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PREFACE

The concept of low-carbon economy is built upon a futuristic theory which depictures the production operating on a low input and energy consumption level so it has a minimal amount of greenhouse gas (GHG) emissions. To measure the loading capacity of the biosphere, researches use carbon-dioxide as a basic GHG unit, therefore all of these gases are generally expressed in carbon equivalent (CO_2e). Briefly, the birth of low-carbon economy is originated from the common opinion of the scientists and the members of the society who recognize the harmful effects of human activity on our environment. Their concern is mostly focused on the GHG emissions indicating such changes in our atmosphere which in a long-term would put our living conditions and the ecological systems in danger. The global interpretation of this initiative encourages the implementation of zero- and low-carbon economic models with the involvement of renewable energies and green technologies. Sometimes, the application of these principles means new challenges for the actors of the economy because our current knowledge serves them with a lack of tools for measuring the real risks and costs of an environmental investment.

In order to develop the appropriate – financial and technological – measurement tools for the examination of climate change, first we must take into account the basic economic interests associated with our appointed targets. Discovering the financial means of the climate friendly projects and tracking the effects of the new technological innovations can be considered quite a new field of study but raising the public awareness of these "start-ups" or "pilot projects" is essential for planning our future systems. Therefore, in the current issue of the AP-STRACT scientific journal it was our aim to introduce some research areas which represent practical business examples for efficient GHG reduction endeavours.

Editor in chief

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SCIENTIFIC PAPERS

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

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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):

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

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

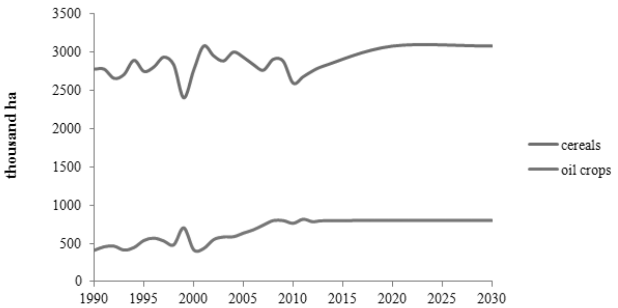
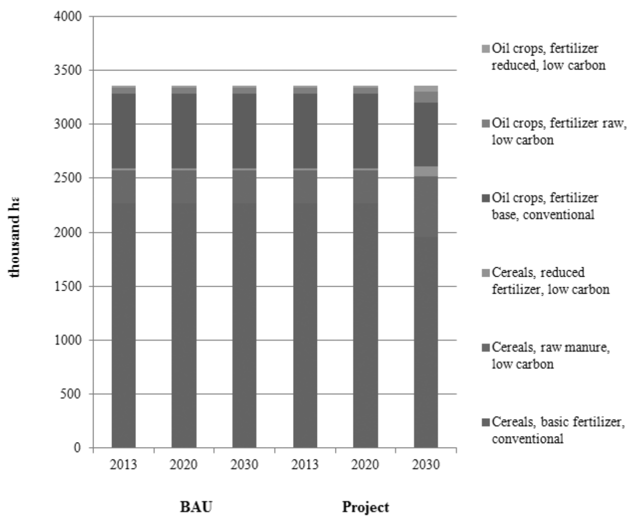


Figure 2: Changes in production structure until 2030



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

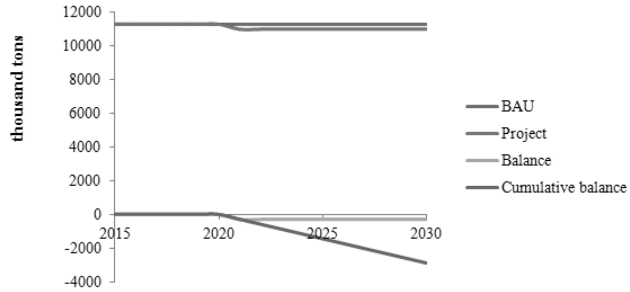


Figure 4 shows how CO_2e emissions per 1 hectare change between the two variants, extrapolated to total area. Thus, a decrease of 0.1 tons of CO_2e per hectare can be achieved over the entire area if an additional 400,000 hectares are included.

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

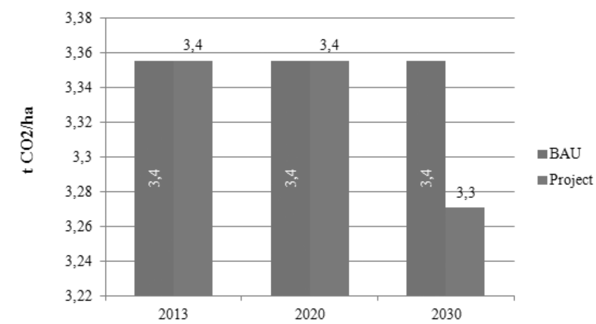
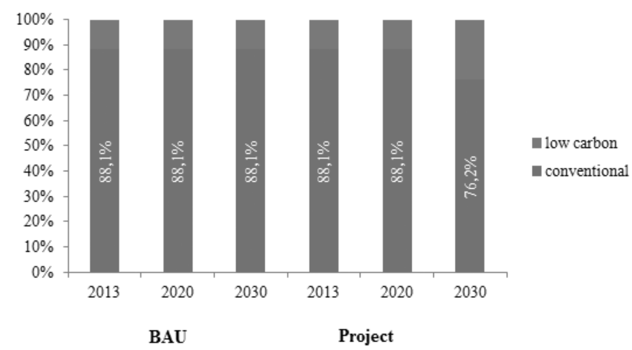


Figure 5 shows the distribution of the various soil cultivation procedures within the two development directions. The proportion of areas treated with „low-carbon" and „no tillage" (or direct seeding) technologies increased to 23.8% by 2030.

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

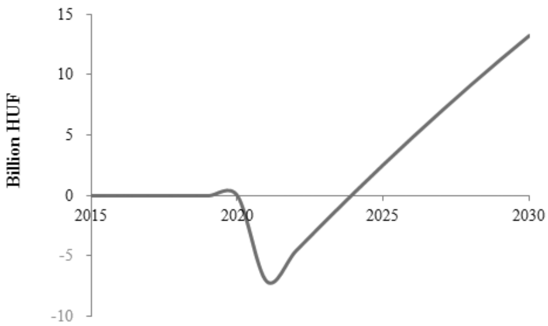


It is apparent from the carbon indices that the areas included in low-carbon soil cultivation lead to the same results as those assumed on the basis of the reduction potential. Both the decrease in absolute emissions and the increase in efficiency were found to be significant. In the future, the index 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

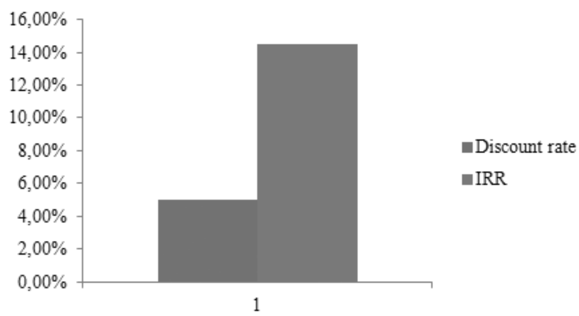
Figure 6 does not only illustrate the project's net present value (NPV) in the traditional sense; it also compares the cost-benefit systems of the BAU and Project variants. The project's investment requirements extend primarily to modern soil cultivation tools and equipment that are suitable for implementing 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



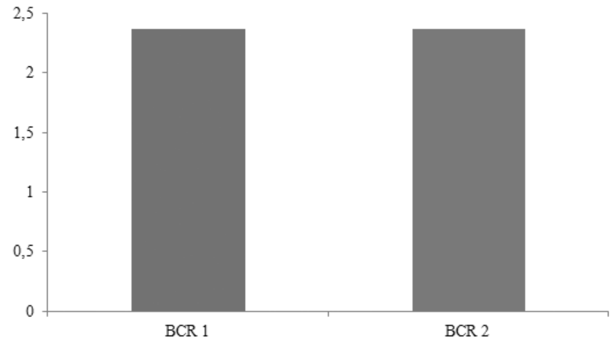
In addition to the discount rate, Figure 7 also shows the internal rate of return, which illustrates the probability that the project's investments will provide a return. The positive values unequivocally support the lessons learned from the NPV curve, which forecast advantageous financial processes.

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.

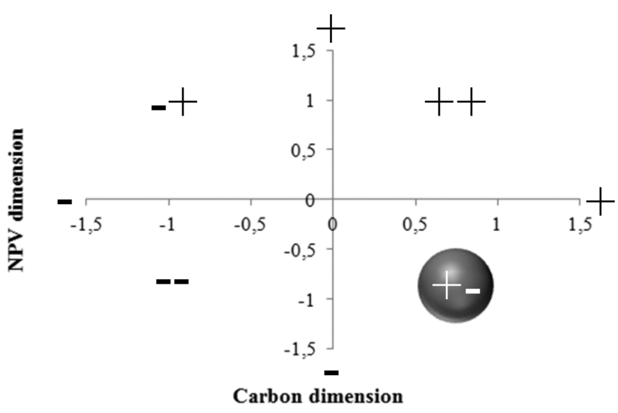
Figure 8: The Project's Benefit–Cost Ratios



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.

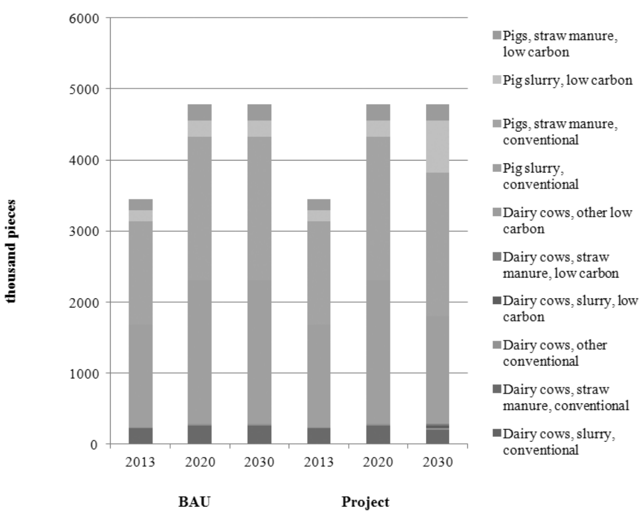
The GHG decrease that can be attained with the project: 4,421,700 tons of CO_2e (decrease extrapolated to a 20-year period)

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

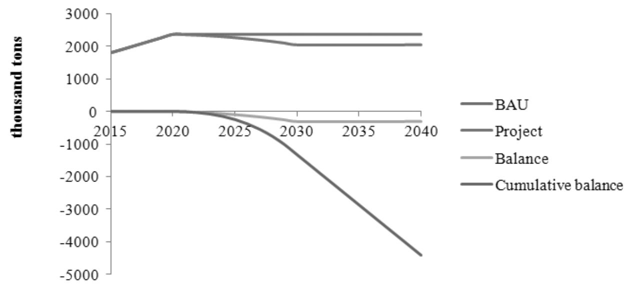


Figure 12: Developments in the industries' average CO_2e efficiency until 2030

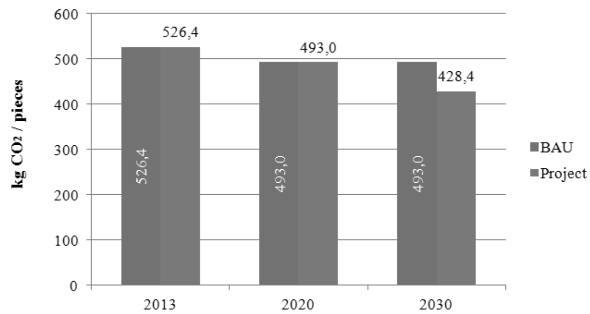
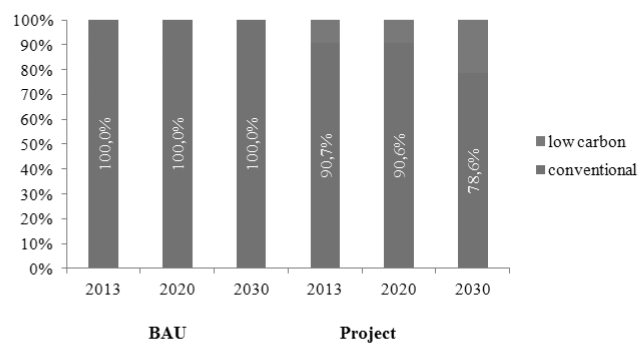


Figure 13: Changes in low-carbon technology ratios in the industries until 2030



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

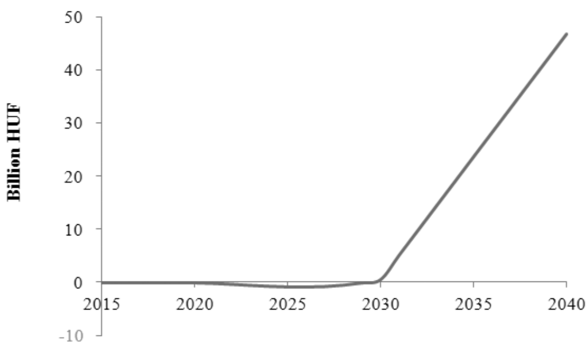


Figure 15: The Project's Benefit–Cost Ratios

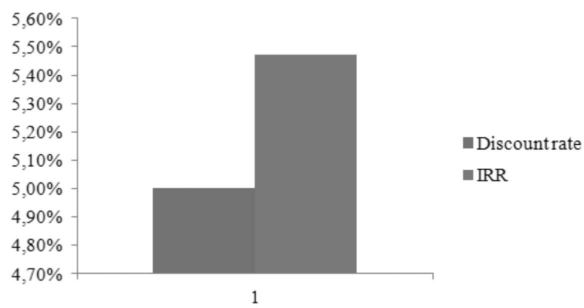
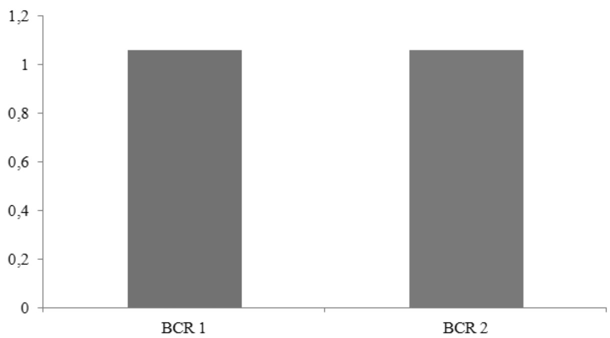


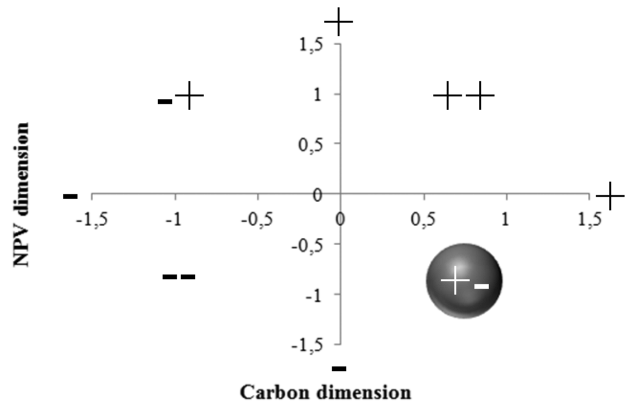
Figure 16: The Project's Internal Rate of Return



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

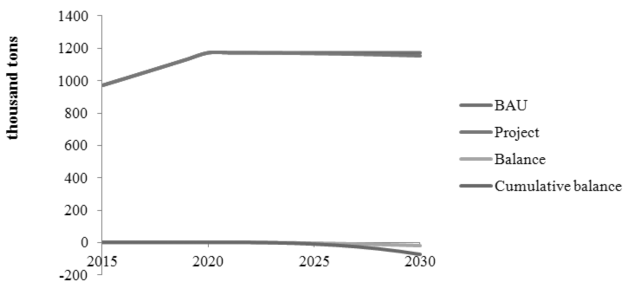
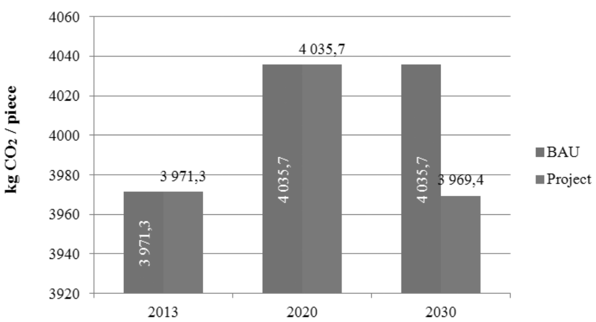
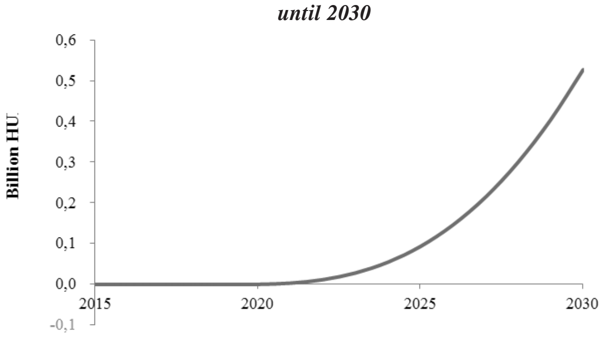


Figure 20: Developments in the industry's average CO_2e efficiency until 2030



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

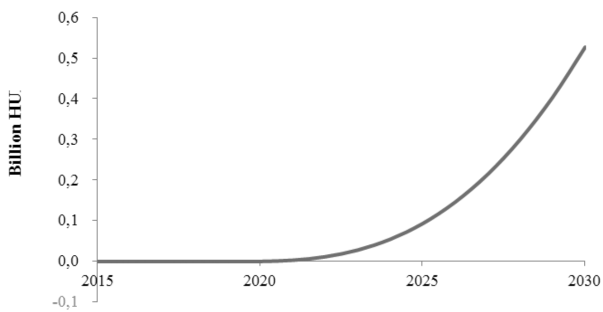


Figure 23: The Project's Internal Rate of Return

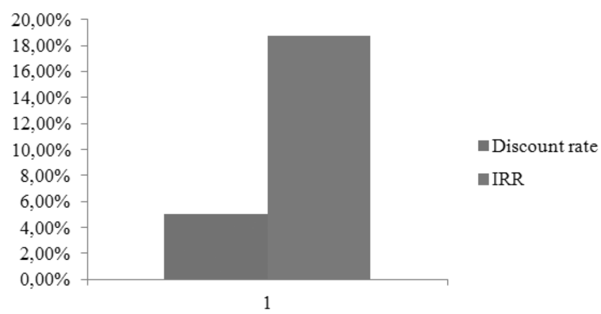
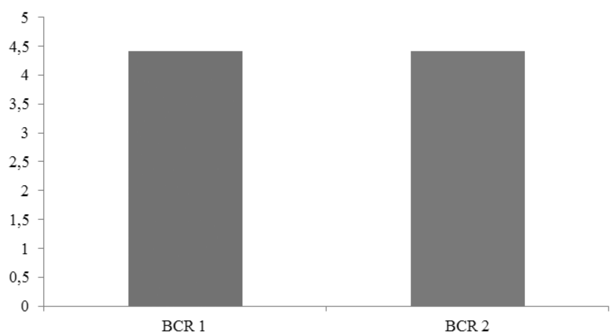


Figure 24: The Project's Benefit–Cost Ratios

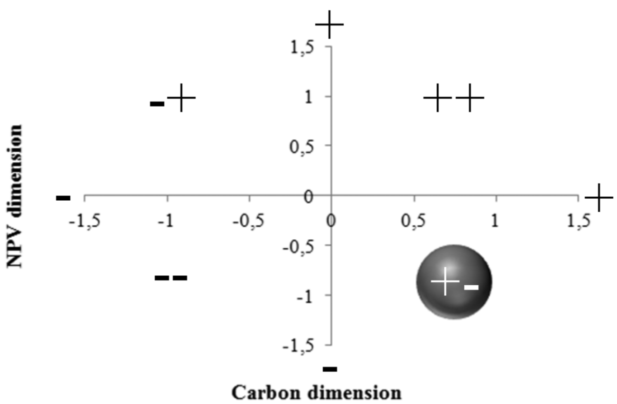


Evaluation of Scenario 3

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

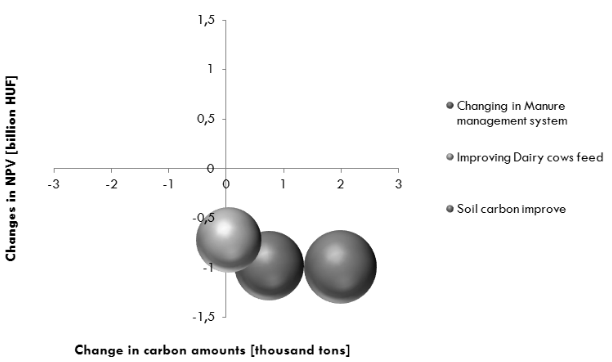
Projects	Scenario 1 Cereals and oilseeds Change in farming technology (for 10 years)	Scenario 2 Dairy cow and pig closed slurry treatment (20 year lifecycle)	Scenario 3 Improving feed practices with consultancy (for 10 years)	Unit (1 EUR/310 Ft)
R+D+I need:	13	18.447	0.274	bn HUF
Amount of change in 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).

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SCIENTIFIC PAPERS

CROSS-SECTOR ANALYSIS OF THE HUNGARIAN SECTORS COVERED BY THE EFFORT SHARING DECISION – CLIMATE POLICY PERSPECTIVES FOR THE HUNGARIAN AGRICULTURE WITHIN THE 2021-2030 EU PROGRAMMING PERIOD

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Abstract: *Ever since 2012, the EU ETS (European Union's Emission Trading Scheme), which is the EU's climate policy was extended to include the ESD (Effort Sharing Decision) sectors' (agriculture, transport, building) regulations. As its name implies, this mechanism is based off of shared interests and efforts, all in order to reach the climate goals. Therefore, analysing the agriculture sector from an environmental viewpoint requires the analysis of related sectors as well, since their performances will have an impact on determining the requirements to be met by the agriculture. Seeing that those primarily present in said sectors are not various firms, but people and public utility management institutions instead, the level of regulations draws from the economic state of the various countries in question (GDP per capita). Therefore, member states like ours did not receive difficult goals until 2020, due to our performance being lower than the average of the EU. However, during the program phase between 2021 and 2030, all nations are to lower their GHG (greenhouse gases) emission, and have to make developments to restrict GHG emission level growth within the ESD, which means we already have to estimate our future possibilities. During the analyses, we will see that analysing agriculture from an environmental viewpoint, without doing the same to their related sectors and their various related influences is impossible. The GHG emission goals determined by the EU have to be cleared by the agriculture sector, but the inputs from transport, waste management and building are required nonetheless.*

Keywords: *effort sharing, emission trading scheme, agricultural emissions, green transport sector, building sector, climate policy* (JEL classification: Q58)

Introduction

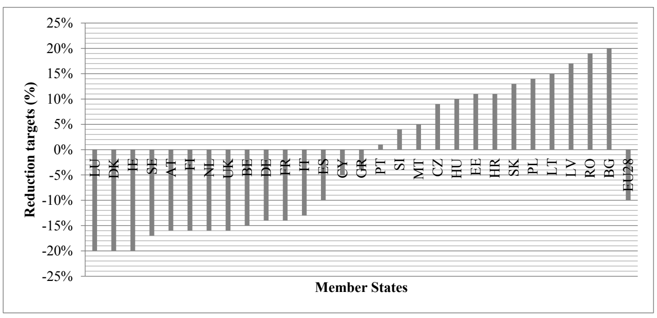
During the operation of the EU's quota-based trade system (EU ETS), one has to see that the sectors in question only hold the EU's greenhouse gas (GHG) emission rates' half, meaning the EU ETS regulations in and of themselves will not fulfil the requirement of reaching the set goals.

This is how the idea to segregate non-ETS sectors (transport, agriculture, building, waste management) and introduce an emission planning program related to them came up. This created the "Effort Sharing Decision" mechanism (ESD), as part of the EU 2009 Climate- and Energy Pack (406/2009/EB). It is in effect for each GHG, and the settling units are also in CO_2 values. However, one could say that other than this fact, it differs from its predecessor in just about everything. The main reason of this is that related sectors (transport, building, agriculture, waste management, etc.) are hard to identify, unlike the ETS, as well as the main actors are not various firms, but often private individuals, whose emission rates are much harder to measure and regulate. Therefore, externalities resulting from this are also harder to identify, which makes internalisation strategy planning complicated. However, it is important to ensure that decision-makers and professionals on the field devise a well-performing framework, since these sectors hold 58% of the entire EU's GHG emissions, or even more - in Hungary's case, this number is around 75% (Kollmuss, 2014a). In many cases, the various ESD sectors intertwine with each other, e.g. the relation between bio-fuels and transport is important during the cross-sector analysis from an agricultural viewpoint. Reason is: the GHG emission reduction goals are determined for the entire ESD mechanism universally, making the processes of sectors one would think are irrelevant to each other become an influencing factor on each other in the end. This is why they can fundamentally influence the cost-effectiveness of GHG emission reduction strategies.

The policies for lowering GHG emission rates inside the ESD are determined not on a level of emission units, but decide border values for each member states' emission reduction - or increase - on a national level, which they have to keep until 2020. In the case of Hungary, an effective +10% GHG emission border value was decided on.

It is important to take note that we are not specifically talking about *lowering* emission rates for some countries, since the limits determined not only advance the completion of the Kyoto goals, but also try to determine the ranking of various nations' economic state using the average EU GDP, and giving them proper goals to aim for, which reflect their estimated capacities. Therefore, countries which are above the average GDP had to make promises to realise a GHG emission reduction of 0-20%, while those who are below it had the option of increasing their emission by up to 20%, to help their economies keep up with that of other EU member states. Figure 1. shows the ranking, which also includes Croatia, who only joined on the 1st of July, 2013 (Forster et. al, 2012).

Figure 1. Goals accepted under the ESD's jurisdiction on EU member state level, compared to the 2005 level.



Source: Forster et. al, 2012

As we can see on Figure 1., the European Commission ordered a 10% emission reduction goal for the entirety of the ESD sector, so that it can reach a 20% reduction overall, compared to 1990 values. However, for this to happen, the three most wealthy member states (Luxembourg, Denmark and Ireland) based on 2005 data, had to maintain a 20% reduction to balance the poorest member state's (Bulgaria) up to 20% increase potential, and for the others to take place between the two ends. Among others, our country was also one of the member states which were allowed an increase until 2020, namely by 10%. Naturally, criticism arose regarding these initiatives ever since, seeing how they do not take the continuous shift in GDP into consideration, and how they require the goals until 2020 to be met based on the 2005 base data from each nation. One of the biggest losses was incurred by Ireland, who is only 5th in the nations' ranking, but had to maintain its 20% goal (Kollmuss, 2014b). Next, we will review how the ESD sectors can be defined both internationally and domestically, most importantly agriculture, which is the focus of our cross-sector analysis.

Connection between sectors of ESD

If we would like to produce a general evaluation of the ESD sectors and their connections, influences on each other inside the EU, we mainly have to discuss transport, building, and agriculture aspects. While waste management also relates here, it has such a low share from both non-ETS (5,4%) and the EU's overall GHG emission rate (3-4%), that not even most of the studies which analyse this factor mention it in detail, since it does not even offer any serious potential for increasing cost-effectiveness. Unlike this, transport with its 34% ESD share, and 20% overall EU GHG emission share (Borkent et. al, 2012) is one of the most influential sectors. Also, unlike the other sectors, its GHG emission decrease costs can be said to be quite expensive, and the volume of emission has been constantly on the rise since 1990. The building and agriculture sectors hold 19% and 18% respective shares of the overall non-ETS GHG emission (Forster et. al, 2012), which is also substantial, but these sectors have their development in a special energy-environment. When remodelling buildings, or making new residences, modern technologies are much more energy- and climate-effective compared to outdated systems, which means that the sector can get rid of a high volume of GHG emission even with non-"low-carbon" orientated programs. Based on this, we can state that the investments of the building sector generate automatic decrease in emission rates even without a regulation framework.

As for agriculture - as we have seen in many occasions regarding European decision-making - due to the priorities of foodstuff production, technological developments are quite contradictive. One of the reasons for this is that its products (foodstuffs, and fodder) always had a special place in the economic system. Therefore, the market protection, income support and rural development functions greatly deformed the optimal use of resources.

This is where we can think of e.g. the Common Agricultural Policy (CAP), which has foodstuff safety as a cornerstone, meaning giving food to as many people as possible, while keeping the quality as high as possible. This immediately offers a proper foundation for those who rationalise against the regulation of agriculture, since they always provide the argument that limiting GHG emission can only worsen the contestability of the sector, and would negatively impact the efficiency of production (Matthews, 2012). Also, the fact that we can view the EU's decisions up until now to be unfounded, since they want to regulate agricultural emission by ignoring the LULUCF (Land Use, Land Use Change and Forestry), which covers the CO_2 volume of land usage, management, and forestry processes. Selecting the optimal decrease strategies is further complicated by the differences in indicators in various countries (default values), and not with ones specifically made for their various attributes (Kovács et. al, 2014). And the biggest problem which stems from these arguments is that they were not concluded as of yet, meaning professionals have a harder job if they want to calculate with the measurements of future endeavours. In conclusion, we can say that the ESD sector which has the most potential to decrease GHG emission is obviously the building sector, where most of the cost-effectiveness optimisation potential lies. This means that most countries do not really dedicate many resources to e.g. transport in terms of climate impact decrease, and they do not really focus on its growth, rather balancing the path to reaching set goals via the investments into buildings. Agriculture remains a stagnant sector, to which no one tends to turn, as long as it is not absolutely necessary. Of course, differences in any country appear compared to this general outline, and we will see how agriculture performs, and aids in reaching the climate policy goals (Hermann et. al, 2014).

Research method

Due to the many perspectives a cross-sector analysis tends to have, we tried to match the indicators of the various sectors during the methodological selection. For this, we implemented the benchmarking method, which is basically a level-comparison method. Its focus is to compare differences in a given space- and timeframe based on a condition system (Bakosne, Fogarassy, 2010). Therefore, we can evaluate a future state of affairs using an attribute group which is at hand at present. Its main advantage is that it can be freely shaped to match the analysis, and highlights how various states differ from our designated state of equilibrium (Camp, 1992). Seeing how this research evaluates the environmental load different sectors have, and by this, also analyses their effect on climate policy, we designated the CO_2 decrease potentials as the main aspect. We also analysed the *technological, environmental and economic* dimensions which have an effect on the changes in CO_2 emission. The first of these factors means technological developments, which offer operation efficiency in the system, and result in lower contamination rates. The environmental side analyses applicability of possible regulations, while the economic dimension shows which areas are the best to invest in (Fogarassy, 2012). To keep the general outlook, each dimension was allotted 3-3 indicator. Next, Tables 1, 2, and 3 show the analysis systems for each sector.

Table 1. Indicator group of agricultural GHG emission's benchmarking analysis

Dimensions	Code	State indicators	Code	Performance indicators (with design method)
		ASPECTS OF DECREASING CO_2 EMISSION		
Technological	CS1	GHG emission's intensity based on technology	CP1	GHG emission based on evaluating technology variants which can be implemented
	CS2	Opportunities to introduce Low-carbon technology in the sector	CP2	Share of bio-ethanol on the field of bio-fuels
	CS3	Composition and volume index of typical GHGs	CP3	Decrease potential of CO_2 share of overall GHG emission
Environmental	CS4	Environmental attributes of GHGs subject to emission	CP4	Detailed characterisation of GHGs' environmental attributes, and analysis related to expected directives
	CS5	Consistency of environmental regulations / norms, border values	CP5	Does the regulation aid or hinder the completion of environmental policy goals?
	CS6	Level of environmental risks for emission	CP6	Attributes and usefulness of adaptation policies
Economic	CS7	Attributes / Level of share in overall GHG emission	CP7	Total volume of CO_2 emission for all sectors under the jurisdiction of regulations
	CS8	General costs for GHG avoidance for each unit of ÜHG CO_{2e}	CP8	Cost index of CO_{2e} emission decrease in the sector
	CS9	Form of aiding the completion of GHG climate policy goals	CP9	Calculations regarding volume and efficiency

Abbreviations: "CS1...9" - state indicators of CO_2 reduction aspect by dimensions; "CP1...9" - performance indicators of CO_2 reduction aspect by dimensions

We can see the generic climate policy analysis' framework in Table 1. We defined two main aspects of the various indicators: *State and Performance indicator groups*. The first defines the analyses' point of view, a starting state, which has to be explored to get a clear view of the current state of the various sectors. This point of the analysis does not change for the sake of comparison, and can be considered constant. The other, performance indicator however is different, since e.g. we cannot evaluate the same technological system both for the transport and agriculture sectors. Therefore, this indicator group was made to measure the previous, in other words, state indicators' change in direction and level. Another important element of the analysis is that the EU wants to draw relevant conclusions for the next program period (2021-2030). However, for this to happen, we also have to know the previous timeframe's specifics. Therefore, the level of change in state between 2020 and 2030 can only mean one part of the analysis, the other one is evaluates processes in effect between 2010 and 2020. This is advantageous, due to a portion of the timeframe already passed, so analysing it can help us evaluate trends in the future.

The basis of scenarios until up to 2030 were built using models and databases like the IPCC Hungary database, the transport analysis mechanism accepted by the EU, the Tremove (Nemry, 2011), and the effect evaluation of our apartment block programme (Vorsatz et. al, 2010).

Table 2. Indicator group of transport GHG emission's benchmarking analysis

Dimensions	Code	State indicators	Code	Performance indicators (with design method)
ASPECTS OF DECREASING CO_2 EMISSION				
Technological	CS1	GHG emission's intensity based on technology	CP1	GHG emission based on evaluating technology variants which can be implemented
	CS2	Opportunities to introduce Low-carbon technology in the sector	CP2	Changing the shares of public transport and traffic
	CS3	Composition and volume index of typical GHGs	CP3	Decrease potential of CO_2 share of overall GHG emission
Environmental	CS4	Environmental attributes of GHGs subject to emission	CP4	Detailed characterisation of GHGs' environmental attributes, and analysis related to expected directives
	CS5	Consistency of environmental regulations / norms, border values	CP5	Does the regulation aid or hinder the completion of environmental policy goals?
	CS6	Level of environmental risks for emission	CP6	Attributes and usefulness of adaptation policies
Economic	CS7	Attributes / Level of share in overall GHG emission	CP7	Total volume of GHG emission for all sectors under the jurisdiction of regulations
	CS8	General costs for GHG avoidance for each unit of ÜHG CO_{2e}	CP8	Cost index of CO_{2e} emission decrease in the sector
	CS9	Form of aiding the completion of GHG climate policy goals	CP9	Calculations regarding volume and efficiency

Abbreviations: "CS1…9" - state indicators of CO_2 reduction aspect by dimensions; "CP1…9" - performance indicators of CO_2 reduction aspect by dimensions

Table 3. Indicator group of building GHG emission's benchmarking analysis

Dimensions	Code	State indicators	Code	Performance indicators (with design method)
ASPECTS OF DECREASING CO_2 EMISSION				
Technological	CS1	GHG emission's intensity based on technology	CP1	GHG emission based on evaluating technology variants which can be implemented
	CS2	Opportunities to introduce Low-carbon technology in the sector	CP2	Level of applicability for known low-carbon technologies
	CS3	Composition and volume index of typical GHGs	CP3	Changes in CO_2 decrease rates
Environmental	CS4	Environmental attributes of GHGs subject to emission	CP4	Detailed characterisation of GHGs' environmental attributes, and analysis related to expected directives
	CS5	Consistency of environmental regulations / norms, border values	CP5	Does the regulation aid or hinder the completion of environmental policy goals?
	CS6	Level of environmental risks for emission	CP6	Attributes and usefulness of adaptation policies
Economic	CS7	Attributes / Level of share in overall GHG emission	CP7	Total volume of CO_2 emission for all sectors under the jurisdiction of regulations
	CS8	General costs for GHG avoidance for each unit of ÜHG CO_{2e}	CP8	Cost index of CO_{2e} emission decrease in the sector
	CS9	Form of aiding the completion of GHG climate policy goals	CP9	Calculations regarding volume and efficiency

Abbreviations: "CS1…9" - state indicators of CO_2 reduction aspect by dimensions; "CP1…9" - performance indicators of CO_2 reduction aspect by dimensions

Interpreting the externalities

During our research, we did not interpret externalities in their usual, economy related meaning, but acted as a container for any positive or negative effect which can induce a change in the related sectors' CO_2 equations instead. The basic goal was to analyse if the indicator supports or hinders the sector in reaching the set GHG emission decrease goals. Since the direction of the indicator's change is not enough for us in and of itself, we also ranked the level of their change, giving each indicator a value between -2 and +2. When they were summarised, the value 0 meant the optimal level of the system (best practice), and any difference was a pointer which meant something was amiss. Where negative externalities are amassed, it means the system has faults in its basic structure, which is why allocating resources into its operation is a lost cause. In this case, we mostly have to remedy errors in structure, and development programs can only come after. If there are too many positive externalities, we can conclude that there are unused capacities. This means that we have to support the sector with funds, since it can produce even better than current results in the future (Fogarassy, 2012).

Research results

The results for the GHG emission reduction benchmarking analysis for each sector can be seen in Table 4. Summarising the externalities can be done from various perspectives, which all have different amounts of inherent information. During our evaluation of results, we used three different points of view, which were named "A", "B" and "C". "A" was the "net

Table 4. Evaluating the benchmarking analysis

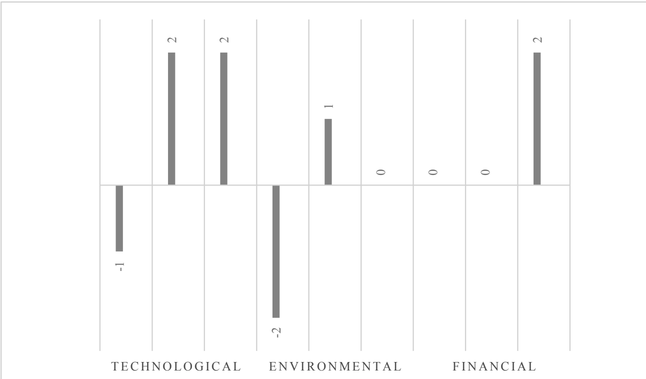
Number		Aspects of decreasing CO_2 emission of the agriculture sector		Aspects of decreasing CO_2 emission of the transport sector		Aspects of decreasing CO_2 emission of the building sector	
		2010/2020	2020/2030	2010/2020	2020/2030	2010/2020	2020/2030
Technological	1	-1	-1	0	-1	0	1
	2	1	2	0	0	0	1
	3	2	2	1	-2	1	2
Environmental	4	-2	-2	-2	1	-2	-1
	5	-1	1	-2	1	0	1
	6	-1	0	-2	-1	0	0
Economic	7	0	0	-1	-2	1	2
	8	0	0	-1	-1	2	2
	9	2	2	-2	-1	1	2
A: Net positive externality ∑ (1;9)		**0**	**4**	**-9**	**-6**	**3**	**10**
B: Total externality ABS (1;9)		**10**	**11**	**11**	**10**	**7**	**13**
C: Share of net positive externality effects in total externality effects		**0%**	**40%**	**0%**	**0%**	**43%**	**77%**

Explanation: *A - Net positive externality sum (1;9) means the amount of appearing positive externalities in the various aspects between 2020 and 2030, if there are not any direct climate policy developments apart from BAU; B - Total externality ABS (1;9) is the absolute value of all externalities present ; C - the share of net positive externality effects in the total externality effects, shown in percentages to describe the dimension of development ability on the examined area.*

positive externality" value, which means a simple summation. "B" became the "total externality ABS", with which we wanted to know the total amount of externalities present in the sector, therefore, we summated the absolute values there. Finally, "C" shows how apparent the ratio of net positive externality (A) is in the total externality (B). We have to be careful here, because if the net positive externality amount is already negative, their ratio will also naturally become 0 (Fogarassy, Bakosne, 2014). However, this does not imply optimal operation, but shows structural faults instead.

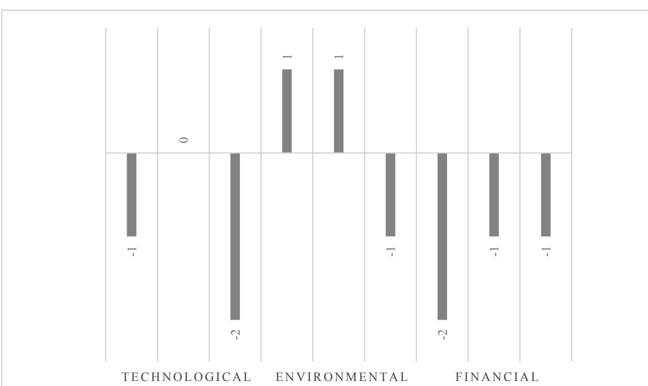
Evaluating the agriculture sector: in the case of the agriculture sector, we can see that there are no decisive differences in externality amassment between the two timeframes, but we can see differences in structure. Hungarian agriculture produces optimal results until 2020 from a climate policy perspective, however, unused potential in the system appears before 2030 (Figure 2). We can follow this best by analysing the indicators which have different externality domains for the two timeframes. We can see that three of the externalities with a +4 value appear for environmental indicators, meaning that is where changes should be made to optimise operations. This dimension means the intensity of environmental regulations, so it is no wonder that the sector's analysis shows unused opportunities. We already mentioned that not only climate policy goals, but other economic interests are pushed back in favour of other priorities of agriculture, so some already say that the operation system is not as effective as it could be (Barry et. al, 2010). We can also see this in the process of amassing negative externalities in the environment dimension, which may be the result of possibly implemented wrong decisions. However, our benchmarking analysis still decided that the current state of affairs is optimal, but not issuing strict regulations may cause problems in the future. The other important aspect is the question of technological development, where we can again see the strong change in an indicator, which may keep this group on the side of positive externality content by 2030. This also means a problem which is already discussed by many: not using the energy production potential of agriculture (Magda, 2011). We have long understood that the sector holds energy production potential, which could support other sectors (e.g. bio-ethanol, biogas for transport), but could at the very least be self-sufficient regarding energy input (Fonseca et. al, 2010; Elbersen et. al, 2012). Therefore, for the next program timeframe, implementing these technological developments is advised.

Figure 2. Number of externalities within the agriculture sector in 2030



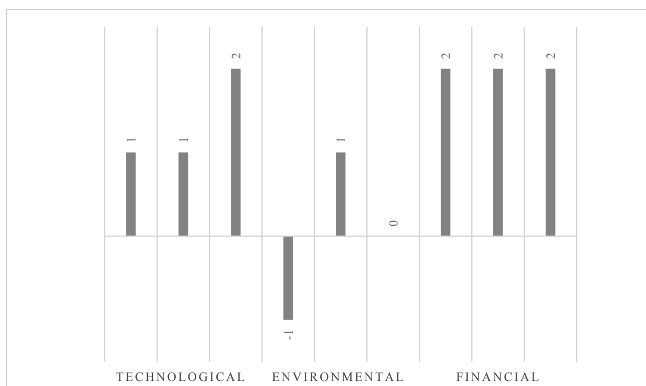
Evaluating the transport sector: the negative externality amassment of the transport sector is not surprising, since it is widely known that this is one of the worst performing sector of the EU's climate policy (Schade, Krail, 2012). The 0% in this instance does not mean optimal performance, but instead an over-abundance of negative externalities. This also highlights how the error should be in the structure of the current transport (both public and private). Out of the nine indicators, seven show a difference in the externality-domain, which means that major developments and changes have to be made. We can see that the current, more-or-less optimal operation in the technological dimension may result in strong negative consequences based on current trends. New, environmentally friendly transport technologies (CNG, electric cars) will become more easily acquired, and their spread - even via subsidies - may become a matter of life and death for the sector's future (Stanley et. al, 2011). For the environmental regulations, we can clearly see that the current structure is not good from a climate policy aspect, but the best positive feedback can be achieved here, compared to others (Figure 3). In the future, it might be advantageous to implement western-European solutions which can advance the dismissal of vehicles ran on fossilised energy resources (e.g. traffic jam fee) (Selih et. al, 2010), and the users of new technology can be aided (e.g. being excluded from said fee) (Strong, Chun, 2014). The subsidy system does not amass externalities by chance for the next timeframe, since it is obvious that resources should never be allocated to traffic systems which were designed with faults.

Figure 3. Number of externalities within the transport sector in 2030



Evaluating the building sector: we have known for a while that the building sector means a lifebelt in the ESD for most climate impact decrease goals to the EU member states (Korytarova, 2010). While the GHG emission of the transport sector is on the rise daily, and that of the agriculture sector is stagnant, the biggest and cheapest reduction volume can be achieved here (Rysanek, Choudhary, 2013). This is the reason that the analysis showed unused development opportunities in the system for the 2015-2020 timeframe already, and their numbers will rise until 2030 (Figure 4). While the technological side works more-or-less optimally until 2020, the next timeframe brings a rise in positive externality amount. This is the result of most - currently, only minor - modern systems will spread until then. The examples are passive houses, or "zero-energy" buildings, which are based on a minimal energy consumption already in concept, and the latter uses renewable energy resources even for these reduced requirements (Schimschar et. al, 2014). Opportunities which show themselves refer to the adaptation of such developments exactly, which have to be implemented to achieve efficiency. The optimal value of the currently slightly negative regulations may be achieved after 2020. This is a result of the EU's decision that new buildings can only be built using said zero-energy concepts after 2018 (Klinckenberg et. al, 2013). The source of non-utilised opportunities obviously result from the economic side, meaning the fact that monetary resources are not utilised to the best effect. In recent years, we saw how various "climate resources" were at hand, which we could not use as effectively as we intended to, since we could not place most of the resources at hand.

Figure 4. Number of externalities within the building sector in 2030



Conclusions

During the analyses, we saw how evaluating the agriculture sector from a climate policy aspect is impossible without doing the same to the effects on other sectors. The GHG emission rate decrease goals set by the European Union have to be achieved by including the inputs of the transport, waste management and building sectors as well. Our research shows that out of our three sectors, transport is the one which has negative development tendencies, that can be balanced out by the cheap development opportunities of old buildings on a national economy level. However, these trends are only good solutions at present, knowing how short the life cycle of apartment blocks became. We have to state that out of the three sectors, agriculture is the one that did not require any climate policy inputs as of now, and due to this, has a more-or-less stagnant emission value as well. The other important aspect of the question is that we never had the chance to maintain climate policy regulations for agriculture, since the ones subject to regulation usually resist through various lobby groups. This resistance relies upon stressing the safe foodstuff support function, which is handled as exceptionally important in the EU since WWII. The question is, how long the sector can escape strong regulations, and when we will need a higher contribution from the agriculture sector to reach the climate policy goals that were enforced upon us. Analysing the data in the evaluation matrix, we can say that the current workings from a GHG emission rate decrease aspect is more-or-less optimal, but various dimensions do not say the same on their own. Many believe that the lax environmental checks, and production discipline results in the energy production potential of the agriculture sector not performing as it should. E.g., an effect of this is that Austria's or Germany's biogas facilities, which can be said to be an important part of husbandry are not present in our own domestic husbandry. This contradictive situation is also supported by our benchmarking analysis, and we can also see how these anomalies may destroy the equilibrium of the entire sector by 2030. As a generic term of economy, the "lock-in effect" describes how currently dismissed developments may cause damages in the long-term, since they may cost a lot more in the future. This may be a fundamental point for agriculture. Therefore, strengthening the energy production scheme of the agriculture in the next program timeframe is highly advised, which may not only help the sector itself, but other sectors (e.g. transport) to realise climate friendly development.

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NEW TOOLS AND OPPORTUNITIES IN GROWTH AND CLIMATE FRIENDLY GREENING FOR SMALL AND MEDIUM ENTERPRISES IN THE EUROPEAN UNION

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Abstract: *The role of Small and Medium Enterprises (SMEs) is unquestionable in the European economies, while financial opportunities are still inadequate for them. The more than 20 million SMEs play a significant role in European economic growth, innovation and job creation. According to the latest EC Annual Report , SMEs are accounting for 99% of all non-financial enterprises, employing 88.8 million people and generating almost EUR 3.7 tn in added value for our economy. Despite the fact that there is plenty of EU funding available for these SMEs, for certain reasons these funds hardly reach them. But we have to see that the EU supports SMEs by various way, e.g. by grants, regulatory changes, financial instrument, direct funds. On the other hand, SMEs and decision makers realised that the environmental sustainability has to be attached to the economic growth, therefore more and more tools are available for these enterprises. Over the last few years, public institutions, the market, the financial community and non-governmental associations have explicitly demanded that firms improve their environmental performance. One of the greatest opportunities might lay in the Climate- and Energy Strategy till 2030 as 20% of the EU budget is allocated to climate-related actions, however the easy access to finance is still a key question.*
Does the EU recognise the actual difficulties? Is there a systemic reason behind the absorption problems? Is the EU creating a more business-friendly environment for SMEs, facilitating access to finance, stimulates the green and sustainable growth and improving access to new markets? The paper analyses the current European situation of the SMEs and the effectiveness of some new tools, which are specially targeting SMEs.

Keywords: *SMEs, EU, CMU, EFSI, Asset Purchase Scheme, Horizon2020, COSME, EIB* (JEL classification: Q18)

Introduction

Small and Medium Enterprises play a significant role in the European economies, while we can explicitly state that the climate aspects are inevitable. The goal of this paper is to give an overall picture about the situation, main challenges and funding sources of the SMEs in the European Union, the new tools and the opportunities in climate actions and growth, including greening. Competitiveness and innovation has an outmost importance nowadays, while the environmental aspects have to be taken into account for our viable future. In information age, technological innovation rather than investment per se become the main source of increased productivity, the major tool of economic competition in the world market. Green innovative and environmental sector performances are crucial to the future competitiveness of environmental targets all the EU Member States.[1]

1 Sudi Apak, Erhan Atay: "Global competitiveness in the EU through green innovation technologies and knowledge production."

SMEs in the EU

SMEs are classified as micro, small and medium enterprises on the basis of the number of employees, and their turnover or balance sheet total. Micro enterprises are defined as enterprises which employ fewer than 10 persons and whose annual turnover or annual balance sheet total does not exceed 2 million euros. Small enterprises are defined as enterprises which employ fewer than 50 persons and whose annual turnover or annual balance sheet total does not exceed 10 million euros. Medium-sized enterprises are defined as enterprises which employ fewer than 250 employees and whose annual turnover does not exceed 50 million euros and annual balance sheet total does not exceed 43 million euros.[2] If we use this classification, the majority of the SMEs in the EU were small and micro enterprises in 2013; ergo, we should focus on these businesses.

2 European Commission. „Recommendation concerning the definition of micro, small and medium-sized enterprises."

These SMEs represent over 90% of all EU businesses and account for two out of three jobs (In 2013, 21.6 million SMEs employed 88.8 million people[3]); therefore we can state that SMEs are the backbone of European economy and they can assist in reaching the climate goals (*Table 1*). It might be shocking at first sight, but we can easily accept it if we reckon that there are over 20 million SMEs in the EU. The latest Annual Report on European SMEs shows that SMEs in the EU-28 experienced a value-added increase of 1.1% (generating the 28% of the EU28's GDP in value added in 2013), while employment fell by 0.5%, and the number of enterprises decreased by 0.9%.[4] As a consequence, we can state that they are significant actors in the European economics, so there should be a political priority for supporting SMEs, especially in terms of access to financing and boosting competitiveness.

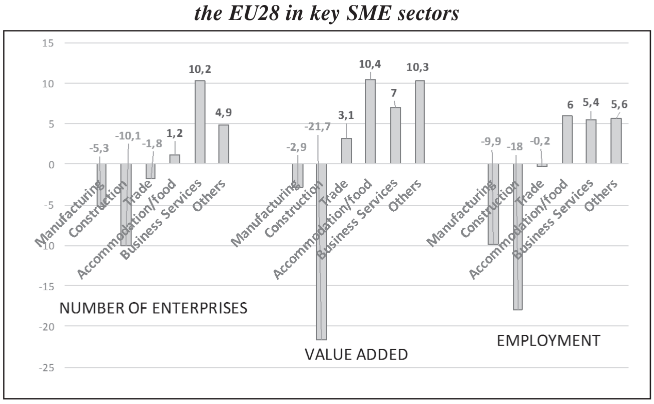
Table 1. SMEs and large enterprises: number of enterprises, value added and employment in the EU28 in 2013

	MICRO	SMALL	MEDIUM	SMEs	LARGE	TOTAL
NUMBER OF ENTERPRISES						
Number	19,969,338	1,378,374	223,648	21,571,360	43,517	21,614,908
%	92.4%	6.4%	1.0%	99.8%	0.2%	100%
EMPLOYMENT						
Number	38,629,012	27,353,660	22,860,792	88,843,464	44,053,576	132,897,040
%	29.1%	20.6%	17.2%	66.9%	33.1%	100%
VALUE ADDED AT FACTOR COSTS						
Million Euros	1,362,336	1,147,885	1,156,558	3,666,779	2,643,795	6,310,557
%	21.6%	18.2%	18.3%	58.1%	41.9%	100%

(Source: Eurostat, National Statistical Offices and DIW Econ)

The main sectors in which SMEs are active are the wholesale and retail trade sector, manufacturing, construction, professional, scientific and technical activities, accommodation and food. These sectors account for about 78% of all SMEs activity in EU-28. Some sectors had a relative strong positive growth from 2008 to 2013, namely business services, retail and wholesale trade, while the industry sector decreased significantly by 2013 (*Table 2*).

Table 2. Change (in %) in three SME indicators from 2008 to 2013 in the EU28 in key SME sectors



(Source: Eurostat)

The number of SMEs is varying, differing by size of the SMEs: there are more micro firms than there were in 2008 (+0.3%), the number of the small and medium firms fell (respectively) by 1.6% and 2.5% since the crisis started. The recovery - in added value - has been driven mostly by the medium (2.7%) and micro enterprises (+0.5%), while the small firms are still lagging behind just below 2008 levels in 2013. In terms of employment, all types of SMEs are still below the 2008 level in 2013 (e.g. the employment rate of the micro firms is 4.2% lower).[5]

It would be a clear assumption that this number of SMEs absorb significant amount of grants to maintain and expand their activities; moreover that they contribute to the green growth actively. We can assume it, as remarkable EU funds had been allocated for environmental (30,548 million EUR), and Research, Development and Innovation (R+D+I- 18,426 million EUR) purposes only in Central and Eastern Europe (CEE) already in the 2007-2013 programming period. However, if we split contracted grants by the intervention types (2010), these two elements represent only the 4th and 5th place while almost half of grants supported operations in relation to transport and human resource development.[6]

Method

This study is based on our desktop research. During our research work we used the relevant documents of European Commission and other analyses, reports. The desktop research methodology refers to seeking facts, general information on a topic, historical background, study results, etc., which have been published or exist in public documents. This kind of information can be obtained from libraries, newspaper archives, and governmental-, EU Institutions-, university websites. Most of the research undertaken by these sites is easily accessible on the internet and we have up-to-date access to this kind of information also. In our case we have chosen this type of methodology to underline our hypotheses.

Discussion

Main challenges for SMEs

SMEs are usually more vulnerable than larger enterprises as they have less capital and market power. The main challenges for SMEs are: difficulty in accessing financing, regulatory burdens, finding customers, ensuring competitiveness, costs of production and labour. Out of these factors, the access to financing is one of the most significant challenges of SMEs after the financial crisis; especially at the stage of creation of such enterprises, to maintain activities, but even to reach growth and innovation. At this point, we have to note that innovation is often neglected, however this could be the key of competitiveness: it generates growth and creates value. But of course, innovation needs stable financial background,

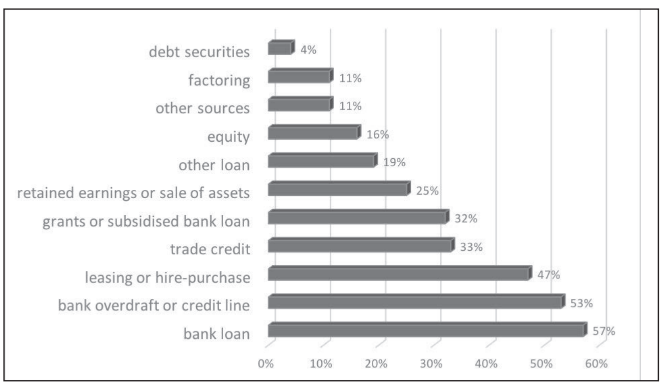
3 European Commission. „Entrepreneurship and Small and medium-sized enterprises (SMEs)."
4 European Parliament Research Service. "Green growth opportunities for SMEs Green Action Plan."
5 European Commission. "Annual Report on European SMEs 2013/2014: A Partial and Fragile Recovery"
6 KPMG. „EU funds in Central and Eastern Europe, Progress report 2007-10."

which means credits and loans for SMEs. Moreover, one of the biggest economic and ecological benefits opportunities for the SMEs is provided by the green growth sectors, and is going to grow considerably in the next years.

Unfortunately, the recent financial crisis led to tighter credit standards for loans in general and particularly in countries where banks are still suffering from the impacts of the crisis. The information gap between SMEs and creditors, and lack of knowledge in general; venture capital, business angels and crowd funding are not available as financing alternatives to regular bank lending. There is a specific feature in the case of SMEs, namely the source of financing, which usually differs from a larger enterprise: at early stages SMEs tend to use internal sources, such as family and friends' savings, own capitals; and they use bank loan and external equity just at later stages. At this phase, SMEs show a preference for debt-based financial instruments (such as loans) rather than equity financing (*Table 3*). There can be no doubt that with the known and hidden obstacles, SMEs have had to navigate in a difficult economic terrain in recent years, while the recovery of SMEs is a slow progress.

Meanwhile, there is a common understanding that environmental sustainability has to be attached to the economic growth. It seems the most opportunity for SMEs lays in the greening tools, by which they could effectively contribute to the climate and energy headline targets, adopted by the European Council in October 2014. However, the greening of the products, processes, and services is not that easy; which has been realised on time. Therefore the Commission provided the so called Green Action Plan for SMEs, which will further stimulate SMEs to develop the benefits of green growth. There are still some uncertainties regarding return on green economy investments, due to the new technologies and business models, a wide pallet of instruments are necessary. There are also some important items missing here, such as the cross-sectoral collaborations, the set-up of informal networks and the invaluable role that sector federations.[7]

Table 3. SME financing sources in EU-28



(Source: Survey on the Access to Finance of Enterprises- SAFE, 2014)

7 European Parliament, Committee on Industry, Research and Energy. "Report on green growth opportunities for SMEs."

Successful delivery of available tools to SMEs

Despite the fact that there are plenty of financial tools for SMEs, there are only few success stories with the delivery to SMEs in practice. There are different European programmes, but SMEs seem to have difficulties to reach them because of heavy bureaucracy, lack of awareness, and lack of up-to-date data.

It seems that the allocated amount of financing, the structure of these investments and access to them need to be improved to guarantee that they will reach the SMEs in different situations. The picture is more complex with significant disparities in conditions of access to financing between Northern and Southern Member States, due (among other factors) to differences in economic conditions, including sovereign ratings. There is no common market with SMEs having low interest rates of 4% in the North, and high interest rates of up to 12% in the South[8].

An other element has to be considered when we talk about the range of available tools: the European Union will reduce domestic greenhouse gas emissions by at least 40 %, increasing the share of renewable energy to at least 27 % and increasing energy efficiency by at least 27 % (or even 30%) by 2030. SMEs shall play their role in fulfilling these targets, as 93 %[9] of them are already taking measures to become more resource efficient. Also to mention some areas: eco-design, waste prevention, recycling and reuse could bring net savings for EU businesses, estimated to represent up to EUR 600 billion, or 8 % of annual turnover, while also reducing total greenhouse gas emissions by 2-4 %.[10]

To reach these goals, to boost the economies and to stimulate investments in the EU, policy initiatives need to be aligned: besides the approximately €180 billion EU budget allocated to climate actions in 2014-2020 - which amount is three time larger than in 2007-2013-, the Investment Plan, the Capital Market Union initiative and the European Central Bank's €1,100bn asset purchase scheme seem to play a significant role for SMEs.

New opportunities for SMEs

It is obvious that EU policies should give additional sources of financing to these companies. The topic is under constant debate in several levels of policy making in the EU. As a common view, it can be deduced that there are more and more financial resources available across the EU, but the effectiveness of these tools for SMEs is still to be proven. It has to be noted that these financial sources should not be considered as free money, but they should be used as tools for innovation, job creation and economic improvements. This is also valid for companies which are developed specifically for foreign markets. A large number of firm-level studies have found that there are

8 European Economic and Social Committee. „Finance for business/alternative supply mechanisms."

9 European Commission. „Report on SMEs, Resource efficiency and green markets."

10 European Parliament, Committee on Industry, Research and Energy. "Report on green growth opportunities for SMEs."

a positive link between innovation and exporting. However, the relationship between innovation and exporting not simple. In recent comprehensive review of the literature on SME exporting, innovation and growth draw three key conclusion. First, there is a strong positive association between innovation, exporting and SME performance. Second, innovation and exporting work jointly to improve performance. And finally, there is strong element of interdependence in this process.[11]

If we take only one promising part of the economy, the global market for environmental goods and services is estimated at EUR 1 000 billion per year, and it is estimated that this amount will triple by 2020. This creates tremendous opportunities for Europe's SMEs and economic growth in general in the EU. The European Union is a world leader in both the import and export of environmental goods.[12]

It is clear that these tools should be seen as opportunities for the development of the companies and now, more tools seem to be enforced.

Let's start with the European Strategic Investment Fund (EFSI or so called 'Juncker- plan'), which has ambitious targets. The EFSI shall provide financial support to companies and other entities having up to 3000 employees, with a particular focus on SMEs and small mid-cap companies. The increased access to financing should be of particular benefit to SMEs, including the creation of start-ups and academic spin-offs, social economy enterprises and non-profit organisations.[13] There may be further discussions about the above stated 3000 employees' limit, as SMEs might not be competitive with large companies. Hence, the 'particular focus' has to be reinforced in the implementing regulations, and the labelling of certain parts of the fund is recommended.

The EFSI is one tool, while all these actions should be seen in a larger picture. As a consequence, we have to talk about the *'Capital Market Union'*, which can be an expanded opportunity for SMEs, through bonds, equity and securities. While there are certain steps taken towards the creation of this union, we have to note that it is not a new idea: just see the idea of the Single Market which was one of the main goals of the Treaty of Rome. The creation of such a union covers a wide range of acts, namely eliminating barriers from an integrated capital market, ensuring a stable economic playing field, eventually boosting the EU's economy. Commissioner Hill made a brave step by identifying the deadline for the establishment (2019), which may turn out to be ambitious.

But let's see the improvements made in this regard: The responsible candidate-Commissioner announced the idea of this union, while the European Commission unveiled further details of the proposal on the 18th of February 2015. Its flagship plan is to strengthen the economy of the EU by making it easier for companies to raise money on stock and bond markets. Publishing a Green Paper, the Commission launched a public consultation on its project to forge a truly single market for capital. It aims at – among other things –, standardising file reports that companies publish to issue stocks and bonds, making it easier for investors to get credit information on small companies asking for cash, and facilitating securitisation, that is, pooling together various types of debt to create a new class of high-quality asset-backed financial instruments.

As a consequence, the CMU is a combination of initiatives aimed at developing non-bank lending and capital market financing. The idea draws inevitable comparison with the US, which has a more diverse financial environment for mid-sized companies. As a comparison, these companies receive approximately five times more funding from capital market than their equivalents.[14]

On the basis of the outcome of this consultation the Commission seeks to identify the actions that are necessary to achieve the following objectives:

- improving access to financing for all businesses across Europe (in particular SMEs) and investment projects such as infrastructure;
- increasing and diversifying the sources of funding from investors in the EU and all over the world; and
- making markets work more effectively and efficiently, linking investors to those who need funding at lower cost, both within Member States and cross-border.[15]

Further to that, the Commission has identified a number of areas where the need for progress is widely recognised, and which have potential to bring early benefits: lowering barriers to accessing capital markets, widening the investor base for SMEs, building sustainable securitisation, boosting long term investment and developing European private placement markets.

We can state that all these efforts are ineffective without proper assets. Thus the *'asset purchase scheme'* – the initiative of the European Central Bank – can also be a remarkable tool for SMEs, as the purchase of assets is always a key question for a SME.

Asset purchases provide monetary stimulus to the economy in a context where key ECB interest rates are at their lower bound. Further, they ease monetary and financial conditions, making access to finance cheaper for firms and households. This tends to support investment and consumption, and ultimately contributes to a return of inflation rates towards 2%.[16] The only barrier of this tool is that it is focusing on the euro-zone exclusively; therefore the expansion of this scheme to non-euro Member States would be more than welcome.

11 James H. Love, Stephan Roper, Ying Zhou. "Experience, age and exporting performance in UK SMEs."

12 European Parliament, Committee on Industry, Research and Energy. "Report on green growth opportunities for SMEs."

13 European Commission Implementing decision (EU) 2015/1214. "Creating the European Investment Projects Portal and setting out its technical specification."

14 Cicero Group. "Unblocking the EU's capital markets: The European Commission's Green Paper on the Capital Markets Union."

15 European Commission. "Green Paper- Building a Capital Markets Union."

16 European Central Bank. „ECB announces expanded asset purchase programme."

Further to these, there are also other tools for the SMEs (also for non-euro countries), such as *loans and microcredits by the European Investment Bank (EIB) and the European Investment Fund (EIF)*. It means that financial instruments are increasingly used to complement traditional grants. In this relation, the credit lines should be better structured to meet with the needs of the different SMEs. Thus the promotion of growth in the manufacturing economy through expansive policies – by European level banks and by those Member States in a more favourable economic situation –, and the launch of a mass investment programme aimed primarily at SMEs and designed to promote R&D&I, including an ambitious European infrastructure plan and a subsidised business training programme.

In the current environment of very low inflation and economic stagnation banks should follow the example of other central banks and apply unconventional measures to encourage credit, such as charging interest on bank deposits in the ECB, establishing lending targets, and even the direct purchase of assets from banks, conditional upon the increase of credit to individuals and SMEs, the sector that creates most employment in Europe.

Funding sources

Investments under thematic objectives of the Cohesion policy is one of the main sources of investment and financial assistance for SMEs, one part has been earmarked specifically for SMEs (about 20%, €57 billion). The European Social Fund (ESF) finances education and training for entrepreneurs. SMEs in maritime regions can also benefit from the European Maritime and Fisheries Fund (EMFF), but we can also mention the Jessica and the Jeremie instruments.

In rural areas, the Common Agricultural Policy offers a large number of tools to enterprises to reach a more sustainable agriculture, such as the cross-compliance mechanism, the green payment and the rural development program (EARDF). In case of the latest tool, two special objectives have been set also in relation to environment and climate change, namely the "Restoring, preventing and enhancing ecosystems dependent on agriculture and forestry" and the "Promoting resource efficiency and supporting the shift towards a los carbon and climate resilient economy in the agriculture, food and forestry sector" objectives.

Financial instruments, provided by the EIB, the EIF and intermediates are complementing grants in order to increase their lending capacity.

Microcredit providers may participate in the Progress Microfinance initiative, the European Angels Fund or the SME Initiative to receive capital for lending to SMEs. The EIB and EIF publish a list of financial providers (by country) providing capital to SMEs on preferential terms.

There are also direct funds for SMEs as part of specific programmes. The largest programme with an SME dimension is the Horizon 2020 Framework Programme for Research and Innovation (nearly €80 billion for 2014-20). This programme has several sections and specific objectives (e.g. the Innovation in SMEs, the Access to risk finance, the Fast Track to Innovation or the InnovFin).

The other large programme is the COSME (nearly €2.3 billion for 2014-20), supports SMEs by facilitating access to finance at various stages of their lifecycle (creation, expansion and transfer), through, e.g. the Loan Guarantee Facility and the Equity Facility for Growth.

The LIFE programme (€1.46 billion for 2014-20) finances investments in environment and climate actions. Grants for SMEs are managed by the European Commission and EASME, while two financial instruments are offered by the European Investment Bank – the Natural Capital Financing Facility (NCFF), focusing on ecosystems, green infrastructure and biodiversity; and the Private Finance for Energy Efficiency (PF4EE).[17]Besides them, other tools are also available, such as the Global Climate Change Alliance (launched in 2007), consisting different funding elements: EU budget, European Development Fund (EDF) and MS contributions. It supports climate actions in developing countries, which can be also beneficial to SMEs.

But the programs alone are not enough! We need a lot of businesses who could and would think green and would use this green approach in his business operation. But to reach this, there need to be information points, advising and advertising tools for the sake of successful absorption. SMEs, seeking for European research funding can make use of the information SME TechWeb portal, the European Resource Efficiency Excellence Centre, the SME National Contact Points, the Enterprise Europe Network (EEN) or through the European Resource Efficiency Campaign; providing practical information and assistance to participants.

Conclusions

The policy makers have recognised the challenges of the SMEs, including the existing absorption difficulties. The systemic reason is also obvious: programs cannot be successful with the lack of consistency and the lack of credits. The above listed tools may be successful if they consider the special needs of a fast changing SME sector. A more innovative approach in the implementation phases is always needed. We have practical experiences that innovation is vital to European competitiveness within global economy. Opportunities arising from it relate to various areas with significant importance such as renewable energy sources, and in particular the economically viable exploitation of wind, solar, hydro and geothermal energy, energy efficiency, resource efficiency, waste management, emission reduction. Further that, detailed empirical field research will light up which correlations between resource efficiency, innovation and cultures of trust can be found and will offer important aspects for the improvement of management

17 European Parliamentary Research Service. "SME support in EU regions."

instruments and qualification concepts for workplace training.[18] There is a considerable economic and employment potential in these areas for different sectors. Greening in the businesses can lead to a unique, future- and environment oriented approach in the EU. The SMEs with this huge numbers have a vast power and opportunity to start to form trends to use green tools for a liveable future.

Accordingly, the new tools of the EU should not endanger the existing programs targeting innovation, and should ensure that these tools support innovation on the other hand. Because the SMEs play an important role in the EU's economy, SMEs should be a particular target for innovation policies. Further to that, the European institutions should promote economic policies that give real priority to economic growth and the creation of employment, particularly in those Member States where unemployment is the highest.

The lack of programs and credits for SMEs is only one side of the coin. There is another side which has to be dealt with: the lack of confidence and information, as SMEs are afraid of financial institutions. It is obvious that these companies dislike allowing a deep insight to externals into their operations, because of various reasons: know-hows, clever practices, or even grey areas in the operation. In most cases, they don't really believe in the success of getting external sources and applying innovative green technics. As a consequence, it is utmost importance from the EU Institutions to convince SMEs that these tools are designed for them, and to encourage them to use these. It is known that innovation is the key to growth and success; nevertheless, many companies are afraid of innovating and of changes. These companies are satisfied with an acceptable performance level, but they do not dare to dream big and expand (even though this is the key to their competitiveness). The communication tasks should cover also this area, emphasising that innovation is in the interest of SMEs, which leads to growth, greener environment by greater success, reaching new costumers on new markets with new products.

Therefore the implementation also has to focus on cranking up real growth in Europe and severe over-dependence on banks. The challenge is how to unlock investment in Europe's companies and infrastructure for the long term. For this we need to build a true single market for capital, as SMEs are no longer supported as drivers for growth. But financing can be hard to come by as banks find them too risky to invest in. There are a lot of financial resources across the EU and the World, yet, not enough financing for SMEs. It's important to work in order to make CMU also a tool to support SMEs. It can be a big opportunity for businesses. Of course, there is a risk attached to the interconnection of potentially 28 capital markets.

18 Anna Bliesner, Christina Liedtke, Holger Rohn. "Resource efficiency and culture — Workplace training for small and medium-sized enterprises"

As a final conclusion, climate actions, including green growth can be the one of the largest development path for the SMEs and we can state that it is important to create such programs and opportunities, which can fit the needs of different sectors, and which are available with equal opportunities for the SMEs in different regions and Member States.

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SCIENTIFIC PAPERS

MORE INSURANCE SUBSIDIES FOR EUROPEAN FARMERS – IS IT NEEDED?

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Abstract: *In addition to traditional sources of uncertainties, such as market price volatility and animal and plant health-related risks, the impacts of climate change have recently become a major concern in the agricultural sector throughout the world. Insurance has been commonly proposed as a key instrument in farm risk management, and agricultural insurance schemes have become more widespread both in developed and developing countries. We conducted a case study in the UK to investigate farmers' risk perception and willingness to pay for crop insurance by using contingent valuation method (CVM). Similarly to the experience from developing countries, we found that farmers are less willing to pay for insurance, however they do take actions to reduce their risks. While these results suggest that the provision of premium subsidies to European farmers can be justified; in order to avoid counter-productive policy outcomes, one may consider the introduction of a risk-based approach in agricultural risk management.*

Keywords: *agriculture, risk management, insurance, climate change, risk reduction* (JEL classification: Q14)

Introduction

In addition to traditional sources of uncertainties, such as market price volatility and animal and plant health-related risks, the impacts of climate change have recently become a major concern for both farmers and policymakers throughout the world, including both developed and developing countries. Extreme weather events already cause substantial losses in the agricultural sector; for instance the European heat wave in 2003 caused grain-harvest losses up to 20% in the affected regions (IPCC 2014) and led to a fall of more than 23 million tonnes in cereal production compared to the previous year (UNEP 2004). The drought affecting some of the major bread baskets (Europe, Russia, Canada and Australia) in 2007 had serious adverse effects on the global grain supply, which led to rapid price increase worldwide. The frequency and intensity of these extreme weather events is likely to increase in the future (IPCC 2012). A recent report suggests that the risk of a 1-in-100 year production shock is likely to increase to 1-in-30 or more by 2040 (Bailey et al. 2015). While the food security implications of these changes are unquestionable, the income security and the survival of rural population is also in danger. The latter one is especially relevant in the context of developing countries, where agriculture has still a key sector both in terms of its contribution to the economy and employment.

While the latest report by the Intergovernmental Panel on Climate Change (IPCC) stresses the need to adapt the food systems to climate change, it also notes that farmers in some regions are already taking actions. The report defines adaptation as reduction of risks and vulnerability through "adjusting practices, processes, and capital in response to the actuality or threat of climate change" (IPCC 2015, p. 513). A wide range of adaptation options is available, process-wise the literature often differentiates between autonomous and planned adaptation. Autonomous adaptation refers to the introduction of incremental changes in existing systems, which are reactive in nature. Planned adaptation on the other hand, is proactive and can mean the adjustment of a broader system (IPCC 2015).

At individual level, farmers have different options to reduce, mitigate and cope with disaster risks. Risk reduction aims at reducing the probability of the occurrence of disasters for instance by making appropriate technological decisions. Risk mitigation, on the other hand, aims at reducing the potential impacts of such events (e.g. via the diversification of production), while coping mechanisms are in place to relieve the impact of risky events once they have occurred, e.g. by borrowing from neighbours or selling financial assets (OECD 2009). At national level, policymakers pursue different strategies to deal with agricultural risks. Most OECD countries for instance either put emphasis on training, competitiveness, liberalization and compensation for catastrophes, or alternatively they rely extensively on (subsidized) insurance mechanisms (Meuwissen et al. 2008). The Health Check of the European Union (EU) Common Agricultural Policy (CAP), followed by its recent reforms suggests that the EU as a whole is moving towards subsidized insurance as a main tool to manage agricultural disaster losses. Taking into account these policy developments, our study focuses on farm insurance as an adaptation tool in the agricultural sector.

In 2011, agricultural insurance premiums worldwide amounted to an estimated USD 23.5 billion, almost four fifth coming from the advanced markets (Swiss Re 2013). And while agricultural insurance penetration is still really low in emerging countries, insurance has been strongly promoted as an essential element of risk management strategies in those regions (Swiss Re 2013). Indeed, recent policy developments suggest that not only developed countries but also developing countries increasingly rely on insurance instruments in agricultural risk management (Wang et al. 2011). Considering the recent interest, it is imperative to study the challenges faced by agricultural insurance especially in terms of uptake and the potential role public sector can play. Several studies are available that investigate the risk management decision-making process of farmers and their perception and willingness to pay (WTP) for insurance, especially in the context of developing countries. WTP studies focusing on Europe are less common, although in the light of the current policy developments they could potentially provide useful insights.

Our case study from that UK investigates farmers' risk perception and their willingness to pay for insurance. The remaining parts of the paper are organised as follows: section 2 provides a brief overview of the relevant literature and introduces the case study. Section 3 describes the methodology, while section 4 presents the results of the case study, followed by some concluding remarks in the last section.

Background

The management of agricultural disaster risks is of significant interest for European policy-makers, as well as for private insurance companies that, although often with public support, provide coverage for farmers against the various climate risks. Following the CAP Health Check in 2008 and recent reforms of the European agricultural policy, there is a clear direction within the EU to move towards subsidized agricultural insurance as a potential tool to manage disaster and other types of risks in the sector as well as to contribute to farmers' income stability. As agriculture is one of the very few sectors that are largely governed at European level, and national competencies are limited compared to other sectors, the above described policy development will have important implications for all Member States. For instance, as a consequence of the CAP Health Check that allowed Member States to reallocate some of their direct payment budget and spend it on insurance premium subsidies for farmers, Hungary has recently introduced a new agricultural risk management scheme. The new scheme is a public-private partnership and one of its core elements is subsidized insurance that is partly financed by the EU. Hungary is only one example but it well demonstrates how much EU developments in the field of agricultural policy influence policymaking at Member State level. The recent CAP reforms were preceded by a long preparatory procedure. Already in 2006, the European Commission conducted a detailed assessment of agricultural insurance markets and other risk management approaches in Member States (Bielza et al. 2008) and provided intense support for research on the topic. Finally, as part of the general EU policymaking procedure, detailed impact assessments were conducted that investigated various aspects of the proposed reforms including the changes in the risk management approach (European Commission 2011). Despite these long preparations, with few exceptions (Liesivaara and Myyräwe 2014) little is known about the WTP of European farmers for insurance, as most studies of that kind are focusing on developing counties.

Ali (2013) considers index-based insurance as an important risk management tool and conducted a survey to investigate Pakistanis farmers' WTP for crop insurance. He identified various factors (such as economic status, membership of local organisations) influencing farmers' WTP bids and suggests the introduction of premium subsidies to make the insurance scheme more successful. Similar studies were conducted among African cocoa farmers by Falola et al. (2013) and Danso-Abbeam et al. (2014) that highlight the importance of awareness raising and education. In addition, Falola et al. (2013) also emphasise the significance of affordable premium rates, without the explicit notion of subsidies, to encourage the uptake of policies. Contingent Valuation Method (CVM) was used to estimate farmers' WTP for crop insurance in Malaysia and findings confirm interest from farmers' side to buy crop insurance coverage, again at affordable rate (Abdullah et al. 2014). The need for subsidized crop insurance premiums is also empathised by the World Bank in the context of Latin-American and Caribbean countries (World Bank 2010). While based on these studies one could conclude that premium subsidies, in general, are required to develop well-functioning crop insurance schemes in developing countries, it remains unclear if and to what extent premium subsidies are necessary in developed countries.

The case study

The case study was conducted in the United Kingdom, where flood insurance in general has been debated for a long time. While flood insurance penetration is virtually 100 percent in the residential sector, traditionally the government do not provided any premium subsidies for these policies; the high penetration is the outcome of the special agreement between the public sector and the insurance industry, which had been in place for decades and expired last year. Since then policymakers and industry representatives have been desperately trying to put together a new agreement with questionable progress (Surminski and Eldridge 2015). The financing of crop losses caused by floods, on the other hand, clearly gets less attention.

One company is dominating on the non-subsidized, private agricultural insurance market in the UK (Bielza et al. 2008). Coverage available for growing crops (only for hail) and livestock (for several disease), but the schemes are not compulsory. Penetration rate is rather low, only 6.9% of the total agricultural area is insured. Coverage for flood risk is available only for farm buildings and machinery, but not for growing crops (Bielza et al. 2008) despite the magnitude of the damages. In 2007, 42000 ha farmland was flooded in England and the national total flood damage cost for the agricultural sector was estimated at £50.7 million representing 1% of the gross value added of the agricultural industry in the country (Posthumus et al. 2009). The largest losses occurred in horticultures in field level, while arable farms were more affected at farm level due to their bigger size. The more recent 2014 winter floods were comparable in terms of affected lands (44410 ha) but the estimated total damages were lower due to the differing land use and the timing of the floods (ADAS 2014).

Methodology

A survey instrument was developed and implemented to collect the necessary data for the research. The pre-tested questionnaire that contained seven, both open and closed-ended questions, was sent to UK farmers with recent flood experience by post. Participants were asked about their general background and land-use practices, risk perception and willingness to pay (WTP) for crop insurance against flood risk that is currently not available in the UK market. The 2007 summer flood in the UK caused significant damages to agricultural producers, which led to intense policy discussions about agricultural flood risk financing thus the focus of our research. Farmers' WTP was measured in a hypothetical market by using contingent valuation instrument. Respondents were asked to state their maximum willingness to pay at different risk levels and land uses. It was done by open-ended questions, which means no value was suggested to them, but to make it easier to state their bids the average damage costs per year were represented in every case.

Both descriptive (to show incidence) and analytical methods (to identify relationship) were used for the data analysis. Variables – such as risk tolerance – were tested for seasonality effects by using paired t test that allowed to identify any potential statistically significant difference between summer and winter values. A simple linear regression model was built to assess the link between the WTP bids and flood damage costs, which first required the application of box cox transformation in order to reduce the number of outliners and improve the distribution of residuals, thereby get a better, more robust model. The quantitative data analysis was supported by qualitative data collected via dedicated survey questions.

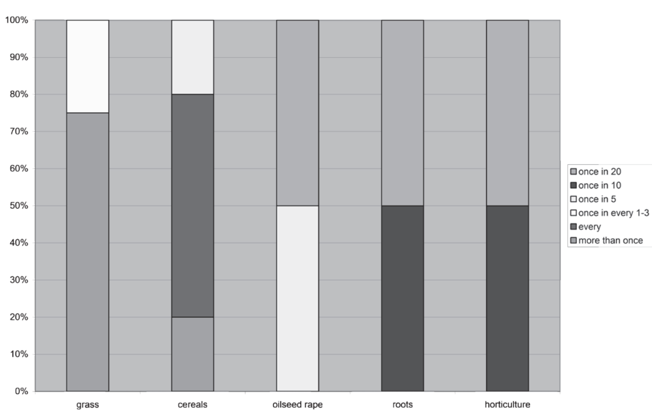
Results and discussions

Farmers interviewed have a total of 2692ha farmland, of which, on average 35.6% was affected by floods. One third of the farmers have no insurance at all, while those with insurance policies, more likely have coverage for machinery and animals (dairy and livestock farmers). Although limited insurance coverage for growing crops was mentioned by many farmers, it is certainly not the main reason behind low crop insurance penetration as more favorable insurance conditions, e.g. the potential introduction of seasonal insurance (coverage for events occurred during the summer period), did not trigger significant interest from the farmers' side.

Relationship between flood frequencies and land uses

Descriptive statistics were used to investigate if there is any special relationship between land uses and flood frequencies. We considered five different land-uses, including grass, cereal, oilseed rape, roots and horticulture that differ in terms of economic output, which has important implications when calculating the agricultural costs of flooding. In most cases, flood damage costs are between the gross output (total value) and gross margin. When flood occurs nearer to the point of harvest costs are closer to the loss of gross output, less savings in harvesting costs plus clean-up costs. However gross margins can be used for broad estimations of flood damages (Penning-Rowsell and Chatterton 1977). Gross margin is the difference between gross outcome and variable costs and it indicates which crops are more profitable. Thus floods cause higher losses in fields where crops with higher gross margins („more profitable crops") are grown. In our sample horticultural cropping and vegetable production have the highest gross margins, which suggests that the highest losses can be expected at these land-uses. Figure 1 below shows the different land-uses and flood frequencies in the sample. It is clear that there is a converse relationship between crop values and flood frequencies. More often flooded fields are usually used for pastures (grass) or cereal production while less frequently flooded fields are more often used for, oilseed rape and vegetable production, or as horticulture.. For instance, while 75% of the grasslands can be found on those fields that are, on average, flooded more than once in each year, then vegetable and horticulture production tends to concentrate on fields that are flooded once in every ten years or less. Farmers are growing less valued crops on flood frequent fields and more valued crops on less affected fields. By doing so, they reduce their risks (potential losses), which can of course potentially reduce the need to take out flood insurance policy.

Figure 1: land uses and flood frequences in the sample



Farmers risk tolerance

As mentioned above the timing of floods can have important cost implications. Therefore survey participants were also asked about their summer and winter risk tolerance in order to investigate the relationships between risk tolerance, seasonality, crop values, farm types and actual flood risk. Our hypothesis was that winter floods are more tolerated as, in line with the previous discussions, they more likely cause less damages. Based on 36 observations, table 1 below confirms our hypothesis as the mean (and the median) summer risk tolerance is lower (0.3371) than the same variable during the winter period (0.5679). The table indicates that farmers, on average, tolerate summer floods (April – September) once in every 36 months, while winter floods (October-March) are accepted once in every 22 months (1.8 years). The lowest reported flood tolerance is 100 years (1:100 return period) for summer floods and 33 years for winter floods.

Table 1: Farmers's summer and winter risk tolerance

Variables	N	Mean	Median	Minimum	Maximum	Standard deviation
Summer risk tolerance (floods/ year)	36	0.3371	0.20	0.01	1.5	0.46
Winter risk tolerance (floods/ year)	36	0.5679	0.33	0.03	1.5	0.48

We used paired t-test to compare the means of the two groups (summer and winter risk tolerance) and confirm if the above found difference between the groups is significant. On average the difference between summer and winter flood risk tolerance is 0.23081, which indicates that farmer are willing to accept 0.23081 more winter floods during the October-March period than in the April-September period each year (Table 2). The outcome of the paired t-test can be summarised as follows: $t(35) = 4.009$, $p < 0.0005$. Due to the means of the two groups and the direction of the t-value, we conclude that there is a statistically significant difference between farmers' summer and winter flood risk tolerance (and winter floods are better tolerated).

Table 2: Difference between summer and winter risk tolerance of farmers in the sample

tolerance	Mean	Std. deviation	Std error	Lower (95%)	Upper (95%)	t	df	Sig (two-tailed)
Winter-summer risk	0.23081	0.34541	0.05757	0.11394	0.34768	4.009	35	0.000

c) Estimation of farmers' willingness to pay for insurance

The demand for insurance was estimated through investigation of the relationships between annual damage cost and farmers' WTP bids. Table 3 presents the summary statistics of these two variables. As it indicates the total number of observations was 80, and the distributions of both variables have skewed coefficients. The large proportion of zero WTP bids (41%) shows, that farmers would not pay for insurance in almost half of the cases (most likely when the damage costs were below £60), while their highest bid was 200 pounds. On average, they are willing to pay 20.03 pounds per hectare.

Table 3: Summary statistics – flood damage costs and farmers' willingness to pay for insurance

Variables	N	Zero value	Mean	Median	Mini-mum	Maxi-mum	Variance	Std. dev.	Skewness
Flood Damage Cost (£/ha)	80	0	257.66	180.0	30.0	1000.0	66228.1	257.35	2.11
WTP for flood insuranc e (£/ha)	47	33	20.03	18.0	0.0	200.0	1665.0	40.8	2.30

In order to investigate if there was a statistically significant association between farmers' WTP bids and the annual damage costs, a correlation was computed, $r(80) = 0.7206$, $p = 0.000$. The direction of the correlation is positive and significant at the 0.001 level, which means that there is usually a higher willingness to pay at higher predicted damage costs and vice versa. As a next step, a linear regression was conducted that required the box-cox transformation of the variables to fulfil the linearity assumption. Table 4 below shows the outcome of the regression analysis with the transformed variables. The outcome (R Square =0.4272, $F = 33.556$, $p<.001$) indicates a positive association between farmers' WTP and expected damage cost.) The R square value indicates a large or larger than typical effect, which means that almost half (42.71%) of farmers' WTP (dependent variable) can be predicted by the flood damage costs (independent variable). We should, of course, note that damage cost is not the only variable that influences willingness to pay decisions of farmers, however WTP bids can be estimated quite well from the loss values (it is consistent with the high B value of the damage cost in the model). The equation found is WTP = 0.0237 + 0.4255*Damage Cost, which suggests that if the damage cost is zero pounds, then the model predicts that the WTP for flood insurance is 0.0237 pounds per hectare.

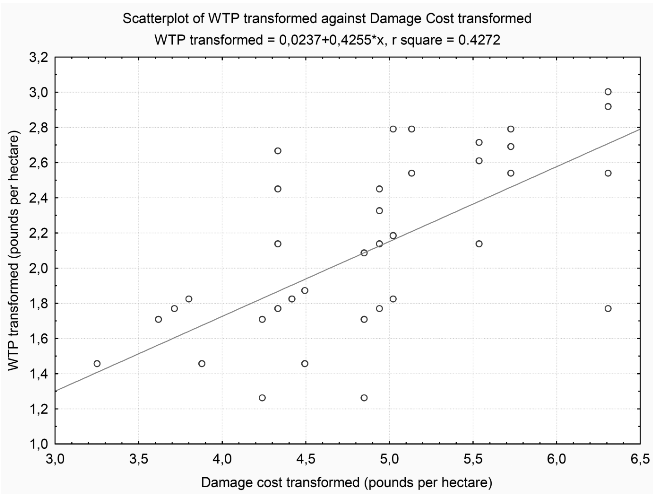
Table 4: Regression result

N = 47	Beta	Std. Err. of Beta	B	Std. Err. of B	t(45)	p-level
Intercept			0.02367	0.3597	0.0658	0.9478
Trans-formed damage cost	0 .653577	0.1128	0.42551	0.07345	5.7927	0.000001

R = 0.65357 R Square = 0.4271 Adjusted R Square = 0.4144
F (1, 45) = 33.556 P = 0.000 Std. Error of Estimate = 0.3543

Figure 2 below visualizes the relationship identified between the WTP bids of farmers (pounds per hectare) and the predicted flood damage costs (pounds per hectare) after the box-cox transformation. The regression line predicts 42.7% of the WTP bids based on the flood damage costs. One might assume that farmers in the sample are risk averse as they are willing to pay proportionately more to avoid higher damage costs (Slovic 2000). Figure 2 indicates that this threshold is around 5 pounds per hectare; above that value farmers tend to willing to pay more than the estimated model values (observations are above the regression line).

Figure 2: Relationships between WTP for flood insurance and potential flood damage costs



Conclusions and policy directions

Insurance has been promoted worldwide as a key element in agricultural risk management. It has been also commonly accepted that well-functioning agricultural insurance schemes require strong support from the governments' side, not only in the form of appropriate regulatory environment, but also often by the provision of premium subsidies. Indeed, several studies from developing countries report low willingness to pay for insurance among farmers and stress the need for subsidies in order to keep premium rates at affordable levels. However farm insurance is also heavily subsidized in many developed countries, one of the most notable example being the US where generous subsidies cost millions of dollars to taxpayers each year (Babcock 2013). The Health Check and the recent reforms of the Common Agricultural Policy suggest that the EU itself is moving towards subsidised agricultural insurance.

Considering these recent policy developments and the relative lack of studies investigating European farmers' attitude towards crop insurance (compared to developing countries), we conducted this case study to investigate the willingness to pay of farmers in the UK for crop insurance. While their low willingness to pay seem to justify public premium subsidies, it is also clear that farmers are taking actions to reduce their risks, which can be especially efficient in case of more frequent, low impact events. Experience from the US suggests that heavily subsidised farm insurance can potentially lead to biodiversity loss (Faber et al. 2012) and discourage farmers to take adaptation actions (Skees 1999). European policymakers should carefully consider these potential implications of farm insurance subsidies. In line with the suggestions made by the OECD (OECD 2011) one may argue for a risk-based approach that distinguishes between low, medium and high-risk layers (Mechler et al. 2014). Low-risk layer represents very frequent events with low impact; in which case diversification and other risk reduction strategies (e.g. appropriate water management practices) could be efficient. Managing these risks should be the responsibility of the farmers themselves. The medium-risk layer includes less frequent, but not catastrophic events and it is often argued that risk-financing mechanisms, including insurance, are well placed to deal with these risks. Finally, high-risk layer events require outside interventions, for instance by the government or international agencies, to cover the losses.

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INTEGRATING ENVIRONMENT ECONOMY TO PROJECT MANAGEMENT

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Abstract: *Environmental sustainability is a horizontal issue that appears at all level of economic activities and private life. Due to the increasing complexity of regulations, particularly in case of EU funded developments, all the projects need to meet a lot of criteria on environment protection issues. These activities include the conduction of environmental studies, data collection, future emission estimations, improving social attitude, acquiring necessary permissions and environment friendly equipment and finally all the administrative activities to monitor everything mentioned previousThe project management organization increasingly needs a special expertise to meet all the requirements no matter what is the original scope of the project. The study collects different type of knowledge and expertise to manage environment economic issues during project management on four different categories, such as legal, technical, financial or human. The summary of the different type of knowledge provides logical conclusion on how the project management organization should meet the challenges of climate change in terms of daily work and organizational operations.*

Keywords: *environment management, project management, externality, organizational management*
(JEL classification: O22)

Introduction

Environmental sustainability is a cross-cutting issue when performing daily activities both at individual and organizational level. Environment friendly actions are either motivated by external factors, such as regulations or may be motivated by internal factors, such as environmental awareness or business interests. Any actions made by humans have an environmental impact and some of them create externalities for others. The aggregated mass effect of these individually created externalities creates cost for organizations, especially in terms of environment management. On the one hand environmental management is mainly about decreasing negative impact and additional cost created by externalities affecting our organization,on the other hand it is about to promote our own organizations to create less externalities resulting negative influence for others. Project management is often the bridge between environmental management and organizational management as it acts as a pioneer of new methods and techniques within the organization. The following study intends to give picture on how project management may assist to integrate environmental management principles and practices into the organizational management activities.

Methodology

The methodology of the study is mainly based on literature analysis of former research focusing on environmental management and project management. The current research intends to discover and analyze the aspects and processes on how environmental sustainability is integrated into organizational practices. The findings and results were complemented by practical experience of mine bases on previous project management career. The current study do not distinguishes project of environment management focus from other projects where sustainability is a horizontal issue. In both cases the same motivations promote the organizational activities toward a more environmental friendly world and the same project management techniques are applied in order to achieve the objectives.

The second step of the methodology is to select projects of various fields and survey whether environmental issues were taken into account during the project and or the positive change have been integrated to daily operations after the project. This step includes the evaluation of renewable energy project financed by Environment and Energy Efficiency Operational Programme in Hungary between 2007-2013. The environment protection indicators were compulsory in these projects;

however, there were no sanctions if the applicants could not meet them. At this step we shall have a look on how much the expected results were fulfilled by the end of the sustainable period after the projects.

Findings

Sustainability issues are more and more integrated into the project management practices as fight against climate change becomes more vital to everyone. "Sustainability has become a component of business success, and project management is one of the ways to get there" (The Bottom Line on Sustainability, Project Management Institute, 2011:1). This is important as the project management organization is a temporal entity, there is a contradiction that how project management may contribute to long-term sustainability affecting the period when the project management organization is ceased to exist (Figure 1).

As environmental sustainability is a cross-cutting issue, related activities include the conduction of environmental studies, data collection, future emission estimations, improving social attitude, acquiring necessary permissions and environment friendly equipment, formalizing and regulating daily processes and finally all the administrative activities to monitor everything mentioned above. According to Hedberg and Jonsson (2013: 15-16) there are 5 main types of theories have been formulated on how project management may influence and alter organizational management:

Evolutionary theories focus on change as a response to external circumstances, situational variables, and the environment faced by each organization. Social systems as diversified, inter dependent, complex systems that evolve naturally over time because of external demands.

Teleological theories or planned change models assume that organizations are adaptive. Change occurs because leaders, change agents, and others see the necessity of change. The process for change is rational and linear, as in evolutionary models.

Life-cycle models evolved from studies of child development and focus on stages of growth, organizational maturity, and organizational decline. Change is conceptualized as a natural part of human or organizational development.

Dialectical models, also referred to as political models, characterize change as the result of clashing ideology or belief systems. Conflict is seen as an inherent attribute of human interaction. Change processes are considered to be predominantly bargaining, consciousness-raising, persuasion, influence and power, and social movements.

Social-cognition models describe change as being tied to learning and mental processes such as sense making and mental models. Change occurs because individuals see a need to grow, learn, and change their behavior

Independently of which approach is used, there are 4 steps to be distinguished when doing theories to practices in term of environmental sustainability according to the literature. The 4 steps cover any activity from planning, though implementing to monitoring organizational activities in terms of environmental perspectives. When all the four steps are achieved professionally, the principles stipulated by the environmental management shall be successfully integrated into the everyday operations of the organizational management.

Principles: the primary mission of environmental management is laying down the principles on how the environmental friendly organization should work; at this phase the managers and experts analyze the current situation, set out environmental objectives and lay down principles to be taken into consideration at all levels of activities.

Solutions: in this context the primary mission of project management is to find the organizational solution on how to implement the environmental principles and objectives within the organizational environment during the project; such solutions may be integrated into the standard organizational operations after the project was finished.

Processes: good solutions of the project or environmental protection practices aimed to be introduced into the organization are to be integrated into the daily organizational operations via standards and protocols that provide a framework for the daily routine; this is implemented via the standardized organizational management activities.

Practices: finally, if the environment related standards and process are well-defined and realistic, they may become an inseparable part of the everyday activity provided the employees are able and willing to adapt to the new protocols.

Figure 1 - Impact of Environmental Management on Organizational Management via Project Management

Source: Based on Hedberg and Jonsson (2013)

Environment friendly actions and practices are motivated externally or internally as Hedberg and Jonsson said: "Pressure to integrate sustainability requirements may come from two different directions: from within the business itself or from outside the company (such as from government, business partners, non-governmental organizations and citizen groups)." (Hedberga and Jonsson, 2013:4) External forces to motivate environment friendly operation may appear in various forms. The external pressure often comes from the society or other market actors, such as externalities unfavorable for the organization. In addition "the governments are also promoting more and more set of laws to protect the environment and the community in general (Chakrabarti and Mitra, 2004)."

Internal pressure comes from the environmental awareness of the organization members or the from the recognition of the business and PR value for the company. "Newman and Breeden (1992 cited Scanlon 2007) imply that the acceptance of an environmental management program by a company would have the following benefits, just like a competitive advantage for green marketing as a reply to consumer expectations, media recognition of environmental efforts, the minimization of risks and future costs and positive recognition of environmental efforts by stakeholders."(Scanlon, 2007). All the factors above contribute directly or indirectly to the profitability of the firm.

When the environment management identified both the external and internal pressure than objectives shall be set out focusing on environmental friendly actions or at least actions that seem to be environmental friendly for the public. Objectives should be clear, realistic, relevant and measurable – exactly the same way as project management defines the project objectives. As a result it is natural to apply project management techniques to define and implement environmental objectives. "If organizations put their money where their mouth is on sustainability, it is inevitable that sustainability criteria and indicators will find their way into project management methodologies and practices in the very near future" (Silvius & Schipper & Planko & van den Brink & Köhler, 2012) A more professional level is the environmental assessment to plan complex and synergic actions to introduce environment aspect into the organizational operations. Environmental assessment has mainly the same function the feasibility study in terms of project management: it analyses the current situation, identifies the objectives, measures the baseline and target indicators and stipulates measures or actions to pursue the objectives. Objectives and indicators are also included in the project plan and become a horizontal target for all other project management actions.

Form project management point of view the environmental requirements often appear as regulations that should be kept, acquisition of the compulsory permissions (e.g. construction, water management, environment protection) or applying standards and protocols for daily activities, especially in case of procurement. By this step, the external pressure is translated to the project management language, as the environmental issues are project requirements and objectives that should be implemented the same way as the other project objectives.

An external motivation for environment management is the compulsory indicators in case of EU funded projects. About 5800 projects were financed in Hungary to replace traditional energy to renewable energy under the 4th priority Environment and Energy Efficiency Operational Programme (EEEOP). The beneficiaries were SME's, NGO's and public organizations. The purpose of the projects was to increase the rate of renewable energy within the total energy consumption. The monitoring system just collected data on the final results of energy utilization; however, there is no information on how the environmental awareness was promoted during the projects (there were other call for proposals for that specific purpose). Therefore, the sustainability of the project results ultimately depended about the financial gain on the utilization if renewable energy.

Results show that although the total amount of utilized renewable energy has been increased slightly, and the rate of the renewable energy within total energy consumption increased a bit more - but the results fall far below the expectations in both terms. The only exception is the electricity, where the solar panel revolution between 2007-2013 showed a positive impact of extraordinary high results. The rapid decrease in the unit cost of investment is a positive side-effect of both the increased demand stimulated by EEEOP and the rapid development of the technology. The total green-house gas

Table 1 – Plan and results of Environment and Energy Efficiency Programme 2007-2013 in Hungary

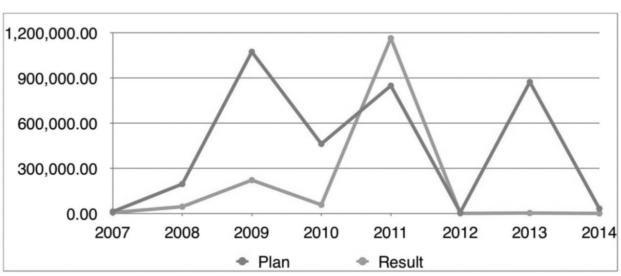
	UNIT	PLAN	RESULT	RESULTABILITY
Primary energy saved	GJ/year	718,500	51,913	7.23%
Renewable energy	kWh/year	115,075,577	15,719,578	13.66%
Total energy saved	GJ/year	4,309	753	17.47%
Decread in GHG	t/year	3,499,886	1,493,510	42.67%
Unit cost of investment	100 HUF/m2	446,997	279,963	62.63%
Renwable electric energy	GWh/year	931	2,594	278.67%

Source: Egysce: electric energyronment and Energy EEMIR), official IT system for administrating EU fund in Hungary

(GHG) emission has been decreased about 43% of the expected result. On the whole the goals of the EEEOP were too ambitious and one reason of unsuccessful implementation might be that environment protection issues were not integrated into project management and the importance of environment awareness was fully neglected. Note that not all the projects have been finished as the projects that started in 2013 (or even in 2014) should be finished by the end of 2015. Therefore the results listed below shall be improved when all the ongoing projects are finished (Table 1).

The most important indicator in terms of climate change is the decrease in greenhouse gas (GHG) equivalent emission. The Lisbon strategy (2007-2013) and the EU 2020 strategy requires all member states of EU to address the problem of using traditional energy. The objective of the Lisbon strategy was to increase the rate of renewable energy to 21% within electricity production in Europe.[1] The EU 2020 strategy stipulated that the member states should reduce greenhouse gas emissions by 20% compared to 1990 levels by 2020[2]. Therefore, decrease in GHG emission is an EU requirement against all related EU funded projects across Europe and it is obligatory to monitor the relevant results. On the other hand higher level of undertaking in terms of GHG emission means higher chance to be funded; as a consequence the projects tend to overestimate their future results and that may be a problem when they cannot fulfill their on estimations since it has a negative impact on programme level indicators. Significant decline in meeting the previously set targets may result the suspension of the operational programme due to serious failure. This is why at the beginning of the 2007-2013 programming period the GHG emission results show a low level of fulfillment of the targets that could have been compensated in 2011 (Figure 2). In 2012 the program was restructured so both the targets and the results are low. As not all the projects that started in 2013 have been finished and processed yet, at the end of the programming period there is only a low level of fulfillment so far, but this should improve as all the projects are finished by the end of 2015.

Figure 2 – Plan and results of GHG emission by year in the Environment and Energy Efficiency Programme 2007-2013 in Hungary



Source: EMIR, 2015

1 Cohesion Policy in Support of Growth and Jobs: Community Strategic Guidelines, 2007-2013 http://ec.europa.eu/regional_policy/sources/docoffic/2007/osc/050706osc_en.pdf

2 http://ec.europa.eu/europe2020/europe-2020-in-a-nutshell/priorities/sustainable-growth/index_en.htm

The internal motivation of the project team or any organization to fully respect and fulfill the environmental issues can be raised by improving environmental awareness. The first step has been made by setting up measurable objectives and conducting environmental assessment "To start using a new method and an overall approach in project management with greater environmental perspective, there is a need for a cultural change within the organization. First, this has to take place on an individual level, but may at a later stage spread through the organization to other partners like suppliers, customers and subcontractors." (Hedberg-Jonsson, 2013). If environmental awareness does not follow the objectives and standards stipulated by the environmental management, the whole process will only focus on meeting the official requirements on the paper, however, real environmental friendly behavior will not be created. This happens when the environmental indicators and objectives are irrelevant from the real environment protection or if the standards are only met on the paper but not in the reality. As Yüksel concluded from his research once "… the firms stated that the problem they typically came across while implementing the environmental management practices is lack of environmental awareness in all the areas including in the employees, suppliers and customers". (Yüksel, 2008). As a result "these systems and this change in culture require a useful and sustained education and awareness effort to ensure that the information necessary for environmental management is acquired and retained, or the benefits of implementing environmental management will most probably not be realized." (Power et al.2004

Conclusion

The project management techniques are useful when attempting to integrate environmental friendly daily routine into on organization whether sustainability is the main focus of the project itself or not. «If you want a culture consisting of discipline where results rule, you must start by creating measurable processes. Processes create habits and habits create culture" (Pennington, 2006, s. 111).[3] This step is beyond the scope of project management due to the temporary nature of the project. If the management intends to integrate the environmental management issues for the long run, then the solutions offered by the project management should be further developed to standardized processes within the organization's operational structure. "Even in project-based organizations, there is often a problem of capturing the learning from projects so that it is available for use by other projects. Instead, each project tends to start from scratch, often making the same mistakes as others have made before. This happens even though most organizations have now instituted project reviews, which ensure that project team members capture what they have done on a particular project, codify these lessons in a written document of some kind, which is then stored on a database that others can search at a later point in time" (Newell, 2004.)

3 Pennington, R. (2006). Results Rule!: Build a Culture That Blows the Competition Away

When project management succeeded in integrating the environmental "cost" into to the production chain, the organization shall operate under environment consciousness. „This means it is optimal to choose a stock corresponding to a direct utility lower than its bliss point when preferences are strongly tilted toward consumption rather than toward the stock as an environmental amenity and/or when its reproduction rate is low relative to other parameters. In this case environment can be interpreted as factor of production."[4]

The introduction of environmental friendly standards and protocols are not enough to fully elaborate the change to create a sustainable organization. As Saha & Darnton (2005) said "having these standards does not mean that the company is green: it just means that they are committing to continuous improvement." The success of the process relies on the employees itself, so it is inevitable to promote environmental awareness among the employees. This is achieved via training and other actions and habits that are integrated into the daily routine. It is a key factor to identify and find those employees, who are the most receptive to environment protection ideas within the organizations. They must be deeply involved in the process, it is a good idea to assign them key roles during the introduction process and exploit the voluntary willingness to implement the objective. According to Patterson and Sorrells (2001) "during periods of organizational change, most attention focuses on the organization in terms of structure, processes, tools, measurements, policies, and procedures. However, for the transition to be successful, people need to be persuaded and committed".[5]

There already widely used methodologies on how to define and evaluate environmentally focused indicators, or on how to introduce environment friendly standards and protocols, or oven a complex environmental management systems but this is not the full story. Graham (1989) writes that "success in implementation of organizational changes rests mostly on people's cost\benefit analysis: people accept changes easily in case they see some personal benefits and they reject it if they don't. This could lead us to a conclusion that organizational culture is the main factor influencing project management methodology implementation, especially considering another project definition that includes people. "The key concept is to make the people understand that "sustainability is not about installing solar panels or using alternative energy. It's about connectivity, and thinking project plans through in terms of environmental impact, and the fundamental relationships between the decisions we make today so we are not compromising ourselves down the road." (Project Management Institute, 2011)[6]

4 Carraro, Carlo & Filar, A. Jerzy (1995). Control and game-theoretic models of environment

5 Patterson, S., & Sorrells, S.: Types of change, http://www.westbrookstevens.com/Types_of_Change.htm

6 Project Management Institute. (2011). The Bottom Line on Sustainability.

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LOW-CARBON INNOVATION POLICY WITH THE USE OF BIORENEWABLES IN THE TRANSPORT SECTOR UNTIL 2030

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Abstract: *The topic of the present study deals with the changes and future trends of the European Union's climate policy. In addition, it studies the manner in which Hungary's transport sector contributes to the success of the above. The general opinion of Hungarian climate policy is that the country has no need of any substantial climate policy measures, since it will be able to reach its emission reduction targets anyway. This is mostly true, because the basis year for the long term goals is around the middle/end of the 1980's, when Hungary's pollution indices were entirely different than today due to former large-scale industrial production. With the termination of these inefficient energy systems, Hungary has basically been "performing well" since the change in political system without taking any specific steps in the interest of doing so. The analysis of the commitments for the 2020-2030 climate policy planning period, which defined emissions commitments compared to 2005 GHG emissions levels, has also garnered similar political reactions in recent years. Thus, it is not the issue of decreasing GHG emissions but the degree to which possible emissions can be increased stemming from the conditions and characteristics of economic growth that is important from the aspect of economic policy. In 2005, the Hungarian transport sector's emissions amounted to 11 million tons, which is equal to 1.2% of total EU emissions, meaning it does not significantly influence total transport emissions. However, the stakes are still high for developing a low GHG emission transport system, since that will decide whether Hungary can avoid those negative development tendencies that have plagued the majority of Western European transport systems. Can Budapest avoid the scourge of perpetual smog and traffic jams? Can it avert the immeasurable accumulation of externalities on the capital city's public bypass roads caused by having road transport conduct goods shipping?*

Keywords: *low-carbon transport, green transport, GHG emission reduction, effort sharing, renewable energy*
(JEL classification: Q58)

Introduction

The purpose of the present study is to assess the long term possibilities for developing the Hungarian transport system, which would allow the sector to change its previous negative tendencies (it fails to follow the leading trends of the EU's transitional countries) and finally be able to donate to performing the climate policy targets set by Hungary and the EU. In addition to identifying the correct future directions, the study also aims to provide recommendations that can be used in practice and that could be useful for the European Union's political decision makers for the 2021-2030 program period.

Hungarian trends in transport development follows those Western European changes that amount to approximately 30% of the ESD (Effort Sharing Decision, emissions not included in the EU Emissions Trading System). In Hungary, this value is presently 20%, which assumes strong growth in the near future. Therefore, Hungary's primary goal could be to implement the necessary growth through low-carbon developments (with the use of systems requiring low energy and resource inputs). It is also important to stress that if the present potentials for development are left unutilized, the result will be a so-called "lock-in effect"[1] which results in serious social disadvantages and can lead to contradictions in development over the long term.

Regarding transport, the greatest challenge we have to

1 It also means the omission of possibilities for development that are presently easily accessible (for example, with the use of tendering funds) but do not pose a fundamental need in the social environment of the given country or economic environment. However, failing to implement developments that extend beyond social needs can increase the economic disparities between developed and developing countries, inducing serious contradictions in development levels.

face is the increasing number of vehicles and the increasing need of the population to travel. Even despite of the 2008 economic recession, the sector has shown continuous growth since the 1990's in the number of kilometers travelled; at the same time, an increasing tendency proportionate to the change in GDP was also apparent. Luckily, the sector was able to break free of this effect (which is referred to by literature as "decoupling"), but no significant GDP-independent decreases were attained (Forster et al. 2012; Šelih et al., 2010).

If indices are also taken into account, another typical figure shows that the transport sector is responsible for close to 20% of the European Union's GHG (greenhouse gas) emissions; public road transport makes up 90% of this figure (Nemry, 2011). In relation to the above, the greatest issue is that although low emissions and electric modes of transport are increasingly common in public transport (for example, electric trains, subways, and trams), public roads are still mainly used by outdated vehicles burning fossil fuels. The spreading of modern electric and CNG technologies in Hungary and most Central and Eastern European countries is not expected for a long period of time due to their high cost (Fiorello et al., 2009).

Ever since the start of the ESD system the transport sector is highly connected to the buildings and the agriculture regarding climate policy goals. Furthermore, the link between these branches goes far beyond this mechanism considering that agriculture would be able to provide biofuel to transportation ensuring a more environmentally friendly operation (Kiss, 2013). Even though there are more innovative and efficient technologies in the field of sustainable vehicle development already, the early predictions rule out these options from the near future of Central and Eastern Europe. So as long as we must rely on traditional fuels, the biofuel provision from the side of agriculture remains a top priority (Fonseca et al., 2010). Therefore the role of this sector is going to appear in the analysis from the aspect of renewable energy use and energy efficiency improvement within the Hungarian transportation.

This is important to stress because the present research program primarily deals with the load on public roads and attempts to include the tendencies characteristic of those into specific studies. In summary, it can be declared that of the sectors governed by the European Union's climate policy, the development of the transport sector is the most disputed and the most urgent, as the sector has the greatest effect on our environment due to the growth of needs that have become apparent in this area and the low rate of utilization of the technological novelties that can be applied in this area (Coussy et al., 2014).

Materials and Methods

The study used the TREMOVE model developed by Transport & Mobility Leuven to assess transport and put the basic data in order; this model is a methodology that has undergone close to 20 years of development in studying the situation of the European Union's transport sector. The basis for calculating the trends valid until 2030 is the public Tremove 3.4 database, which includes country-specific data.

Due to the chronological nature and variability of the available data, the benchmarking study method was selected to conduct the basic assessments. Benchmarking is fundamentally a level comparison method that is suitable for comparing the condition of a given time and place by concentrating on a predefined system of conditions (Fogarassy, Bakosne 2014; Camp, 1992).

In essence, it ranks, then qualifies future states based on characteristics available in the present and on the indicators that make up those characteristics. Benchmarking analyses can be specified and ranked in accordance with the purpose of the study; they are also suitable for identifying deviations from a state of balance or from best practices. In the present study, the methodology was specified by making the processes taking place in Hungarian transport scenarios quantifiable according to the cornerstones of the European Climate Policy. These were the following aspects for study:

- the ratio of renewable energy sources in the sector,
- the rate of energy efficiency, and
- aspects of decreasing CO_2 emissions.

The studies analyzed the *technological, environmental, and financial* dimensions of the building sector along the lines of the above three main dimensions, assigning 3 indicators to each of the above dimensions. Tables 1, 2, and 3 illustrate the study framework developed by the study.

Table 1. Indicator group 1 of the transport sector benchmarking analysis

Dimensions	Code	Status indicators	Code	Performance indicators (defining the method of development)
ASPECTS OF THE RATIO OF RENEWABLE ENERGY				
Technological	RS1	A specific study and the general characteristics of the applied energy mix	RP1	Changes in the use of expendable resources (in the present case: fuel): the increase or decrease in the ratio of fossil energy source usage in the examined sector between 2020 and 2030.
	RS2	The general standard and improvability of technical equipment	RP2	The state of the technical standard and the ratio of environmentally friendly technologies
	RS3	The ratio and characteristics of renewable energy source utilization	RP3	The possibilities for increasing the utilization and percentage of renewable energy sources (in the present case: biofuels) in the sector
Environmental	RS4	The characteristics of participation in a waste energy reuse system	RP4	Renewable energy system support, classified according to roles
	RS5	Results/relations between emissions/imissions benchmarks	RP5	Ratio of the potential for decreasing emissions levels as compared to the other ESD sectors
	RS6	The rate/level of corporate environmental management and the general sectoral attributes of environmental management systems	RP6	The role of social responsibility programs in attaining GHG reduction targets

Dimensions	Code	Status indicators	Code	Performance indicators (defining the method of development)
Financial	RS7	To what extent does the ratio of the sector within the ESD influence the country's position on the quota market (AEA)	RP7	Evaluation of activity (characteristics of carbon financing)
	RS8	The intensity/activity of environmental policy and climate policy regulation	RP8	The effects of regulation on emissions
	RS9	Resource efficiency complexity: labor market effects and effects on employment	RP9	Study of job creation effects and the description of its significance

Abbreviations: 'RS1 - 9:' status indicators of the ratio of renewable energy, according to dimensions; 'RP1 - 9:' performance indicators of the ratio of renewable energy, according to dimensions

As apparent by Table 1, each indicator has two aspects: a *Status Indicator* and a *Performance Indicator Group*. Of these, the former provides a basis, the characteristics of which have to be known in order to have a picture of the examined system (which in the present case is the transport sector). The latter is a similarly parameterized indicator that enables the direction and rate of the changes to be quantifiably measured (Fogarassy et al., 2014). An important factor of the studies is that the state of affairs in 2020 has to be defined in order to be able to define the changes that take place between 2020 and 2030. In order to determine this static state interpreted amongst dynamic changes, a point of reference must first be set. The evaluation of the indicators set for 2020 were individually set with the help of a professional program, with the help of which a provisional picture was obtained on the 2010-2020 period. The study compared the expert estimations for 2020 with European models (Tremove, Primes, National Transport Infrastructure Development Strategy 2014), after which the 2020 indicators were finalized.

Table 2. Indicator group 2 of the transport sector benchmarking analysis

Dimensions	Code	Status indicators	Code	Performance indicators (defining the method of development)
ASPECTS FOR INCREASING ENERGY EFFICIENCY				
Technological	ES1	The ratio of electrical energy use in total energy use	EP1	The evaluation of the type of energy utilization, with proportionality
	ES2	The possibility and degree of connections that can be created with ETS sectors	EP2	Connections with ETS sectors and the resulting production surplus created therein
	ES3	The degree/rate of possible clean tech applications	EP3	The possibility of introducing low-carbon technological solutions
Environmental	ES4	The intensity of input utilization within the sector	EP4	Transport sector energy use
	ES5	Optimization level of vehicle lifecycles	EP5	The ratio of vehicles not older than 5 years compared to the total number of vehicles
	ES6	Level of energy loss	EP6	Degree of avoiding losses
Financial	ES7	Cost effectiveness parameters of increasing energy efficiency	EP7	Ratio of cost effective potential for reduction
	ES8	Typical costs of increases in eco-efficiency	EP8	Changes in the ratio of urban to rural public road transport
	ES9	The significance of regulatory elements in production processes	EP9	The effects of regulation on improvements to technological levels

Abbreviations: 'ES 1 - 9:' status indicators of the energy efficiency aspect, according to dimensions; 'EP 1 - 9:' performance indicators of the energy efficiency aspect, according to dimensions

Table 3. Indicator group 3 of the transport sector benchmarking analysis

Dimensions	Code	Status indicators	Code	Performance indicators (defining the method of development)
THE ASPECTS OF CO_2 REDUCTION LEVELS				
Technological	CS1	The intensity of GHG emissions in light of the given technology	CP1	GHG emissions based on the evaluation of the available technical variants
	CS2	The possibility of introducing low-carbon technologies to the sector	CP2	Changes in the ratio of public transport to road transport
	CS3	Composition/volume index of characteristic GHGs	CP3	The potential for reducing the ratio of CO_2 compared to total GHG emissions
Environmental	CS4	Environmental characteristics of GHG emissions	CP4	Description of GHG environmental characteristics and their evaluation from the aspect of the expected measures
	CS5	Environmental regulations/norms, thresholds/consistency	CP5	Do regulations support or hinder the meeting of environmental policy targets
	CS6	The level of environmental risks in emissions	CP6	The characteristics and nature of adaptation measures
Financial	CS7	The characteristics/level of participation in the GHG market	CP7	The ratio of total GHG emissions in all sectors subject to the regulation
	CS8	Typical costs of GHG reduction per unit of CO_{2e}	CP8	CO_2e reduction cost index in the examined sector
	CS9	The nature of the contribution to the meeting of GHG climate policy targets	CP9	Volume and efficiency calculations

Abbreviations: 'CS 1 - 9:' status indicators of the aspect of reducing CO_2 emissions, according to dimensions; 'CP 1 - 9:' performance indicators of the aspect of reducing CO_2 emissions, according to dimensions

The indicators included in the tables are required in order to define the amount of externalities (influencing factors without market value) accumulated in the sector.

Interpreting externalities

In the course of the present study, the term externality was used not in the traditional sense, but rather as any positive or negative (environmental, financial, or social) resource factor that can affect the developments of the Hungarian transport sector but that is not included in decisions on development. The point of examining externalities is to identify market errors, contradictions in development, and hindering or impeding factor groups within the studied economic system. The main aspect of the evaluation was to determine the degree to which a given indicator aids or hinders the transport sector in attaining the targets set by climate policy. In accordance with the above, each of the 9 indicators of the three evaluation system categories were allocated a value [(-2), (-1), (0), (1), (2)], with negative numbers indicating under-performance and positive numbers indicating over-performance. Thus, when compiling the results, a score of 0 indicates the optimal level of a system (best practice), while all other numbers indicate the presence and the rate of externalities. If the accumulation of positive externalities will be characteristic of the various aspects of transport, this means there are many possibilities that are not utilized and to which sources have to be allocated after 2020. However, an overabundance of negative externalities is expected if the opposite is encountered (Fogarassy 2012). This could be a result of the fundamentally incorrect structure of one of the aspects of the sector. Investments should therefore not be made in such aspects, as that would only support disadvantageous development directions that are detrimental to both society and the economy (Fogarassy 2006).

Research results

Table 4 presents the results of the study based on the presented methodology logic. The table summarizes 3 aspects of the analysis: case *"A"* is a simple sum of the externalities

Table 4. Evaluation of the transport sector benchmarking analysis

Serial number		ASPECTS OF THE RATIO OF RENEWABLE ENERGY		ASPECTS FOR INCREASING ENERGY EFFICIENCY		THE ASPECTS OF CO_2 REDUCTION LEVELS	
		2010/2020	2020/2030	2010/2020	2020/2030	2010/2020	2020/2030
Technological	1	-2	-2	1	1	0	-1
	2	-1	-1	2	2	0	0
	3	0	0	1	2	1	-2
Environmental	4	-2	-2	-2	1	-2	1
	5	2	2	0	1	-2	1
	6	-1	-2	0	1	-2	-1
Financial	7	0	-1	-1	-1	-1	-2
	8	-2	0	1	1	-1	-1
	9	0	-1	-1	0	-2	-1
A: Net positive externalities ∑ (1;9)		**-6**	**-6**	**1**	**6**	**-9**	**-6**
B: Total externalities ABS (1;9)		**9**	**10**	**9**	**10**	**11**	**10**
C: The ratio of net positive external effects within total external effects		**0%**	**0%**	**11%**	**60%**	**0%**	**0%**

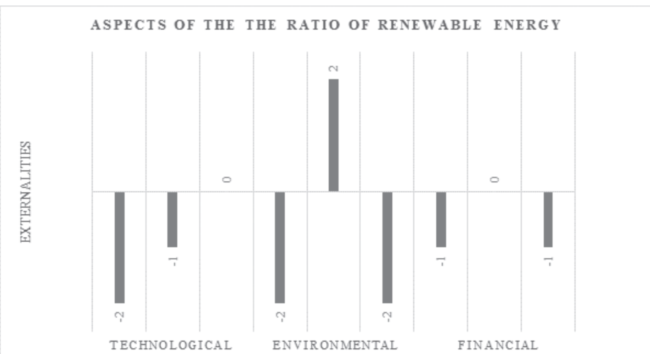
Explanation: A: Net positive externalities ∑ (1;9): the number of positive externalities within the various aspects in 2020 and 2030, respectively, if no directed climate policy developments take place outside of BAU; B: Total externalities ABS (1;9): the absolute value of the total number of externalities; C: The ratio of net positive external effects within total external effects; expressed as a percentage, it indicates the dimension of improvability in the studied area.

manifest in the sector (A: net positive externalities). Index *"B"* is the total amount of externalities calculated by adding their absolute values (B: the absolute value of total externalities). Finally, index *"C"* indicates the ratio of net positive externalities (A) within the total number of externalities (B). Naturally, if the latter is negative because disadvantageous effects have accumulated, the whole index receives a value of 0%.

Evaluation of the study aspects

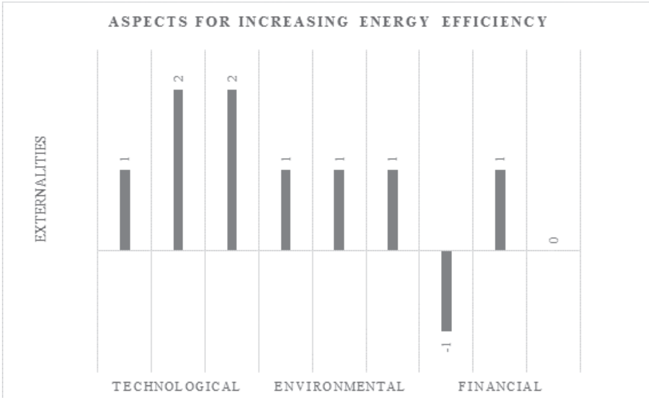
The percentage of renewable energy: the negative figures apparent until 2020 are probably not surprising, since it can be forecast even now that modern technologies within the transport sector (electricity, CNG) will have not spread at all by 2020 (Schade, Krail 2012). However, it is a sad fact that not even the popular scenarios (Tremove and Primes) include those political regulations in their calculations that alone enable these values to be increased. Another obstacle generally encountered in transport is the fact that the sphere of GHG polluters is mostly made up of private persons, who are difficult to delineate and regulate. As a result, the measures between 2020 and 2030 have to affect areas that central regulations can directly influence (Figure 1.). For example, such is the increasing of the percentage of public transport and upgrading the tools it uses. It can be observed that in the case of countries such as Poland and Romania, where CNG buses have been operating for several years, the national level of CO_2 emissions is significantly better.

Figure 1. The number of externalities within the renewable energy aspect



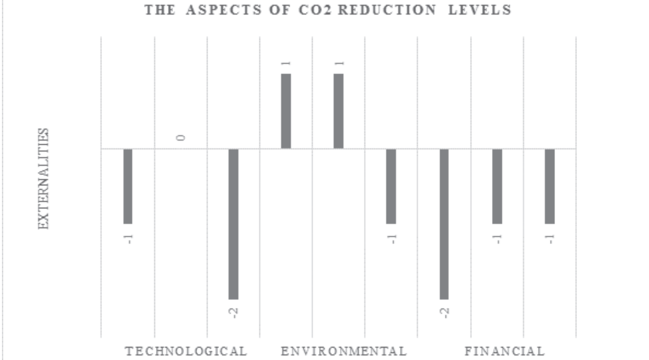
Increasing energy efficiency: this is the only category in which the Hungarian transport sector has received positive results. It can be established on the basis of the study that positive factors can be manifest by 2020 among the externalities that can pose the basis of development for the period ending with 2030. Using the previous indicator group as an example, it is clear that this will not take place with the inclusion of renewable energy sources, but can rather be based on measures that make better use of technologies presently available (for example, the optimization of toll roads, speed limits, etc.). Another important factor is continuously developing technological innovations in the case of vehicles that operate with traditional fossil fuels in order to increase their efficiency (for example, using bio-ethanol and gas in gasoline powered cars). On the other hand based on the experimental data we need to realise the negative feedback in case of financial practice, the renewable-transport finance is a pretty underdeveloped and unprofessional therefore we have few unsustainable programs from the past years. (Figure 2.).

Figure 2. The number of externalities regarding energy efficiency



The aspects of CO_2 reduction: regarding this aspect, it must be said that although a certain improvement is apparent between the two periods, this is far behind expectations. According to forecasts, carbon dioxide emissions will stagnate or, in certain cases, decrease slightly (by 1-2%) by 2020. Despite the above, a large accumulation of negative externalities takes place in the first interval, which will not substantially improve by 2030 (Figure 3.). This could end up being the determining factor for the entire sector. Regardless of whether various climate policy directions have been defined within the EU, the original Kyoto commitments pertain to the reduction of GHG emissions. Based on the study, the increasing of energy efficiency will result in only marginally decreased levels of CO_2 emissions, which can re-evaluate the importance of the sector from the aspect of climate policy and can therefore influence the factors for planning. Consequently, this is the indicator group that best presents the importance of the sector, since it shows the dangers it can have for the meeting of climate policy targets over the long term. This basically means that the increase of energy efficiency results in the increase in the number of vehicles (rebound effect), thus GHG emissions will end up not decreasing.

Figure 3. The number of externalities regarding CO_2 reduction levels



The main development cornerstones of the Hungarian transport sector based on benchmarking studies

The strength of the Hungarian transport sector lies in its inherent cost effective GHG reduction potential. It is well known that the European Union's transport sector main problem is not a lack of possibilities for reduction, but the cost of doing so. It is also well known that it is much cheaper to implement the developments in other areas than in transport. According to international forecasts, the sector will continue to show a large degree of dependency on fossil fuels (gasoline and diesel) by 2030. In consequence, despite the improvement in energy efficiency, long term GHG reductions can only be achieved with the use of renewable energy sources (Hill et al., 2012 Borkent et al. 2012). This is also confirmed by the results of our benchmarking analysis (Table 4), which indicates that the low level of negative externality content in energy efficiency in itself is not sufficient for moving the level of CO_2 emission reductions in a positive direction. The inclusion of renewable energy sources in the transport system is clearly required to achieve this result. Within the aspect that deals with renewable energy sources, it is shown that the values of the technological and environmental indicators remain unchanged, meaning they do not provide the possibilities that would enable developments. Contrary to the above, the complex results table of the financial dimension presents quite a contradicting picture. It leads to the conclusion that the present financing/support system requires the implementation of changes (for example, fuel tax discounts, parking fees, etc.) that are suitable for substantially restructuring the transport sector's fuel use and the mix of fuels it uses.

Another perspective for development is the responsible regulation of urban transport. It is well known that due to its concentrated form, urban transport poses a much greater burden on the environment than suburban transport (Selih et al. 2010; Leduc, Blomen 2009). Regarding this point, the disorganization and imprudence of economic policy decisions poses a significant disadvantage, as a result of which contradicting regulations are often legislated. For example, such is the congestion charge, which is known to be a suitable tool for limiting traffic but is politically quite unpopular. Among climate policy developments, imposing congestion charges on large cities has been a recurring recommendation for years now; it entertains the logic that people who want to participate in urban traffic have to pay the price (Strong-Chhun 2014). Contrary to this notion, the county based toll system was introduced in Hungary, which forces traffic into cities instead of around them in several points, as bypass roads have also been included in the toll system. In Hungary, it is sad that from the perspective of the GHG emissions of urban and extra-urban transport that the new county toll road system introduced in the interest of increasing budgetary revenue is delaying the introduction of the congestion charge in Budapest. The study results illustrated in Table 4 show that the greatest positive results regarding the aspect of CO_2 reduction between the two periods were achieved in the environmental dimension. This means that the system of environmental protection regulations (for example, emissions restrictions, periodical traffic limitations. etc.) has to be amended in the interest of utilizing development possibilities, as that can motivate the development of the system in the direction of reducing GHG emissions.

Based on the benchmarking analysis, the value indicative of the percentages of public transport and road transport proved to be one of the most important indicators. On the one hand, public transport can be much more effective regarding the number of passengers, and in large part it also uses technologies that have low GHG emissions (for example, electric trains, subways, and trams) (Stanley et al. 2011). Regardless of this fact, the models evaluated by the present study show that public transport will show a 5% decrease between 2010 and 2030, its rate thus falling below 20% in comparison with road transport. The retention of present public transport levels and the introduction of regulations that can shift users to this form of transport thus has to be one of the main priorities of transport development. This can take place through the improvement of system efficacy or with protectionist measures that grant greater benefits to people who use public transport. In the case of the public road-based format of personal transport, there are other tools besides the expensive technical development of existing tools. A good example can be the development of the vehicle stock structure by increasing the number of electric mopeds. This simple yet practical mode of transport is much cheaper than vehicles that use similar technological solutions but are nevertheless significantly more expensive. At the same time, it would be a solution akin to reducing emissions and congestions.

In addition to public transport, goods transport is the other sector in which the easily delineable sphere of GHG polluters can aid development interventions (Dobers et al. 2013). In this industry, companies document their trips, making it possible to accurately track the amount of the pollution they produce. In addition, business sector players are naturally easier to regulate than the behavior of individual persons in individual transport. The easiest solution from the aspect of environmental protection would be to have shipped goods transported mainly by low-environmental burden electric trains or with heavy goods vehicles (over 16 tons) that are more efficient in CO_2 emissions per kilometer (Pan et al. 2013). Contrary to the above, the business sector does not prefer railway transport at all, since it is not as flexible as road transport. However, central regulations ban heavy tractor trailers from certain roads in the interest of replacing them with smaller vehicles. This leaves two possibilities for intervention, the first being the gradual replacement of smaller capacity transport vehicles with vehicles that use electric or CNG technology, which obviously requires companies to make large investments. The other choice is to ensure that the shipping routes of goods transported by heavy tractor trailers is short, moving utilization away from smaller capacities towards the direction of electric trains. Both of these directions are basically aimed at using low GHG emitting technologies to provide for the sector's traffic. This was also a trend in personal transportation, where recommendations were either to use electric modes of public transportation or electric cars and mopeds that can be used on public roads. This comes as no surprise, since of the results summarized in Table 4, the technical dimension of the CO_2 reduction aspect shows the larger changes. According to our forecasts, a significant amount of externalities are expected to accumulate in the 2020-2030 period unless the percentage of public transportation and the number of developments in rational private transport (i.e. mopeds) increase. These negative external effects will become apparent in the form of congested roads and the fast amortization of public roads starting in the first half of the 2020's.

Conclusions

Up until recently, Hungarian climate policy generally felt that Hungary did not have to implement any special measures in order to achieve its targets, as those would be met with the modern technological advancements anyway. For example, such is the spread of new heat insulation in the built environment sector, which appear in practice as a result of a need on behalf of society and also end up automatically decreasing the amount of GHG emissions. Developments in the transport sector are contradictory to this trend, as the use of fossil fuels (gasoline, diesel) is still significant and, although energy efficiency will improve as the amount of cars in Hungary increases, the total amount of GHG emissions will continue to grow due to the greater number of vehicles. Studies show that the use of electric cars and environmentally friendly fuels is not trendy and is significantly less economical than in Western European countries. Still, Hungarian agriculture has a good potential to provide bioethanol which puts the country among the top producers in the European Union. The problem occurs with the fact that most of this capacity goes to countries like Germany just as it happens with other biological products from the sector. Therefore the use of this material falls far behind the amount that would be expected considering the size of production.

Based on the present study, it also becomes apparent that it is difficult to effectively implement regulations in a sector where private transport is so prevalent (80%). The authors therefore attempted to identify the areas of development through which the amount of GHG emissions can be easily measures and thus controlled. The results of the benchmarking analysis performed as part of the present study helped define two main points of intervention. The next step would be to perform specific economic studies in regard to these. The first point of intervention is the increase in the percentage and size of public transport (or at least maintaining present levels: around 20%), since this form of transportation poses a significantly smaller environmental burden than private transport. The second area that could hold significant possibilities for development is the sector of goods transport, where the utilization of environmentally friendly modes of transport in shipping is essential. The primary way to achieve a significant increase is by developments aimed at electric or CNG use.

In the interest of successfully applying the results of the study, the authors also recommend performing a cost-benefit analysis (CBA) for the sectors mentioned above; the results of these CBAs would indicate the amount of GHG decrease that a unit of investment would create. In addition, it must also be clear how the applied resources (i.e. EU support) would provide a return over the long term, thus what values the cost efficiency indices would have. In the case of climate prevention developments, it often happens that the actual returns on the investments are only realized after the lifecycles of the developments; this however cannot be an option in any of the aspects in question. Only those developments should be granted central or EU support that are sure to provide a return before the end of their lifecycles and where the cost efficiency of the GHG decrease remains less than the EU ETS quota price forecasts. If the development principles fail to adhere to this target system, externalities (primarily negative externalities) will end up accumulating in the sectors, which will make cross-sectoral low carbon developments fundamentally impossible.

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ENHANCING THE EFFECTIVENESS OF THERMAL WATER CONSUMPTION VIA HEAT PUMPING

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Abstract: *Renewable technologies and the extension of their scope of usage basically has to face the general obstacles like any other novelties newly introduced to the market. In the case of environmentally friendly and clean technologies we must consider another critical aspect: the knowledge and the trust of the potential future users. To influence these people first we must extend their knowledge regarding renewable energies so they will be able to change their own approach about them. Usually the most crucial factor is the economic efficiency which determines the attitude of the majority of the users. Even the ones whose decision making process is highly based on the environmental patterns. In the case of any technology, the economic aspect is significantly influenced by its operational effectiveness. So this analysis – besides the direct economic matters – aims to examine how the performance of thermal water heating in greenhouses can be improved by using heat pumping.*

Keywords: *renewable energy, thermal water heating, energy efficiency, heat pumping, cost-effectiveness*
(JEL classification: Q42)

Introduction

According to geothermic assets and potentials Hungary is considered as one of the best countries in Europe. It is originated from the fact that the average crust of the earth has around 22-28 km of thickness at the Great Plain and it does not go above 30 km at the rest of the plain territories within the country (Nagygál, 2005). Therefore the geothermic gradient (thermal gradient) is also favourable which means a 5 °C/100 m value while the European average is 3 °C/100 m. The same advantage is valid in the case of the heat flux data which is also higher in Hungary (90-100 mW/m^2) than in Europe (62 mW/m^2 in average) (Nagygál, 2014).

The point of the geothermal energy utilization is to use the inner energy content of the water from the hot rocks below the ground. There are two ways for the water to reach the surface: its own elastic expansion and the excess pressure of the steam. During the extraction the layer pressure of the storage starts to lessen which is followed by the decrease of the yield and the temperature of the well. To maintain the layer energy of the storages and avoid the environmental pollution, it is inevitable to reinject the thermal water into the ground. In case of the older wells the fluid is only accessible with artificial methods. It means that the certain thermal water systems can be distributed into closed or open systems based on their structure (Csikai, Nagygál, 2007). Whenever we utilize thermal water from closed systems it releases heat on the surface under excess pressure then it returns to its original layer by reinjection. While the cold water flows from the injection well to the production well, the direction of the thermal conductivity goes the opposite (Tóth et.al. 2012, Fogarassy et al., 2009).

Considering the uneven usage of the thermal water, it is better to keep them in large storage tanks from where it could be pumped into the heat exchanger devices (Fogarassy et al., 2011b).

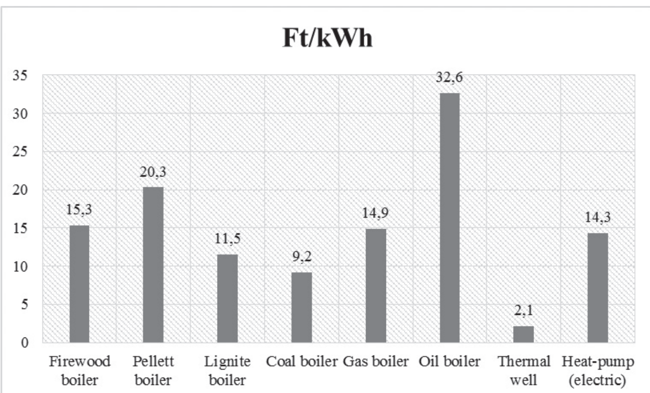
After the heat exchanger the water with a decreased enthalpy flows through the reinjection pumps to the reinjection well (Ádám, Tóth, 2011; Holm et al., 2010). According to the new Hungarian regulations from 2018 wells can only be drilled for heat production if the conducting company makes sure of the reinjection procedure as well.

Today the 30-35% of the thermal water usage serves communal activities while the same amount is used for greenhouse heating (Figure 1).

Figure 1: Greenhouse structure with three several heating purposes (air, ground and plant row side)

Heating greenhouses is being considered as a business activity so there is a competition in the market of energy resources. During our previous research, we analysed these resources and heating technology variants applicable to winter heating greenhouses by their respective pros and cons, and took a look at their investment and maintenance costs as well. We also evaluated the specific energy yield costs of the systems (Figure 2).

Figure 2: The price of 1,0kWh heat energy in case of the system's 15 year return



Source: Self-made after own calculations, 2015

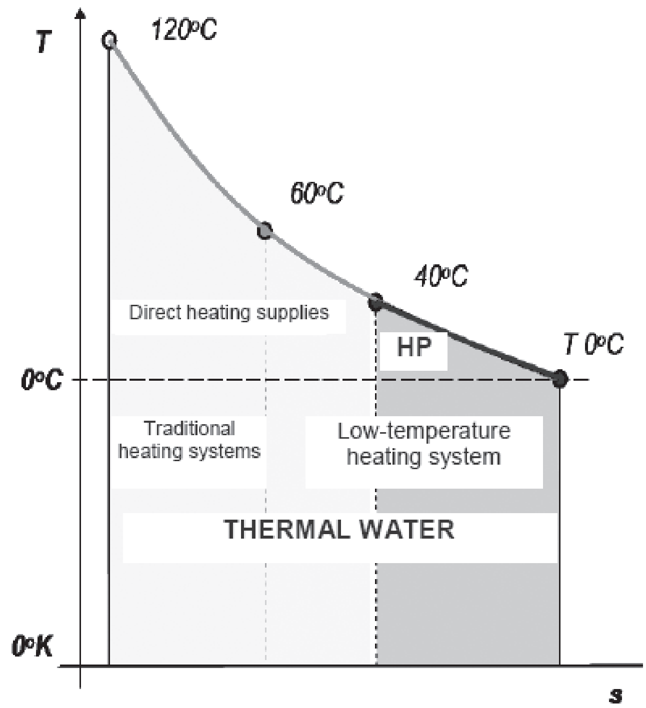
We successfully determined that using geothermic heat energy gained from thermal water would be the most economically sound decision (2,1 HUF / kWh). We also analysed the specs of heat pumping already consumed heating water, its opportunities, pros, and cons.

Literature review

Introducing the technological system

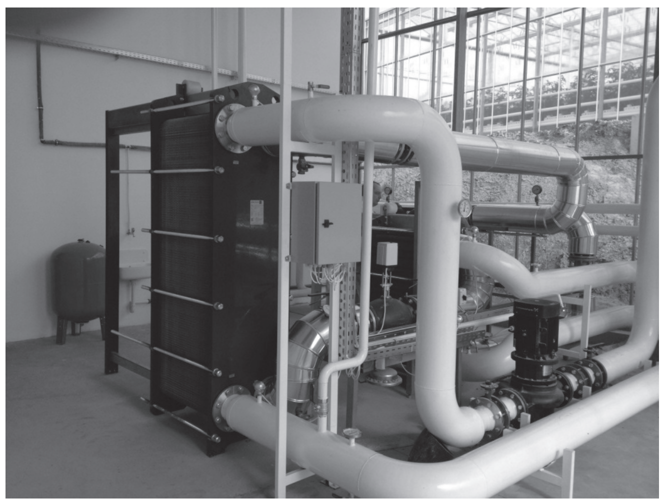
Figure 3 shows a T-s diagram which illustrates the temperature ranges of the certain thermal heating forms. So the entropy content and the temperature altogether determines the applicable heating mode and the necessary technological equipment (Büki, 2010a).

Figure 3: The utilization of thermal water on the T-s diagram



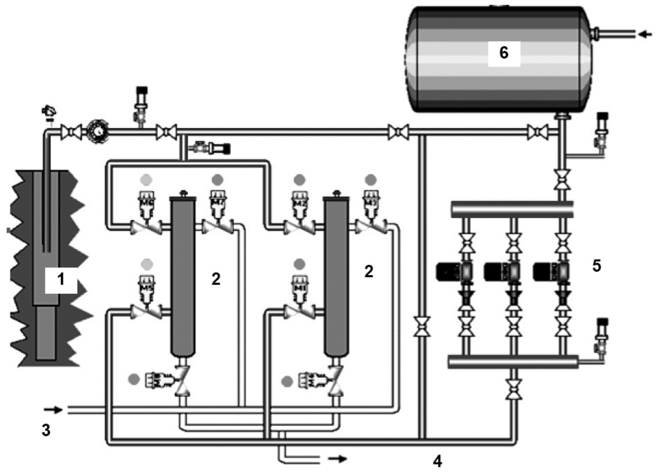
Today's thermo-conventional systems siphon the heat energy from wells through heat exchangers - almost exclusively (Figure 4), and transport it to the consuming side.

Figure 4: Sheet-metal heat exchanger used at the first heating cycle



For the protection of the thermal water assets we must only reinject the completely pure fluid into the origin layers. (Ádám, Tóth, 2010; Holm et al., 2010). This can only be conducted with the appropriate storage and filtering system (Figure 5).

Figure 5: The treatment of the thermal water before the reinjection

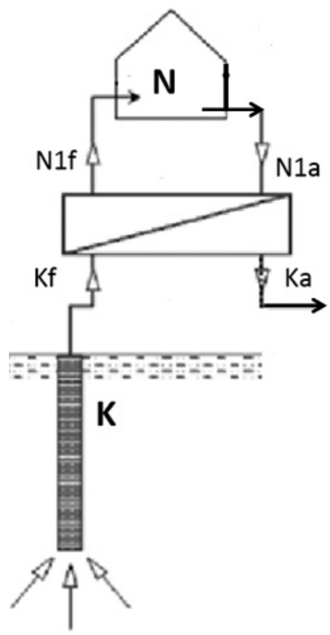


Explanation: 1- reinjection well, 2- filters, 3- rinse the filters with clean water, 4- settling the filtered minerals and the other pollutants, 5- pumps, 6- storage tanks (Tóth et al., 2012)

Letting thermal water from wells off on the surface (Figure 6) and relocating it (into lakes and rivers) poses environmental protection risks due to its high salt content (this is why an environmental load fee exists). Sequestration into thermal wells - the aquiclude - in case of more shallow bands - also becomes a problematic factor due to water purity protection. Contrary to this, these have to be utilised due to sustainability reasons.

Siphoning heat energy via heat pumping from the high-enthalpy fluid before sequestration, or subterranean placement is a definite option (Büki, 2010a; Nagygál, 2007)

Figure 6: Heating greenhouse with fluid let off (N-greenhouse)



Abbreviations on the illustration are as follows (Láng, 1999):

- Temperature of the well fluid – **Kf** (60-80°C)
- Temperature of fluid leaving - let off - from the heat exchanger – **Ka** (25-32°C)
- Temperature of heating water entering the greenhouse – N1f
- Temperature of heating water returning from the greenhouse – N1a

Due to the theorem of energy conservation, we can define that the heat absorbed by the medium being heated equals the heat expended by the medium losing heat (Beke, 2000), which is as follows:

$$Q_K = \dot{m}_1 c(T_{Kf} - T_{Ka}) = \dot{m}_2 c(T_{Nf1} - T_{N1a}) = Q_N$$

Meaning the heat successfully produced from the well is dependent on the difference in inbound and outbound temperatures, and the mass flow volume of the fluid from the well. When deciding the performance of the heat exchanger, the defining factor is obviously the supported maximum mass flow rate.

Heat supplied to the greenhouse is as follows:

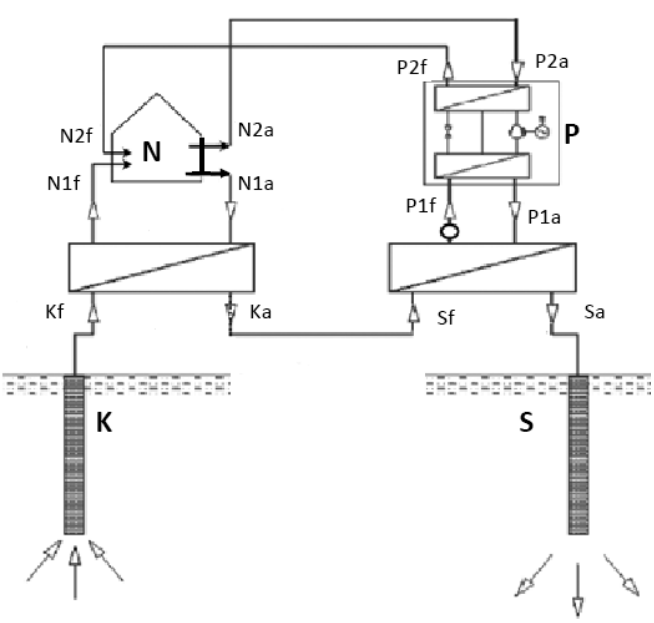
$$Q_N = \dot{m}_2 c(T_{Nf1} - T_{N1a})$$

Even in case of soil cooling, the temperature of water let off in case of greenhouses is between 25-32 ^{0}C (ANSI/ASEA, 2003).

For such a medium temperature, heat pumps can be operated with a high COP value (COP=4-5). This is why heat pumping water before letting it off into open water, or sequestrating it may be productive.

In this case, the heat exchanger on the heat pump's vaporizer side can be linked directly to the fluid to be sequestrated, but in case of a higher concentration of minerals, operating it from an inserted heat exchanger which also allows for mass flow rate control might be more preferable (Figure 7).

Figure 7: Installing the heat pump



Abbreviations:

- Sf (=Ka) – temperature of the fluid arriving in the inserted heat exchanger,
- Sa - temperature of the fluid leaving the inserted heat exchanger - via letting off, or sequestration.
- The respective values of P1f and P1a are dependent on the DT value possible to realise on the heat exchanger, but even more dependent on the mass flow rate set in this support circulation.
- The respective values of P2f and P2a are the temperatures of heating water leaving, and returning to the heat pump's capacitor. Their ranges are defined by the attributes of the heat pumps, and the heat extraction of the greenhouse.

The heat extracted, and the temperature of the fluid before sequestration may be changed by the mass flow volume induced by the circulating pump inserted between the heat exchanger, and the other heat exchanger on the heat pump's vaporizer side (Ghosal et al., 2003). With a higher mass flow rate, temperature can be lowered, if the vaporizer of the heat pump can absorb heat.

Therefore, heat gained via the heat pump is as follows:

$$Q_s = \dot{m}_1 c(T_{Sf} - T_{Sa})$$

And the total heat extracted from the fluid is as follows:

$$Q_{Ö} = Q_N + Q_S$$

The amount of heat energy diverted from the heat pump to the greenhouse (taken from the capacitor) is higher, via the coefficient of performance (COP) of the heat pump (see Illustration 3).

$$Q_{N2} = \dot{m}_3 c(T_{N2f} - T_{N2a})$$

Where: m_3 is the mass flow rate of this cycle.
When heat pumping, COP is fundamentally influenced by the average difference in temperature (DT) between the capacitor and the vaporizer (Frank, David, 1990).

Therefore, our theoretical heating coefficient is as follows:

$$\varepsilon_f = \frac{\overline{T}_K}{\overline{T}_K - \overline{T}_{Ep}}$$

- The average outbound temperature of the capacitor:

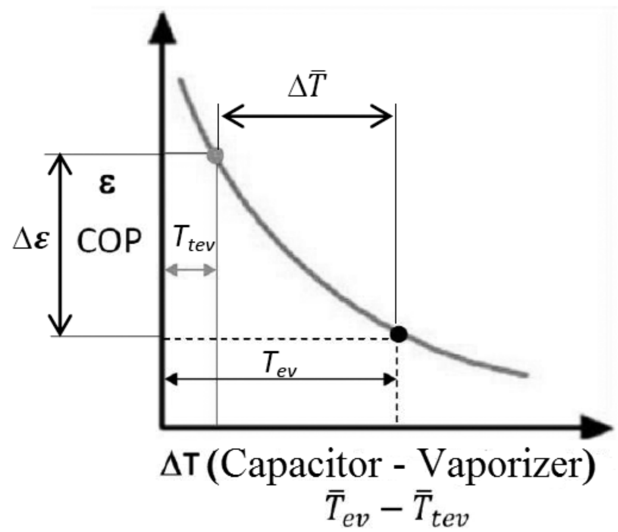
$$\overline{T_K} = \frac{\overline{T}_{P2f} - \overline{T}_{P2a}}{\ln \frac{\overline{T}_{P2f}}{\overline{T}_{P2a}}}$$

- The average temperature of the heat-absorbing side (vaporizer):

$$\overline{T_{EP}} = \frac{\overline{T}_{P1f} - \overline{T}_{P1a}}{\ln \frac{\overline{T}_{P1f}}{\overline{T}_{P1a}}}$$

According to what was written until now, if we chose a vaporisation temperature too low, thereby lowering the sequestration temperature, but disregard to do the same with the capacitor's temperature, the value of the COP will be worse. The similar can be said about the capacitor side, if we want to raise the heating temperature (Figure 8) (Ghosal et al., 2003).

Figure 8: Changes in COP due to temperatures of the capacitor and the vaporizer



Using an example close to real values, we calculated the COP for a system (Rennie, Raghavan, 2015):

Example:

a. The fluid's inbound temperature is 30°C, and outbound temperature is 13°C at the vaporizer side, while the respective temperatures are 50°C outbound and 38°C returning respectively.
   This results in a theoretical 13,78 COP value, which in practice[1] (including various losses) is reduced to a 5,5-6,0 value, which can be said to be economically positive.
b. If the fluid's inbound temperature is 25°C, and outbound temperature is 8°C at the vaporizer side, while the respective temperatures are 55°C outbound and 40°C returning respectively, theoretical COP value is only ~7,0, which in practice (including various losses) becomes a 2,8-3,0 value. This can't be said to be economically positive anymore.

For the economic evaluation, let's take a look at an example really close to actual facts (Thulukannam, 2013):

- The well's mass flow rate is 100m³/h.
- The extracted heat energy at the first heat exchanger at DT = 30°C (68-38) value is 3540kW.
- The second heat exchanger's DT = 17°C (30-13), while the heat energy value is 2006kW. This heat exchanger's cold side is linked to the vaporiser of the heat pump.

– This heat energy has a ~5.0 COP value, which means the operating energy is around 400kW.

If we take 8000 hours of annual operation time for the system, the annual electricity costs for 18-25 HUF / kWh adds up to about 60-80 million HUF annually.

The energy gain at the heat pump re-calculated for the case of using gas heating results in a 90% furnace efficiency, which would cost about 160 million HUF annually, at an average gas energy price of 2,8 HUF / MJ.

This way, the system results in a cost reduction of about 80 million HUF (about 50%) annually for a COP value of 5 (which is completely possible).

If we take a look at the costs of gas heating on Illustration 1, which is at a 14,9 HUF / kWh on average, half of which is 7,45 HUF / kWh, we can see that this kind of heat pumping is the cheapest compared to other variants.

Which means it's implementation is an economically sound decision!

The costs of the heat pump, the heat exchanger, and the various accessories (including installing fees) is about 60 million HUF. Figure 9 shows an example for a regular heat pump system.

Figure 9: AERMEK twin-capacitor heat pump

Using this for estimations, and a 5-year life cycle (we won't expand on amortisation and continual costs), it wins even against the cheapest coal heating. If we calculate as a further variation for this efficiency (even if digging a new, average H=1400-1600m well), we still get a positive result.

Methodology

General energetic evaluation

The question of how effectively heat pumping uses the renewable energy (in our case, post-heating of geothermal heat) pops up concerning our introduced heat pumping method. We arrive at the most critical answer if we compare the heat pumping method to more traditional heat extraction methods (f.e. natural gas-based) (Büki, 2010b).

In case of producing Q amount of heat with heat pumping, the consumed electric energy's

$$P = \frac{Q}{\bar{\varepsilon}_f},$$

Primary energy complement, f.e. when using the aforementioned natural gas is as follows:

$$G_{fg} = \frac{P}{\eta_E} = \frac{Q}{\bar{\varepsilon}_f \eta_E}$$

Where e_f = Q/P is the heat factor of the electric heat pump, and h_E =P/Q_{fg} (45%) is the production efficiency of consumed electric energy.

We disregard volume losses of heat pumping.

Heat produced by the pumping method - for identical Q heat requirement - turns out to be better, compared to natural gas heating, if $G_{fg}<G_K$, meaning:

$$\bar{\varepsilon}_f > \frac{\eta_K}{\eta_E}$$

Heat extracted via heat pumping can be considered renewable energy[1] if the following holds true for the heat pump's heating factor:

$$\bar{\varepsilon}_f > \frac{1{,}15}{\eta_E} \text{ (condenser furnace);} \quad \bar{\varepsilon}_f > \frac{0{,}95}{\eta_E} \text{ (traditional furnace);}$$

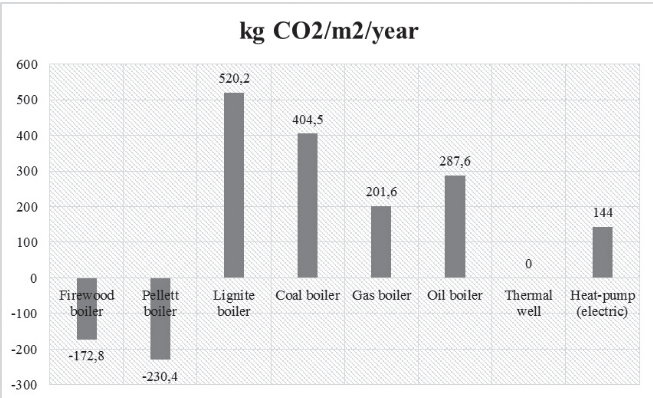
This condition means that the COP value of heat pumping had to be above 0,38.

This condition, as we saw before, will hold true for heat pumping geothermic fluid, if size adjustments are correct. When improving the heating factor and the efficiency of electric energy production, the condition is even easier to satisfy. When thermal water is further cooled at an average heating factor of = 4-5, a consumption efficiency of 50-80% can be realised (Büki, 2010b).

This concludes that heat energy extractable via heat pumping before sequestrating, or letting off thermal water may be up to 50-70% of the energy extractable at the original consumption. If correct calculations are prepared, this energy, and the respective costs of the heat pump's initial investment and operation all have to be compared to heat production using natural gas furnaces, or the costs of digging a new well. In places where sequestrating thermal water can be done without any problems, this solution is more than adequate as an alternative to other energy resources. However, using electric energy from renewable sources, heat pumping serves the goals of sustainability best.

Regarding the environmental aspect we also examined the CO_2 emissions of the certain heating methods. Even though the firewood and the pellet boilers look the most efficient forms, previously they proved to be the most expensive ones too. So it can be concluded that the utilization of geothermal energy is the best way for greenhouse heating in the case of the economic and the environmental aspects as well.

Figure 10: The CO_2 emissions of the certain fuels in a calendar year



Source: Self-made after own calculation, 2015

The chart does not include the follow-up pumping method. It is obvious that the operation of the heat-pump is going to generate CO_2 emissions which can be calculated with the energy mix of the used electricity (Fogarassy et al., 2011a).

The current value of this data in Hungary is 0,35 kg CO_2/kWh. In case COP is equal with the value of 5, it means that the utilized energy will be 20% of the all CO_2 emissions from the energy mix (Büki, 2010b).

Therefore: 0,37 x 0,2 = 0,074 kg CO_2/kWh. If the heat energy from the heat-pump system reaches 40% of all the utilized energy, then the previous data will be modified to (0,074/1,4) = 0,052 CO_2/kWh.

The required 3100 MWh/year energy for a 1ha sized greenhouse generates (3100 x 0,4=) 1240 tons of CO_2/year emission level even with the most efficient gas burning system. In the case of the geothermal heating system and its reinjection the emission level is only (3100 x 0,052=) 161,2 tons of CO_2/year which is only 30% of the gas boiler system emissions.

Conclusions

In this article, we analysed the respective costs of energy resources usable for the winter heating of greenhouses. We also examined the accessible energy resources in Hungary and their yearly costs for a 1 ha sized greenhouse. One of the main outcomes of the research was that geothermal heating proved to be the cheapest and the most environmentally friendly method. It can be concluded that if the COP value of the heat pumping system is higher than 3,8, then it will be cost-effective in any cases and it will operate on a low CO_2 emission level (only 30% of the emissions of the gas boiler). Furthermore, it is an efficient way for energy utilization to use the thermal water of the greenhouses before the reinjection. However in the case of greenhouse heating this method turned out to be the most cost-effective among all of the energy resources.

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METHANE REDUCTIONS TO MODERATE THE GLOBAL WARMING EFFECTS

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Abstract: *The case-study overviews the possible reduction for the methane gas emission in order to avoid of the more global warming effects and climate change caused by the human activity at latest decades. To collect international data base is for analysing and valuing methane gas emission based on the different country-groups, emphasizing responsibility of developing countries and highly developed countries for gas emission, also the methane emission based is on the economic sectors. China and India have share 8% of China and 2% of India respectively of cumulative CO_2 emissions over the period 1900-2005, the US and the EU are responsible for more than half of emissions. Based on the estimation the global gas emissions of methane in the whole world has increased by 37% for period of 1990- 2030, as four decades, and this was 0,92% annual rate growth, while the OECD has increased the methane emission by 8,5% for this period, which means 0,21% growth rate annually.*
Scenario in developing countries for 2013-2020 the methane gas emission reduction could have been 8200 Mt of CO_2e (Equivalent) and less than 10 US dollar per ton in more cost financing.
Highly developed and developing economies (last one their methane emission share 56% in 1990, estimated 66,8% in 2030) increase their economic growth by mostly fossil energy resulted in increasing also methane gas emissions. The methane gas emission can be solved by those results-based-finance forms relevant to Kyoto Protocol, which can extend in the world by financial institutions.

Keywords: *Climate change, Results-based-finance, Scenario, Developing countries, World Bank*
(JEL classification: Q54)

Introduction

The methane gas emission is very actual issue at present, because the methane has considerably contributed to the global warming and climate change for the last decades. The environment friendly economic strategy and GDP growth focus on preventing the global warming by decreasing the gas emission including the methane emission.

The international cooperation can be stronger at latest time, which shows the UN Environment Program accepted in 2011 on the reducing the methane gas emission strongly in order to avoid of highly level rate of the climate change. According to the UN Environment Program Report (UNEP, 2011a; 2011b) the methane emission decrease can result about 0,4 – 0,5 ^{0}C reduction in direction to the avoiding global warming by 2050. Also additionally to the decreasing the methane emission the international cooperation should be forced to reduce CO_2 emission in order to avoid the critical climate change.

Some international data given by EEA (UNEP, 2011and 2011b) emphasize the correlations between the air pollutions and food security, which means that the cost efficiency methane reduction can ensure more air quality human health in positive direction, when they decrease the crop losses by about 27 million tons annually.

The US EP (US EP, 2010) reported that in developing countries for the period of 2013-2020 the gas emission reduction could have been 8200 Mt of CO_2e (Equivalent) and less than 10 US dollar per ton in more cost financing. The data show the main expected plan of the country-group to decrease gas emission. The methane emission can be considerable in spite that time length of methane emission is extending not too long, mainly short comparably to CO_2 gas emission effects.

Material and Method

The case-study analyses the gas emission from methane based on the methods, first how the methane emission is distributed by different economic sectors and different regions of the world economy, emphasizing the main country groups selected in highly developed economies and developing countries.

1. Hypothesis: The *highly developed and developing economies* increase their economic growth by increasing gas emissions including methane and also they try to reduce this gas emission by depending on *using innovative cost-effective methane reduction* measures to improve the air quality.

2. Hypothesis: The using innovative cost-effective methane reduction measures to improve the air quality is considerably depending on the *results-based-finance* relevant to Kyoto Protocol.

The statistical data are coming from different UN organizations and the international measuring systems and also different national environmental reports of different economies. The international reports also focus on the incentive the cost-effective methane reduction technology by using different financing resources from governmental, banking and private sectors. The prevention for the increasing gas emission needs for innovative investment and their financial background (US EP, 2012, EPA, 2012; UNEP, 2011ab).

Results and Discussion

Recently the developing countries have increased their economic growth by increasing gas emission including methane gas emission for the last two decades. The gas emission can increase the threaten level of the gas emission measure which can lead to the catastrophic climate change.

According to international data base coming oil-importing countries, poorer countries had greater reduction in GDP, which will be due to *high oil prices* (UNDP/ESMAP 2005). The *IMF estimated in 2004* that a sustained US$10 oil-price increase would lead to a reduction of 1.5 per cent in the GDP in those countries after one year. In Asia, this would induce an overall reduction of the GDP of 0.8 per cent after a year with some countries suffering more, such as the Philippines which could lose 1.6 per cent of its GDP (IEA 2007a; IEA 2007b). This means that mostly developing countries had less economic growth, which could decrease the gas emission of theirs because of the international oil price increase and not to use cost effective gas and methane reduction measure.

Recently Asian countries realised considerable economic development using energy resources, but reports of different international organizations declared that while China and India have had share as *8% of China and 2% of India respectively of the cumulative CO_2 emissions over the period 1900-2005*, the US and the EU are responsible for more than half of these emissions (IEA 2007a).

But the international comparing data show completely different overview for two main gas emission countries, namely China and India. Because China has reached the first position for CO_2 emitter in the world economy and while Japan and India became already fourth and fifth position. Also China and India have accounted for 56 per cent of the increase in CO_2 emissions for period of 2005 and 2030 belonging to the scenario of the IEA (IEA, 2007a). Therefore Chinese emissions are forecasted to be 66 per cent higher than one of the US, ranked second. Therefore, challenges in terms of CO_2 mitigation are huge and should, at some point, take place in Asia.

The gas emission resulted pollution in air, therefore this polluted air leads, among other things, to respiratory illness, cancer, tuberculosis, and low birth weight and eye disease. For example, exposure to biomass smoke may explain 59 per cent of rural cases and 23 per cent of urban cases of tuberculosis in India. In China and India, it has been shown that two-thirds

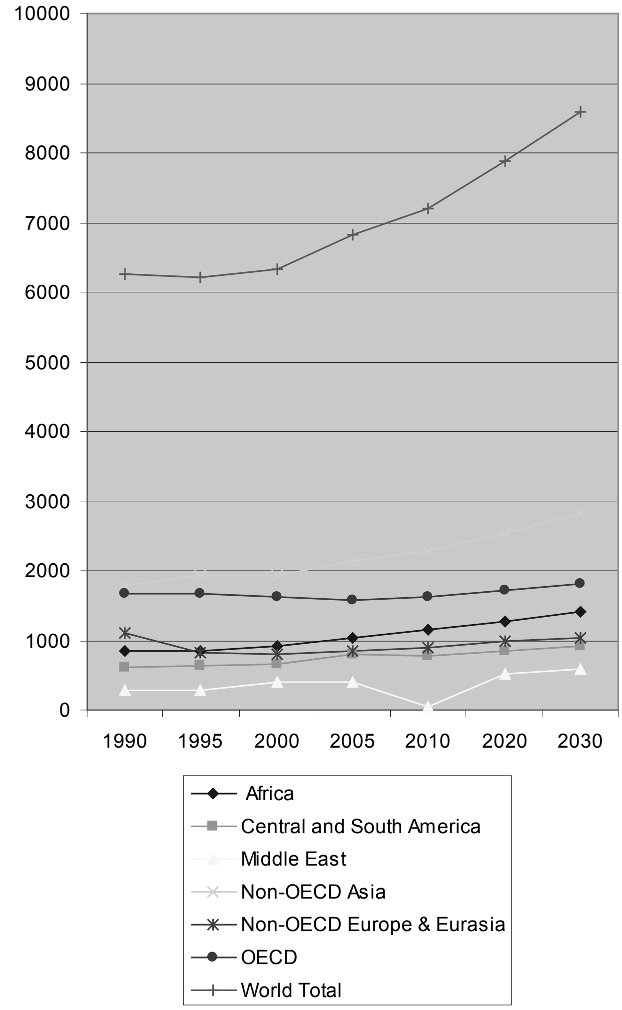
Table-1: Global Emissions of Methane by Regions, 1990-2030

Regions	1990	1995	2000	2005	2010	2020	2030
Africa	841	846	911	1037	1,154	1,275	1,409
Central and South America	606	639	663	795	784	856	911
Middle East	277	291	400	405	41	519	585
OECD	1,666	1,668	1,617	1,572	1,628	1,708	1,807
Non-OECD Asia	1,784	1,933	1,936	2,150	2,286	2,535	2,829
Non-OECD Europe and Eurasia	1,095	829	799	857	901	994	1,045
World Total	6,269	6,205	6.324	6,816	7,196	7,888	8,586

Source: EPA 2012. Global anthropogenic Non-CO2 Greenhouse Gas Emission: 1990-2030

of women with lung cancer were non-smokers (Bruce et al. 2000). And according to Zhang and Smith (2007), indoor air pollution is responsible for more than 400,000 premature deaths annually in China.

Figure-1: Global Emissions of Methane by Regions, 1990-2030



Source: EPA 2012. Global anthropogenic Non-CO_2 Greenhouse Gas Emission: 1990-2030

The considerable role of oil price increase is in increasing the gas emission in spite that the use of oil considerable decreased. The oil price decrease did not result decreasing gas emission because this leaded to diversified energy resource use in order to compensate the oil price increases. According to the CO_2 emission the methane gas emission has increased by performance of China, India and Japan, which CO_2 gas emission resulted considerable threat for increasing the global climate change.

The data of *Table-1* provided proof the trend of gas emission even in case of the methane. The global gas emissions of methane in the whole world has increased by 37% for period of 1990- 2030, as four decades, and this was 0,92% annual rate growth, while the OECD has increased the methane gas emission by 8,5% for this period, which means 0,21% growth rate annually. The Non-OECD Asia has reached the highest level of methane gas emission by 58,6% and 1,46% annual methane emission growth for the same period in the world. The data base can show the dominant role of the developing countries in increasing methane gas emission by share of each country-group.

In this case share of *developing countries including Africa, C-S America, Middle East, Non-OECD Asia including China and India* was 56% in 1990, 54,7% in 2010, estimated forecast data 66,8% closed to about 70% in 2030 according to the international possible future review. This data clearly show how the share of developing countries could increase their methane emission. After the economic crisis of 1998 and financial bank-crisis of 2008 the developing countries decreased their economic growth, which was also seen in the reduction of the methane emission, namely this decreased from level of 56% share of developing countries in 1990 to level of 54,7% in 2010. But the international estimation shows a considerable share increase of developing countries in methane emission by 2030. This means that mostly the Non-OECD Asia including China will realise a considerable economic growth based on the fossil energy uses stimulating gas emission and increasing the climate change possibility resulting global warming.

The *strategy of China based on the diversified energy resource use* can make less vulnerable to the world price increase of each energy resource. The diversified energy resource use can also contribute to the more oil energy resource use in cases of Chine and India, which can lead to increase of the oil world price level. Two countries are considerable crude oil importers in the world economy and for the last decade China and India have increased their crud oil import. The world price of crude oil contributed to the increase of input price increase of production and services in both of countries.

Mostly China has a considerable economic growth based on the oil energy resource use, which also contributed to increasing gas emission including the methane as first responsible for the global warming. China is basically export oriented economies; therefore the input cost is vulnerable to energy price in export oriented sectors including mostly manufacturing industries. So the increasing oil price results in increasing input price of exported processed products in China. Based on the international compare the labour force input price is lower in China, therefore in spite of the increasing oil price the Chinese export can be competitive on the world market. Additionally to low labour force input price the innovative advanced technology also contributes to the competitiveness of China in the world economy.

The oil price increase more impacted on the increasing price input of processing industry than gross household consumption. The gross household consumption is kept somehow at low level results low level of domestic national consumption level, therefore as little narrow domestic consuming market. The more processed products and services can be transferred to the world market. The oil price increase leads to decrease gross household consumption to keep the level of export orientation, and for example, by assumption, the oil price decrease leads to little increase gross household consumption at the given level of export orientation. Also there is a possibility for increasing the exported products and services at remaining level of the domestic gross household consumption. China can make foreign consumers on the world market pay increase oil price by increasing input price of export oriented sectors and oil costs embedded in gross exports of China.

In the half of 2000s according to UNDP one of the adjustments available to reduce the effects of an oil-price increase relates to the price elasticity. Indeed, in non-OECD countries this price elasticity tends to be much lower in absolute value than in OECD countries, lowering the reduction in consumption that follows such a price increase (UNDP/ESMAP 2005).

Methane Emissions by Sector

The other considerable issue for the methane is the Global Anthropogenic Methane Emissions by sector at present, which shows the considerable share of enteric fermentation with its 26,9% and oil-gas share with its 23,4% resulting ethane gas emission in 2010. These two main shares of methane gas emission is amount for at least half of all methane gas emission. The other considerable shares are landfills, rice cultivation, wastewater, combustion and livestock waste producing methane emission, also coal mines according to the industry contribute to methane emission. This clearly shows that the methane gas emission share of industrial development is dominant and also the agriculture and some economic activities according to this sector has important role for increasing methane gas emission (Table-2 and Figure-1).

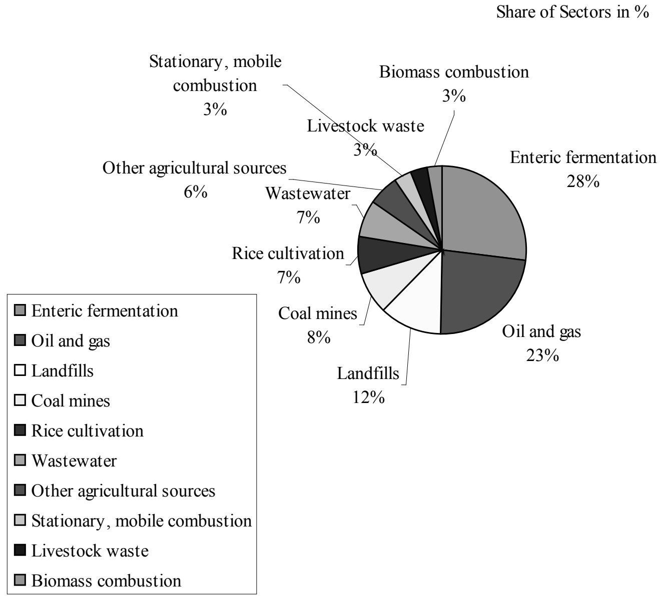
In case of the EU there are some difficulties connecting with methane emission, even in agricultural sector, for example waste in soil and water. Therefore the EU aims at restricting untreated municipal solid waste from landfills leads to significant reduction in greenhouse gas (GHG) emission, while this contributes to the more satisfactory resource-use efficiency and cost-effective methane reduction (EEA, 2011; UBA, 2010).

Table-2: Global Anthropogenic Methane Emissions by Sector, in %, in 2010

Sector	Share of Sectors in %
Enteric fermentation	26,9
Oil and gas	23,4
Landfills	11,8
Coal mines	8,2
Rice cultivation	7,2
Wastewater	7,1
Other agricultural sources	5,9
Stationary, mobile combustion	3,4
Livestock waste	3,2
Biomass combustion	2,8

Source: US EPA 2012. Summary Report: Global Anthropogenic Non-CO_2 Greenhouse Gas Emissions: 1990-2030

Figure-2: Global Anthropogenic Methane Emissions by Sector, in %, in 2010



Source: US EPA 2012. Summary Report: Global Anthropogenic Non-CO_2 Greenhouse Gas Emissions: 1990-2030

Table-3: Needed Incremental cost Finance to Incentive Abatement Mt CO_2e Abatement Potential in Developing Countries' by Sector at Break-Even Price \$/tCO_2e (Cumulative 2013-2030)

Sector	\$0	\$5	\$10	\$15
Coal Mine	404	1,763	1,902	2,088
Landfills / Waste Management	814	1,293	1,581	1,776
Wastewater	6	10	13	27
Oil & Gas[b]	2,647	3,427	4,122	4,368
Livestock Management[b]	357	450	538	633
Approximate Total	**4,200**	**6,900**	**8,200**	**8,900**

Source: EPA 2012. Preliminary Draft Global Mitigation of Non-CO_2 Greenhouse Gases Report, March, 2012

The Table-3 shows that the how developing countries can decrease the methane emission cumulatively between 2013 and 2020 with policy intensive for methane reduction as a price per ton of CO_2e (equivalent). In case of coal mine by 10 US Dollar per tone added, therefore 1.900 million tons of CO_2e methane gas emission reduction can possibly be realised between 2013 and 2020 based on the scenario of EPA (2012). In general there are some difficulties for realising this scenario in the practice, mostly the financial barriers probably cannot solve and implement the methane reduction meeting the strategic climate aims. Therefore the banking sector should follow the *pay-for-performance mechanism*, which performance of firms can be also adequate for the strategic climate aims and these aims followed by firm performance.

The international practise in case of the *pay-for-performance mechanism, by the other words as results-based-finance*, which means given by the OECD (2011) and World Bank

(2011) that performance risk is shifted from the founder to the project implementer concerning the investments for methane reduction, which *results-based-finance* also stimulates projects to be success. This *results-based-finance* originally was created within the Clean Development Mechanism (CDM) of the Kyoto Protocol with its qualified demands for reducing greenhouse gas (GHG) emissions equivalent to one ton of CO_2. This CDM has positive and considerable results, which has registration of 6,500 projects and the issuance of 1,2 Gt of CO_2e from nearly 2,100 projects, of which more than 300 are in methane sectors (World Bank, 2011).

According to the OECD (2011) the Official Development Assistance provided 134 billion US dollar for different economic investments to improve performance of firms for reduction of methane emission, strengthening multilateral institutions and cooperations based on *results-based-finance* concerning the Kyoto Protocol. The amount of financial resources is at very low level comparably to the global foreign direct investment (FDI), of which value is 1,6 trillion US dollar. Also the World Bank (2011) has provided 1,2 billion US dollar for managing manure, municipal solid waste and gas emission reduction for period of 2007-2012.

According to the *first Hypothesis*, that it is proofed that the highly developed and developing economies increases their economic growth by mostly fossil energy resulted in increasing gas emissions including methane. This event is proofed by statistical data provided by the Table-1, and Figure-1. Developed and developing countries should use *innovative cost-effective methane reduction measures* represented by scenario of Table-3, to decrease the gas emission.

According to the *second Hypothesis*, it is proofed that the energy use of *different economic sector*s mainly comes from the fossil energy resources use including methane (Table-2; Figure-2). The methane emission can be solved by *results-based-finance* forms relevant to Kyoto Protocol, which can also be more extended at the world-wide side by different financial institutions. Naturally this scenario is a possibility for accounting the innovative cost-effective methane reduction, but firms and governments are responsible for that how they use possibilities of scenario. Because firms should overcome financial, technical and international market obstacles, for example duty on the international markets.

Also the international attention should be paid for Sustainability Innovative Low-Carbon investments which were analysed by principles for "Rubik's Cube" solution (Fogarassy, et al. 2014a; Fogarassy, et al. 2014b). Also in stead of fossil energy resources including methane the firms should use renewable energy resources for reduction of methane and other gas emissions.

Renewable energy resources should be more used for solving energy demands of firms and generally for performance of the nations. Main renewable resources are water resources, of which importance is declared by some experts, the "present appointed target … is monetary valuation of the link between human economic activity and water. Evaluation of water as natural resource could raise numerous questions at theoretical level" (Fogarassy, et al. 2014c, p 2.). The other renewable common resource is the wind, of which about experts declared that this needs for increasing the better capacity use of water and extending water use in performance for energy supply (Fogarassy, et al. 2014d).

Conclusions

Recently the Asian countries achieved important economic development process by using mostly fossil energy resources, which could considerably contribute to global warming and climate change. Therefore this country group at present also became responsibly to the climate change additionally to the OECD and other highly developed economies. Because the developing countries cannot own enough developed technology to decrease gas emission including methane, they are pressed to create strong cooperation with highly developed economies to improve innovative environment friendly technology for reduction of gas emission.

The financial cooperation also needs for introducing financial support or supplying financial resources for implementers investing for technology using renewable energy resources for reduction of gas emission. This financial cooperation can extend in *results-based-finance* as a form of Kyoto Protocol to create direct connection among founder of financial institutions and implementer-investor to realise successful investment for reduction of methane emission measured in ton of CO_2e. A payment program would also rely on existing offset standards' systems for monitoring, reporting and independently verifying emission reductions, thereby minimizing administrative costs. This results based approach would use a competitive action to determine the level of funding each project will receive, guaranteeing the lowest possible cost to the founder (World Bank, 2011; Zéman et al, 2000).

The renewable energy resource use can be solved by active strong cooperation among governments and private firms, either transnational corporation, international companies and small and medium scale firms at both of macroeconomic, microeconomic levels and also international cooperations given by international organizations as EU, OECD, and also financial institutions as World Bank, International Monetary Fund, and in case of firm level see in detailed in Zéman, et al, 2013.

Also when companies need for financial resources, even for investment relevant to the reducing gas emission, in any case the financial institutes should follow the financial conditions and risk management of the firms or small-medium enterprises, for example analyse all business cycles, evaluate the risks and determine risk sensitivity of company (see detailed in Zéman at al, 2014, p. 196 and Végh et al, 2014, p. 184.).

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GREENER CEMENT SECTOR AND POTENTIAL CLIMATE STRATEGY DEVELOPMENT BETWEEN 2015-2030 (HUNGARIAN CASE STUDY)

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Abstract: *Advancing the domestic industrial production towards a sustainable, resource-preserving direction can become an important pillar to support competitiveness in the European Union, as well as in Hungary. Reaching the de-carbonization goals for industrial production via lowering the production volume may result in less desirable macro-economic effects, so decisions which concern the industry require a lot of attention from the climate policy as well. In the case of the cement sector, economic actors have to be motivated to make energy-efficiency investments and technology developments, which also show promise in terms of business efficiency. In the more natural-resource-intensive branches of the industry, both innovations and technological developments will be required to reduce the amount of used non-renewable energy resources, keep it in the industrial cycle, and reduce environmental load. The importance of greener cement will be essential in the near future to reduce the sector's CO_2 emission levels. We need to identify more sector branches which relate to sustainability, which can aid the country in establishing long-term competitiveness that points towards the de-carbonization goals. The cost-efficiency aspects of this development process are the most tedious questions in today's business planning.*

Keywords: *emission trading; EU climate policy; cement sector; benchmarking; EU ETS; industrial climate change effects, green cement* (JEL classification: Q55)

Introduction

The role of the cement sector is important for both the European Union (EU) and the Hungarian economy. It affects the construction industry directly and has a strong connection to energy production, due to its energy-intensive nature.

The cement business utilizes 60-130 kilograms (KG) of oil or oil equivalent, and an additional 90-130 kilowatts (KWh) of electricity for each ton of cement produced (Iozia and Jarre, 2011). In the European Union, cement is mainly produced with the dry method, which conserves up to 50% energy when compared to the wet process, a technique commonly used by developing countries. If we want to produce cement in a low carbon way, a range of alternative fuels can be mentioned such waste oil, sewage sludge, used tires and waste derived fuels also. The cement sector's production requires high amounts of capital, approximately 150 million EUR for every million tons of raw materials. Regarding manufacturing costs, consumed fuel and electricity expenditures are usually 35-45% of the total production costs for each ton of cement (Iozia and Jarre, 2011). According to the cement sector, well-prepared scientific processes can go to waste if their limitations have not been evaluated as a result of the absence of information on implementation, theoretic unpreparedness, lack of motivation, or other various reasons (Kovacs and Fogarassy, 2015). The role of the cement sector is important for both the European Union (EU) and the Hungarian economy. It affects the construction industry directly and has a strong connection to energy production, due to its energy-intensive nature.

The importance of the cement industry can be analysed by using other relations as well. The sector can contribute to reducing the usage of fossilized fuels via waste incineration technology. This could result in a global reduction in gas emission, and advance the establishment of real sustainable waste management. (Reid and Huq, 2014) The cement sector aims to reduce its energy-consumption and CO_2 emission by enhancing the effectiveness of cement kilns, discarding the wet process, while also modernising and optimising the technological processes. This research aims to explore the sector's possible routes of low-carbon development in detail using this analysis between 2015-2030.

Experimental section

A. C. Pigou was the first to highlight externalities as outside economic effects, appearing parallel to production activities in his 1920 work, '*The Economics of Welfare*'. These external forces can either be positive or negative macro-economic impacts. If manufacturers are influenced by their own net marginal propensity, which does not match that of society, these damaging outside effects will reduce the welfare of society. The solution Pigou offered for this problem was to levy taxes on polluters, forcing producers to decrease their emission of harmful externalities.

If the manufacturer uses their environment for free understanding that such an activity causes damage to a third party, it can become the source of serious economic malfunctions (Farkas et al., 2008; Kovacs et al., 2014).

Fogarassy (2012) mentions the following economic faults that relate to the existence of externalities:

- The activity causing pollution goes beyond the tolerable level, which leads to an imbalance of the economy,
- Pollution is over-generated due to the manufacturer having no motivation to reduce the activity,
- If the price of the contaminated product is low and does not contain exterior costs, an excessively high demand for said item may appear on the market,
- As long as pollution expenses can be said to be external, there is no motivation to reduce the average pollution level for each product,
- The fact that releasing pollution into the environment is cheaper than handling it makes recycling waste and polluting substances much more challenging.

In order to clearly understand the actual processes currently present in the cement industry, the first priority of this research was to analyse the positive and negative externalities in the sector. Based climate policy goals (increasing renewable energy use, reducing greenhouse gas (GHG) emission, and increasing energy efficiency) and deadlines (2020, 2030, 2050) it was obvious to set the 2015-2020 and 2020-2030 intervals as the spectra of analyses. This examination uses the benchmarking method to include and evaluate externalities.

Different schools and literary sources have different definitions on the principle of benchmarking. This research relies on the simple definition, which states: 'the goal of benchmarking is to measure and compare levels while also exploring the limitations of systems'. According to this structure, benchmarking is an organised leadership process that aids leaders in finding and analysing the best techniques. Seeking the method assisting in the best decisions is not limited to evaluating the direct contenders. Camp (1998) defines benchmarking as the search for, and implementation of unsurpassed practices. Management and surface-survey borrowed the term benchmarking from architecture, where it means a stilt or column, which acts as a reference for all further measurements. The original meaning of the word is: elevation or level of height. According to Evans (1997), benchmarking is a leadership tool, which helps the user find the best business practice that consequently leads to the highest levels of performance.

The goal of the methodology section is to analyse the basic interrelations influencing the implementation of climate policy goals related to the cement sector. This is done by using the characteristics of renewable energy's share and expected changes in it, along with the current trend of raising energy efficiency, and reducing carbon-dioxide equivalence (CO_2e), including its expected aspects as important factors. This study organises the data sets related to sub-sectors into different tables, then evaluates each aspect in three different dimensions (economical, technological and environmental) for nine attributes each, all of which can either be quantified or qualified. After summarizing the results, it was important to draw the appropriate conclusions as to the certain climate policy aspect (renewable, energy-efficiency, CO_2e reduction), and which one of its evaluation dimensions may cumulate negative or positive externalities in a given sector.

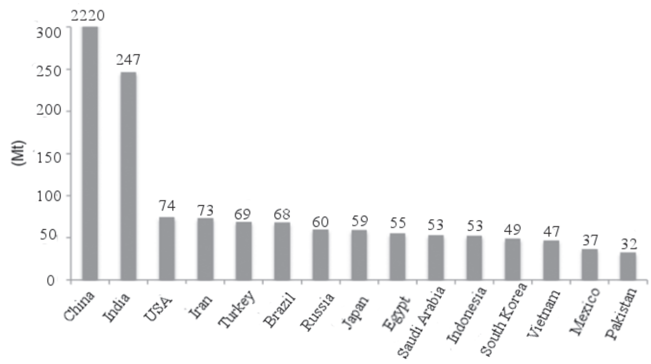
After recording the basic tables, all of the factors received *Status and Performance indicators*. The interrelations of the initial state and 'achievements' compared to the original goals can be evaluated using these indicators. Therefore, *Status indicator* values must be recorded according to the method of this analysis, which becomes the defining parameter for the 2020 period. From this, its related target value for the 2030 period can be determined. The optimum of the *Performance values* (-2, -1, 0, 1, 2) was based on available information results in the *Target indicator* (with a value of '0'), where any other values represent either the under or over performance of the indicator. The results will clearly show what additional climate policy decisions in the sector must be made for the given indicator to achieve the *Target value*. The accumulation of negative externalities and their dominance shows that the framework of the evaluated system is faulty, and leading it towards sustainability can be achieved via re-constructing the framework (Fogarassy, Bakosne, 2014). The amount of positive externalities, and their dominance shows that the system is sustainable, or low-carbon development methods are applicable to it. However to create the balance of welfare indicators, the use of auxiliary resources such as subsidies, tax concessions are required.

Results and discussion

Cement is an exceptionally important material for the construction industry, and its production relates directly to the overall condition of this business. In addition, it is in a tight interrelation with the general state of the economy (Dean et al., 2011). Cement is mainly produced using the dry method in member states of the EU. This technological solution demands an average 50% less energy compared to the wet process, during which clinker, the base material that is ground to powder and mixed with other ingredients to make cement, is incinerated in a kiln. Reducing the heat energy required to cremate clinker is imperative for the manufacturers, as one of the most notable expenses of cement manufacturing is the fuel material (Krzaklewski M. and **Činčera** P., 2007).

Due to the possibility of a carbon leakage (corporations related to this left the area of the EU due to the introduced regulation system, but still relocate their products to its market), the cement sector is of higher importance, since it may affect the emission of related industries beyond that of itself such as construction and transport. (Akashi et al., 2014) The exposure of the cement sector is substantial in countries which are not under the effects of the EU Emission Trading System (ETS) regulation mechanisms, or do not have a strict regulation system targeting hazardous emissions (Figure 1).

Figure 1. The 15 most notable cement manufacturing countries in 2012

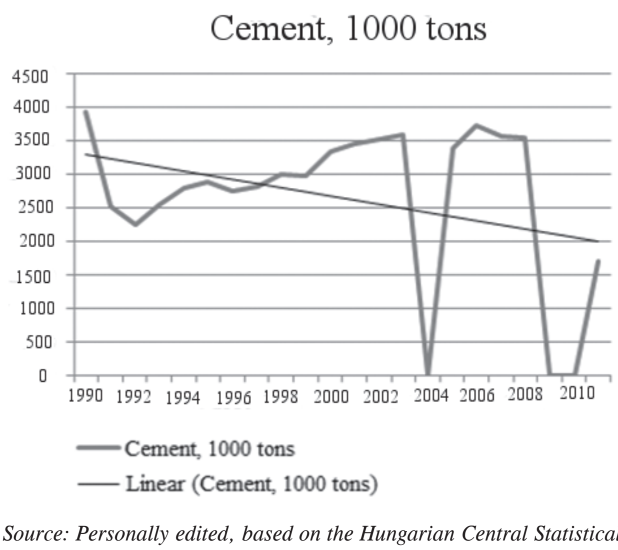


Source: Armstrong (2013)

State of the Hungarian cement sector

The cement sector of Hungary is one of the most endangered and energy intensive sectors, as energy costs make up to 35-40% of the total production expenses (Iozia and Jarre, 2011). The fact that more than 50% of the total emission comes from technological de-carbonisation is a problem. It is not affected by any attempts of cost sparing, or the exchange of fuel materials (Fogarassy et al., 2012; Bakosne and Fogarassy, 2011). Additionally, specific emission-reduction in the national cement sector only has limited opportunities, due to reasons related to technology and the market.

Figure 2. Emissions of Hungarian cement production for the 1990-2011 period



Source: Personally edited, based on the Hungarian Central Statistical Office's data

To reduce the total CO_2 emission by 21% (which is the target of the EU), the use of fuel materials would need to be reduced by 50,5% (based on studies). However, this is highly unlikely due to current technology (Hungarian Cement Concrete and Lime Association, 2008). In this case, factories would have to acquire unavailable carbon-dioxide quotas from the market. The amount of cement production showed a tendency to decrease in recent years, according to the data of the Hungarian Central Statistical Office (Figure 2). This trend (no accessible data for the years of 2004, 2009-2010) to decrease relates to a decline in the demand of the construction industry. If the investments in the construction business start to increase, the amount of available free quota will probably hinder the expansion of corporate emission in the cement sector. In the future, distribution methods of the (free) ETS quotas will determine how the sector's market actors keep or discontinue manufacturing.

Benchmarking analysis of the cement sector

The analysis of the Hungarian cement sector was conducted along three aspects adhering to the climate policy targets. These characteristics are: *'Aspects of renewable energy's share'* (Table 1), *'Aspects of raising energy efficiency'* (Table 2), and *'Aspects of reducing CO_2 emission'* (Table 3). Subsequently, the various indicators in each table had to be defined, which served as the basis of the evaluation. They were selected and defined using the assessment of international literary resources, and the coordination with professionals as the basis.

Tables 1, 2 and 3 which include *attributes of renewable energy's share and its changes, and the current trend of increasing energy efficiency, and decreasing CO_2e (carbon-dioxide equivalence) and their expected aspects*, show the syllabus of the concluded analyses.

Table 1. First indicator group of the cement sector's benchmarking analysis

Dimensions	**Code**	**Status Indicators**	**Code**	**Performance Indicators (including the method of establishment)**
ASPECTS OF RENEWABLE ENERGY'S SHARE				
TECHNOLOGICAL	RS1	Specific analysis and general characteristics of applied energy mix	RP1	Changes of depleting energy resource use, increase or decrease of fossilized resource usage in the evaluated sector between 2020 and 2030
	RS2	Average quality and development opportunities of machinery and tools	RP2	Development options of engineering level under certain economic circumstances
	RS3	Level and characteristics of renewable energy resource utilisation	RP3	Opportunities to use renewable energy resources in the sector, opportunities to increase share in the sector

Dimensions	Code	Status Indicators	Code	Performance Indicators (including the method of establishment)
ENVIRONMENTAL	RS4	Characteristics of recycling in waste energetics system	RP4	Evaluated by assisting role in renewable energy systems
	RS5	Results/connections of emission/injection value benchmarking	RP5	Possibility of decreasing emission levels using renewable energy resources
	RS6	Level of corporate environmental management, general sector attributes of environmental management systems	RP6	Evaluating ISO 14001 systems in the process
ECONOMICAL	RS7	Is the sector a participant in the renewable emission market (CDM, JI, VER), green electricity production, trade	RP7	Evaluation of activity (description of carbon financing)
	RS8	Intensity/activity of Environmental policy - Climate policy regulation	RP8	Effect regulation has on production output
	RS9	Complexity of resource efficiency - labour market effects, effects on employment	RP9	Analysing workplace-establishing effect, and describing its importance

***Abbreviations:** ‘RS (Renewable status) 1 - 9:’ status indicators of the ratio of renewable energy, according to dimensions; ‘RP (Renewable performance) 1 - 9:’ performance indicators of the ratio of renewable energy, according to dimensions*

Table 2. Second indicator group of the cement sector’s benchmarking analysis

Dimensions	Code	Status indicators	Code	Performance Indicators (including the method of establishment)
		ASPECTS OF INCREASING ENERGY EFFICIENCY		
TECHNOLOGICAL	ES1	Share of nuclear energy in total consumption	EP1	Evaluating quality of nuclear energy usage, with scaling in the EU
	ES2	Opportunities and levels of system interconnections in energetics	EP2	Connectivity to local and international networks, for optimal supply and cost reduction
	ES3	Opportunity and level/rate of clean tech usage	EP3	Opportunities to introduce clean tech solutions
ENVIRONMENTAL	ES4	Opportunity of industrial ecology usage	EP4	What system attributes that assist circular processes are like
	ES5	Level of waste lifecycle optimisation	EP5	Based on the practice of waste usage in energetics
	ES6	Level of energetic losses	EP6	Level of decisions made to avoid losses
ECONOMICAL	ES7	Cost-efficiency parameters of increasing energy efficiency	EP7	Cost-efficiency analysis based on general technological levels
	ES8	Usual costs of increasing eco-efficiency	EP8	Eco-efficiency analyses based on general sector attributes
	ES9	Importance of regulation elements in the manufacturing process	EP9	Effect regulation has on the increase of technological quality

***Abbreviations:** ‘ES (Energy status) 1 - 9:’ status indicators of the energy efficiency aspect, according to dimensions; ‘EP (Energy performance) 1 - 9:’ performance indicators of the energy efficiency aspect, according to dimensions*

The attributes of different characteristics and measurement units compared to each other in the *economical, environmental and technological indicator groups* properly define the positive and negative interrelations, along with the specifics of the non-market attributes for a given evaluation area.

Table 3. Third indicator group of the cement sector’s benchmarking analysis

Dimensions	Code	Status indicators	Code	Performance Indicators (including the method of establishment)
		ASPECTS OF REDUCING CO_2 EMISSION		
TECHNOLOGICAL	CS1	Intensity of GHG emission, in relation to technology	CP1	GHG emission based on evaluating obtainable technological variations
	CS2	Opportunities to introduce low-carbon technologies in the sector	CP2	Level of applicability for known low-carbon technologies
	CS3	Constitution / volume index of specific GHG	CP3	General characteristics of GHG emission for the area
ENVIRONMENTAL	CS4	Environmental characteristics of emission gases	CP4	Description of environmental attributes of harmful emission, and evaluation in regards to foreseeable decisions
	CS5	Border values / consistency of environmental regulations / norms	CP5	Does the regulation aid or hinder the completion of environmental policy targets
	CS6	Level of environmental risks for emission	CP6	Attributes and quality of adaptation decisions

Dimensions	Code	Status indicators	Code	Performance Indicators (including the method of establishment)
ECONOMICAL	CS7	Attributes and levels of GHG market share	CP7	Activity in the EU ETS system, practice of carbon management
	CS8	Usual costs of avoiding GHG emission for each unit of CO_2e	CP8	Cost index of CO_2e in the analysed sector
	CS9	Nature of contributions to completing GHG climate policy targets	CP9	Volume, cost and efficiency calculations

Abbreviations: *'CS (CO_2 status) 1 - 9:' status indicators of the aspect of reducing CO_2 emissions, according to dimensions; 'CP (CO_2 performance) 1 - 9:' performance indicators of the aspect of reducing CO_2 emissions, according to dimensions*

The evaluation of various indicators (1-9) was done by first naming the value used to describe the attribute and then its selection was explained to define the performance indicator, which can imply the change (estimated performance). The method of evaluating performance for the chosen indicator happens via categorisation on a scale of (-2); (-1); (0); (1); (2). The research uses the data sets of international and Hungarian databases to determine performance levels. The analyses are mainly based on forecasts, for which 2020 is the first milestone, and 2030 is the final planned time of the performance results and changes. The benchmarking provides a clear description of what prognosis the data describing the current (2010-2015) state of affairs generates in the various sectors. Moreover, what development trends Hungary can expect in 2020 and 2030, based on the 2015 plans, meaning what criteria are needed for the national EU climate targets to be achieved was determined.

The following summary will describe the indicator of '*Aspects of renewable energy's share*'.

The evaluation score shows what changes can be expected for 2020 and 2030 respectively, in relation to accumulation of externalities. According to the results if no change happens by the end of 2020, the EU targets will still remain reachable. However developments based on EU resources must be made until 2030 for their completion.

The next session shows a detailed description of the '*Share of electricity in total energy consumption*' State indicator from the '*Aspects of increasing energy efficiency*' indicator group's analysis.

Aspects of renewable energy's share (indicator group 1)

State indicator: level and attributes of renewable energy resource utilisation (Table 1, indicator 3).

Reason for choosing the indicator: The indicator was chosen because renewable energy usage / utilisation may differ in the evaluated sector.

Performance indicator: Opportunities for using renewable energy resources, and increasing its share in the sector.

Method of evaluating performance:

(-2) the renewable energy resource usage of the sector can be increased by 0%

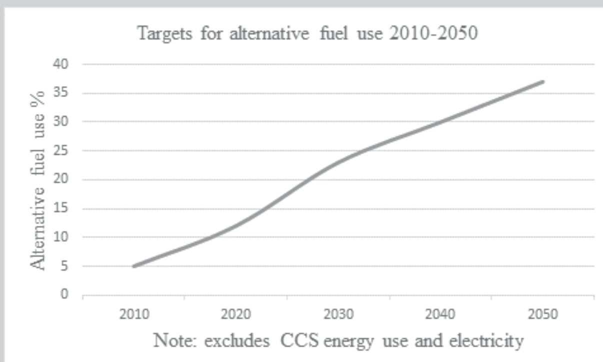
(-1) the renewable energy resource usage of the sector can be increased by 1-3 %

(0) the renewable energy resource usage of the sector can be increased by 5-10% (low)

(+1) the renewable energy resource usage of the sector can be increased by 15-20% (moderate)

(+2) the renewable energy resource usage of the sector can be increased by 25-30% (substantial)

Figure 3. Graph of cement sector's renewable energy resource usage



Source: IEA *(2009)*

	Results for 2010-2020 period	Results for 2020-2030 period
Evaluation score	0	+1

Reason: *The share of renewable energy can be increased by approx. 7% in the 2010-2020 period. The share of renewable energy resources for the 2020-2030 period can be increased by approx. 10-11%. (Figure 3).*

Aspects of increasing energy efficiency (Indicator group 2)

1. Status indicator: Share of electricity in total energy consumption.

Reason for choosing the indicator: The indicator was chosen because the end product's energy efficiency indicators are determined by the share of electricity in the analysed sector.

Performance indicator: Evaluating quality of energy consumption, with scaling in the EU.

Method of evaluating performance:
(-2) electricity consumption of industry/sector is substantial more 15 Million ton equivalence
(-1) electricity consumption of industry/sector is notable; 10-15 Million ton equivalence
(0) electricity consumption of industry/sector is optimal; 5-10 Million ton equivalence
(+1) electricity consumption of industry/sector is moderate; 1-5 Million ton equivalence
(+2) electricity consumption of industry/sector is trivial.

	Results for 2010-2020 period	Results for 2020-2030 period
Evaluation score	0	+1

Reason: *The electricity consumption of the sector in the EU will be approximately 15 million ton equivalence by 2020.*

The electricity consumption of the sector in the EU will be approximately 13-15 million ton equivalence by 2020. It will show a tendency to decrease, but stay substantial. (Table 4.)

Table 4. Energy consumption of the cement sector

Sum of EU 25	BLUE low demand			BLUE high demand		
Technology	2015	2030	2050	2015	2030	2050
Energy consumption (Mtoe)	15.5	13.3	13.7	16.5	15.7	19.0

Source: IEA (2009)

Note: the Mtoe measurement used by OECD and IEA indicates oil equivalence value: 1TWh = 0.086 Mtoe.

Aspects of reducing CO_2 emission (indicator group 3)

9. State indicator: Opportunity to capture and store CO_2 in the sector.

Reason for choosing the indicator: The indicator was chosen because by making the CO_2 detachment and storage possible for the sector, up to 95% of CO_2 can be saved in the long-term.

Performance indicator: CO_2 reduction reachable in the sector on the EU level by introducing a Carbon Capture and Storage (CCS) project.

Method of evaluating performance:
(-2) CO_2 emission decrease using CCS is 0 Million tons
(-1) CO_2 emission decrease using CCS is 1-2 Million tons
(0) CO_2 emission decrease using CCS is 2-3 Million tons
(+1) CO_2 emission decrease using CCS is 4-8 Million tons
(+2) CO_2 emission decrease using CCS is over 10 Million tons.

	Results for 2010-2020 period	Results for 2020-2030 period
Evaluation score	-1	+1

Reason: *Using CCS projects, substantial emission decrease can be achieved in the long term.*

A CO_2 emission decrease of about 4-9 million tons can be achieved using CCS projects by 2030, and even more after that. (Table 5)

Table 5. Amount of captured CO_2 in the cement sector

Sum of EU 25	BLUE low demand			BLUE high demand		
Technology	2015	2030	2050	2015	2030	2050
Captured CO_2 (Mt)	0	4.3	20.7	0	9.4	69.8

Source: IEA (2009) (BLUE scenario of IEA)

After comparing the results, the evaluation score for 2020 is '0', which forecasts no changes. For 2030, the score is '+1', that suggests development and subsidy needs for the decision makers of the sector.

Eventually the evaluation the '*Opportunity to capture and storage CO_2 in the sector*' indicator for the *GHG, or 'Aspects of reducing CO_2 emission*' indicator group's analysis:

Carbon Capture and Storage (CCS) technological solutions will not be mainstream for the cement sector until 2020, and regulatory or normative redesign of the sector will be required for them to be implemented. Therefore the sector's greenhouse gas (GHG) reduction targets of 2030 are not achievable in the 2020-2030 period without at least partially introducing the usage of CCS.

The results of indicators related to the respective GHG reduction aspects were summarized in Table 6.

Table 6. Summarising the benchmarking analysis of the cement sector

Numbers and dimensions		ASPECTS OF RENEWABLE ENERGY'S SHARE		ASPECTS OF INCREASING ENERGY EFFICIENCY		ASPECTS OF REDUCING CO_2 EMISSION	
		2010/2020	2020/2030	2010/2020	2020/2030	2010/2020	2020/2030
technological	1	1	1	0	-1	1	1
	2	1	1	-1	1	0	1
	3	0	1	-1	1	1	2
environmental	4	-1	1	0	1	-1	2
	5	1	1	1	2	1	1
	6	0	0	0	1	0	1
economical	7	-1	0	-1	0	1	2
	8	1	1	-1	0	0	-1
	9	0	-1	1	1	-1	1
A: Net positive externality ∑(1;9)		**2**	**5**	**-2**	**6**	**2**	**10**
B: Total externality ABS (1;9)		**6**	**7**	**6**	**8**	**6**	**12**
C: Share of net positive external effects in total external effects		**33%**	**71 %**	**0 %**	**75 %**	**33 %**	**83 %**

Explanation: **A:** *Net positive externalities ∑ (1;9): the number of positive externalities within the various aspects in 2020 and 2030, respectively, if no directed climate policy developments take place outside of BAU;* **B:** *Total externalities ABS (1;9): the absolute value of the total number of externalities;* **C:** *The ratio of net positive external effects within total external effects; expressed as a percentage, it indicates the dimension of improvability in the studied area.*

The examination includes 3×9 State indicators, 3 each for economical, environmental and technological groups respectively, for each reduction system. The function of the sector is not influenced by the high amount of indicators by the same measurements or effect mechanisms. The five categories of [(-2); (-1); (0); (+1); (+2)] based on the benchmarking analysis created one of the most honest analytical frameworks for evaluating the accumulation of externalities.

Table 6 illustrates the summarised 'Net positive externality quantity' of all present externalities for the evaluation (A) and the absolute values of all externalities (B), which helps to determine the amount of all positive effects within all externalities (C).

During the evaluation of the scores in the results table, it can be concluded that there are developments or GHG decreasing alternatives for augmenting the share of renewable energy. This mainly describes using more waste as fuel material. The 33% value related to the 2020 period may signify a mid-level development priority, which is optional since it is also tied to changes in regulation. The 71% change value related to the 2030 period can be attributed to the intensification of climate policy regulations on the sector. Increasing energy efficiency can change due to criteria from economic policy, however the current structure does not necessarily lead the sector towards a sustainable low-carbon strategy (0%). The area's opportunities until 2030 are defined and affected either positively or negatively by the constitution of Hungary's energy production (energy mix). This may create exceptional opportunities (75%) under certain circumstances, but then may stay unchanged as well. Regarding the development areas of CO_2 reducing aspects, the remaining elements of the technological system may offer efficient development options for the GHG decrease target system until 2020. CCS development may prove to be a substantial step forward for the sector. This changes the system-wide emission in its entirety (83%), but economic influences of this possibility are the least definitive.

The importance of the cement sector nationally, and on the EU level is substantial, since it has both direct and indirect influences on employment and the increase of Gross Domestic Product (GDP) (Schneider et al, 2011). The Hungarian cement industry currently manufactures using quite modern technological solutions, with the exception of one factory. It is only by implementing the CCS solution that more substantial decreases in emissions are possible on the current technological level. However, this can only be a realistic alternative for production in 2030. The environment-centred control systems used in domestic factories adhere to both the EU's and Hungary's requirements, which can assure the professional development of the situation, along with it's monitoring.

The production of the cement sector is very energy-intensive; it has high requirements both for fossilized energy resources, and electricity. Any modernisation or structural interventions shake the entirety of the sector, which makes handling an important factor. The manufacturing process requires high amounts of capital, and investment, which are basically dependent on EU resources. Developments made by owners to assure an increase in profit and the climate policy targets are not expected in the next few years. However, due to adhering to changes in regulation policy and climate goals, improvements targeting GHG reduction have a realistic chance of being implemented.

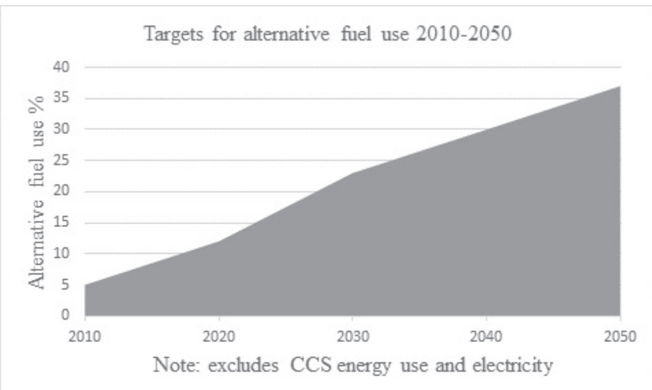
Presently, cement production technology utilises waste effectively. Nevertheless, there is a potential for development in this area until 2030. Hungary has the capacity to incinerate hundreds of thousands of waste annually, which can be consumed by the cement sector. However, extending the development of selective waste collection systems to consumption may hinder this. There are additional opportunities in terms of alternative energy resources, and by utilising the CCS projects by 2030, the CO_2 reduction potential can become substantial as well.

With alternative fuel use at the cement industry conventional fuels like coal and/or petcoke can be replaced during the cement kiln heating process. These alternative fuel sources can be alternative fossil fuel sources like natural gas and some kind of biomass fuels. According to IEA studies with this kind of fuel mix the process can be 20-25 % less carbon intensive than with the use of coal. Practically cement kilns are suitable for alternative fuels since the energy component of them can replace the fossil energy components and the other inorganic byproducts integrated into the clinker product. Alternative fuels could be used by the cement industry like biomass forms, discarded tyres, waste oil, plastics, textiles and paper residues, and pre-treated industrial and municipal solid wastes.

Biomass commodities such recycled wood and paper; sewage sludge; biomass crops; animal meal, wood chips and residues can be used as well.

Even though the energy need of cement production could be satisfied entirely with alternative fuels, in practice we must face some limitations. The problem is the major difference between alternative and conventional fuels regarding their physical and chemical attributes. So we must distinguish the ones that are suitable for industrial production from the others which lead us to technical challenges. According to IEA in the next few decades the share of alternative fuel use can be raised up to 37% until 2050 (Figure 4).

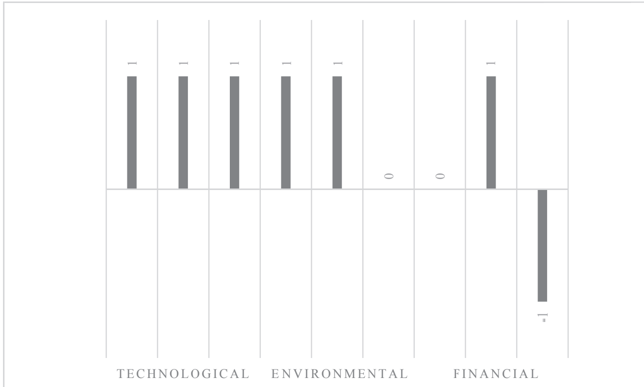
Figure 4. Graph of cement sector's renewable energy resource usage



Source: IEA (2009)

It seems that alternative fuel costs will be increasing and this tendency will be there for the CO_2 costs also. If it happens it can be much more difficult for the cement industry to reach the sufficient amount of biomass resource on acceptable prices. According to IEA studies for the cement industry the use of alternative fuels can be economically viable until 2030. Based our research results this point is the most sensitive among the different dimensions. On the next figure we can see the negative externality aggregation problems connected to renewable fuel use (Figure 5). It shows that for 2030 there will be a major positive externality accumulation regarding renewables in the cement sector. Most of these unused potentials are observed in the case of the technological and the environmental dimensions which means there is still room for technological development and stricter regulations for the optimal long-term operation. Considering that these indicators are kind of related to each other it is obvious that policy makers should drive this sector to spread clean technologies within their production.

Figure 5. The number of externalities within the aspect of renewable energy's share in 2030



By this time the prices will reach about the 30% of conventional fuel costs and by 2050 it will rise up to 70%. This can be the obstacle for the growth of alternative fuel use in the sector on long term, however technically higher substitution rates could be possible.

Conclusions

The cement sector is highly dependent on the EU's policies and decisions related to carbon-dioxide-emission, and other pollutants. As it was already mentioned, this sector is the most sensitive to changes in quota distribution. The dispersion of EU's rations requires a high level of foresight for the sector's future. The market players have to be motivated to reduce emission rates, as well as using energy efficient technology, while also fixing the effects of CO_2 emission decreases that distort the market. The result of the benchmarking analysis showed that the potential of CO_2 decrease and energy efficiency optimisations is limited until 2020 in the sector, and more substantial changes will only be apparent in 2030. The industry is to be handled with higher priority due to the chance of a carbon leakage. This can defined as the migration of the sector's actors into other, non-EU countries, and the relocation of their products back to the EU market may easily happen due to the unfavourable climate policy regulations. This may have further impacts beyond the cement sector in the related industries like construction and transport. The prognosis of this research for emissions may increase by 5-25% due to the increase of transport demands. The exposure of the domestic and EU cement sector is high, unlike in countries which are not subject to the ETS regulation mechanisms, or do not have a strict regulation system targeting pollutant emission. This may result in an edge for them on the market, due to the changes in the regulation environment. Therefore, changes in the global market trends have to be handled carefully. Heavily influenced by Asian markets, the international marketplace usually operates with lower prices along with a strictly regulated environment, thereby also becoming a potential cause for market failure in Hungary.

This study showed that the European ETS's rising quota prices and the increase of energy prices put together could cause a rise in manufacturing costs. This cannot be resolved later, neither by technological innovation, nor market policy tools. It may lead to the sector losing its competitiveness in Europe. Quota prices cannot be determined prior to their change and the cement sector is one of the high-risk sectors for the climate policy interventions because of its high sensitivity for allocations. Still, according to the benchmarking results it was clear that positive externality accumulation will occur in the long-term operation of the sector meaning a lot of unused potentials. While the financial dimension of the several aspects stays balanced even until 2030, the technological and environmental sides follow this underperforming trend. Even though the point of this research was mostly to examine the changes within the renewable energy aspect, the similar tendencies to the other aspects show that they are highly connected. Therefore the optimal operation of the sector cannot be achieved without a bit more serious environmental regulations – even if there is a risk for carbon leakage.

For a sustainable cement industry, the requirement of reaching climate policy goals is that the energy resources derived from waste increases substantially by 2030. Based on the positive externalities of the technological dimension, new alternative solutions will be also necessary to reduce the CO_2 emission levels of the sector. There are opportunities in alternative fuel use and alternative clinker producing methods during the manufacturing process. In the future the greener cement will be priority since the producers have to fulfil the market's demand in parallel with the low carbon emission requirements. Considering the return indicators, it is clear that further technological development of the sector aimed at CO_2 reduction is moderate at best, and currently there are no technological changes ahead. CCS technological solutions would be able to achieve a substantial decrease in CO_2 emission, however this may require hard investment decisions from national actors, as it will not bring short-term profitability. Therefore, this option cannot be foreseen until 2020 or even until 2030. Only theoretical opportunities are present based on the required investments.

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CLIMATE CHANGE IMPACT ON CROP PRODUCTION IN CENTRAL ASIAN COUNTRIES

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Abstract: *Increased risk due to global warming has already become embedded in agricultural decision making in Central Asia and uncertainties are projected to increase even further. Agro-ecology and economies of Central Asia are heterogeneous and very little is known about the impact of climate change at the subnational levels. The bio-economic farm model is used for ex-ante assessment of climate change impacts at sub-national levels in Central Asia. The bio-economic farm model is calibrated to ten farming systems in Central Asia based on the household survey and crop growth experiment data. The production uncertainties and the adaptation options of agricultural producers to changing environments are considered paramount in the simulations.*
Very large differences in climate change impacts across the studied farming systems are found. The positive income gains in large-scale commercial farms in the northern regions of Kazakhstan and negative impact in small-scale farms in arid zones of Tajikistan are likely to happen. Producers in Kyrgyzstan may expect higher revenues but also higher income volatilities in the future. Agricultural producers in Uzbekistan may benefit in the near future but may lose their income in the distant future. The negative impacts could be further aggravated in arid zones of Central Asia if irrigation water availability decline due to climate change and water demand increase in upstream regions. The scenario simulations show that market liberalization and improved commodity exchange between the countries have very good potential to cope with the negative consequences of climate change.

Keywords: *bio-economy, climate change, farm income, integrated farm model, Central Asia*
(JEL classification: Q11, Q18)

Introduction

Central Asia covers an area of 400 million hectares, however, only 20% of that is suitable for farming while the rest is deserts and mountainous areas. Nevertheless, agricultural production forms the backbone of Central Asian economies. Agriculture is the main source of export revenues for these countries except the oil rich Kazakhstan and Turkmenistan. The contribution of agriculture to GDP is lowest at 11% in Kazakhstan and highest at 38% in Kyrgyzstan (Bucknall et al., 2003).

The research focus of further studies in the region was analysing the impact of a changing climate on crop yields and natural resources. There have been no studies investigating the economic consequences of these biophysical changes at sub-national levels while taking into account adaptive capacity of agricultural producers to the best of our knowledge. Therefore, this study aims at filling this gap in the region through assessing the impact of climate change at the farm level in Central Asia. Additional contributions of this study are the use of the data based on extensive farm surveys, field trials and inclusion of the risk coping behaviour of the decision makers in representative farms in the analysis.

Climate change adds additional dimensions to the problems in the Central Asia region and increases the vulnerability of rural producers. Increasing frequency of droughts is causing serious damage to the livelihoods of rural population in semiarid and arid regions of Central Asia. For example, droughts in 2001 and 2008 damaged more than a third of the cropping areas in Tajikistan (Christmann et al., 2009; CAREC, 2011). Furthermore, rainfall is getting heavier and increasing frequency of floods in mountainous regions of Central Asia and the impact is hitting the poorest population the hardest. Rural populations are already suffering from the increasing sequence of extreme events, and projections show even more changes in the future.

The study analyses the role of the Intergovernmental Panel on Climate Change (IPCC) for interest of Central Asia to face declining rainfall during spring, summer and autumn and slightly increased or unchanged precipitation during the winter periods. Also study analyses effects of declining rainfall on the land degradation in this region.

Material and Method

Available literature broadly distinguishes three types of quantitative assessment methods of climate change impact analysis: Ricardian models, agronomic models and agro-ecological zoning studies. The Ricardian model is one of the most widely used methods that is based on the econometric analysis of climate change impact on economic indicators (e.g. income or revenues). Flexibility of this approach is that the scale of the analysis (on farm or regional levels) can be selected depending on data availability. Another advantage of this approach is that it enables the drawing of conclusions based on empirical observations derived from long term historical records (or cross sectional data), which already includes adaptation adjustments of the decision makers. However, availability of long-term data is often difficult in developing countries, especially when smaller production units (e.g. farm level) are considered.

Using national or regional level observations may disregard differences in the levels of sensitivity by farm types (e.g. subsistence vs. commercial) (Weersink et al, 2002). Furthermore, this approach may face some difficulties in foreseeing the impact of climate change on agricultural productivity in the far future, especially under changing technology levels and increasing CO_2 concentrations. In contrast, agronomic models could be very suitable to capture complex effects of climate change on crop productivity. This complexity could be well taken into account using agronomic models such as CropSyst and DSSAT (Jones et al, 2003; Stockle et al, 2003).

These models are well-known tools used to analyse the impact of biophysical environment, management practices and climate variation on crop yields. The usefulness of crop simulation models to predict yields have been proven to a large extent and the assessment of farm level impact of climate change is already well investigated with these models. However, one of the disadvantages of this model for impact assessment is the consideration of management as exogenous which disregards the decision makers' adaptation behaviour. The impact of climate change on agricultural producers is very much dependent on available adaptation options (Gibbons -Ramsden, 2008) especially in irrigated systems such as those that exist in Central Asia.

A bio-economic farm model with risk component is calibrated for 10 representative farm types in four Central Asian countries (Kazakhstan, Kyrgyzstan, Tajikistan, Uzbekistan) with different agro-ecological and socio-economic characteristics. We consider the impact of climate change on three main crops which have crucial importance for the rural economies and food security in Central Asia. Cotton is included in this study as it is the main export crop in Uzbekistan, Tajikistan and Kyrgyzstan.

Results and Discussion

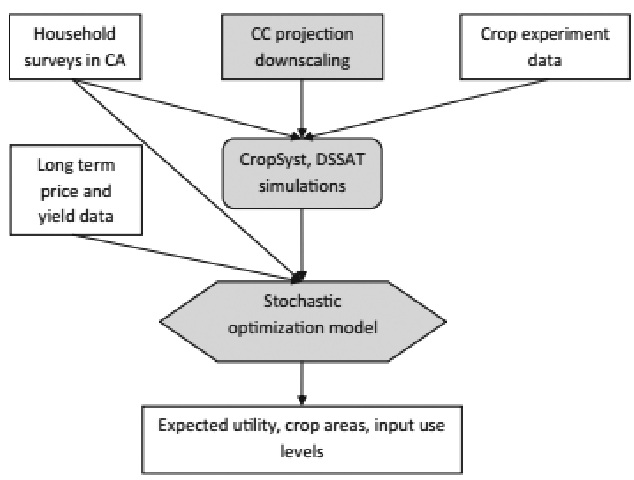
Modelling approaches to assess the impact of climate change

Decision makers' adaptive behaviour could be considered in the well-known integrated models often known as bio-economic farm models when analysis are conducted at farm levels (Janssen - Ittersum, 2007). Integrated models are capable of simultaneous consideration of bio-physical changes and management decisions in different farming systems, which makes this approach suitable for analysing the impacts of climate change on whole farm or sector levels. Additional advantage of integrated models is the possibility of combining agro-ecological zoning approaches since these models could be made spatially explicit. Integrated models give an opportunity of analysing complex functional relationships between agro-ecological characteristics (e.g. soil type and fertility) and farm level decision making (e.g. input use, technology choice) under climate change scenarios.

This makes integrated models very attractive for ex ante assessment of scenarios (e.g. climate, policy, technology) even with restricted data availability. Consideration of the uncertainties associated with climate change projections plays an important role in ex ante assessment of climate change impact. Clear superiority of these three approaches over the other does not exist and selection of one of these models can be decided based on the objective of the study and data availability. Since this study aims to investigate the impact of climate chance of agricultural producers in the far future considering adaptation options we consider bio-economic modelling framework suitable to our context.

Average share of cotton in total crop area in some regions of Central Asia reaches up to 40–50%. Potato and wheat are also included due to their importance in food security and farm income. Wheat is the main export crop in Kazakhstan and is also essential for food security reasons in the entire region. Climate change scenarios are spatially downscaled to the local levels. The crop simulation models then use these downscaled scenarios (Figure. 1). This combination allows consideration of impacts of climate change on the productivity of different crops. These crop simulation models are calibrated with the crop experiment data as well as actual farm management practices collected from farm surveys. The results of the crop simulation models (yields) were then used in a farm-level stochastic-optimization model in order to identify the climate change impact of farm income volatility and potential of different management options to improve farm income (Figure. 1).

Figure 1. Bio-economic farm model components.
Source: Owned work



Also climate change has influences on the cotton exports, which significantly contribute to the countries' revenues. For example, cotton fibre exports accounted for about 18% of the total export revenues in Uzbekistan (CEEP, 2005). Many aspects of the agricultural sector, including specialization, farm sizes, land ownership and agricultural production efficiency have been undergoing steady transformation since the breakup of the Soviet Union. (Pomfret, 2007; Bobojonov et al, 2013). Irrational water use during the Soviet Union time have caused several problems in the region including the disappearance of the once fourth largest lake in the world, the Aral Sea. (Glantz, 2005).

The climate change impacts on the land degradation, which also effects on these improper policies as major problems in all Central Asian countries. In this region the land salinization affected about 12% of the total irrigated area in Kyrgyzstan, 50–60% in Uzbekistan and even more than 90% in Turkmenistan (Bucknall et al., 2003; CAREC, 2011). Reduction of the cropping areas in the irrigated lands has been observed during the last decades, which often occurs due to land degradation (Kariyeva-Leeuwen, 2012). Uncertainties during the transition phase combined with land degradation caused high rates of poverty in most of the regions in Central Asia. More than 90% of the population living in the rural areas is defined as poor.

According to IPCC's fourth assessment report, the temperature in Central Asia may increase by 3.7 C on average by the end of the century and this is mainly expected to occur during June, July and August, which are the most important months in the vegetation period. Higher temperatures during the vegetation period may cause higher probability of drought risk and declining productivity of agricultural production.

Existing studies in Central Asia indicate negative effects of weather shocks on the livelihoods of small-scale farmers who are currently operating at a very narrow margin of profits and who lack access to financial resources and technological knowledge in the region (World Bank, 2009; Akramov, 2011). There is very limited research available on the impact of climate change on agro-ecosystems and analysis of the adaptation strategies in response to the growing urgency in Central Asia. Especially developing integrated assessment tools are becoming very important in order to analyse environmental, economic and social trade-offs in adaptation options in Central Asia.

The current knowledge of the economic impacts of climate change on agricultural production in Central Asia is limited in the existing literature at global levels, and is very limited in the literature at national or sub-national levels (World Bank, 2009; Mirzabaev, 2013). One of the first few assessments was done for the Syr Darya river basin (one of the transboundary river basins in Central Asia) by Savoskul et al. which addressed the adaptive measures to cope with increased drought or flooding but mainly based on the data of crop yields taken from global and regional level models rather than considering parameters observed in Central Asia.

Farm surveys and representative farms

We have identified 10 representative farms for Central Asia (Kazakhstan, Uzbekistan, Tajikistan and Kyrgyzstan) according to agro-ecological and socio-ecological diversity of the regions in Central Asia. Water availability is the main climatic factor constraining crop growth in Central Asia and aridity zones are considered one of the main factors characterizing agro-ecological diversity (Figure 2) within the country according to farming system and bio-economic modelling studies. Moreover, similar aridity zones have been distinguished in different countries as different farming systems due to socio-economic differences such as farm size, land tenure and agricultural policies between the counties.

A household survey with a total sample of 1591 was conducted in the representative farming systems during the last 2 years. The survey covered both family farms (household plots) as well as commercial farms (farmers). The stratified random selection procedure was applied to select several villages from these representative provinces for the abovementioned 10 agro-ecological zones. The number of villages selected from each aridity zone was determined by the number of farms and agricultural areas used for crop production by different producer types.

After identifying the number of villages per each zone, random sampling was used to identify the names of the villages from an available list of villages. Collected data included household characteristics and farm level production characteristics (as farm size, fertilizer use, irrigation practices, input use and fertilizer availability) as well as climate change perceptions. This household data was the main source of information for the identification of representative farms (Table 1) and BEFM calibrations. One representative farm with average production endowments (as farm size, input use) from each farming systems is selected for calibrating the bio-economic model (Table 1).

The study considers two representative medium size farms in Uzbekistan (34.1 ha in the semiarid, 27.1 ha in the arid zone). Three farm types in Kazakhstan were selected: a representative farm with 28 ha of land in the arid zone, 77 ha in the semiarid and 773 ha in the sub-humid zone (including some agricultural areas in humid zones). In the north, the large scale grain cooperatives are predominant with small vegetable plots given to the cooperative workers for subsistence production or others rented out to rural people living in the area. Northern zones produce the largest share of wheat in Kazakhstan and play a very important role for food security in Central Asia. The model is calibrated for a small representative farm of 5.1 ha in the semiarid zones of Kyrgyzstan. Potatoes and wheat producing farm also with 5.1 ha is modelled in the sub-humid areas (including some humid areas) of Kyrgyzstan. The model is calibrated for a farm with 2.1 ha in the humid zone (including per-humid areas) of Tajikistan. Similarly a farm growing wheat, cotton and potato on 4.6 ha in the semiarid zone of Tajikistan is modelled. The selected farm in arid region also have 4.1 ha of land.

Table 1. Representative farm characteristics

Country	AEZ	Farm size, ha	Family size	Fertilizer use per ha	Land ownership
Kazakhstan	arid	28	4,1	134,4	private
	semiarid	77	5,7	52,3	private, cooperative
	sub-humid	773	6,2	-	private, cooperative
Kyrgyzstan	semiarid	5,1	5,6	136,3	private
	sub-humid	5,1	5,1	-	private
Tajikistan	arid	4,1	7,3	119,5	state, private
	semiarid	4,6	7,8	43,5	state, private
	humid	2,1	8,2	166,7	state, private
Uzbekistan	arid	27,1	6,7	138,4	leased
	semiarid	34,1	5,9	120,2	leased

Source: Sommer et al. (2012) and Kato and Nkonya (2012).

Climate change scenarios

The Intergovernmental Panel on Climate Change (IPCC) developed long-term emissions scenarios. These scenarios have been widely used in the analysis of possible climate change, its impacts, and options to mitigate climate change.

Future greenhouse gas emissions are the product of very complex dynamic systems, determined by driving forces such as demographic development, socio-economic development, and technological change. Their future evolution is highly uncertain. Scenarios are alternative images of how the future might unfold and are an appropriate tool with which to analyse how driving forces may influence future emission outcomes and to assess the associated uncertainties. They assist in climate change analysis, including climate modeling and the assessment of impacts, adaptation, and mitigation. The possibility that any single emissions path will occur as described in scenarios is highly uncertain.

Four qualitative storylines yield four sets of scenarios called "families": A1, A2, B1, and B2. All are equally valid with no assigned probabilities of occurrence. The set of scenarios consists of different scenario groups drawn from the four families: one group each in A2, B1, B2, and three groups within the A1 family, characterizing alternative developments.

A1b and A2b greenhouse gas emission scenarios of Intergovernmental Panel on Climate Change (IPCC, 2007) care considered in the analyses. There are 23 General Circulation Models (GCM) available and each of them could be used

Table 2. Model scenarios, mean annual temperature and precipitation changes to the baseline scenario

Country	AEZ	A1b(2010-2040)		A2b(2010-2040)		A1b(2070-2100)		A2(2070-2100)	
		Temp °C	Precipitation, mm	Temp °C	Precipitation, mm	Temp °C	Precipitation, mm	Temp °C	Precipitation, mm
Kazakhstan	arid	1,3	8,4	1,4	9,3	3,6	11,5	4,4	5,3
	semiarid	1,3	12,9	1,4	16,5	4	27,7	4,8	19,8
	sub-humid	1,3	10	1,5	16	4,2	25,3	5,1	11,9
Kyrgyzstan	semiarid	1,3	6,6	1,4	8,4	3,6	22,7	4,2	19,3
	sub-humid	1,3	8,1	1,4	10	3,6	36,5	4,2	36,3
Tajikistan	arid	1,3	6,2	1,5	8,3	3,7	9,7	4,3	2,7
	semiarid	1,4	8,6	1,5	21	3,8	13	4,4	7,3
Uzbekistan	arid	1,3	7,7	1,3	12,6	3,5	12,7	4,1	10,4
	semiarid	1,3	14,9	1,4	18	3,6	25,4	4,2	17,1

Source: Sommer et al. (2012) and Kato and Nkonya (2012).

under different emission scenarios. From these GCMs, 7 most advanced models were used to downscale precipitation, minimum, maximum and mean temperature changes under these scenarios for different future time periods by GIS modelling team. The downscaling was implemented by overlaying coarse-gridded GCM change fields into current high-resolution climate grids. The main advantage of this method is that it yields results close to the observed situation, even in areas with complex topography, and directly generates climate surfaces. This downscaling method provided absolute deviation of monthly temperature and relative deviation of monthly sum of precipitation from historic data.

The temperature and precipitation is expected to increase (Table 2) in all considered farming systems but the magnitude of changes very much differs among the farming systems. Downscaled climate change scenarios were used in crop simulation models in order to determine the yield change under climate change scenarios. Average of 7 GCMs are considered for each considered farming system under A1b and A2 scenarios for two different future time periods (2010–2040 and 2070–2100) in the scope of this study.

As it is seen below in the table A1 storyline and scenario family describes how precipitations will have changed with temperature alterations by the end of the first period of 30 years. The A2 storyline and scenario family describes the same trend as A1 does however with a little increasing of temperature in all represented countries with different climate conditions.

Since crop models require daily time step data, stochastic weather generators are commonly used for estimating daily data.

Climate change impact under market liberalization

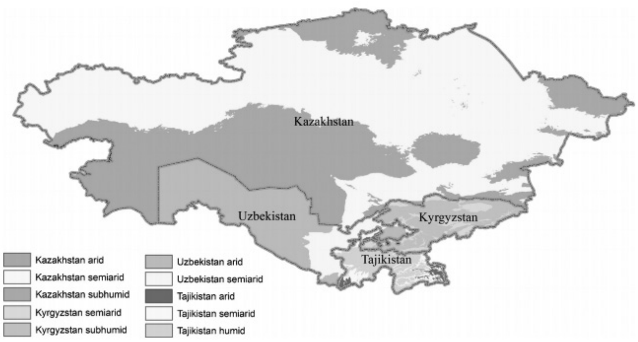
Political and ethnic disputes in Central Asia are causing serious constraints to trade between the countries (FAO and WFP, 2012). Restrictions in commodity trade between the countries prevent farmers from planting crops according to their comparative advantages and obtaining increased revenue with the available resources. Furthermore, trade limitation is not only related to agricultural commodities but also limits agricultural input exchange between the countries. Also the international attention should be paid for Sustainability Innovative Low-Carbon investments which were analysed by principles for "Rubik's Cube" solution (Fogarassy, et al. 2014a; Fogarassy, et al. 2014b). Also instead of fossil energy resources including methane the firms should use renewable energy resources for reduction of methane and other gas emissions.

Therefore, salient price differences in input and output prices in Central Asia countries exist. This scenario investigates how market integration will impact farm revenues under climate change scenarios. Agricultural commodity and input prices are expected to be similar in all four countries under this scenario. Only the price of cotton is treated differently in the simulations due to selling cotton to the world market. The price levels observed in Kazakhstan are used for Uzbekistan and Tajikistan in the case of cotton as considered in similar studies (Bobojonov et al., 2010; Bobojonov et al., 2013).

All other model parameters remain the same in the previous scenario. The results that farmers in Uzbekistan and Tajikistan will particularly benefit from such policy in the future. Thus income gains from market integration will offset negative impacts of climate change. There were no large gains observed in Kazakhstan and Kyrgyzstan since farmers already receive competitive market prices in those countries. However, some gain was still observed which offset income decline under climate change.

Thus, the results of this simulation show that political measures such as market liberalization could increase risk coping potential of farmers under climate change. However, the careful interpretation of results in light of model assumptions and limitation is still needed. The model does not consider the impact of changing income levels and consumption patterns on input and output prices which require careful interpretation of the results of this scenario. Further research is also required on the potential impact of changing world market prices on regional prices under climate change scenarios.

Figure 2. Representative farming systems in Central Asia. Adapted from De-Pauw (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article)



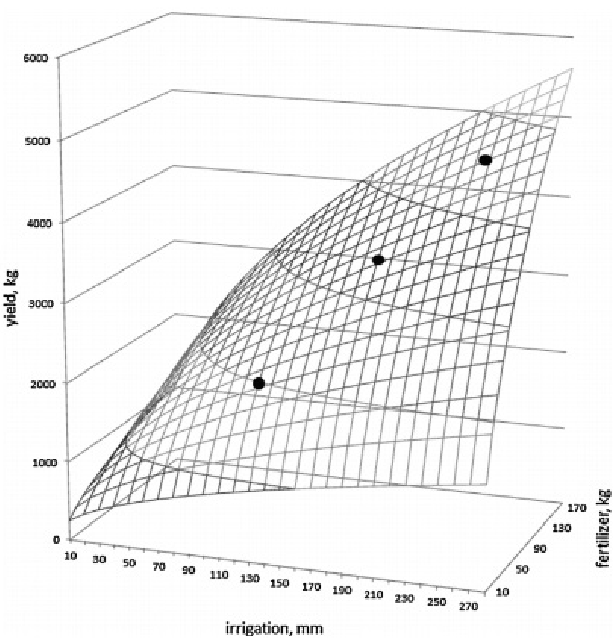
Source: Bobojonov I. and Aw-Hassan A. / Agriculture, Ecosystems and Environment 188 (2014) 245–255

Crop yield simulation under climate change

CropSyst and DSSAT models are used to assess the impact of climate change on crop yields in Central Asia (Jones et al., 2003; Stockle et al., 2003). These models were calibrated for each of these countries and selection of the locations is done according to the importance of the farming systems in production of wheat, cotton and potato. Data on crop experiments conducted by national research institutes in Central Asia was obtained in order to calibrate the crop simulation models (Kato and Nkonya, 2012; Sommer et al., 2012). The production of wheat was simulated by CropSyst (Sommer et al., 2012) while production of cotton and potato were simulated by DSSAT model (Kato and Nkonya, 2012). Crop yields under these scenarios for the years of 2011–2040 (near future) and 2071–2100 (far future) were analyzed with the help of CropSyst and DSSAT models.

The selection of these models was determined by two independent modelling teams according to data availability and their experience in a certain platform (Kato and Nkonya, 2012; Sommer et al., 2012). The CropSyst model was calibrated with the experimental data with different fertilization rates and irrigation practices (Sommer et al., 2012). Calibrations of crop models were implemented with at least three years of daily weather records and crop growth experiment data conducted at national research stations in selected farming systems. After the calibration of the crop models, crop yields under different management options were simulated for the abovementioned scenarios and time periods. In order to reduce the dimensionality problem, the CropSyst modelling team has selected three management options as presented in Fig. 3.

Figure 3. Illustration of CropSyst yield simulation for different irrigation and fertilizer use in the example of wheat.



Source: (Sommer et al., 2013).

Mean yield and standard deviation of yield for these three management options for all locations and climate change scenarios were available from crop simulation results. These three input use bundles are hereafter named as low, average and high input intensive management options (see Supplementary Material). Only one planting date for each farming system is considered in the crop yield simulations (Sommer et al., 2013)

DSSAT model was calibrated to simulate different mineral fertilizer and organic fertilizer (manure) levels (Kato and Nkonya, 2012). Irrigation water for cotton and potatoes were kept constant in levels observed in the farming systems. An example of crop model mean yield and yield volatilities is given in Tables 3 and 4 in the case semiarid farming systems in Uzbekistan. The mean yield and volatilities differ between the crops as well as the climate change scenarios (Tables 3 and 4).

Table 3. Crop yields under different management options and climate change scenarios in semiarid zones of Uzbekistan, ton ha.

Crop	Management option(input use level)	Baseline	A1b (2010–2040)	A1b (2070–2100)	A2 (2010–2040)	A2 (2070–2100)
Cotton	low	3,27	3,33	2,08	3,52	1,63
	average	-	3,6	1,56	3,92	1,06
	high	-	3,79	2,35	4,03	1,73
Potatoes	low	18,9	21,41	23,38	21,47	22,11
Wheat	low	2,83	2,88	3,27	2,88	4,01
	average	4,3	4,36	4,87	4,42	5,45
	high	5,44	5,69	6,37	5,73	6,87

Source: Source: Sommer et al. (2012) and Kato and Nkonya (2012).

Table 4 Crop yield volatilities (coefficient of variation) under different management options and climate change scenarios in semiarid zones of Uzbekistan.

Crop	Management option(input use level)	Baseline	A1b (2010–2040)	A1b (2070–2100)	A2 (2010–2040)	A2 (2070–2100)
Cotton	low	0,11	0,14	0,21	0,1	0,23
	average	-	0,17	0,27	0,14	0,31
	high	-	0,14	0,23	0,09	0,24
Potatoes	low	0,32	0,29	0,22	0,29	0,25
Wheat	low	0,46	0,49	0,48	0,47	0,34
	average	0,31	0,34	0,37	0,33	0,27
	high	0,22	0,25	0,27	0,24	0,21

Source: Sommer et al. (2012) and Kato and Nkonya (2012).

The representative farms considered in the study are assumed to be commercial farms and no constraint associated with household consumption demand is considered. Furthermore, only one farm type per farming system is considered and no differentiation between subsistence and commercial farm is elaborated. All farms are assumed to be price takers and no price changes associated with their production decisions are considered. The mean and variance of output prices used in the climate change simulations are estimated from historical observations. Furthermore, no adjustment to input prices are made due to the lack of data related to future input price changes in the region. Occurrences of rare events are considered on the base of current probabilities which might be one of the shortcomings of this study.

Additionally, simulated yields under climate change scenarios do not consider any impact of changing diseases and pests in the future. Furthermore, the static nature of the model does not consider any accumulation effect of climate change over the years. The study does not provide information about the effect of technology changes as well as changes in crop varieties in the future. Further information needs to be obtained in order to adjust model parameters to potential improvements of technologies and the crop varieties considered in the study.

Conclusions

To sum up, climate change impacts on agricultural systems in Central Asia different depending on agro-ecological zones and socio-economic aspects. Farmers in Uzbekistan will benefit from climate change due to more favourable weather conditions for crop growth in the near future (2010–2040). However, revenues are expected to decline in the late future (2070–2100) due to increasing temperatures and increasing risk of water deficit, especially if availability of irrigation water declines.

There might be a slight increase of expected revenues in semiarid zones of Kazakhstan. Some increase in revenues also is also expected in arid areas of Kazakhstan which will not increase the farmers' utility due to expectation of higher variances in crop yields associated with climate uncertainties. In contrast, farmers in sub-humid zones are expected to benefit from increasing temperature and precipitation. Impact of climate change on income of Kyrgyz farmers in semiarid zones will be neutral in the near future, but expected to be positive in the late future. Farmers in sub-humid zones of Kyrgyzstan will probably have higher expected income under all emission scenarios in near and late future scenarios.

However, this might not increase their utilities since additional gain is prone to increased risk associated with weather extremes. In Tajikistan, impact of climate change is crop specific. Wheat revenues may not change in the future, but income from cotton will decline due to drop in yields if current levels of management are maintained. Potato farmers may receive higher revenues in the future as yields are expected to increase. Overall, the impact of climate change is positive in semiarid and humid zones of Tajikistan, but producers in arid regions may suffer from losses under climate change scenarios. Scenario simulations with the condition of market liberalization show great potential for policies to enable producers to mitigate negative consequences of climate change, especially in Tajikistan and Uzbekistan.

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THE EFFECTS OF CLIMATE CHANGE ON CEREALS YIELD OF PRODUCTION AND FOOD SECURITY IN GAMBIA

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Abstract: *Increasingly, empirical evidences are substantiating the effects of climate change on agricultural production is a reality. In the early part of the 20th century many were skeptical about the so-called climate change that is due to global warming. The Intergovernmental Panel on Climate Change (IPCC, 2007) defines climate change as follows: "climate change refers to a change in the state of the climate that can be identified by changes in the mean or variability of its properties and that persists for extended periods, typically decades or longer" This study analyses the impact of climate change on cereals production (millet and maize) in the Gambia using a time series data for a period of 46 years (1960 – 2013) at an aggregate level to assess the relationship between climate (temperatures and rainfall,) and non-climate variables fertilizer, area planted respectively and yield. The specific objectives of the research are: (1) How climate change affects the expected cereals (Millet and Maize) output or yield in the Gambia. (2) How the level of output risk within cereals (Millet and Maize) farming is affected? In order to achieve these set objectives, the paper will adopt Just and Pope modified Ricardian production functions for climate change impact assessments (e.g., Chen et al. 2004), the paper will also control for the impacts of regular input factors in the production process. The study used a data set for the Gambia comprising variables relevant for cereals production and climate information from 1960 through 2013. There is strong evidence that climate will affects Maize and Millet; according to the analysis 77% and 44% of the variability in the yield of Maize and Millet respectively is explained by the climate and non-climate variables included in the model. Given the effects of climate variables on cereals production, and increasing climate change vulnerabilities on other food production section, the result of this paper will add voice to the growing call for policy makers to step up funding in research and development in climate change adaptation and mitigation.*

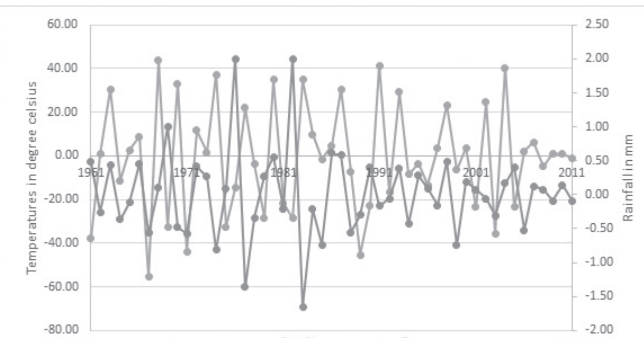
Keywords: *Temperatures, rainfall, fertilizer, Green House gases production and Gambia*
(JEL classification: Q54)

Introduction

Over the past forty years the country has experienced a decline in mean total annual rainfall("Gambia (Vol 7, 2010)," n.d.). Since the mid-1960s, changes in climate observed in The Gambia have been characterized by erratic rainfall patterns; unseasonal rains and torrential rainfall, storms, Intraseasonal drought, cold spells and Climate change has become a household name in 21st century, Increasingly, empirical evidences are substantiating the effects of climate change on agricultural production. In the early part of the 21st century many were skeptical about the so-called climate change that is due to global warming.

The Intergovernmental Panel on Climate Change (IPCC, 2007) defines climate change as follows: "climate change refers to a change in the state of the climate that can be identified by changes in the mean or variability of its properties and that persists for an extended period, typically decades or longer "According to previous studies rainfed agriculture produces nearly 90% of sub-Saharan Africa's food and feed (Rosegrant et al., 2002), and is major livelihood activity for 70% of the population (FAO, 2003). The graph below (figure 1) depicts the variability of temperatures and rainfall in the Gambia for the past forty years. The variation is no near the desired condition for farming especially when rainfall is the main source of water for crop production.

Figure 1: The trend of temperatures and rainfall in the Gambia from 1961 to 2011



Source: Self-made according to Climate Research Unit, 2015

Climate change and its inconsistency will poise an imperative short-term and long-term bottlenecks to improvement efforts in the Gambia exclusively crop production and sustenance sanctuary of the rural farmers. In the interim dangerous climate occasions comprising windstorms, rainstorms, droughts and dust storms will become more frequent with increased severity. Land use and land cover change, sea level rise, and coastal erosion present significant long-term challenges. According to (FAO, 2003) Rainfed agriculture employs 80% of labour force more than the sub Saharan Africa average which is 70% of the population and accounts for 25%GDP.

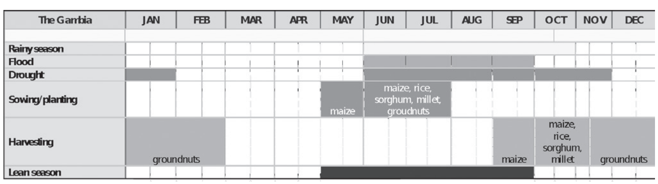
1. Research

1.1. Problem Statement

Droughts is one of the prime problems caused by global climate change in the western Sahel region in general and The Gambia in precise has observed an increased in rate and severity of dry spell events. Direct effects of repetitive tenacious dry spells comprise of ecosystem desiccation by increased salinization in freshwater wetland and loss of productivity in croplands, saltwater encroachment up the river, deforestation, and loss of productivity and biodiversity in woodland ecosystems as a result of wildfires and land use change. More than 97% of croplands in the Gambia are entirely rainfed.

Regardless of attempts to initiate early-maturing crop diversification and institute sustainable water management practices, crop production is still very impotent to persistent droughts. In The Gambia the topography is predominantly monotonous made up of riverine flats and mangrove swamps divided by tidal creeks and savannah forest with shrub and grass. Twenty per cent of the country is classified as wetlands. The Gambia is situated in the Sahelian zone of the West Coast of Africa and the climate is tropical with a distinct dry and rainfall season. The rainfall season runs between June and October as shown by the table (1) below.

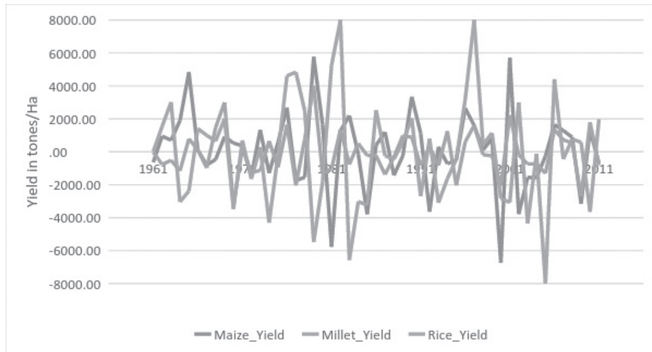
Table 1: Seasonal calendar of the Gambia



Source: Self-made according to the Ministry of Agriculture (MOA), 2015

According (Malanding and Babucarr; 2011), Windstorms are recurrent occurrence in the Gambia, especially at the beginning and about the end of the rainy season. In general, windstorms cause most of the natural disasters especially in the provinces and it account for most damage to properties in rural areas. As forest degradation and land use change strip of the landscape, windstorms could become even more severe, resulting in even greater loss of life and property, the forest which use to serve as wind breaking agent is no more, hence wind move freely in all direction. Floods and storm water runoff are most common in urban areas due to the poor infrastructure and sewage system. Inadequate storm water management systems and lack of compliance to land use zoning regulations have increased the frequency and severity of flooding in urban areas and the resulting loss of human life and property damage they cause. Although catastrophic seasonal floods are rare in the Gambia, the risks of having them are nevertheless present. As extreme weather events become more frequent due to climate change as depicted in figure (1) both temperatures and rainfall has been fluctuating for the past four to five decades. With almost 97% of farmers are depended on rainfall, the consequences of lack of rain and rising temperatures are a threats to the main source of food and income; hence an ultimatum to the entire food chain and food security in the Gambia as a whole.

Figure 2: the changes in the yield of maize, millet and rice from 1961 to 2011.



Source: Self-made according to FAOSTAT, 2015

1.2. General Objective

Given the above situation, the general objective of this study is to intensify the comprehension on the effects of climate change on crop production specifically (Maize and Millet) and food security in the Gambia. The specific objectives of the study are as follows.

1. To determine the effects of temperatures, rainfall and CO_2 on cereals (maize and millet) yield in the Gambia,
2. To use fertilizer and Area planted as non-climate variables in relation to the climate variables
3. To establish a correlation between climatic variables and non-climatic variables and how they affect the yield cereals (maize and millet) in the Gambia

In disparity with several prior studies, which adopt Just and Pope style functions for climate change impact assessments (e.g., Chen et al. 2004), In this study, the rice yield data is regressed on the climate factors to estimate their effects on the cereals yield in the Gambia. We examined the distribution of cereals yield against time by drawing histograms before we selected the Ordinary least squares (OLS) or Quadratic Regression (QR) regression type. We make use of a data set for the Gambia comprising variables relevant for cereals production and climate information from 1960 through 2013.

1.3. Literature review

Farmers generally do not possess any mastery of the exact output as they engage in making their production commitment, that is largely due to the reality that agriculture in as a whole has a long production cycle and is influenced by a large number of endogenous and exogenous precarious factors (Just and Pope 1979; Kumbhakar and Tsionas 2008; Meyer and Yu 2013). The existing climate conditions for instance are crucial sources of unpredictability because factors such as temperature or precipitation are distinguished by inter-annual variability, part of which can be explained by gradual shifts in mean climate conditions caused by global climate change, in contrast another part is constituted by seemingly random variations. Since the precise patterns of the variations are beyond farmers' control and their predictive capabilities, production risk emerges.

The most imminent factors to climate change are; Temperatures, Rainfall and CO_2**;** all of which are very instrumental in crop production. In the process of adapting to the uncertainty caused by climate change, it is important to have a clear view as to what extent does each of these factors of climate variables poised to cereals production in The Gambia, hence it will serve as yardstick for the relevant authorities in decision making.

Deressa and Hassan (2009) conducted a study regarding the economic influence of climate change on the Ethiopian crop production with the Ricardian method. The research employ county-level survey data and the net crop revenue was regressed on climate (rainfall and temperature), household, and soil variables. The estimation established that, the crop net revenue is slightly affected by climate elements like temperature and precipitation. Their outcomes showed the rather negative effects of the small temperature changes which will occur during the summer and winter time through the net crop revenue. Still they discovered a positive pattern as well, while the crop production could benefit from a small growth in the intensity of rainfall the spring.

Mendelshon (1996) focused more on the 1960-2000 time interval in case of the effects of climate change on agriculture. The research uses a cross-sectional model, experimental (crop simulation) model, and response functions for temperature, precipitation, and carbon-dioxide. The study concluded that temperature and precipitation move the global agricultural GDP between a -0.05% and 0.9% change interval. When carbon fertilization is incorporated in the prototype, historic climate change swells the world's agriculture production from 2% to 4%. So as an empirical result he discovered that climate change impacts differ between geographical locations. The outcome recommend that the positive upshot is greater in the mid to high latitude countries while is smaller in the low latitude countries. Most developing countries unfortunately are on the developing countries are located in the low latitudes while developed countries on the mid to high latitudes.

During the examination of the Japanese rice production Horie (1995) concluded – with using the SIMRIW rice crop simulation model – that, the growing CO_2 levels in a warmer atmosphere result in higher rice yields and yield stability. Still it is only valid for the northern and north-central part of Japan because in the case of the south-central and south-western parts of the country the same pattern causes a 30% loss in the rice yields.

Also with a simulation model Basak (2009) has studied climate change effects on rice production in Bangladesh. His tool was mainly developed for Boro where the 58% of the total rice production of the country took place in 2008. Therefore it meant a good example for the examination of the impacts of climate change in the future rice production in Bangladesh. The study uses soil and hydrologic characteristics of the locations, classical crop management Practices, accustomed production interval and climate data in 2008 was employed in the assessments and temperature and CO_2 levels are controlled in the simulation model called DSSAT (Decision Support System for Agrotechnology Transfer). The outcome of the research indicate that rice production varies for two reason geographically and climatically.

Mathauda et al. (2000) analysed the impact of temperature variation on the yield of rice in Punjab, India; the CERES RICE simulation model from1970 to 1990. The study designated the weather scenario to 5 different conditions which are normal weather, slight warm (0.5°C increase in temperature), moderate warm (1°C increase), greater warm (1.5°C increase), and extreme warm (2°C increase) in the simulation model. The research outcome was an increase in temperatures will decrease rice yield up to 3.2% during the slight warm period, 4.9% during the moderate warm period, 8.2% during greater warm and 8.4% during the extreme warm condition juxtapose to normal conditions. Temperatures increase according to the research outcome will have negative impacts on rice production as well as biomass, crop duration and straw yield.

Later on the Ricardian method – besides five AOGCM experimental model – came up again during the research of Seo (2005) who studied the effects of climate change on Sri Lankan agriculture. The research analysed the net revenue per hectare of the four most important crops (rice, coconut, rubber, and tea) in the country. The studies concentrated majorly on rainfall on crop production. The research output illustrates how an increase in precipitation on both the Ricardian method and five AOGCM experimental models. The benefit to the four tested crops ranges from 11 % to 122 % of the current net revenue of the crops in the model. The effects of increase in temperatures are projected to be detrimental to the nation and the loss extent from 18 % to 50 % of the contemporary agricultural productivity.

Most of the studies on climate change have concluded that the impact will be more sevier on developing countries than developed countries according to (Mendelsohn and Dinar 1999) in their research they employed three different models Ricardian method, agro-economic model, and agro-ecological zone analysis for investigating climate change impacts in India and Braizil. Non-environmental variables such as farm performance, land value or net income, was regressed on a set of environmental variables, traditional economic inputs (land and labour), and reinforce systems such as infrastructure in the models. The research highlighted the significance of farmers' adaptation to new techniques as their environment change, the argue farmers will judicious decision to serve their best interest. According to the output of the three different models used in the studies an increase in temperature will eventually reduce the yield of most crops especially those grown on clod areas such as wheat.

Using simulation modelling, Mendelshon (2005) studied the effects of climate change on South East Asia by adopting three AOGCMS models to project the state of agriculture in 2100. As indicated by the outcome of the PCM model will increase agriculture revenue up to $35billions per annum with a 6% benefit. The other two models; the CCSR scenario and the CCC scenario are likely to make net revenues decline about $60 billion per year, 11% loss and $219 billion, 39% loss to Southeast Asian agriculture.

Maddison (2000) explored the elements of agricultural land prices in England and Wales using a hedonic price equation. He recognized that indeed soil quality and climate factors do influence farm-land earnings. Suitable climatic factors such as the number of frost days during winter, temperature and good grade soil were found to be beneficial to agriculture because the cost to farmer is reduced as tilling becomes easier. High elevations and relative humidity on the other hand appeared detrimental because of the tendency of diseases. Specifically, higher summer temperatures and altitude caused a reduction in farmland prices by £883.78 per degree Celsius and £3.68 per meter respectively. Winter temperatures on the other hand increased farmland revenue by about £485.45 for every degree Celsius rise.

According to the findings of (Mano and Nhemachena, 2006) on small scale farmers in Zimbabwe, increase in temperature affect net farm revenue negatively while an intense in precipitation has definite impact on net farm income. The findings also indicated that rainfed farms will be more affected than irrigated farms.

In a similar study by (Gbetibouo and Hassan, 2005) indicates that marginal changes in temperatures is more sensitive compared to a marginal change in precipitation on field crops production in South Africa. Although rising temperatures seems to affect net revenue positively, while reduction in rainfall negatively affect net farm revenue. This was remotely far from the studies of (Deressa, 2007): according to his findings climate variables have significant effects on farmer's net revenue after analyzing net revenue on climate, soil variables and household among Ethiopian farmers. Although the effects are uniform in all seasons, rising temperature and declining precipitation as a whole have negative and serious impact on the Ethiopian agriculture.

In (Kurukulasuriya and Mendelsohn 2007), conducted a research on the effect of climate change among 11 African countries cropland based, they regressed net farm revenue against water, soil, climate and economics variables; according to the findings a decline in precipitation and an increase in temperatures will also have negative effects on net income. These two variables may not be the only climate variables but in the study of climate change the have been widely used to forecast the future agriculture globally. The study concluded that the impact cannot be generalized within the African continent, since different geopolitical zones have different climate features and climate scenarios.

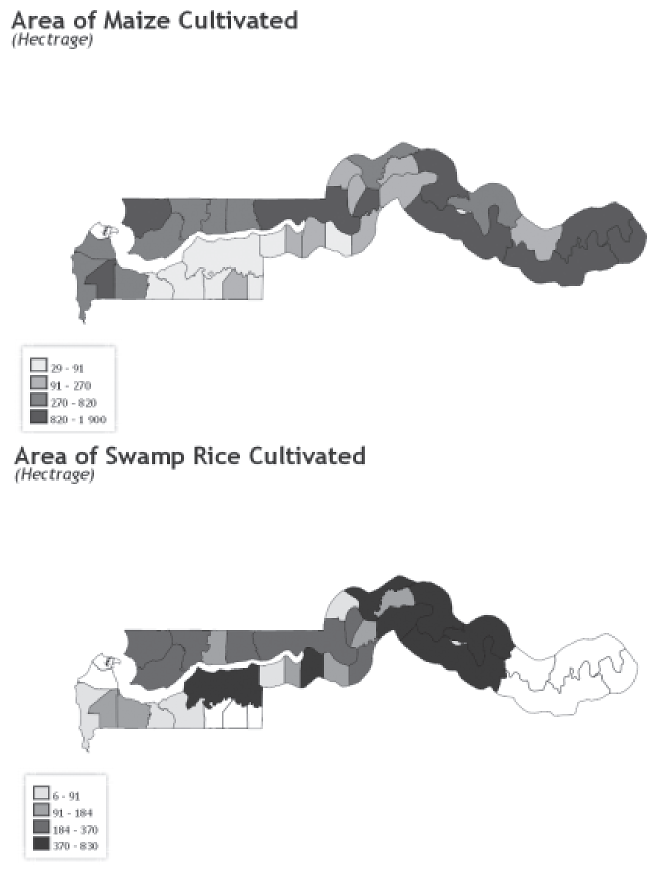
Mendelsohn et al, 2007 Using the data from (Kurukulasuriya and Mendelsohn 2007) established that African agriculture is vulnerable to the threats posed by the effects of climate change specially those countries with searing climate are likely to suffer considerable loss in the productivity as compared with cooler climate. According to the analysis it was estimated that Burkina Faso and Niger will suffer a loss of 19.9 percent and 30.5 percent productivity, respectively; while Ethiopia and South Africa will entail a loss of 1.3 percent and 3 percent of their productivity respectively.

2. Methods

2.1. Study Area and source of data

The Gambia is an agrarian country and more than half of its inhabitants are directly or indirectly involved in crop production. In Figure (3) below are portrayals of areas where Maize, millet and rice are mostly grown. The pattern of millet is almost the same with that of maize. The Upper River Region (URR), Central River Region (CRR), North Bank Region (NBR) and West Coast Region (WCR) are the major maize and millet while Central River Region and Lower River Region (LRR) and the North bank region are the major rice producers. Since we import more than 75% of the rice we eat we will dwell more on millet and maize for this paper.

Figure 3: Maps showing growing areas for Maize, Millet and Rice in the Gambia



Source: FAO, 2013

The most common farming system in the Gambia is subsistence farming: on average every farmer is engage with two or more cereals crop including the main cash crop groundnut (*Arachis hypogaea). Due to the poor soil conditions, farming is getting more expensive year by year due to the high cost of chemical fertilizer as well as pesticides. Priority is given to groundnut for it is the main cash crop of the country and have multiple usage.*

2.2. Climate Data

The meteorological data used for the climate analysis in this study were recorded at the meteorological stations by the Climate Research Unit (CRU) of the University of East Anglia in collaboration with IPCC and UCAR database system. The database contained long-term (from 1960 to 2006) the additional seven years (2007 to 2013) were estimated using a moving average; for the daily rainfall and temperatures. Daily temperature was averaged over the rainy season to represent the seasonal temperatures.

2.3. Quadratic Regression Model

$$Y=\alpha-\beta x1+\beta x12+\beta x2-\beta x22+\beta x3-\beta x22+\beta x4+\beta x5+e \qquad eq1$$

Hypothesis
H0 = β1=β2=β3=β4=β5=0 (None of the independent variable is significant)
HA= β1≠β2 (at least one of the independent variable is not equal to zero hence is significant)

The above model is aim at predicting the effects of climate change on cereals production (maize and Millet) in the Gambia in a nonlinear format. The Y in the model; is representing the dependent variable or the predicted variable which is the yield of cereals, α is the constant, as for x1, x2, x3, x4, and x5, denotes the independent variables i.e. Temperature, rainfall, CO_2, fertilizer and Area planted respectively and *x12,x22and x32 are denoting the squared root of Rainfall and* CO_2 while β is denoting the slope of each of the independent variables and e is representing the error terms which usually represent those variables that affect the dependent variable but are not included in the model.

2.4 Log-Regression Model

The Log-Regression method involves the transformation of both the dependent and the independent variables data into log form. When data is transformed into log form any measurement made by the data will be in the form of percentage and hence changes expected to the dependent variable are also expressed in term of percentages. It is important to understand that when we use log scale for the predictor, we are saying that a given percentage change in the predictor has the same impact on the response. That is to say every time we increase the predictor, we expect the same change on an average in the respond. Below is the Log-Regression model:

$$lnY=\alpha-ln\beta x1+ln\beta x2+ln\beta x3+ln\beta x4+ln\beta x5+e \qquad eq2$$

Hypothesis
H0 = β1=β2=β3=β4=β5=0 (None of the independent variable is significant)
HA= β1≠β2 (at least one of the independent variable is not equal to zero hence is significant)

The model is aim at predicting the effects of climate change on cereals production (maize and Millet) in the Gambia in logarithm form. The lnY in the model; is representing the dependent variable or the predicted variable which is the yield of cereals, α is the constant, as for lnx1, lnx2, lnx3, ln x4, and ln x5, denotes the independent variables i.e. Temperature, rainfall, Co_2*, fertilizer and Area planted respectively. The symbol β is denoting the slope of each of the independent variables and e is representing the error terms which usually represent those variables that affect the dependent variable but are not included in the model.*

2.5. Theoretical Assumptions

1. ***Temperature:*** Temperatures are said to have negative effects on cereals yield that's if temperatures increase the yield of cereals will reduce significantly. According Basak (2009) who conducted a research on rice production in Bangladesh, a fall in minimum temperature will reduce rice yield while an increase in maximum may causes damages to rice crops. In Deressa and Hassan (2009) studies on the economic effects of climate change on crop production in Ethiopia employing Regression modelling, concluded that a proportional increase in temperature during summer and winter will have negative effects.
2. ***Rainfall:*** Cereals required high volume of water hence consistent rainfall will have positive effects on cereals yield. According to Deressa and Hassan (2009) and (Basak et al 2009) increase in rainfall will increase the yield of cereals. Although they also indicated that high rainfall will only have negative effects if the cereals plant is to face flooding for a long period of time, thereby it will reduce the yield of most cereals plant.
3. $\boldsymbol{CO_2}$ which one of the most fundamental elements that plants required for their growth has positive effects in cereals production an increase in CO_2 concentration will increase the rate at which photosynthesis occur which will boost the yield of cereals plants. Horie et al (1995) studied the effects of an increase CO_2 level and maximum temperature on Japanese rice and concluded that an intensify CO_2 levels in a high temperature aerospace will considerably increase rice yields and yield steadiness in northern and north-central Japan. It is worth mentioning that despite CO_2 being very crucial to plant growth; higher concentration of CO_2 on the atmosphere will increase Temperatures as well as transpiration and evaporation thereby serving as agent for the depletion of the ozone layer.

3. Result and discussion

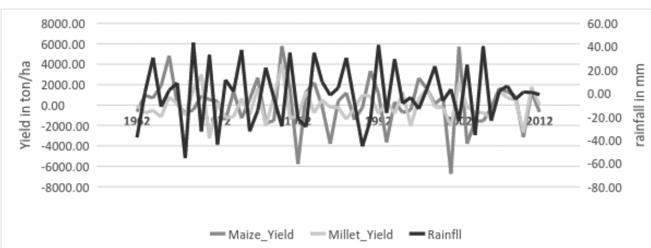
3.1. Observed trend of climate in the Gambia

*The climate is "Sudano-Sahelian, with a short rainy season from June to October and a long dry season from November to May. Mean annual rainfall varies from 900mm in the South West to about 500mm in the North East. Variably cloudy, humid and warm atmospheric conditions combined with scattered to widespread thunderstorms sometimes with strong winds, accompanied by moderate or heavy rains has prevail over the years. Normal temperatures across the country vary between 27°*C and 28°C. In the meantime, extreme temperatures varied between 32°C and 34°C over the entire country, whilst minimum temperatures fluctuated between 21°C and 24°C with high average relative humidity across the country mostly above 70% demonstrating an increased level of moisture in atmosphere. With high temperatures the condition is ideal for rainfall occurrences.

3.2. Cereals yield and climate variability

Regular rainfall is an ideal condition for a successful farming season, over the past five decades (1962 to 2012), crop yield has been fluctuating just as temperatures and rainfall as shown in the figures (4 and 5) respectively. This is due to mere fact farmers are unable to give a good prediction about the climate pattern in the country. Most cereals are usually pre sown refer to table (1) gambia seasonal calendar, hence a small amount of rain could trigger their seeds to germinate and in most cases the gap between the first and the real raining season is huge, therefore both the cereals and grasses that germinate might eventually die due lack of water and crop stress.

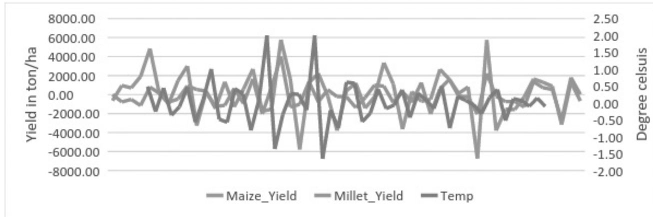
Figure 4: the trend of cereals yields (maize and millet) and rainfall from 1962 to 2012



Source: Self-made according to FAO, Climate Research Unit (CRU), 2015

Rainfall is the bedrock of agriculture in the Gambia; the fluctuation of rain during the raining season means a huge economic and livelihood lost. An agriculture that is 97% reliant on rain could be easy brought to standstill, hence rural farmers mostly are very prone to poverty and food insecurity. The river Gambia could be a big source for irrigation along its banks from Central River Region to the Upper River Region with approximately 8000ha of irrigable land suitable for continuous or year round production which is yet to be exploited. Although, it is doable, but, it requires huge financial muscle to be fully operational and sustained for the future. There are many development projects designed for land development; but in many cases the visibility studies that set the tone and direction and intervention areas is done without proper consultation of the indigenous people.

Figure 5: the trend of cereals yields (maize and millet) and temperatures from 1962 to 2012



Source: Self-made according to FAO, Climate Research Unit (CRU), 2015

International consultants, are usually hired by most international developments agencies of the United Nations and private funded NGOs. In many cases these consultants and expert have limited knowledge about the socio-demographic patterns of the country, hence rely heavily on the official version of the situation on the ground.

3.3. Log Multi-Linear Regression Model

It is important to understand that when we use log scale in regression analysis the unit of measurement for the predictors changes from their actual unit to percentages. Thus in table 2, the results indicate that 44% of the variability in millet yield is explained by the independent variables; all in all, both the F-statistic and the Probability test conformed to the fact that the model is reliable. Individual predictors are all significant at the 95% confidence interval although entire model is fit for the purpose of explaining the variation in millet yield, but it can only explain 44% which mean more variables could also account for the low or variation of millet yield in the Gambia over the past five decades.

Dependent Variable: Millet Yield, R-squared 44%: significant level P-value < 0.05** Table 2: Results of a quadratic regression model for maize production in the Gambia.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	10.29103	0.447178	23.01326	0.0000
Temperature	0.259098	0.065637	3.947416	0.0003**
Rainfall	-0.228980	0.094074	-2.434041	0.0189**
CO_2	-0.412209	0.076910	-5.359649	0.0000**
Millet Area	0.143521	0.031773	4.517101	0.0000**
Fertilizer	0.023952	0.019199	1.247567	0.2185

Source: Self-made, 2015

Although almost all the independent variables are significant except fertilizer; holding all other factors constant, each variable will affect millet yield. Temperatures will positively affect millet yield especially during maturity period until it is finally dehusk; during this period the millet crop require good exposure to sunlight with normal temperatures as this is very essential to postharvest handling. According to the FAO (2003), almost 20% to 40% of crop losses is incurred during postharvest period, consequently it contradicts to earlier studies on rice by both Dressa and Hassan (2009), Mathauda et al. (2000) (Basak et al 2009) and Horie et.al (1995) that temperatures will have negative effects on the yield of rice. Rainfall will negatively affect the yield of millet for the simple fact the Gambia raining season start from June to October as shown in table (1) above and millet is an early maturing crop approximately three months it is ready for harvesting; if the rain continues pouring till October, the millet will not dry properly and eventually some will develop fungal disease and some might start to germinate on the millet plant itself. Therefore, rainfall is a prerequisite to crop production but too much of rain or irregular raining season can cause either delayed or damage millet plants, hence yield of millet will reduce during these periods.

3.4. Quadratic Regression Model

Yield of Maize is the dependent variable and the rest are the independent variables or the predictors. The impacts of climate factors on maize yield is depicted in Table 3, which shows the models is statistically signiﬁcant in general which means that the climate variables are able to explain some of the variation in maize yield of production in the Gambia. The R-square shows that 77% of the difference on maize yield is described by climate variability.

Dependent Variable: Maize Yield, significant level P-value < 0.05**
R-squared 0.77829 F-statistic 18.4299 Prob(F-statistic) 0.000000
Table 3: results of a quadratic regression model for maize production in the Gambia.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-13.26506	12.53503	-1.058239	0.2960
Temperature	1.527299	0.593229	2.574553	**0.0137****
Rainfall	-1.532830	0.714510	-2.145289	**0.0378****
CO_2	5.517022	3.772533	1.462418	0.1511
Fertilizer	0.096077	0.039419	2.437325	**0.0191****
LAGMYIELD	0.528496	0.103769	5.093024	**0.0000****
Maize area	0.049234	0.067345	0.731075	0.4688
Sq. Rainfall	4.93E-05	2.37E-05	2.076057	**0.0440****
Sq-CO_2	-0.432385	0.283039	-1.527651	\` 0.1341

Source: Self-made,2015

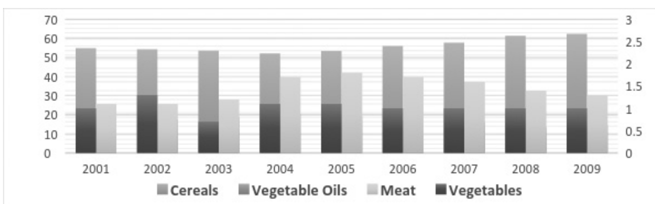
Individually only temperatures, rainfall and area planted are significant at 0.05 significance level; as depicted by both the P-values and the T-test, thus we reject the Ho and accept the alternate *(Hypothesis H0 = β1=β2=β3=β4=β5=0 (None of the independent variable is significant) HA= β1≠β2 (at least one of the independent variable is not equal to zero hence is significant)). The results indicated most of the predictors will increase or decrease yield the equivalent of its coefficient along the curve, hence the marginal changes will not be constant as in the case of linear model. This is because every movement along the curve is independent of its original position. In a quadratic regression model interpreting individual variables will not give any meaning to us, therefore the most important elements are the test for overall significance which help in identifying whether the correlation between the predicted variable and the predicting variables is strong.*

As revealed by most research the effects of climate change will be felt by every part of the world but the magnitudes or the extent to which it affects people differ depending on the their geographical and resources available to cope with these changes. The changing socioeconomics conditions can also play a crucial part on the magnitudes of the effects, according to (Thapa and Joshi, 2010) on the Nepal agriculture; they examined the relationship between net farm revenue and climate variables; regressing climate variables and net farm revenue independently in one model and the other model including socioeconomic variables, the findings shows that low precipitation and high temperatures affects net farm income positively during the fall and spring which are peak harvest season.

4. Research summary

Cereals production is very crucial for the attainment of food security which is highly emphasizes in the National Agricultural and food policy (figure 6) below by 2009 60% of the total food supply was cereals, thus environmental factors plays a vital role in the determining the performance of cereals (maize and millet) production which is the core of food security in the Gambia; as cereals are the staple food of the country. The main environmental factors related the crop productions are rainfall, temperatures and carbon dioxide (CO_2) concentration which are believed to have significant effects on crop yield.

Figure 6: Food group shares in total food supply (%) in the Gambia from 2001 to 2009.

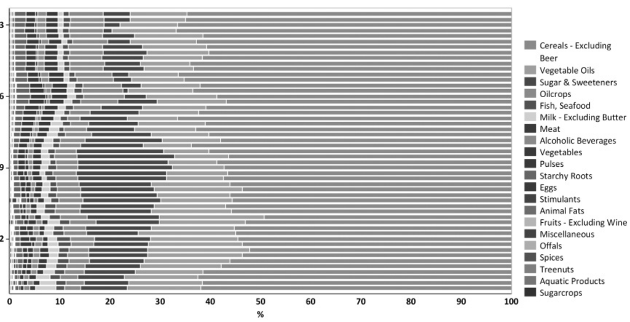


Source: Self-made according to FAOSTAT, 2015

The study endeavours to analyse the consequences of climate change on cereals yields of production in the Gambia's. Secondary data for climate change and cereals yield are used to estimate the effects; a modified production function is employed to highlight the effect of climate change in cereals yield of production from 1960 to 2013. A regression model was used to approximate the impacts of both climatic and non-climatic factors on cereals production particular attention was given to maize and millet which is grown nationwide. The non-climatic variables in the model are fertilizer and area planted, accordingly the purpose of their inclusion into to the model was based on their significance on cereals plant and their relationship with the climatic variables example; temperature precipitation and CO_2.

Climate change if not immediately addressed, looms to unbutton years of development endeavor in a near distance period time. A significant portion of development investments in the Gambia are in activities affected by climate risks, since most sectors are susceptible to climate change. The achievement of self-sufficiency in food by the year 2016 as enshrine in the vision 2016 Gambia Government blue print will only be a realistic if the irrigable area is fully functional. Many times governments have to divert resources meant for development projects to serve as first aid for people subsist up with effects of utmost weather and climate events. With increased frequency of occurrence of utmost weather and climate events, poverty has progressively shot up and development efforts have continuously been frustrated. The MDGs whose chief objective was to eradicate poverty were continuously frustrated by climate change and variability.

Figure 7: Depicting share of food products in daily diet, % in the Gambia from 1963 to 2014



Source: FAO, 2014

The General objective of this research was to intensify the knowledge on the results of climate change on crop production specifically (Maize and Millet) and food security in the Gambia. As highlighted in table (2) and (3) climate change indeed will have impacts on cereals production in the Gambia and thus food security. According to the data 77% of the variation in maize yield could be explained by both climate and non-climate variables, whereas only 44% of the variation in millet yield could be explained by climate and non-climate variables. Cereals are an important tool in the reduction of food insecurity in the Gambia; cereals constitute almost 60% of food products in daily diet in the Gambia as depicted in the figure (7) above.

The Gambia like any developing country need massive investments in infrastructure and agricultural production. If these are pursued using customary technologies and carbon potencies, these much-needed investments will increase the presence of greenhouse gases and, eventually, more climate change. Therefore, the multi-million-dollar question, is not just how do we make development further pliable to climate change but rather how to pursue development and success without inducing "treacherous" climate change. Developing countries should strive to slip to lower-carbon path without hampering development, the financial muscle of a country will dictate the applicability of the above and will rely on the extent of financial and technical assistance from developed countries; off course, the Gambia is in the forefront among the developing countries who will need such fiscal and high-tech assistance to help in combatting climate change.

4.1. Adaptation and Mitigation

An impact relates a particular change in a process caused by its exposure to climate change, which may be concluded as to be damaging or useful (Schneider et al 2007). The outcomes of climate change both direct as well as incidental are particular to divergent socio-geographic regions; livelihood groups and areas. In sectoral terms, agriculture, social amenities infrastructure, and the environment are the most affected. Incidentally, climate change eventually leads to malnutrition as a result of food insecurity, health problems and conflicts due to resource insufficiency and ignominy, and finally the decision to migrate.

Since it is evident that we cannot reverse our climate, the only way coexist with these rapid changes in climate change is to look for channels that will help in minimizing it effects on both agriculture and society as a whole by means of adaptation and mitigation.

Adaptation is a powerful means of minimizing the effects of climate change on the variability of cereals yield; it should be quickly established that adaptation cannot eliminate climate change as a whole but if no adaptation measures are put in practice, the effect of climate change will be more serious. Hence, adaptation involves the act of reducing the risk of adverse consequences from expected crop response to the projected climate change. Therefore, adaptation activities can be used as a mechanism to increase the resistance and elasticity of ecosystem to climate change.

(Fuhrer and Gregory, 2014) in their studies remark that another adaptation practices that relates to biotic and abiotic stresses is crop breeding. Rising temperatures and variation in humidity affects the diversity and responsiveness of agricultural pest and diseases. Therefore, in the context of this study adaptation will be use modern agricultural techniques, adapting planting dates, diversification of crops planted and mixed cropping adopt early maturing and drought-resistant crops use irrigation- from close by rivers especially the Central River Region (CRR)and Upper River Region (URR), planting trees as shade for and windbreak seedlings closely planted as Insurance strategy increase use of inorganic fertilizers and improved soil moisture contents and finally Livestock rearing to diversify.

Adaptation strategies should be used to build the normal development strategies by balancing competing objectives. The transformation to a sustainable energy future i.e. energy efficiency and low-carbon technologies accelerating innovation and advanced technologies integrating policy transcending the tensions between climate and development in the Gambia.

Mitigation on the other hand is composed of measures that dwell mostly on the legal aspect and policy implementation. These policies should play a balancing role of the consequences between socio economic development, technological advancement, population growth and governance with the climate change. Mitigation in essence is the use of available resources without compromising their effects on our agricultural production. Controlling emissions and concentration of greenhouse gases is an integral part in any mitigation strategies that policy maker might come up with. Finally, the introduction new varieties and the use of advance technology will play a key role in minimizing the impact of climate change on cereals production in the Gambia.

Climate Change is a problem of immense proportions and is a threat to the majority of development efforts in the Gambia and its livelihood. The process of development itself has a huge impact on vulnerability to climate change (both positive and negative). Therefore, there is the need to climate-proof all development processes and plans this include both government and the private sector climate-proof policies are important and therefore must constitute the basis of climate smart policies for development in the Gambia.

4.2. Limitation of the study

The study has some shortcomings ensuing most specially from the scope of the climate indicators considered. The variables used to represent climate change in these studies are part and parcel a whole lot of other elements that affect cereals production, beside temperatures, rainfall and carbon dioxide. This include environmental indicators such as soil type, magnitude, daily sunlight, humidity and radiation rate all of which greatly affects cereals yield. Secondly the fertilizer used in this study does not represent the total amount since most farmers buy fertilizer from Senegal which is usually cheaper, hence it is not accounted for, thus it is to be regarded as suboptimal data, which do not give full representation of fertilizer as far as the it effects on cereals yield is concerned. It was difficult to collect data on fertilizer used hence the study could only rely on the government import.

Finally, the research is basically based on inherent assumption of the regression analysis method. That yield is fixed through the period, thus yield changes from period to period and the omission of yield variation will exaggerate the effect climate variable on cereals production. Above all the Ordinary least squares (OLS) regression analysis challenges researchers to work hard not to be biased by considering variation of econometric testing. Lack of finance to travel back to the Gambia to collect firsthand information has resulted in the dependence of secondary data as a source of information, which make the research to be biased towards quantitative rather than qualitative research.

4.3. Recommendation for future research

The study has aroused many questions requiring further investigations. Firstly, there is an immediate need to conduct research on other agricultural related activities such as livestock in the Gambia in other to arrest the whole picture on the performance of these segments in relation to climate change issues. Secondly, the impact of other climate predictors such as solar radiation, light length, humidity, socio-economic and sea level, should also be considered in any further research on cereals production in the Gambia. Research should also be able to highlight regional variation in terms of magnitude of climate change effects to enable the usage of a better strategy to minimize the damages that arises due the climate change in different regions and for different crops.

5. Conclusion

Generally, the effects of periodic rainfall and temperature variability on cereals yield is greater than that of the long-term Changes in climatic variables. The important distinctive amongst rainfall and crop production is the rainfall distribution which is connected to the number of dry days throughout the rainy season. The significant escalation of the number of dry days during the rainy season over the period 1960–2013 and its impact on yield makes it one of the most important specification of climate change in the Gambia. An average total rainfall in the Senegambia regions is not necessarily synonymous with good rainy season or with good crop production. In our study which is based on an analysis of empirical data or secondary data, it appears that the effects of declining soil fertility, postharvest handlings are as important as those of climate variability and change.

Nevertheless, disentangling the effects of climate and soil fertility is not straightforward, and results depend on the spatial scale of analysis which will require further studies and analysis on the subject. It is unanimously agreed by all researchers that excessive rainfall and high temperatures during extreme climatic conditions will have adverse impact on the yield of cereals. A marginal increase or decrease in both rainfall and temperatures may negatively affect cereals productivity. Carbon dioxide which is a fundamental element for plant growth has positive effects on crop yield and simultaneously it serves as the mother of all climate change activities. There are strong evidence suggesting that the agriculture sector in the gambia as a whole is vulnerable to climate change. An examination of historical data from 1960 to 2013 on climate change and crop production especially maize and millet has provided supporting evidencing that the impact of climate change on crop production in the Gambia could affect the food chain system which will have multiplier effect to the socio economic development. The knowledge of this potential impact can contribute in reducing the level of crop damages and environmental losses in the future.

With the increasing uncertainties of the impact of climate change is the key to maintain economic growth and productivity, especially in the agricultural sector. Sequel to this, effective measures need to be taken to avoid the worst possible climate change impacts in the future. In general, all stakeholders in cereals production should undertakes different mitigation and adaptation strategies to help minimize the effects of changes in climate provided they have proper information about it potential impact. Overall, the study adds to existing body of knowledge of climate change in the Gambia, by modifying the production function to capture variables such as area planted and fertilizer in cereals production. The modified framework could be used in future research in assessing the direct and indirect effects of climate change in other crops in the agricultural sector. Finally, the findings of this study could be a takeoff point in a drive to measure the future impact of climate change on agriculture in order to sustain agriculture as the backbone of the Gambia's economy. The reality of climate change cannot be sideline anymore, all plans and policies should be climate-proof inclusive.

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