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## The impact of energy crop production on land use in Hungary

**Abstract.** Use of land, as a limited resource is gaining importance due to the rapid growth of Earth's population, the subsequently increasing demand for energy and the presumed impact of climate changes. Despite of the land being a specific resource, as lots of experiences confirm, in most of the countries, as in Hungary, it is not managed optimally. It is a question whether the optimum balance can be reached between different land utilization and production methods and not harming food supply safety but improving the competitiveness of agriculture, decreasing the energy dependence and avoiding an excessive use of soils. The paper analyses the impact of energy crop production on land utilization in Hungary. The current production and technology on the available land cannot satisfy the total energy need by bioenergy. But if land is used which is not cultivated at present due to economic reasons and the possibilities of by-products available in great quantities are exploited, the Hungary's EU commitment can be fulfilled by 2020. and the country will not risk food production losses or modify the land use considerably.

**Key words:** arable land, land utilization, energy crop production, biofuel, energy dependence, food safety.

## Introduction

The concept of land use can have two meanings. The beginning and expansion of land cultivation, when the land is drawn into cultivation, and the development of cultivation methods is land utilization in the classical sense. In current sense, land utilization means the state in connection with the full exploitation and protection of land, in correspondence with the records of users [Dömsödi 2006].

Land has an outstanding role among the means of production as the basis and source of agricultural activities. Arable land belongs to the group of renewable resources. It is available in limited quantity in all countries.

The wasteful consumption, the low-performance technologies and the accelerated growth of the world's population numbers confronts the people on the Earth with the limits of natural resources and the urging need to manage these resources rationally.

According to the forecasts, the population of Earth will be more than 9 billion by 2050 and the agricultural production should therefore be increased by 70% compared to the current level due to the growth of specific needs. It means that land and land utilization will be of significantly higher value [Bozsik & Magda 2010].

In the Hungarian and international references, a lot of studies discuss the changes of land use [Rabbinge & Diepen 2000], introduces the altering land use in Europe and tries to determine the degree of optimal land use. Fekete-Farkas-et al. [2008] used scenario analysis to explore how the climate changes, agricultural policies, social and economic changes affected land use in Europe. Ben Frajd et al. [2012] set up an agricultural supply side model

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to examine the impact of European miscanthus yield changes on land use. The Global Biosphere Management model helped to analyse the impact of world climate changes on yield fluctuations and land use, as well as, through these, on food safety [Fuss et al. 2011].

Garay et al. [2012] examined the impact of energy crop production on land use. Their paper analyses the potential quantity and utilization of biomass-based energy sources in Hungary. They have concluded that sufficient biomass, waste and by-products are available in Hungary in order to reach the targets defined in the energy strategy, therefore it is not necessary to involve more land in energy crop production.

Ciaian et al. [2012] explored how the changes of fuel and biofuel prices affect the land use. They have concluded that land use changes if the fuel prices change and this impact is strengthened by biofuels. The impact can be direct or indirect. The direct impact regarding land use changes refers to a situation when the land is already in use and crops for biofuel production are planted. In case of indirect impact, plots of land that were not used previously are involved in agricultural production. Empirical results have confirmed that energy prices affect the land use. The authors say that all agricultural products have an impact on energy prices, even those which are not used directly for bioenergy production.

The greatest problem regarding land use is that there are more competing needs on behalf of users. The production of renewable energy sources actually competes with the aims of food production and nature preservation, in addition to other land-use purposes. The different biomass production technologies for energetics purposes are also rivals of each other because the production of bio-fuel raw materials needs land as much as energy forests or herbaceous energy crop plantations [Gyulai 2010].

The price of land in Hungary, in spite of the fact that it is constantly increasing, is much lower at present than in the member states of the European Union [Takacs-Gyorgy et al. 2007], [Takacs-Gyorgy et al. 2011] which significantly affects the competitiveness of agriculture [Biro 2007.]. The land market in the EU countries, as well as almost the whole world, is in shortage of land supply. The demand is increasing but the supply grows only at a smaller pace. If farmers expect greater profits, the price of land will continue to grow.

Another risk factor is the climate change [Fekete-Farkas et al. 2008]. The forecasted climate change will affect crop yield, animal husbandry and the locations of agricultural production, considerably endangering the incomes from agriculture and increasing the risk of withdrawing land from production. The risks connected with food production may cause problems in some parts of Europe because the heat waves, drought and insects will probably result in more yield losses. The higher is the changeability of yield, the greater is the risk of global food supply [Szabó-Barótfi 2009].

In 2009, in the frames of directive 2009/28/EC about the promotion of use of energy from renewable sources, the EU determined, as a mandatory target to be reached by 2020, that 20% of the total energy use should come from renewable sources within the EU (Hungary targeted at 13%). The transport sector's target is 10% as a share of biofuels in transportation fuels as a whole. At the same time, the 2009/30/EC directive, as regards the quality of fuels, approved as a mandatory target for the EU as a whole to reduce the greenhouse gas emission intensity of fuels used in transport by 6% by 2020. These international expectations stimulate a growing competition in the changes of land use.

## **Material and method**

The database of the Central Statistical Office (KSH) of Hungary was used for the analysis of land use. When examining the raw material price changes, the calculations were made with the average wheat prices and the annual median EUR rate of the Hungarian National Bank (BÉT) was used for changing from HUF (Hungarian forint) to EUR. Then model calculations were carried out to determine the size of land required in Hungary to achieve the European Union target.

## **Analysis of the situation**

The human society consumes or uses different resources in order to maintain life activities. Two big groups of resources can be distinguished: social and natural resources. The definition of social resources is very far-reaching but essentially it means labour force which is one of the main factors of production. In modern economic sense, it also involves the qualification, competency and other features of human capital. Natural resources include those natural qualities which are exploited by the society for fulfilling its needs at the given development level of society [Bora & Korompai 2001].

The basic resources of agricultural production (labour, means, land) still offer an exploitable comparative advantage in international comparison for the national economy as a whole. The land, as a natural treasure is the most important and most complex, multifunctional resource.

Due to the special features of land, the characteristics of competitive market do not prevail in pure form in case of land market. The specific features of land, as a factor of production, can be summarized according to the following.

- It is fixed, it cannot be moved from one point of Earth to the other. Its geographical position usually depends on the changes of environment. Therefore land is often purchased with speculation purposes [Mizseiné Nyiri 2010].
- Its supply is given and inflexible. The land available for the agricultural sector of a country is usually given, although there are some countries which engage new areas in production in order to provide food for the increasing population (e.g. South America). The situation is different in Europe, because here the quality improvement of existing land or investments (e.g. irrigation) are implemented to produce enough foodstuff on a given area of land.
- Its demand is a derivative demand, so the price is determined by the marginal income of products produced on it. It depends on the quality of land, thus the price of different quality land changes according to the range of products that can be produced on the given area and the quantity connections of marginal returns, average and marginal efficiency of individual products.
- Its alternative utilization is limited, not all the land plots are suitable for any kind of agricultural activities.
- Its fertility can be improved by amelioration, so it is possible to produce a number of products there.

- If it is used properly, it does not go down in value, it is not amortized. Moreover, its value can even be increased by rational use, so it has capital accumulation and asset increasing role.
- The land value or land price as a cost is also specific, because, unlike other means of production, it is returned not in the value or price of the produced output, but it is used without being used up. Thus the money spent on land purchase is always available and can be withdrawn from production by land sale.

Agriculture and related land use is closely connected with the livestock breeding sector, too.

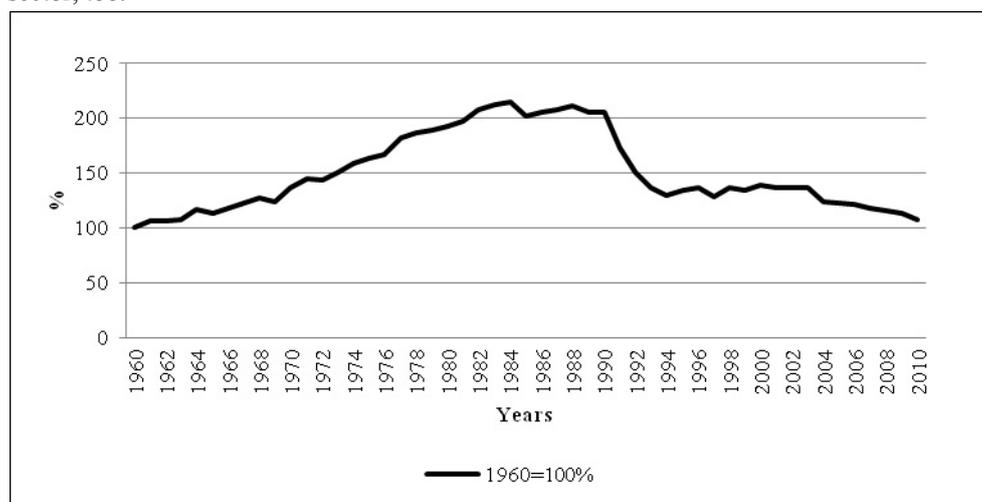


Fig. 1: Gross production index of livestock breeding between 1960. and 2010.

Source: own work on the basis of KSh publication [Mezőgazdaság,, 2012].

The structure of land utilization significantly affects the performance of agricultural production. In Hungary, the livestock number has dramatically decreased from 1990, following the social transition, and it has resulted in considerable changes in land use. Subsequently, new possibilities should be explored in order to improve the stability and profitability of agricultural sector. In addition to the well-known ways of use like food production, industrial raw material production, fodder production, herbs production, nature protection, recreation services, environmental maintenance, a new alternative has emerged: the energy raw material production, which offers new ways of utilizing the redundant stocks thus improving the situation of agricultural sector and reducing our energy dependence.

It is obvious from Table 1 that Hungary needs significant volumes of imports with regard to crude oil and natural gas consumption. The import of natural gas is 2.9 times higher than the domestic production, while the crude oil import is almost 6,9 times higher. Our energy dependence is around 70% at present, due to the scarce stocks and because the marginal cost of their exploitation is higher than the market price. Hungary can ease this dependence by growing energy crops and producing bioenergy from them. In order to implement this, however, the questions of land use should be discussed because the security of food supply cannot be harmed.

Table 1: Energy production and imports of Hungary in 2009

Type of energy resource	Production		Imports	
	Tj	%	Tj	%
Coal	65 104	14.20	47 117	6.43
Oil	33 055	7.21	226 747	30.93
Natural gas	113 760	24.81	331 059	45.16
Firewood and other biomass	76 404	16.66	1 294	0.18
Electric energy	170 155	37.12	126 923	17.30
Total energy consumption	458 478	100.00	733 140	100.00

Source: Own work on the basis of reports [Energiamérleg... 2012].

Branch of cultivation means the method of utilizing the soil. In the recent decades the territory of the country was as follows in terms of different ways of land use and cultivation branches:

Table 2: Branches of cultivation in Hungary, thousand hectare

Type of land	Year						
	1950	1960	1970	1980	1990	2000	2011
Arable land	5518.1	5309.8	5046.2	4734.7	4712.0	4499.8	4322.3
Vegetable garden	94.4	107.5	146.3	291.4	341.2	101.6	81.5
Orchard	58.1	82.3	171.6	138.4	95.1	95.4	92.4
Vineyard	230.2	203.6	229.7	167.8	138.4	105.9	82.1
Grassland	1474.7	1437.9	1281.3	1294.2	1185.0	1051.2	758.9
Agricultural areas	7375.5	7141.1	6875.1	6626.5	6473.0	5853.9	5337.2
Forests	1165.9	1306.2	1470.7	1610.3	1695.0	1769.6	1921.7
Reeds	29.4	26.1	32.3	37.7	40.4	60.0	65.5
Fish ponds	..	..	..	25.3	26.8	32.0	35.4
Cropland	8570.8	8473.4	8378.1	8299.8	8235.0	7715.5	7359.9
Area withdrawn from cultivation	728.2	829.7	925.1	1003.8	1067.0	1587.5	1943.5

Source: own work on the basis of KSH reports [Magyarország... 2012].

Table 3: Share of agricultural land of Hungary in the total area, %

Type of land	Year						
	1950	1960	1970	1980	1990	2000	2011
Arable land	59.34	57.08	54.24	50.89	50.66	48.37	46.46
Agricultural area	79.31	76.76	73.90	71.23	69.59	62.92	57.37
Cropland	92.17	91.08	90.06	89.21	88.53	82.94	79.11
Area withdrawn from cultivation	7.83	8.92	9.94	10.79	11.47	17.06	20.89

Source: own work on the basis of KSH reports [Magyarország... 2012].

The division of the country according to branches of cultivation is the result of a long historical development [Magda 2001]. In 2011, the cropland occupied 79.11% of the total

9,303.4 hectare area of Hungary. The cropland includes agricultural areas, forests, reeds and fish ponds, the ratio of which has been growing in the recent years. A major part of the agricultural area is the arable land.

The ratio of agricultural area to the total territory of Hungary has decreased by almost 22% in the last 60 years. The most obvious is the reduction of arable land by 13%. The size of land withdrawn from cultivation, however, has doubled since 1950. Industrial development, water settlement, urbanization and modernization of transport networks take away considerable areas from agriculture year by year. Some land is withdrawn from cultivation due to economic reasons. Foodstuff raw material cannot be produced profitably on these areas but they could be utilized for growing energy crops.

The size of territory with unfavourable conditions is 883,558 ha, which is 14% of the total cultivated area. These fields are not competitive in the market due to environmental drawbacks (climate, height above the sea level, soil features, etc.) but farmers on these areas should perform farming activities aimed at the environmental protection or improvement, protection of landscape as well as maintenance of touristic attractiveness of the region. The fertility of soil is worse on these areas, therefore the yield is much smaller than on better land [Kukovics 1972]. State subsidies can be requested for the cultivation of these areas, but it is stipulated in regulations that no subsidy can be given for the production of wheat, rice, maize, sugar beet, potato, vegetables and industrial crops.

Land utilization is measured on the basis of the value of land area expressed in arable land units. The different branches of cultivation and the arable land used in different ways are transferred into arable units. The changes of land utilization index is introduced in Table 4.

Table 4: Land utilization index in Hungary between 1990 and 2011, %

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Land utilization index	79.56	79.42	82.35	81.68	81.70	81.18	81.07	80.94	80.88	80.72	79.32
Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Land utilization index	78.70	78.54	78.49	78.53	77.99	78.01	77.97	77.30	77.21	77.35	77.19

Source: own calculation on the basis of data from Central Statistical Office (KSH).

The land utilization index helps to analyse how the land use changed during the examined period. In Hungary, the land use has decreased by 2.37% compared to 1990, which cannot be regarded as a significant change. The land exploitation was 77.19% in 2011.

If the pressure to use biofuels increases, the demand for raw materials will be greater. The prices will grow together with the demand and more people will consider a purchase profitable. It will lead to an increase of cropland at the expense of nature. It is obvious that the land use competition will first damage the natural ecosystems, then the production of raw materials. In this regard, as in case of other European intents of environmental improvement, the environmental load will be shifted to the third world, too [Gyulai 2010].

The raw materials for biofuels can be produced on land transformed directly from other category of land into agricultural field. If, however, these crops are grown on existing agricultural plots, it can oust the production of other crops which ends in the conversion of the land into agricultural area. This indirect impact manifests itself in the changing demand

in the world market for agricultural raw materials and substituting products. The price change can alter the behaviour of market actors, it may lead to increased land use, which often results in modifications in land use. The higher prices can also stimulate the market actors to increase the volume of yield on the existing agricultural areas [Report... 2010]

## Results

Hereinafter the eleven-year changes of yield averages, sowing area and sales price of two crops, wheat and rape, are analyzed. These crops serve not only as foodstuffs but also as raw materials for alternative energy sources.

Table 5: Wheat production output in Hungary during the last eleven years

Calculation item	Year										
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Median yield, t/ha	4.31	3.52	2.64	5.12	4.50	4.07	3.59	4.98	3.85	3.71	4.21
2001=100%	100.00	81.69	61.26	118.72	104.40	94.47	83.22	115.58	89.42	85.96	97.71
Sowing area, thousand ha	1208.7	1112.2	1116.7	1176.4	1136.5	1091.4	1115.1	1125.6	1156.1	1065.6	986.9
2001=100%	100.00	92.02	92.39	97.33	94.03	90.30	92.26	93.13	95.65	88.16	81.65
Sales price, EUR/t	113.53	96.62	126.74	123.81	90.99	105.80	174.97	165.71	97.44	136.23	191.70
2001=100%	100.00	85.10	111.64	109.05	80.15	93.19	154.12	145.97	85.83	119.99	168.86

Source: own work on the basis of KSH (Central Statistical Office) and BÉT (Budapest Stock Exchange) databases.

Table 6: Rape production output in Hungary during the last eleven years

Calculation item	Year										
	2001.	2002.	2003.	2004.	2005.	2006.	2007.	2008.	2009.	2010.	2011.
Median yield, t/ha	1.87	1.60	1.52	2.78	2.31	2.38	2.20	2.65	2.22	2.16	2.23
2001=100%	100.00	85.77	81.43	148.45	123.53	127.22	117.67	141.89	118.92	115.63	119.54
Sowing area thousand ha	110.94	128.30	81.73	103.78	122.72	144.72	223.58	251.91	267.22	265.16	240.02
2001=100%	100.00	115.65	73.68	93.55	110.63	130.46	201.54	227.08	240.88	239.02	216.36
Sales price, EUR/t	206.55	209.90	228.66	194.97	..	235.68	293.69	371.18	250.00	320.48	433.98
2001=100%	100.00	101.62	110.70	94.39	..	114.10	142.19	179.70	121.03	155.16	210.11

Source: own work on the basis of KSH (Central Statistical Office) and BÉT (Budapest Stock Exchange) databases.

One of the most important cereals in Hungary is wheat. Its sowing area has been about 1.1 million hectare on average in the last 10 years, but it is decreasing. The yield average is

4 t/ha, which is also affected by the weather. In drought-stricken years the median yield is below 4 t/ha. The sales price depends on the quality of wheat and the quantity of crop, too. The sales price of wheat had a peak in 2007, which was a very dry year. The sales price was the best in 2011.

The median yield of rape was 2.12 t/ha in the last ten years. The importance of rape is constantly increasing, its sowing area has doubled as compared to 2001. Rape is grown on bigger areas mostly for eating purposes but also because the rape production can be well mechanized and the by-products of oil making are valuable fodder. The sales price of rape has also more than doubled in the recent years.

The territorial limits of substituting our full energy consumption are demonstrated by the case of rape. The rape would give 1.45 tonne of rape oil in case of 3 t/ha/year yield. The heating value of this oil is 40MJ/kg. (Table 6. shows that there is no such median yield in Hungary.) It is 58 GJ/ha/year, and 539.4 PJ on 9.3 million hectare. So about half of the total average energy demand could be met with rape. According to the literature, in case of rape half energy should be reinvested for the production of this amount of pure energy [Gyulai 2010].

1293 million liters of petrol and 1587 million liters of diesel oil were consumed in 2011. Since we do not know how much our fuel consumption will be in 2020, we presume on the basis of data of 2011 that 10% of this consumption should be replaced by biomass in the transport sector. If in case of ethanol, we calculate with 1200 l/ha annual production, in case of biodiesel with 1400 l/ha [Gyulai 2010, p. 63] we need about 221 thousand hectare of land for this. It could be satisfied by involving the non-utilized areas (the size of not-utilized agricultural areas was 240 thousand hectare in 2007 [Bai 2008]) but we still do not include the biomass energy used not for transport purposes which would significantly increase the land size required for this.

Moreover, as the by-product of food production, there is about 8-10 million ton maize stalk and straw available as well as other by-products like e.g. vine-shoots and sunflower stems, and only part of these should be returned to the soil as nutrient. The remaining quantity could be used for energy production, so it would not be necessary to involve further land plots into energy crop production.

## Conclusions

Although it seems to be a good idea to grow less soil-intensive, ligneous energy crops because they reduce the fertility of land only slightly, in author's opinion those energy crops should be farmed in Hungary which can also be utilized for human consumption after a year of weaker yield. Following a year of better yield, however, the remaining part, above the fodder and foodstuff needs, can be utilized for energy purposes. The areas which are not cultivated for economic purposes can be involved and thus the soil decay can also be decreased.

If, however, the farmers regard energy crop production more profitable than traditional crop production, it can happen that the changing demand increases the prices of agricultural food products which might lead to the expansion of cropland and the modification of land use. It would also endanger the safety of food supply.

Considering the safety of food supply, it seems to be necessary to develop a background industry which undertakes the profitable processing of agricultural by-products, which are available in great quantities, for the purposes of energetics.

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