly to the livestock unit value. Regardless, the authors believe that the financial indicator will be that which primarily lends feasibility to this approach, since the program's strength lies in its efficiency (yield-increasing effect) and not in its size. However, the rate of GHG reductions resulting from the expansion of the program can also be increased by an order of magnitude. (In the consultancy program, the costs were defined per animal, in which breakdown the consultancy costs amount to approximately HUF 750 / animal / year. This represents a financial result of HUF 1000, or a net profit, thanks to climate friendly process management.)

Figure 19: Developments in the industry's CO_2e emissions until 2030

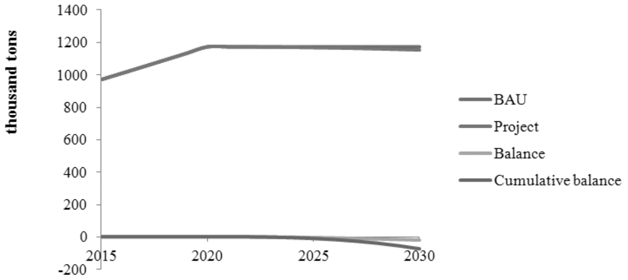
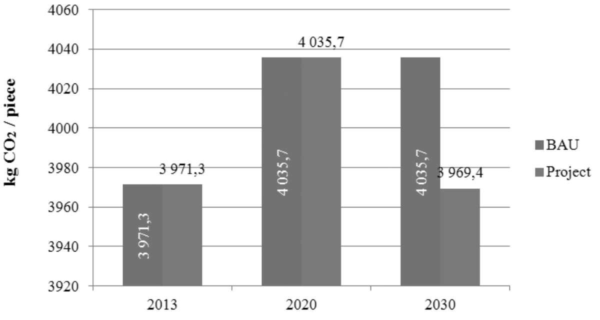
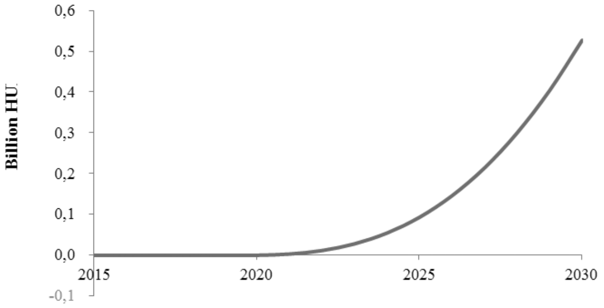


Figure 20: Developments in the industry's average CO_2e efficiency until 2030



Own research, 2015

Figure 21: Changes in low-carbon technology ratios in the industry until 2030



The following financial return figures illustrate whether the relatively low GHG reduction can provide a financial return on the investment.

Financial return indices in Scenario 3

The quick return indicated by the NPV curve (Figure 22) is a result of the almost immediate return (within 2-3 years) provided by the consultancy-related costs, since if consultancy is included, the changes are implemented quickly. This is also supported by the BMR (Figure 23) and BCR (Figure 24) curves, which means that a rapid return can be realized with this program. However, care must be taken to consider the fact that savings cannot be increased beyond a certain amount, since the emissions factor cannot be decreased under a certain level due to the biological attributes of cows.

Figure 22: The additional income at present value in the project's cost-benefit calculation

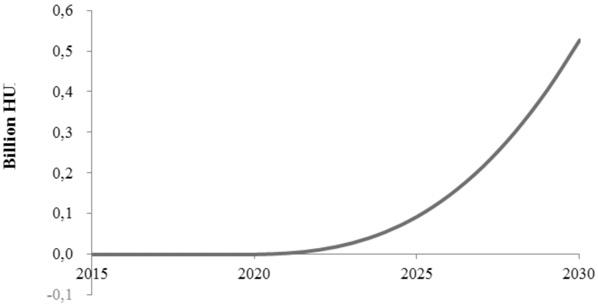


Figure 23: The Project's Internal Rate of Return

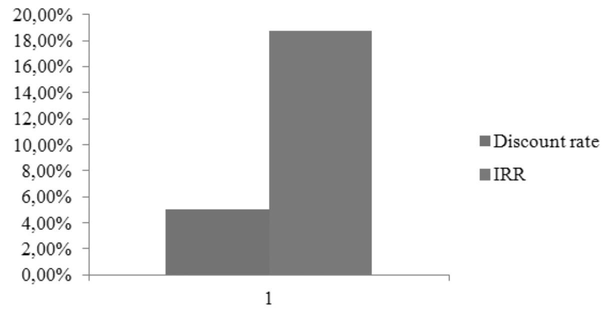
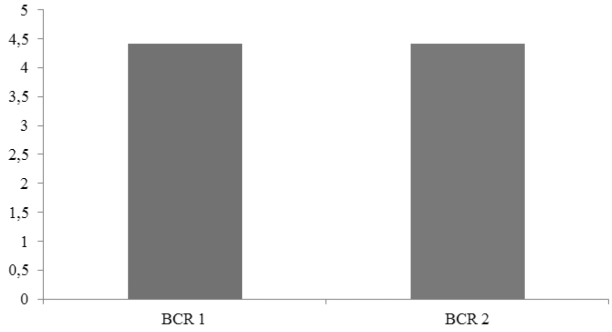


Figure 24: The Project's Benefit–Cost Ratios

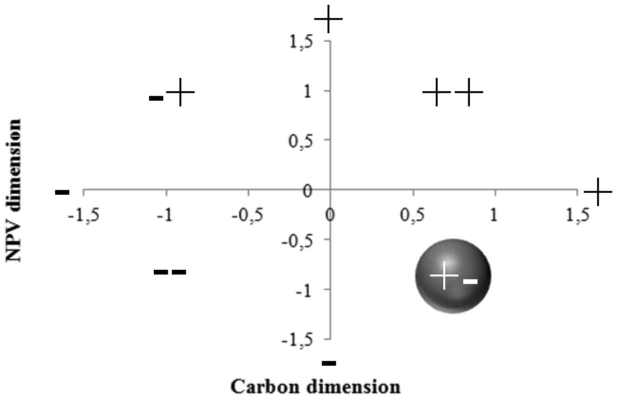


Evaluation of Scenario 3

Similarly to previous projects, Scenario 3 also lies in the bottom right quartile of the carbon orientation matrix (Figure 25), regardless of the fact that it was unable to achieve substantial GHG reduction results. However, it can be stated that as a so-called "additional project" it was definitely worth testing, since it can be a very good example of the fast and effective methods that can be chosen when a decision has to be made on how to spend "leftover development funds."

If we take a closer look at the program structure, it can be established that it is financially more efficient than Scenario 2, which targeted the development of animal production and also included manure treatment and the cost of the related technological investments. This means that the combined technical reform can result in a greater decrease in GHG, but the cost of investment per GHG emissions unit is higher when combined with manure treatment than the low-carbon update of feeding applications. Based on the study, it should be stated that the project presented in Scenario 2 is still preferred for livestock production. However, in cases that provide an opportunity for only low budget projects, it is expedient to launch the consultancy program first, and transfer the development to Scenario 2 later on.

Figure 25: Scenario 3 carbon orientation matrix



Discussion and conclusions

Of the three projects that were run in the framework of this study (the financial conditions and environmental effects of which are illustrated in Table 1), the authors were able to designate two main development directives. One includes the large-volume GHG reduction programs connected to agricultural activities as well as the investments that result in smaller GHG reductions but have effective return indicators (of which Scenarios 2 and 3 are excellent examples). As discussed in the introduction, the primary podium for climate friendly programs in Hungary will not be the agriculture sector due to its complexity and its inherent cross effects, the reasons for which lie mainly in politics. Nevertheless, it must also be taken into account that although the development of certain production system elements (the transition from open to closed production methods, closing manure treatment plants) could result in a significant one-off GHG decrease, additional developments could greatly influence the unit cost of GHG reductions. The fact that the present agricultural GHG reduction projects cannot contribute to achieving long term GHG reduction goals to the same degree as can be experienced in other sectors due to food market insecurities and production limitations is also an important factor. What can be said in general about climate-friendly developments in agriculture is that climate-friendly agricultural investments have more advantageous returns and the costs of decreasing GHG emissions (EUR 11-15/ton CO_2e) are less than the general EU average forecast of EUR 23/ ton CO_2e for 2020-2030 (Thomson, 2014). In certain cases, the nominal cost of decreasing agriculture GHG emissions is less than in other sectors or in other EU countries, but the possibilities available for decreasing GHGs can be substantially limited by the fact that the sector is strongly ingrained in society (as the channel of support in addition to regular income) and economics (the priorities of maintaining food production), for which reason the rationale of climate-friendly developments in agriculture is presumably not defined by the nominal cost indices of avoiding GHG emissions.

1. Table: The financial and GHG cost indicators of the projects run in the various scenarios

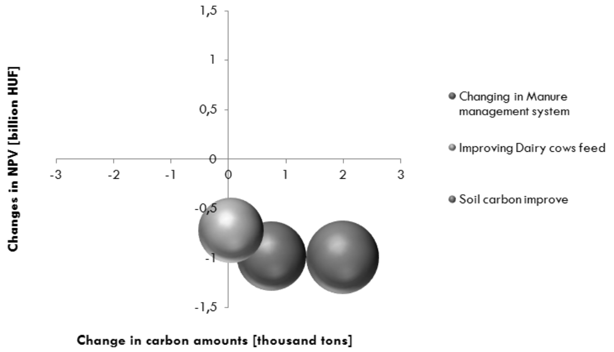
Projects	**Scenario 1 Cereals and oilseeds Change in farming technology (for 10 years)**	**Scenario 2 Dairy cow and pig closed slurry treatment (20 year lifecycle)**	**Scenario 3 Improving feed practices with consultancy (for 10 years)**	**Unit** (1 EUR/310 Ft)
R+D+I need:	13	18.447	0.274	bn HUF
Amount of change in CO_{2e}	-2840.7	-4421.7	-74.863	thousand tons of CO_{2e}
Cost of GHG reduction	**14.76**	**13.45**	**11.08**	EUR/ton CO_{2e}

Regardless of the above, these projects are necessary, since even if they fail to serve the achievement of climate policy targets to an exceptional degree, they still have a strong mitigating influence on the greenhouse effect by spreading low-carbon production methods. Furthermore, as already mentioned at the end of the analyses for Scenarios 2 and 3, despite the fact that of the two animal production approaches, the authors recommend the one in which innovation is focused on low-carbon manure treatment, merely reforming feed methods can also serve as an excellent example.

The summary „Relative carbon cost" diagram (Figure 26) shows that the change to low-carbon production technologies in cereals and oilseeds (Scenario 1) can result in significant GHG savings and in a financial return, as a result of which it can be included amongst the preferred programs. The location of the red bubble tells us that a substantial GHG decrease can be realized during the course of Scenario 1; in addition, the NPV is in the best location of the three scenarios. Although the volume and potential for GHG reduction is smaller than that shown in Scenario 2 (the introduction of closed manure treatment), the difference in the length of the lifecycles (10 years for Scenario 1 and 20 years for Scenario 2) leads to the conclusion that the initiation and expansion of projects such as Scenario 1 is the most effective method for implementing GHG reduction programs.

GHG reductions are the most effective in the case of the consultancy program (Scenario 3) due to the low avoidance costs, but it must be stressed that the calculation connected to the program is aimed mainly at ensuring that the costs primarily cover the transfer of climate-friendly knowledge and the provision of the conditions required for the related data collection. Due to the characteristics of the intervention (the investments are primarily related to human resources), the rate of GHG reductions in the program cannot be as significant as if direct changes were being applied to a given production process.

Figure 26: The relative carbon costs of the scenarios included in the analysis



Using the relative carbon cost figure as a basis, a good decision regarding climate-friendly developments can thus be made if low-carbon development projects are commenced in the field of plant production (for example, changes in farming methods); in addition, the long term development of energy systems linked to manure treatment, which can even be self-sustaining, can also be implemented, depending on the availability of funds.

In the case of the innovations planned for the agricultural sector, it can be considered a rule and has been shown by these studies to be true for the animal husbandry sector, that developments cannot be implemented as isolated projects, as there are very few innovations that are feasible in such a manner. That is why the conclusion of the present research can be summarized by saying that the livestock production sector unequivocally requires a complex approach that treats low-carbon developments together with the innovations taking place in plant production (i.e. feed and feed production).

References

AL-BOAININ MR, SZELENYI L, ZSARNOCZAI S. The gas emission in environmental pollutions and as externalities in point of view of economy. Economics of Sustainable Agriculture, 2013: 159-160.

BOROS Á. Vízi közmű beruházások gazdasági értékelésének dilemmái - A 2007-2013 közötti magyarországi szennyvízkezelési projektek tapasztalatai, Kaposvár, 2014 URL: http://phd.ke.hu/fajlok/1410529064-boros_aron_doktori_ertekezes_final.pdf

COWI Ltd. and National Development Agency of Hungary 2009. Methodological Guide for Cost –Benefit Analysis in case of Environmental Investments / Módszertani útmutató költség-haszon elemzéshez KEOP támogatáshoz http://palyazat.gov.hu/download/15601/M%C3%B3dszertani%20%C3%BAtmutat%C3%B3%20k%C3%B6lts%C3%A9g-haszon%20elemz%C3%A9shez.pdf

ELBERSEN B, STARTISKY I , HENGEVELD G, SCHELHAAS MJ, NAEFF H, BÖTTCHER H. Atlas of EU biomass potentials. Biomass Futures Project, London, 2012 URL: http://ec.europa.eu/energy/intelligent/projects/sites/iee-projects/files/projects/documents/biomass_futures_atlas_of_technical_and_economic_biomass_potential_en.pdf

FOGARASSY CS. Karbongazdaság (low-carbon economy). Monográfia., Budapest: L'Harmattan Kiadó 2012, ISBN: 978-963-236-541-1 p. 262 URL: http://www.harmattan.hu/konyv_972.html

FOGARASSY CS, BAKOSNE BOROCZ M. Externality analysis of sustainable cattle breeding systems. Hungarian Agricultural Engineering 2014 N° 26/2014 5-10 DOI: 10.17676/HAE.2014.26.5

BARRY F, KING M, MATTHEWS A. Policy Coherence for Development: Five Challenges, Irish Studies in International Affairs, 2010:207-210. URL: http://www.tcd.ie/iiis/documents/discussion/pdfs/iiisdp335.pdf

FONSECA MB, BURRELL A, GAY H, HENSELER M, KAVALLARI A, M'BAREK R, DOMÍNGUEZ IP, TONINI A. Impacts of the EU biofuel target on agricultural markets and land use: a comparative modelling assessment. European Commission, Joint Research Centre, Seville, 2010 URL: http://www.eurosfaire.prd.fr/7pc/doc/1281625394_jrc58484_biofuel.pdf

FORSTER D, OKAMURA S, WILKINS G, MORRIS M, SCOTT P, KUIKMAN P, LESSCHEN JP, GARDINER A, BOERMANS T, GRÖZINGER J, EICHHAMMER W, REICHARDT K. Next phase of the European Climate Change Programme: Analysis of Member States actions to implement the Effort Sharing Decision and options for further community-wide measures. AEA group, Harwell, 2012 URL: http://ec.europa.eu/clima/policies/effort/docs/esd_final_report_en.pdf

GOHAR LK, SHINE KP. Equivalent CO$_2$ and its use in understanding the climate effects of increased greenhouse gas concentrations. Weather, 2007:307–311. DOI: 10.1002/wea.103

KISS CS. A bioetanol gyártás alapanyagául szolgáló kukorica szemtermésére ható legfontosabb termesztési tényezők. Egyetemi Doktori Értekezés, Debreceni Egyetem. Debrecen, 2013 URL: https://dea.lib.unideb.hu/dea/bitstream/handle/2437/163332/PhD%20v%C3%A9gleges_bek%C3%B6ttetett-t.pdf?sequence=6&isAllowed=y

KOVACS A. A mezőgazdasági vállalatok tervezése a környezeti kölcsönhatások figyelembevételével. Szent István Egyetem, Gödöllő, 2014 URL: https://szie.hu//file/tti/archivum/Kovacsa_Attila_ertekezes.pdf

KOVACS A, HORVATH B, FOGARASSY CS. The Influence of Cultivation Method on The Soil's Organic Carbon Content Calculations (Hungarian SOC Reference Values vs. IPCC Defaults). Columella – Journal of Agricultural and Environmental Sciences 2014; 2:77-80. URL: http://www.columella.mkk.szie.hu/archives/columella_2_2014/Kov%C3%A1cs_Columella%20Vol.1%20No.2.(2014).pdf

KOVACS A, DUNAI A, LENCSES E, DAROCZI M. The use of cost-benefit analysis in the selection of alternative milking technologies in the dairy sector. Animal Welfare

Ethology and Housing Systems. 2014; 1: 9-10 URL: http://epa.oszk.hu/02000/02067/00029/pdf/EPA02067_animal_welfare_2014_1_008-013.pdf

KSH: Agrárkörnyezeti adatok, 2000-2010, Központi Statisztikai Hivatal. Budapest, 2012

LEDUC G, BLOMEN E. Sectoral Emission Reduction Potentials and Economic Costs for Climate Change (SERPEC-CC), Transport – Passenger cars, road freight and aviation. Ecofys, London, 2009 URL: http://www.ecofys.com/files/files/serpec_transport_report.pdf

MAGDA R. A megújuló energiaforrások szerepe és hatásai a hazai agrárgazdaságban. Gazdálkodás – Agrárökonómiai Tudományos Folyóirat, 2011: 6 URL:http://www.gazdalkodas.hu/index.php?l=hu&p=cikk&cikk_id=901

MATTHEWS A. Greening the CAP: the way forward, QA Rivista dell'Associazione Rossi-Doria, 2012; 4: 37-40. DOI: 10.3280/QU2012-004002

MATTHEWS, A. (2015): Food security as a driver of integration in Europe, in Brennan, L. and Murray, P. eds., Drivers of Integration and Regionalism in Europe and Asia: Comparative Perspectives, London and New York, Routledge 2015: 148-150 URL: http://www.researchgate.net/publication/278646369_Matthews_A._2015._Food_security_as_a_driver_of_integration_in_Europe_in_Brennan_L._and_Murray_P._eds._Drivers_of_Integration_and_Regionalism_in_Europe_and_Asia_Comparative_Perspectives_London_and_New_York_Routledge_pp._148-163

Point Carbon. Annual Survey- 2015, Thomson Reuters, 2015 https://forms.thomsonreuters.com/AnnualCarbonSurvey2015/

Thomson Reuters. EU carbon price to average €23/t between 2021 and 2030: Thomson Reuters assess the future, 2014. http://blog.financial.thomsonreuters.com/eu-carbon-price-average-e23t-2021-2030-thomson-reuters-assess-future/