COMPETITION FOR LAND RESOURCES RESULTING FROM BIOENERGY DEVELOPMENT: THEORETICAL APPROACH

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It is well established that agriculture-based bioenergy development has direct and indirect effects in economic, social, and environmental fields. In social and economic fields, some effects emerge as a result of a close interaction between biofuel and agricultural product markets. Such interaction arises where agricultural products are used to satisfy both food and energy demands. Consequently, this interaction gives rise to competition for agricultural products, including land resources, between biofuel and food industries. Generally the levels of competition intensity depend on the availability of land resources, which essentially determines the potential volumes of agricultural production where other traditional measures for increasing production volumes are exhausted.

The article aims to reveal a theoretical approach towards competition for land resources resulting from bioenergy development and to formulate preconditions for minimizing this competition. The research methods include monographic method, analysis for comparison of different opinions, analysis and synthesis of scientific literature, generalization, modeling, and logical abstraction techniques.

In many cases, various bioenergy development studies and models make only a passing reference to the issue of land resources. This article reveals competition for land resources triggered by agriculture-based bioenergy development, the preconditions for its formation and possible ways of manifestation. It discusses the competition for land resources through land conversion and land reallocation. Furthermore, it looks at the most common arguments to deny the competition for land resources, its scope and importance. These arguments are usually grounded on the possibilities of improving agricultural productivity and the use of additional or set-aside land that is marginal in terms of food/fiber production. Some bioenergy development scenarios consider waste generated in food/fiber production to be the main source for biofuels production.

One of the main outcomes of this article is a theoretical model of changes in the use of land resources under the conditions of intense bioenergy development, which focuses on the national level. This model displays the distribution of land resources in both pre-bioenergy and post-bioenergy environment. Following this model preconditions for minimizing competition for land resources are presented. Firstly there are discussed a view on exogenously restricted allocation of land resources, which is vital to preventing food shortages and food price shocks in the short term. On the other hand there are also presented a viewpoint that government regulation (various prohibitions) cannot bring about an appreciable effect in this land resource allocation area. However, the experience of various countries shows that subject to political regulation of the said competitive area coexistence of the production of biofuels and food is basically possible.

Key words: bioenergy, biofuels, competition, land resources, land conversion, land reallocation, agricultural products, biomass.

JEL Code: Q24, Q28, Q42, R14.

Introduction

Depletion of conventional energy sources leads to a more rapid uptake and broader use of renewable energy sources, including bioenergy. According to the data of the international organization Renewable Energy Policy Network for the 21st Century (REN21) (REN21, 2010) about 18 percent of global energy production came from renewable sources and by 2010 reached a turning point in the context of global energy supply. During the period 2007 - 2009 the number of countries engaged in specific programs of renewable energy development increased from 68 to 85. European Union (EU) Member States also have high ambitions to develop alternative energy. Those countries should reach the target of meeting at least 20 percent of total energy needs from renewable sources. (European Commission, 2010a). Already now Germany, France and some other EU Member States are world leaders in different areas of renewable energy development.

Among renewable energy sources, bioenergy has an important place. There is a rapid increase in the supply of bioenergy, which is commonly associated with the production and placing on the market first generation biofuels (Rathmann et al., 2010). Bioenergy enjoys advantages over conventional energy. The advantages can be seen in both environmental and socio-economic fields.

In defining the environmental benefits, it should be emphasized that bioenergy extraction produces low levels of net CO₂ emissions (Berndes et al., 2003, Ignaciuk et al., 2006). Furthermore, bioenergy contributes to the supply of sustaining power and it is essential in pursuance of sustain-
The main problem lies in the potential of bioenergy being harvested from potential socio-economic problems. Here, undesirable effects of this development are clearly understood and they are given increasingly more consideration, there is a constant debate on possible undesirable effects of this development. Intensive bioenergy development based on existing technologies is inexcusable from potential socio-economic problems. Here the main problem lies in the potential of bioenergy (equated with the production of biofuels) being largely identical to the potential of producing raw materials for food. With the high rates of bioenergy development and limited and/or ineffective extraction of biomass from non-agricultural land areas, it becomes apparent that land areas are diverted from their original and main purpose, i.e. food and feed production. Larger or smaller agricultural land areas are used to produce biomass, which is intended specifically for bioenergy purposes, while agricultural products that are normally allocated for food and feed, are put to an alternative use (biofuels production). This can be described as the reallocation of agricultural land for the needs of food industry and bioenergy, which creates a fundamental contradiction between the solution of problems of providing with food and energy.

For all those reasons, the interaction between biofuel and agricultural product markets and the problem of a sufficient supply of agricultural products for food and non-food needs (bioenergy in particular) are becoming increasingly evident (BRDB, 2009). This is a big challenge for agriculture of any country, including the EU Member States. As pointed out by Ignaciuk et al. (2006), Europe creates favourable conditions for a growing demand for biofuels. On the other hand, the land resources and their productivity growth potential for additional agricultural production are insufficient. Scarcity of land resources, the demand for a fast development of bioenergy and the posed challenges of food security lead to a new trend in the agrarian economy: increasing competition for land resources for food industry and bioenergy development. This new trend has to be fully investigated and modeled by researchers.

Research aim: to reveal a theoretical approach towards competition for land resources resulting from bioenergy development and to formulate preconditions for minimizing this competition.

Research tasks:
1. to discuss competition for land resources for food and bioenergy needs, preconditions for its emergence, and potential effects;
2. to reveal the theoretical aspects of land resource allocation for bioenergy needs by creating a theoretical model of changes in land use with regard of the potential competition for land resources and to formulate preconditions for minimizing this competition.

Research object: competition in the field of land resources.

In this article, land resources are understood as agricultural land which is used or could potentially be used for agricultural production for food and bioenergy needs. The study relates exclusively to the field of bioenergy, which is associated with the use of agricultural products (agriculture-based bioenergy development).

Research methods: the article is based on monographic method, analysis for comparison of different opinions, analysis and synthesis of scientific literature, generalization, modeling, and logical abstraction techniques.

Competition for land resources, its essence, preconditions for emergence, and possible effects

All countries have old traditions of using biomass for energy generation. Meanwhile, bioenergy as an industry and a business is only coming into being by gaining essential competitive advantages in the market. The bioenergy production chain is long and complicated. In bioenergy development, land and other agricultural production resources become an input in the bioenergy production chain. Agricultural products, which are commonly considered to be an input of the food production chain, also become an input in the bioenergy production chain (Rathamann et al., 2010). In other words, a certain amount of land resources lies under each first-generation biofuels unit, which was not used for other needs, such as food, fiber or feed. Bioenergy leaves its ecological footprint not so much through land resources needed to absorb carbon dioxide emissions but rather through the amount of land resources required for biomass production. It should be noted that in the bioenergy production and consumption chain the competition is likely to emerge for: (a) land and other production resources; (b) agricultural products; (c) intermediate bioproducts; and (d) energy market share. To get a better view of the competition, which keeps increasing due to the bioenergy development, it is necessary to take into account the so-called displacement impact. According to Madlener and Myles (2000), there are two possible forms of this displacement:
1. market displacement; and
2. factor displacement.

Market displacement. Increasing amounts of biofuels provided by the market lead to a displacement of the energy market, which is related to changes in the market structure of energy sources. In the market, a certain
amount of electricity and/or heat obtained from conventional sources is to a certain extent replaced and/or supplemented by bioenergy supply. Furthermore, this displacement causes certain consequences of the competition in the energy market and increases the demand for agricultural products as raw materials for bioenergy. The agricultural product market that used to satisfy the food and fiber producers’ demand now sees a new source of demand opening up: a demand generated by bioenergy producers. According to Ignaciuk et al. (2004), who cite Azar (op. cit.), increasing growth of biofuels production can make significant adjustments to the prices for relevant agricultural products. The markets of individual agricultural products show high sensitivity to the new source of demand. Usually, significant growth in the production of certain products results in a reduction in the production volumes of others (BRDB, 2009) due to a decrease in the land resources allocated thereto. This is related to the so-called factor displacement.

Factor displacement. Factor displacement is affected by displacements in the bioenergy production chain. With the growing demand for bioenergy and thus for agricultural products, major changes can also emerge in the allocation of land as the main agricultural resource. Participation in the bioenergy chain is an individual decision of a farmer. The return of agricultural activities depends on how different cultures are spread on a fixed land area (Rathmann et al., 2010). The growing biofuels market can adjust their farming activities and affect the current land-use structure (Rathmann et al. 2010; Ignaciuk et al. 2006; RUBIRES, 2010). Rathmann et al. (2010) describe this phenomenon as increasing dynamics of land-use changes. An effect may also result from region-specific land-use characteristics, the farmers’ existing knowledge, technologies, and government policies.

Basically, farmers are motivated by expectations of future markets. Typically, these expectations are concerned only with short-term (Rathmann et al., 2010). Expectations of high returns from energy crops prompt to increase the areas of these crops. Rathmann et al. (2010) and Ignaciuk et al. (2006) cite Borjesson (op. cit.) and argue that conversion of a part of agricultural land to plantations of biomass for energy would lead to scarcity of land resources for food production. According to Hart (op. cit.), it is unlikely that sufficient additional amounts of required land resources would be gained from uncultivated or less fertile land since such option is available only in individual cases (Ignaciuk et al., 2006). When less fertile land is used for the production of energy plants, there is an additional burden not only on the land resources but also on the environment. The endeavor to obtain yields comparable to the yields from good quality soils call for resource-intensive technologies, and this, in its turn, produces negative effects on the environment.

The issues of land resource sufficiency for food, fiber, bioenergy, and other needs have been addressed by scientists for more than a decade. The outset of “food or bioenergy” dilemma dates back to 1970, when the search for alternatives to conventional energy sources got underway (Rathmann et al. 2010; Timilsina, Shrestha, 2010). The interest in biofuels was triggered by the 1970s oil crisis. However, the breakthrough of biofuels was impeded by the lack of competitiveness, which inherently reduced the competition for land resources between biofuels and food products. Obviously, this reduced the urgency of the problem of competition.

In recent years, the growth of biofuel production has been moderate but nevertheless persistent. There have also been changes in the production of their raw materials (Ajanovic, 2010). Its growth was coupled with a growing demand for land resources. Consequently, there are growing numbers of global scientific debates over biofuels competing with food, feed and fibre due to the limited arable land resources and the effects of such competition (Rathmann et al., 2010). According to Walsh (1998), it is imperative to deepen the scientific understanding of the competition arising from the allocation of land resources for bioenergy and food production. The issues of competition for land resources are addressed by Berndes et al. (2003), Ignaciuk et al. (2006), Rathmann et al. (2010), Bergsma et al. (2006) and Doran (2009), Keeney and Hertel (2009), Rosegrant et al. (2006), Ros et al. (2010), and others.

The analysis of the various approaches to the competition resulting from bioenergy development requires taking into account biofuel sources in the first place. There are many potential biofuel sources. Theoretically, biofuels can be produced from any organic material. Scientific literature (Diamantidis, Koukios, 2000, European Environment Agency, 2006, De Wit, Faaij, 2010) usually provides the following sources for biofuel production:

1. forest biomass including logging and woodworking waste;
2. agricultural crops (e.g. wheat, corn, rapeseed, sugar cane, etc.) and their waste (e.g. straw);
3. short rotation energy crops (e.g., willow, hybrid poplar, etc.);
4. animal waste (such as livestock and poultry manure);
5. organic waste from food industries;
6. organic material accumulated in sewage sludge;
7. organic fraction of municipal waste.

It should be noted that the research analyses agriculture-based bioenergy development and therefore the focus is placed on biomass from agriculture and the resources needed to produce it. The resource category is constricted to the most complicated field: land resources. To analyse the competition for land resources resulting
from bioenergy development, all biofuel sources can be conditionally divided into two groups:

I. **group one** – sources that do not require specifically allocated land resources. They include forest biomass, livestock, food industry and agricultural crops waste, sewage and municipal waste organic fractions.

II. **group two** – sources that require specifically allocated land resources. They include agricultural crops and bioenergy crops. Land resources used to provide biomass for energy production can be two-fold: 1) abandoned and other land areas that are not used (set aside) in agricultural activities due to low yields or food surplus, 2) land used for agriculture.

All of the first group and the second group biofuel sources that do not require areas already used for agricultural activities do not give rise to competition for land resources. Based on this argument, some researchers (Evans, 1992; Berndes et al., 2003) argue that bioenergy development potential, where competition for land resources for agricultural use is eliminated, is physically possible. They think that bioenergy production is likely to evolve through better waste disposal and use of land resources non-included into the production of agricultural products, and thus making no impact on the global food supply. This is also supported by Ignaciuk et al. (2006), Johnston and Holloway (2007); similar approaches can be found in some scientific studies (e.g., BRDB, 2009).

These statements can be accepted only to a certain extent. Most of the arguments denying the competition for land resources also reject the possibility of a diverse land use. This is contrary to the previously made assertion that farmers are directing their existing resources to economic activities that generate the highest returns. Furthermore, bioenergy production by using waste and cultivating biomass on abandoned and set aside land is limited in respect of waste and land, and therefore, it is only possible at the initial stages of the development of bioenergy, when the needs for biomass for this purpose are not high. Only then such needs can be satisfied without using land resources dedicated for food and fiber needs. At later stages of development, land resources, which are used for food and fiber, can be included into the production of raw materials for bioenergy on a competitive basis. Moreover, according to Ravindranath et al. (2010), it should be borne in mind that currently economically viable production of the first generation biofuels is based mainly on the use of food and feed agricultural products.

The changes in land use that occur as a result of the competition for land resources are influenced by both internal and external factors (Rathmann et al., 2010). These factors may reduce the competition for land resources. The growth of agricultural productivity should be regarded as the key internal factor, whereas the increase in the efficiency of biomass conversion into biofuels should be attributed to external factors. Although the efficiency of the biomass conversion into biofuels is growing, the possibilities to reduce the competition for land resources are doubtful. The main reservations are related to the economic theory called Jevons Paradox (Alcott, 2005; Sorrell, 2009). An increase in the efficiency with which a resource is used tends to increase (rather than decrease) the rate of consumption of that resource.

There are also technological and economic factors that determine the involvement of land resources used for agricultural purposes in energy biomass production. The production technologies of biodiesel, ethanol and some other dominant bioenergy products commonly use agricultural products (rape, cereals, etc.) produced on land intended for agricultural activities rather than waste. Moreover, bioenergy has to be competitive against other energy produced from renewable energy or conventional sources. Therefore, bioenergy raw materials must be cheap. They can be most effectively grown on fertile farmland with an intensive use of fertilizers, plant protection measures, and cutting-edge technologies. Obviously, that facilitates the harvesting of those raw materials. Neither the costs nor the quality of biomass produced in natural systems meet the modern requirements of biocatalysis (Gutierrez, Zhang, 2009).

While identifying the potential competition for agricultural land resources, it is important to distinguish target energy crop plantations from traditional commodity crops. Establishment of energy crop plantations leads to a displacement of land as a production factor, which takes the form of a decrease in relevant land areas intended for food. Traditional agricultural products, both food and bioenergy needs, are grown in the same areas and the competition between bioenergy and food is not directly related to the land resources but rather to the produced agricultural products, and it takes place in agricultural commodity markets. The competition for agricultural products exists between food/fiber producers and biofuel producers. This competition may result from: agricultural product market prices (corn, wheat, rape); food prices; prices of conventional energy sources or even other renewable energy sources; cost-effective bioenergy production technology; bioenergy user-friendliness; and energy and environmental policy.

Discussions on competition for land resources inevitably touch upon its effects. When elaborating on those effects, it should be noted that they are primarily concerned with the aforementioned factor displacement, when the increasing demand for bioenergy raw materials can lead to a change in the structure of land resources. According to Ros et al. (2008), the effects produced by the development of bioenergy can be generally divided into direct and indirect.

**Direct effects.** Direct effects directly and exclusively relate to the bioenergy production and consumption chain. This chain uses resources, generates a certain emission, provides services or products, and employs people. The
changes in these categories are considered as direct effects (Ros et al., 2008). Such direct effects include: certain changes in land use, changes in water resource use, changes in labour resources, profit changes, changes in greenhouse gas emissions, etc. Since those effects are directly linked to the production-consumption chain, they can be controlled by the production chain players.

**Indirect effects.** Indirect effects are caused by the introduction of biofuels in the energy resource structure, however they cannot be directly associated with the production-consumption chain (Ros et al. 2008). Indirect effects include any effects that manifest themselves in all activities while their expression can be reasonably identified.

When the effects of competition for land resources are singled out, it is appropriate to draw attention to a number of similar but essentially different processes that affect the changes in land use: 1) land involvement; 2) land conversion; 3) land reallocation.

**Land involvement.** This can be seen as involvement of less fertile land into the production of raw materials for bioenergy. Ros et al. (2008) argue that in the instances where poor soil (the authors assume that the soil does not generate any agricultural or forestry products) is taken for biomass cultivation all the resulting effects are direct effects, however no competition is observed.

**Land conversion.** Land conversion means a change in the land-use. New land areas, which previously used to be passively exploited, would be taken for bio raw material production, where intensive production of bio raw materials would start. This would produce an additional amount of biomass required for agriculture-based bioenergy development. New sources of land for biomass production include pastures and rangelands (BRDB, 2009) or land that is free due to low yields. Generally, this is referred to as an indirect land-use change effect. It should be noted that land conversion is an important aspect for the environmental issues, as it is likely to affect the carbon cycle. High food, feed and energy crop prices may result in the conversion of pasture and forest land to farming land, which may affect the sustainability. In this study, this aspect is not addressed. It must be noted that land conversion effects are attributed to indirect effects.

**Land reallocation.** In this case it means allocation of the existing agricultural land for various uses (production of raw materials for food, fiber, and bioenergy). When land resources are reallocated, some of them can be used for biomass plantations. Most studies consider biomass plantations to be the main source of biomass energy (Berndes et al., 2003). Some authors (Ignaciuk et al., 2006) no longer attribute that to agricultural production. It is noted that the expansion of biomass plantations would reduce land areas suitable for agricultural production (ibid.). Therefore, it may lead to agricultural intensification and a need for changes in consumption patterns. There is another specific change that could be attributed to land reallocation. Some land areas are used to produce export production, therefore theoretically some land resources can be considered to be allocated for export needs. Some studies address the possibility to use those areas for bioenergy needs (EEA, 2006), which would lead to the effect of a decrease in agricultural export potential. Land reallocation effects are also attributed to indirect effects.

Under land reallocation, when energy biomass cultivation starts on the existing fertile land (e.g., agricultural land, which was previously used for food, feed, and fiber production), indirect effects become apparent. Then, the primary agricultural crops have to be grown somewhere else or the consumption habits must change (Ros et al. 2010). In other words, the consumer behaviour should change. Lately, such agricultural production "change" is increasingly discussed in the literature (Searchinger et al., 2008, Fargione et al., 2008). Consumers do not always have the possibility to change their behaviour (consumption habits), particularly regarding basic consumer goods. When agricultural products are used for both food and bioenergy, the supply of those products may fail to meet the demand, and consequently that would result in reduced agricultural supplies and a destabilised market. That manifests itself through fluctuations of agricultural product prices in international and domestic markets. It is often difficult to say unequivocally what are the major causes of such fluctuations, however, it is recognized that an intensive development of bioenergy has an effect on them (Schmidhuber, 2006, FAO, 2009). Price fluctuations are determined not only by the differences in demand and supply but also by the expectations of the possible difference between them in the future.

Whether the development of bioenergy will affect agriculture towards extensification/intensification depends on land involvement, conversion, and reallocation opportunities. Extensification ensues from expansion of cultivated land that can be used to produce energy biomass. Limited land involvement, conversion and reallocation opportunities give rise to production intensification, i.e. an increase in the yields from the same unit of area. Technological achievements also contribute to the intensive growth of agricultural productivity. Intensification potentially limits the competition for land resources but increases the demand for other factors of production. Failing to meet the growing demand for bio raw materials by increasing the yields, it would be necessary to exploit previously unused land areas or to impose further restrictions on food, feed or fiber crop production in order to satisfy energy needs. This should be taken into account when allocation of land resources for bioenergy purposes is planned.
Theoretical aspects of land allocation for bioenergy needs

As noted before, bioenergy development and food security represent two national strategic objectives. In pursuance of both goals competition for land resources can emerge. It can be observed when bioenergy development policies are modeled on various levels. Those pre-conditions for competition emergence have been discussed above. Compatibility of the said goals can be sought in different ways, through various policies and measures. For this purpose, a targeted bioenergy development policy is formulated. Minimization of competition for land resources should be one of the most important tasks of the bioenergy development policy. Such policy-making cannot do without specific agriculture-based bioenergy development principles.

In order to formulate agriculture-based bioenergy development principles, potential changes in land-use associated with an intensive development of bioenergy must be taken into account. A theoretical model of changes in land-use under intensive bioenergy development conditions may serve this purpose (Figure 1). Such models are based on a positive attitude, which takes into account the potential land-use changes. The positive attitude is revealed through the biomass potential approach, which is used in many models of bioenergy development (RUBIRES, 2009).

![Figure 1. Theoretical model of changes in land use under intensive bioenergy development conditions (concluded by the authors)](image)

It should be noted that to find a solution to the problem of competition for land resources it is necessary to take a normative approach, which lays down how the land resources should be distributed or how the distribution should be performed. It must be said that the model focuses on the production of first generation biofuels that is mainly based on agricultural products, which means potential competition for land resources.

The land resources in Figure 1 comprise non-targeted land and agricultural land, which in its turn can be subdivided into temporarily set-aside land, traditional agricultural crops (e.g. cereals), and non-traditional crops (e.g. medicinal herbs, flavoring herbs, etc.). One of the factors increasing the demand for the said land is agriculture-based bioenergy development. Those needs may also be boosted by other factors such as a strong economic growth in some countries (e.g. China, India), leading to a large demand for food and non-food products. The changes in the structure of land resources caused by bioenergy development are likely to result in shrinking non-targeted land and temporarily set-aside areas. This process can feature both inclusion of temporarily set-aside land and conversion of the non-targeted land to agricultural areas. That would likely allow maintaining unshrinking areas of traditional agricultural crops. Those areas are important in meeting the demand for agricultural products, which stems from both the growing demand for agricultural products and the growing demand for biofuels (ethanol, biodiesel). In other words, adequate areas of traditional crops are an important factor in maintaining the food system adaptability (or adaptive capacity). The adaptive capacity depends on the geographical location of the country, its economic development level, natural resources, social environment, institutions, government, and technologies.
Bioenergy development can lead to one of the main changes in land-use: increasing land areas devoted to energy crop plantations. The initial land resource composition contains energy crop plantations, which are considered to be scarce and thus they are not separated from non-traditional agricultural crops.

The land resources described in the model generate both primary products and by-products that can be used for bioenergy and other purposes. The proposed model identifies three groups of products: agricultural products (obtained from traditional and non-traditional agricultural crops), biomass suitable for energy needs only (produced on energy crop plantations), and waste or by-products arising from the aforesaid production and processing. It should be noted that the waste that is suitable for bioenergy production can also be derived from other economic activities (forestry, food industry, public utilities, etc.).

The model also indicates that moderate agricultural intensification, balanced with the requirements of the good farming practice, can help to mitigate the competition for land resources between biofuels and food production. It should be noted that the quantity of agricultural products that can be used as raw materials by food and fiber industries is also affected by foreign trade flows. Big volumes of imports of agricultural products can allow larger quantities of locally produced agricultural products to be used for bioenergy; however, that would undermine food security. Conversely, intensive agricultural product exports reduce the opportunities for locally produced agricultural products to be used for bioenergy needs. Furthermore, it should be emphasized that non-agricultural biomass (generated from other activities), for example, peat, wood, etc., can also be used for bioenergy.

Bioenergy development needs a compromise not only with land resources used for food production but also the land resources falling on natural systems (Bergsma et al., 2006). The areas that belong to natural systems are not reflected in the model. However, it can be assumed that the need to increase land areas required for food and energy production can reduce the land areas belonging to natural systems.

Some authors (Rathaman et al., 2010) argue that there is no guarantee that the development of bioenergy is not going to aim at the existing agricultural land, which is devoted to traditional crop production. According to the said authors, subject to an increase in areas used for energy plantations, changes in the structure of fertile land resources is quite likely. This can be caused by subjective decisions of farmers, their expectations for the future, a user-friendly infrastructure, etc.

Most countries have ambitions to develop bioenergy by using superfluous, deteriorating, and marginal land (Ravindranath et al., 2010) and thus to reduce the competition for land resources. Some authors (Charlton et al., 2009) think that biofuel competition with food production can be reduced by growing non-food products. However, this type of bioenergy development still exposes competition for agricultural land (Timilsina, Shrestha, 2010) (e.g. growth of energy plantation areas in Figure 1). Therefore, there are attempts to find ways to minimize this competition. That benefits from clear principles of the development of bioenergy and a targeted bioenergy development policy that takes into account different effects of bioenergy development, including competition for land resources.

As mentioned above, the attempts to find a solution to the problem of competition for land resources require a normative approach. It is true to say that this approach is based on the "food first" paradigm (De Wit, Faaij, 2009). It is argued that a country (or region) must maintain a certain level of food and feed self-sufficiency. John Lozier (quoted in Straten, 2007) suggests that a country has to produce about 90 percent of food and feed it needs. This approach may also be supplemented by bioeconomic approach, which takes into account the economic and environmental aspects of bioenergy development (RUBIRES, 2009). Walsh (2008) emphasizes that the allocation of land resources for bioenergy must be determined exogenously, which is also consistent with the normative approach. The main reasons for this allocation are based on the need to increase energy crop areas, which is consequent on the expectation that prices of raw materials for bioenergy will increase. However, significant amounts of land are required to meet food needs, which are basic necessities above all. Therefore, in order to preserve social stability, it is advisable to determine the limits of land-use changes exogenously. The maximum amounts of land allocation for bioenergy may be determined in several ways (Walsh, 2008): (a) a percentage of the total land resources (land suitable for agricultural production), (b) the difference between the total land resources and the average quantity of land resources satisfying the food and feed needs, (c) only idle lands is used for production of bioenergy raw materials.

The preconditions for competition for land resources caused by agriculture-based bioenergy are discussed above. Nevertheless, according to Ajanovic (2010), coexistence of the production of biofuels and food is basically possible subject to political regulation of this competitive area. However, this may take a variety of ways. In particular, it is necessary to ensure that sufficient agricultural resources are allocated to traditional agricultural crops. It is argued that straightforward bioenergy development principles, which would serve a point of reference in making a clear bioenergy development policy, could improve the coexistence and mitigate the competition. Minimizing the described competition for land resources is among the challenges of the policy.

The key agriculture-based bioenergy development principles, which enable to pursue coexistence between biofuels and food production, include:

- priority of food security over bioenergy development (increased energy security) (De Wit, Faaij, 2009; Walsh, 2008);
• priority development of bioenergy based on waste and biomass, generated from non-targeted land or temporarily set-aside areas (Bergsma et al. 2006; Prabhakaran, Elder 2009; Timilsina, Shrestha, 2010; Ravindranath et al., 2010);
• moderate intensification of agricultural production (increasing yields on existing energy crop plantations) combined with good farming practice requirements (Bergsma et al., 2006, Prabhakaran, Elder 2009; Rathmann et al., 2010);
• bioenergy development at the expense of agricultural exports (Timilsina, Shrestha, 2010);
• competitiveness with respect of conventional and other alternative energy sources.

The moderate agricultural intensification principle can sound rather contradictory. Prabhakaran and Elder (2009) note that various studies try to assess how much agricultural land would free for various needs as a result of increased agricultural productivity. According to Gutterson and Zhang (2009), the best way to maximize biodiversity in the region is to increase agricultural productivity. Productivity growth helps to prevent destruction of forests and other environmentally destructive economic activities (Prabhakaran, Elder, 2009). Productivity growth is often inseparable from intensification of agricultural production. It allows maximizing land resources which can be diverted from the production without reducing the product and returned to natural environmental systems, thus enhancing biodiversity.

Based on the above-formulated principles, the directions for agriculture-based bioenergy development can be formulated (Table 1). The table below shows the preconditions for bioenergy development in a particular direction and the potential negative social and economic consequences. A bioenergy development direction chosen by a country or a region is specific, since it depends on various circumstances. It should be noted that in practice a few directions of bioenergy development can be selected. It is worth mentioning that satisfaction of the local demand for bioenergy is a priority over biofuels exports (RUBIRES, 2009).

Table 1. Potential negative social and economic consequences of agriculture-based bioenergy development (concluded by the authors)

<table>
<thead>
<tr>
<th>Agriculture-based bioenergy development directions</th>
<th>Preconditions</th>
<th>Potential negative social and economic consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Based on waste</td>
<td>Environmentally-friendly technologies</td>
<td>N/A</td>
</tr>
<tr>
<td>Based on food and non-food crops from non-targeted land and temporarily set aside areas</td>
<td>Set-aside land returned to production with regard of its economic potential, Environmentally friendly technologies, Products suitable for food applications, which are used for bioenergy needs, are surplus products</td>
<td>N/A</td>
</tr>
<tr>
<td>Based on food and non-food crops, when the crop structure features an increasing share of crops with the largest energy potential</td>
<td>Environmentally friendly technologies</td>
<td>Socially undesirable land-use changes, Competition for land resources</td>
</tr>
<tr>
<td>Reduction of agricultural exports</td>
<td>Regular exports of agricultural products suitable for bioenergy</td>
<td>An adverse impact on the foreign trade balance due to agricultural and food products export decrease</td>
</tr>
<tr>
<td>Based on energy crop plantation</td>
<td>Environmentally friendly technologies, Economically viable second-generation biofuels</td>
<td>Socially undesirable land-use changes, Land resources are diverted from traditional crop production for years to come, Competition for land resources</td>
</tr>
</tbody>
</table>

It is necessary to notice that this priority is prevalent in European countries (Timilsina, Shrestha, 2010). Most countries fail to satisfy the set national bioenergy consumption volumes with domestic production capacities only. As a result, this is achieved with recourse to foreign trade.

The directions are arranged in order of priority based on the formulated negative social and economic consequences of bioenergy development. Agriculture-based bioenergy development directions in order of priority are as follows:

1) bioenergy development based on waste;
2) bioenergy development based on food and non-food crops from non-targeted land and temporarily set-aside areas;
3) bioenergy development based on food and non-food crops, when the crop structure features an increasing share of crops with the largest energy potential;
4) bioenergy development by reducing exports of agricultural products;
5) bioenergy development based on energy crop plantations.
The formulated priority directions allow tracing the ways in which the demand for bioenergy should be satisfied in the first place. Most discussions can arise from energy plantations being given the lowest priority. The authors of the article take the view that energy crop plantations required diverting land resources from the production of commodities suitable for food for years to come, and this may pose threats to food security.

While participation in the bioenergy production chain is a decision made by an economic operator, it may nevertheless be influenced by governments and other institutions (Rathamann et al., 2010). The decisions of economic operators may be adjusted by both the EU-level policies and national policies. There are various global and national initiatives investigating land-use alternatives, e.g. Roundtable for Sustainable Biofuels, Roundtable for Sustainable Palm Oil. Most of the initiatives focus on biomass supply problems (Gutterson, Zhang, 2009). Kartha and Larson (2000) note that, in deciding on how much and what resources should be allocated for bioenergy purposes, political mechanisms will be all-important. The authors argue that the market alone may not be an adequate land resource allocation mechanism and it cannot reduce the risks. It must be understood what are the agricultural production development priorities at the local level and what resources will help develop the priority areas.

Intensification of bioenergy development requires changes in related policies. A policy that limits the negative effects of agriculture-based development of bioenergy can be considered suitable. Agriculture-based bioenergy development represents a cross-sectoral challenge. A relevant bioenergy policy coupled with sustainable development practices can result in a synergy effect. In terms of policy areas, it can be distinguished between energy, environmental, and agricultural policies. The synergy effect is also possible where those policies are combined. In the future, those polices are expected to converge (Rajagopal et al., 2007). They can stimulate the development of bioenergy and adjust the direction of the development. For example, national land-use programs, which encourage crop rotation, fallowing areas, etc. (Rathamann et al., 2010).

It is recognized that policies can influence land conversion (Ravindranath et al., 2010). For example in India, conversion of forest land into agricultural land is prohibited. On the other hand, it is argued that government regulation (various prohibitions) cannot bring about a significant mitigation of competition between fuel and food production (Prabhakaran, Elder, 2009). Therefore it is claimed that where it is not possible to prevent biofuels from competing for agricultural resources which are used in food production or diverting resources from major export income-generating activities, the biofuel production capacities of the country should not be developed (Ewing and Msangi, 2009). If the balance of payments allows, domestic biofuel production should be replaced by biofuel imports. Still, some authors observe certain impact areas that can directly or indirectly help mitigate the competition for land resources between biofuels and food production and/or reduce other potential negative socio-economic effects (Table 2).

Table 2. Potential impact areas for agriculture-based bioenergy development (concluded by the authors)

<table>
<thead>
<tr>
<th>Agriculture-based bioenergy development directions in order of priority</th>
<th>Potential impact areas</th>
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<tbody>
<tr>
<td>1. Based on waste</td>
<td>• Promotion of agricultural waste collection and use in energy production</td>
</tr>
<tr>
<td>2. Based on food and non-food crops from non-targeted land and temporarily set aside areas</td>
<td>• Taxes imposed on abandoned, derelict land</td>
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<td></td>
<td>• Support for energy crop production on temporarily set-aside or non-targeted land (Ravindranath et al., 2010)</td>
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<tr>
<td></td>
<td>• Promotion of modernization of agricultural holdings with a priority for resource-friendly technologies (Bergsma et al., 2006, Prabhakaran, Elder 2009; Rathmann et al., 2010)</td>
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<tr>
<td>3. Based on food and non-food crops, when the crop structure features increasing an increasing share of crops with the largest energy potential</td>
<td>• Promotion of logistics and modernization of the processing (Wirsenius et al., 2010)</td>
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<td></td>
<td>• Promotion of changes in eating habits (promoting use of products that require less land resources) (Wirsenius et al., 2010)</td>
</tr>
<tr>
<td></td>
<td>• Promotion of modernization of agricultural holdings with a priority for resource-friendly technologies (Bergsma et al., 2006, Prabhakaran, Elder 2009; Rathmann et al., 2010)</td>
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<tr>
<td>4. Reduction of agricultural exports</td>
<td>• Reduction in export subsidies and other market-distorting measures</td>
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<td></td>
<td>• Promotion of bio-product exports with high value-added only</td>
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<tr>
<td>5. Based on energy crop plantation</td>
<td>• Restricted or prohibited direct foreign investments in energy crop plantations (Ravindranath et al., 2010)</td>
</tr>
<tr>
<td></td>
<td>• Promotion of modernization of agricultural holdings with a priority for resource-friendly technologies (Bergsma et al., 2006, Prabhakaran, Elder 2009; Rathmann et al., 2010)</td>
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</table>
It is important to note that bioenergy can be developed in a number of directions by applying measures specific to those directions. In addition to those presented in the table, several related impact areas can be mentioned, which would help reduce competition for land resources between food and biofuel production. Certain limits of bioenergy development, and thus limits of land allocation for bioenergy use, are determined by the export ban on biofuels until the domestic demand for biofuels is satisfied. Needless to say, this measure alone would not mitigate the said competition (Ravindranath et al., 2010). The saving of production resources, including land resources, is affected by the certification of bioenergy production systems taking into account the costs of energy production (Prabhakaran, Elder, 2009). To maximize the best use of land resources in various sizes it is necessary to develop the biomass collection infrastructure. It is also necessary to have initiatives to promote the production of biomass with energy potential in areas with handicaps (Bergsma et al., 2006). According to these authors it is necessary to promote research and development, in other words, to seek a breakthrough in agricultural technology (Gutterson, Zhang, 2009), i.e., to maximize the yield of plants used for both food and bioenergy production, and also to create and develop new energy plant crops, which have not only higher yields, but also make less impact on biodiversity. The support to biomass producers should be adequate to the promotion of biofuel producers, failing which, products suitable for food will be used in order to meet the increased demand for biomass.

In view of the European Commission’s Communication on the Common Agricultural Policy (CAP) after 2013 "The Common Agricultural Policy towards 2020" (European Commission, 2010b) the issue of prudent public finance should be emphasized. It is therefore necessary to bear in mind that priority is given to those impact areas, which do not use or use less taxpayers' money, and where it is not possible to do without it, it should be used as efficiently as possible.

Agriculture-based bioenergy development allows diversifying the use of arable land. That leads to an increase in the alternative costs of arable land (Rathmann et al., 2010). Rathman et al. (2010) note that a study of an area in Brazil showed that increasing demand for biomass results in increased land value. If there is no change in the national agricultural sector regulation and bio-fuel supply does not grow, in the long-term agricultural areas will expand into areas that have not previously been used for those purposes (Rathmann et al., 2010). The demand for less fertile land is also likely to increase. However, it may be environmentally unacceptable.

In summary, it can be maintained that competition for land resources resulting from agriculture-based bioenergy development can be minimized through a variety of political mechanisms. The selected impact areas and specific measures depend on the bioenergy development scale, technologies used, and possibilities to fund certain measures.

Conclusions

Both studies and expressed insights by most authors as well as the economic logic itself reveal the fact that with agricultural products becoming an input for bioenergy production there is competition for agricultural products, including land resources.

Increasing competition for agricultural products caused by bioenergy development manifests itself through market displacement and factor displacement. The market displacement is caused by an increase in the demand for biofuel raw materials, i.e. agricultural products. The increased demand for those products is satisfied by directing increasingly more agricultural products for the needs of bioenergy. That prompts the agricultural production to use growing quantities of land resources, unless there are changes in other factors. That leads to the aforementioned factor displacement, which results in competition for land resources.

Looking into competition for land resources resulting from bioenergy development, the biofuel sources can be conditionally divided into two groups: those that do not require and those that require specifically allocated land resources. The sources of biofuel that do not require land used for agricultural practices do not create competition for land resources.

Having summarized the arguments of the aforementioned authors it can be maintained that the contribution of bioenergy to the growth of the global energy supply largely depends on two critical parameters: the availability of land resources and the yield of traditional agricultural products and energy crop. The condition of the latter parameters determines the amount of land resources required for bioenergy needs. The less land resources are allocated for bioenergy, the more of them is left for competing needs, such as food production, etc.

With regard to land scarcity and the likely competition for it, attention should be drawn to a number of similar but essentially different processes - the inclusion, conversion, and reallocation of land.

The arguments supporting the point of view that competition does not exist or that it is insignificant are usually grounded on the use of additional or set-aside land that is marginal in terms of food/fiber production. Furthermore, they emphasize the possibilities of improving agricultural productivity. Some bioenergy development scenarios consider waste generated in food/fiber production to be the main source for biofuel production as that would allegedly ensure the non-existence of competition for land and agricultural products.

The theoretical modeling of land-use changes often embraces both the positive and normative approach. The
positive aspect reveals through a point of view based on the biomass potential, where reliance is placed on the physical, technical, and economic potential of bioenergy development. The normative aspect emerges when assumptions are made on what distribution of land resources would be acceptable for public or how land resource allocation should be accomplished. This approach is often based on the “food first” paradigm.

The theoretical model of land-use changes under the conditions of an intensive development of bioenergy displays the distribution of land resources in both pre-bioenergy and post-bioenergy environment. Following changes in land-use triggered by bioenergy development, agricultural products should account for a bigger part of biomass suitable for biofuels, while the biomass that is suitable for energy needs only should represent a smaller but nevertheless important part. In this case by-products - biodegradable waste - would also be obtained, which are also suitable for biofuel production.

In scientific discussions, arguments can be found saying that in market economy there can be no guarantees that bioenergy development will not attract too much agricultural land that is commonly used to produce agricultural products for food. Therefore scientists speak for exogenously restricted allocation of land resources. Such restrictions would keep the production of agricultural products used for food and the supplies of such products required to prevent food shortages and food price shocks in the short term from being reduced to an unsafe level.

The experience of various countries described by foreign authors shows that subject to political regulation of the said competitive area coexistence of the production of biofuels and food is basically possible. But in this case the policy of bioenergy development should embrace the land-use regulation, intervention into the distribution of agricultural products between domestic and foreign markets, and promotion or restriction of the use of agricultural products for biofuels. Generally, the energy, environmental and agricultural policies are expected to converge.

To frame the bioenergy development policy advocating co-existence between the biofuel and food production it is vital to have clear bioenergy development principles. Those principles should serve the basis for shaping priority bioenergy development directions. They would focus on bioenergy development that does not reduce the food self-sufficiency of the country, i.e. uses surplus agricultural products for bioenergy purposes and does not withdraw land resources from the production of agricultural products suitable for food for years to come (the case of energy crop plantations) but rather uses non-food biomass.

The foreign bioenergy development practice shows that political measures can affect the possibilities of land conversion. On the other hand there are also those saying that government regulation (various prohibitions) can not bring about an appreciable effect in this area. It is therefore concluded that a country must assess its ability to ensure that biofuels do not compete for agricultural resources with food production and do not divert resources from major export income-generating activities. If the country fails to achieve this, biofuel production capacities of the country should not be further developed.

References