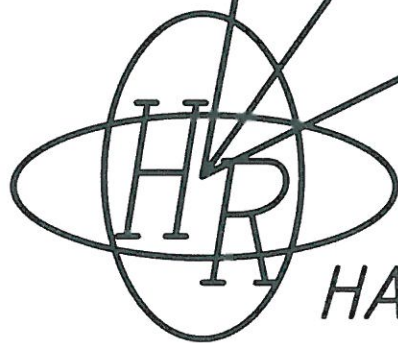


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Market of Producers and Processors of Agricultural Biomass for Energy Purposes

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Abstract

Development of renewable energy sources and efficient use thereof are universal indicators of responsible environmental policy. It is estimated that in EU countries, biomass can provide approximately 2/3 of the declared share of energy generated from RES in 2020.

This paper identifies, on the basis of the example of Warmińsko-Mazurskie province, both the existing producers of biomass and operators involved in the processing and purchase thereof. Furthermore, an attempt was made at assessing local determinants affecting the development of the production trend concerned, with account taken of sustainable development of agriculture and rural areas.

In order to identify the producers and processors of biomass for energy purposes, a computer application called MapInfo Professional was used, it being a useful GIS tool for data acquisition (building databases), processing, and visualization in the form of tables and thematic maps.

Keywords: GIS, energy policy, RES, biomass, natural environment

Introduction

Development of the RES sector is one of the EU's priorities; pursuant to Directive 2009/28/EC, EU Member States shall gradually increase the share of energy from renewable sources in both total energy consumption and the transport sector. The detailed objectives of Poland's energy policy include an increase in the RES share in final energy consumption to 15.5% in 2020 (19.3% for electricity, 17% for heating and refrigerating, and 10.2% for transport fuels) [1].

The need to take decisions on the direction of the development of energy generation results from both the current situation in the energy sector and the measures taken by the European Union, i.e. meeting the Member States' commitments as regards increasing the share of energy from renewable sources by 2020. The growing

demand for energy requires considering the possibilities for ensuring new energy sources being sustainable and, at the same time, safe from the point of view of the environment in general [2].

An increase in the share of renewable energy sources (RES) in the fuel and energy balance may contribute to an improvement in the efficiency of the use and saving of the resources of raw materials intended for energy purposes, and to an improvement in the state of the natural environment. The trend toward obtaining energy from renewable sources may, in many experts' opinions, contribute to reduction in pollutant emissions to the atmosphere and waters, and to reduction in the amount of generated waste. Both the energy (and economic) security and the state of the environment where we live will depend on the energy policy shape to be taken in the coming years [2, 3].

Biomass means the biodegradable fraction of products, waste and residues of biological origin from agriculture (including vegetal and animal substances), forestry, and

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related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste [4]. For Poland, management of agricultural biomass provides the greatest possibilities for obtaining energy from renewable sources [5].

GIS encompasses methods, technical means including hardware and software, spatial data base, organization, financial resources and people interested in its functioning [6]. GIS is the system allowing integration of different types of data stored in different formats and originating from multiple sources [7, 8]. Openness, i.e. the ability of easy development and continual cooperation with geographic information systems that are created in parallel or already operating, represents the supreme assumption for GIS [9, 10].

The aim of our paper is to indicate the possibilities for identifying producers of energy from biomass with the use of GIS tools, and indicate determinants affecting the development of this particular trend in economic activity. The proposed solutions may be useful for solving, at the local level, the problems associated with establishing the policy of sustainable development of rural areas, and an improvement in the efficiency of the use and saving of the resources of raw materials intended for energy purposes, and primarily an improvement in the state of the natural environment.

Materials and Methods

With the use of MapInfo Professional, the existing biomass producers were identified, as were biomass processors located in particular communities of Warmińsko-Mazurskie province. The information obtained using GIS tools was supplemented with opinions gathered through interviews, with the use of survey questionnaires, among the identified 123 producers and 30 processors of biomass in Warmińsko-Mazurskie province. After having verified the filled-in questionnaires, information provided by 108 farmers and 27 entrepreneurs was used for analyses. While analyzing the information obtained from respondents, particular attention was paid to both the factors affecting the development of biomass market and problems concerning biomass production and processing. As part of the research conducted, an analysis was performed of factors affecting the development of biomass market, including, *inter alia*, searching for an answer to the question as to which measures should be taken in order to stimulate the development of regional market for manufacturing fuels and generating energy from biomass, agricultural waste and other sources. Respondents were to select from among 11 measures that had been identified on the basis of relevant literature as those affecting biomass market development the most, namely: subsidies/support programs, profitability of production, education, contracting energy crops, dispersed energy generation, production within the homestead, stable state policy on RES and climate change/environmental protection, market outlet, support from local governments, and the development strategy under implementation.

Determinants of Biomass Production in the Main Crop

Agriculture and energy policy are two closely related elements. In the future, energy crop cultivation may become the strategic trend of agricultural production, and may thus contribute to an increase in the share of biofuels and energy supplies, as well as to achieving the objectives of the current energy policy [11]. Renewable energy has been increasingly important in Poland. The adopted long-term strategy for the development of energy sector addresses the problem of making use of the potential production capacity of cropland with simultaneous introduction of the principles of sustainable development, being in compliance with environmental requirements [5, 12]. The market of biomass of agricultural origin in Poland is, in practice, in its formative stage, since it is the biomass from forests that has so far been predominant in it. It is assumed that the forest biomass will be gradually replaced by agricultural and waste biomass from agricultural production or agri-food sector [13-15]. According to Stolarski, in Poland, in 2009, biomass was the largest source for obtaining renewable energy (over 85%), while in the European Union the share thereof was at a level below 50% [16].

The energy accumulated in biomass is the least capital-consuming source of renewable energy [17]. The attractiveness of the raw material concerned is enhanced by the fact that significant resources thereof are found in Poland [18]. Decisions concerning biomass production for energy purposes in the main crop are taken due to the anticipated improvement in the economic efficiency as measured by the relationship between sales revenue and production costs. This is one of the fundamental conditions for being competitive in the global market for agricultural products. However, this new production trend raises concerns over degradation of the natural environment, and the traditional agricultural crops being replaced with energy crops in regions with conditions favorable for agricultural production [19]. The current structure of Polish agriculture is considered to be ensuring food security, and there is a belief that other trends would not be able to ensure such security.

It is important, however, that a proportion of holdings should change the existing production profile, given, *inter alia*, the unfavorable production conditions, location of a holding in a zone of raw material supply market, the level of utility infrastructure in a holding, etc. This direction of changes implies that a proportion of farmers would search for new opportunities to diversify agricultural activity, and one of the directions of measures is, besides non-agricultural economic activities, either changing the production profile or a trend toward finding new market outlets (sales of straw, green fodder, etc.). The use of all arable lands, including fallows and idle lands as well as grassland, creates an opportunity for the use of large power engineering potential [20].

Biomass may be used for production of solid, liquid and gaseous fuels. Solid fuels from biomass include straw, woodchips, sawdust, shavings, bark, etc., as well as refined

fuels including bales, briquette, and pellets. Liquid biofuels produced from biomass primarily include natural vegetable oils, bioethanol, biodiesel, and biomethanol. On the other hand, gaseous biofuels include landfill gas, biogas from sewage sludge, and agricultural biogas obtained by anaerobic digestion of animal manure, as well as from production residues from the agri-food sector [16]. Biomass may be used for energy purposes in processes of direct combustion of solid biofuels (e.g. wood, straw, sewage sludge), or converted into liquid or gaseous fuels. Energy may be obtained from biomass in processes of combustion, gasification, alcoholic fermentation, or synthesis [18].

According to research by Romański, the RES source being most frequently used in agricultural holdings is solid biofuels, particularly wood and straw, which are used by approx. 60% of farmers [15]. The second most frequently used source is liquid biofuel, namely rapeseed oil. The remaining RES sources are used in agricultural holdings in Poland to a rather small extent. The effective use of biomass in energy generation would be favoured by establishing local, scattered energy centers located in rural areas. Setting up a local system for the use of biomass is considered to be very energy-efficient, fully environmentally-friendly, and stimulating to rural areas [21, 22].

Research Findings

Biomass producers in Warmińsko-Mazurskie province are mainly distributed in its western part thereof, and in the belt of communes in the northeastern part of the region (Fig. 1). An important element of the location of activities associated with agricultural biomass production is the

location of a plantation in relation to the potential reception points. The decisive factor affecting the profitability of production is the cost of transport [23-25] – not only related to the distance on which the energy raw materials are transported, but also the type of raw material and its processing level. Both the optimal location and adaptation of a raw material type to the specific needs of its receiver allow earning satisfactory revenue.

From the point of view of operators involved in the purchase and processing of biomass for energy purposes, the northwestern part of the province clearly stands out compared to the rest of the region. As can be seen, the location of a significantly higher number of operators being the potential receivers of raw materials favors the concentration of field biomass production for energy purposes. In the central part of the region, single operators are found, while in the northern and southeastern belts there are few receivers and producers of biomass (Fig. 1). Based on the data of the Energy Regulatory Office, it can be concluded that the uneven distribution of operators involved in biomass production results from the fact that in the central and eastern part of the region, operators involved in biomass processing mainly use biomass of forest origin (Ostródzki and Szczycieński districts).

GIS is a system allowing integration of various types of data stored in a variety of formats, and originating from a variety of sources. Not only does the system concerned create quality as regards data accumulation, but also processing and sharing thereof, resulting in the information it transmits being clearer and easier to be found, which leads to drawing accurate conclusions [26]. The application MapInfo Professional supports various formats of spatial data, and is compatible with numerous types of databases [27].

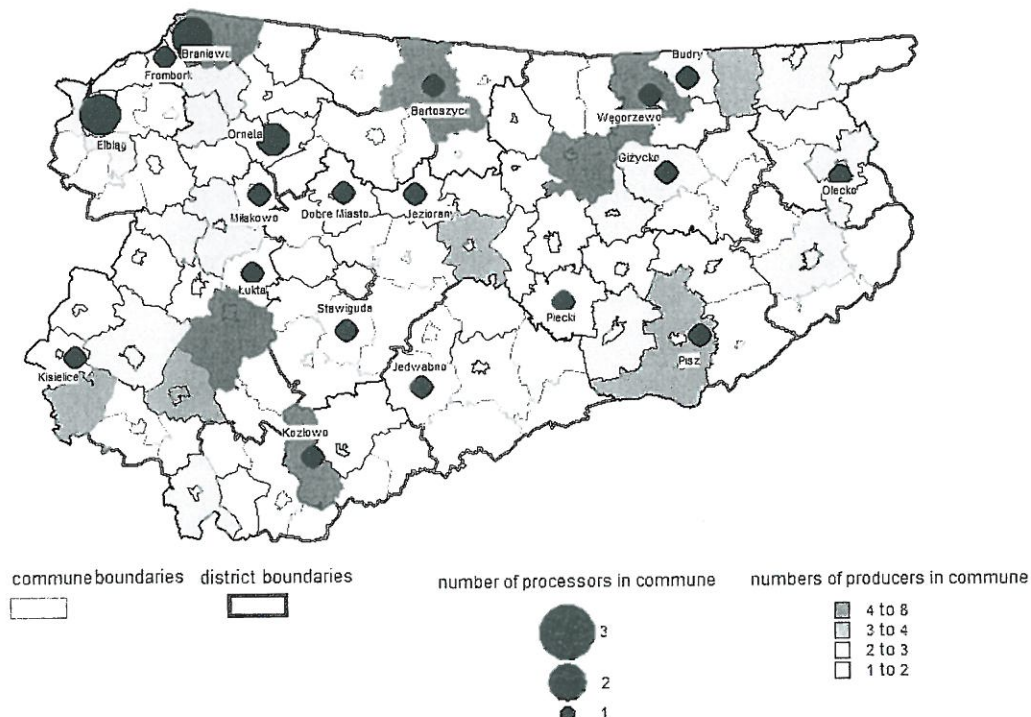


Fig. 1. Distribution of biomass producers and processors in Warmińsko-Mazurskie province.

Table 1. The structure of the area under crops to be used for biomass production in 2012 in holdings (producers, for which biomass is the main crop).

Specification	Percentage of farmers	Number of indications	Average area under crops, [ha]	Minimum area under crops, [ha]	Maximum area under crops, [ha]
Cereals	13.9	15	50.2	5.0	200.0
Legumes plants with grasses	2.8	3	26.0	5.0	48.0
Maize	1.9	2	180.0	180.0	180.0
Grasses	4.6	5	52.5	11.3	96.1
Rape and turnip rape	7.4	8	79.4	6.0	277.7
Energy crop	37.0	40	30.0	0.6	330.0

Source: own work based on survey research.

Data originating from the Energy Regulatory Office (URE), Warmińsko-Mazurski Agricultural Advisory Centre (W-MODR), GEOPORTAL, and Google Maps were imported to the programme and subsequently displayed as layers composed of a map and a table of attributes based on the biomass production and processing potential in the region.

The average area of holdings of the producers of biomass to be used for energy purposes amounted to 199.21 ha, including the average area of 180.10 ha for agricultural land (AL). The minimum area of a holding under analysis amounted to 12.6 ha, while the maximum area was 1,988.0 ha. As can be seen, it is the commercial holdings with large areas of agricultural land that are involved in production of biomass for energy purposes. Table 1 presents the structure of the area under crops to be used for biomass production in 2012 in holdings of the farmers participating in the research. According to the information obtained from respondents, perennial energy crops were cultivated in 37% of holdings. This was the group for which the average area of the holding was 30.0 ha. Further crops in the discussed structure, with a significant area of cultivated surface, include cereals (13.9%, average plantation area is more than 50.2 ha), and rape and turnip rape (7.4%, on average nearly 80 ha per holding). The remaining crops, i.e. papilionaceous plants with grasses, maize, and grasses, were of minor importance (Table 1). In total, plants with the main crop being intended for biomass were cultivated by 67.6% of holdings, while for the remaining 32.4%, the main raw material for energy purposes was the secondary crop (straw). It was noted that livestock was produced in 28% of holdings under the research.

More than 65% of respondents concluded that within a time span of the next 2-3 years they intended to increase, in the structure of the acreage planted, the share of crops to be used for energy purposes; primarily that includes crops such as cereals (21.3% of indications), common osier (16.4%), and rapeseed (11.5%).

In Warmińsko-Mazurskie province, solid biomass is primarily used for generation of heat energy in the form of domestic hot water (d.h.w.) and central heating water (inter alia, the Municipal Services Department (ZGK) in Łukta – woodchips; boiler plant of the Housing Co-Operative in

Jonkowo, boiler plants in Lidzbark Warmiński and Reszel, boiler plant in Frombork – straw). An opportunity for the development of the biomass market is the implementation of an investment project of the ENERGA Group (Grupa ENERGA), involving the start-up of a new power unit combusting biomass, i.e. straw pellets, in Elbląg.

As noted by Jasiulewicz, biomass production is mostly dependent on both the prices of raw materials used for energy purposes and the guaranteed multiannual market outlet of biomass [28]. The biomass being obtained should primarily originate from local sources, i.e. from agriculture, but industrial waste, municipal waste, sewage sludge, slaughterhouse waste, catering waste, and vegetable and animal waste (both liquid and solid), should also be taken into account. Basically, the biomass obtaining models as tested on a large scale must be applied, where traditional crop cultivation for energy purposes or establishing energy crop plantations are the basic options for obtaining agricultural biomass. The main criterion for suitability of energy crops for energy generation is the yield of biomass in the dry matter, and the energy content thereof [29]. Further important criteria also include: fidelity of yield, harvesting technology, biomass harvest multiplicity during vegetation, plantation durability, etc. [30]. It is estimated that most biomass is used by individual users (approx. 1 million households). However, the consumption concerned may not, in the light of applicable regulations, be credited against the reduction in the domestic pollution of atmosphere with greenhouse gases. The only way to fulfil those obligations is to use an appropriate amount of biomass in energy generation [15, 31].

According to Gostomczyk, the most important arguments to support the use of biomass for energy purposes include, among others, the constant and reliable supply of the domestic energy carrier; ensuring income which is difficult to be earned under the conditions of the overproduction of food; creating new jobs, which is particularly important in rural areas threatened by unemployment; stimulation of local rural communities; and decentralization of energy generation, and thus greater energy security through broadening the offer of energy generators [32].

Within the context of the aim of this paper, it is important to identify the demand for biomass sources among the

operators involved in the purchase and processing thereof, with account taken of local determinants of energy crop cultivation. Based on the research carried out (Fig. 2), it can be concluded that the predominant source of agricultural biomass used in the region is cereal straw (27% of processors), rapeseed straw (approx. 16% of processors), cultivated energy crops (i.e. common osier, 21%), and, to a much lesser extent, tall wheatgrass (*Agropyron elongatum*) and poplar (7% each). The remaining biomass sources are only used occasionally by operators involved in the purchase and processing of biomass for energy purposes in Warmińsko-Mazurskie Province. The use of biomass of animal origin is of particularly little importance. These results indicate that the predominant form of activity for operators involved in the generation of energy from RES is converting them into heat.

As part of our own research, both farmers involved in the production of biomass for energy purposes and operators involved in the purchase and processing thereof for energy purposes were asked to indicate and rate, on a 5-point scale, the factors that, in their opinion, affect the present situation in the sector in question. As results from the research, in the biomass producers' opinions, the main restrictions affecting the development of the sector include: poorly developed market of biomass receivers, the absence of programs for support of RES development, and the absence of aid for cultivation of crops for energy purposes. What seems to be equally important is the low level of prices being achieved for biomass, the absence of specialized equipment for cultivation and harvesting of biomass, and unsatisfactory condition of the equipment in plants processing or using biomass (Fig. 3). The indicated determinants that are frequently barriers in nature, restricting the

development of biomass production may, in the respondents' opinions, be minimized or even eliminated with more effective financial support to that agricultural production trend, and introduction of clear principles and solutions in the state policy on RES.

The problems indicated by farmers show a new place being formed in agriculture for a certain group of agricultural producers searching for alternative sources of income. The changes being observed set a new place for the group of holdings, the role of which is to serve the function of suppliers of raw materials to be used for energy purposes. It must be noted, however, that the environmental function of those holdings may be denied due to, inter alia, heavy fertilization of plantations of crops intended for energy purposes, or landscape value being decreased by such cultivation. On the other hand, attention is drawn to social functions such as creating new jobs, or an improvement in agricultural families' income. In this case, biomass producers' impact is indirect. New jobs are created at the operators involved in the organisation of supplies, processing, and distribution of energy. The agricultural producers' trend towards biomass production does not create new jobs directly.

It was observed that for agricultural holdings developing the production of biomass for energy purposes, three basic groups may be distinguished:

- changing the organization and methods of management – such strategies are adopted by holdings in the industrial model group
- diversifying agricultural production – those holdings mainly allot, to biomass production, the land of little suitability for cultivation of other crops, and focused on sales of biomass being the side-line crop

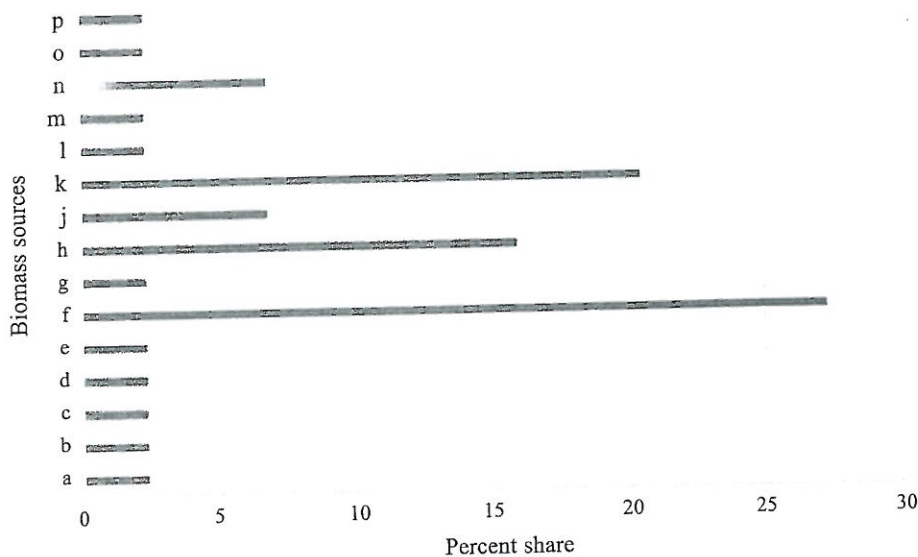


Fig. 2. Biomass sources used by operators involved in the purchase and processing of biomass for energy purposes in Warmińsko-Mazurskie Province

a – pig slurry, b – cattle slurry, c – pig manure, d – cattle manure, e – maize silage, f – cereal straw, g – cereal grains, h – rapeseed straw; energy crops: i – tall wheatgrass, j – common osier, k – tall fescue (*Festuca arundinacea*), l – Virginia Mallow (*Sida hermaphrodita*), m – poplar, n – *Miscanthus*, o – *Phalaris*

Source: own work based on survey research.

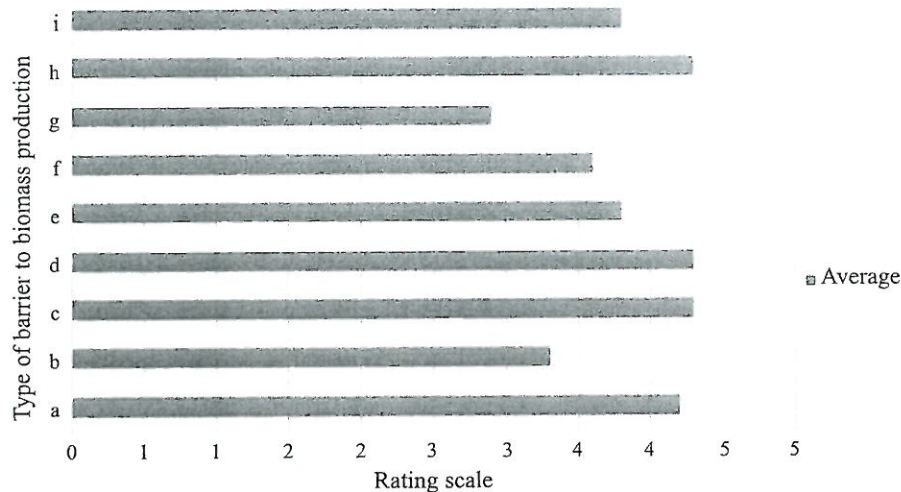


Fig. 3. Determinants of biomass production for energy purposes in opinions of its producers from Warmińsko-Mazurskie Province. a – the absence of a developed market of biomass receivers, b – the absence of appropriate knowledge among farmers on the establishment and maintenance of crop plantations for energy purposes, c – unsatisfactory level of prices being achieved for biomass, d – the absence of programmes for support of RES development, e – unsatisfactory status of development and modernisation of plants processing or using biomass for energy purposes, f – high costs of biomass production, g – restricted access to sources of knowledge on the opportunities for production and use of biomass for energy purposes, h – the absence of aid for crop plantations for energy purposes, i – the absence of specialised equipment for cultivation and harvesting of biomass for energy purposes. Source: own work based on survey research with the use of MapInfo Professional.

- producing biomass for their own use – those are mainly holdings, the owners of which conduct non-agricultural economic activities.

The two latter groups of holdings may serve important environmental and social functions typical of both the concept of sustainable model of agriculture, and the idea of its multifunctional development.

As for the parallel group of operators under research, i.e. entrepreneurs involved, within the energy production chain, in further stages of biomass processing, the key factors for developing this trend in economic activity differ significantly from those determined for the group of agri-

cultural producers. It was observed that the biggest problems were the absence of stable regulations, and the absence of aid programs for the sector. In the opinions of representatives of operators involved in the purchase and processing of biomass, the development of biomass market in the region is also being hampered by the poor state of infrastructure, and the unfavorable situation in the fuel market (Fig. 4).

In order to assess the level and stage of biomass market development in the region, biomass producers were asked to indicate factors that, in their opinions, play a decisive role in the development of biomass production for energy purposes

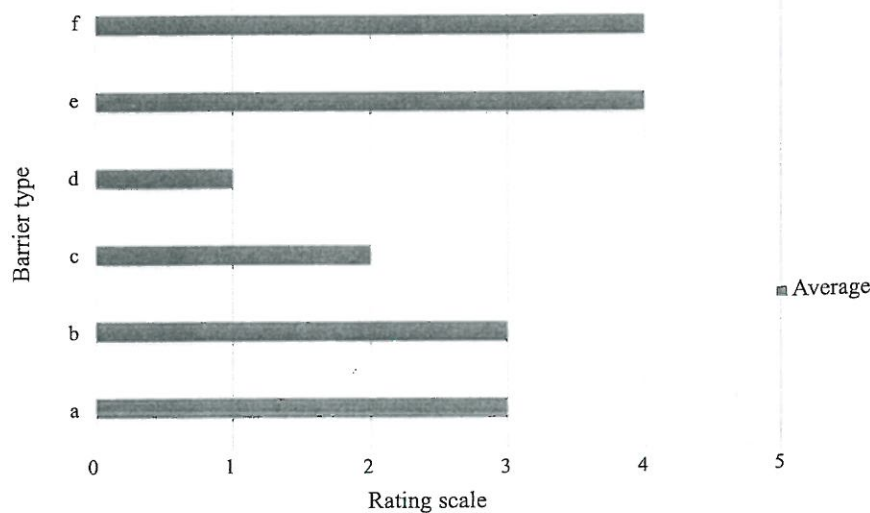


Fig. 4. Determinants of biomass market development in the opinions of biomass processors from Warmińsko-Mazurskie Province. a – state of infrastructure, b – situation in fuel market, c – low public awareness, d – absence of installators, e – absence of support programs, f – regulations, procedures. Source: own work based on survey research.

in their agricultural holdings. Each respondent could indicate a maximum of 3 factors. The factors as indicated by more than every fifth research participant are as follows: low price of biomass, restricted market outlet of biomass, and the absence of stable conditions of sales – contract award procedures. It may be noted that those factors are indeed barriers. In addition, it must be emphasized that farmers do not discern positive environmental aspects that might arise in connection with the development of the generation of energy from RES. The decisive factors affecting the dynamic development of biomass market appear to be mainly the economic determinants of carrying out production.

On the map showing the location of operators involved in the purchase and processing of biomass for energy purposes, the three most important factors (in the respondents' opinions) were marked, which had been identified as those affecting the improvement in the situation in the sector the most, namely: support to the sector (subsidies), stable energy policy, and education. The other factors may prove useful instruments for the development of biomass market, yet they are perceived as minor (Fig. 5).

As can be seen, there is a spatial diversity of opinions of representatives of operators involved in the trading and processing of biomass for energy purposes. In general, the main factor appears to be support for the developing sector. As noted during the interviews, there is deep conviction, among the representatives of operators connected with the RES production market, about the extraordinary role of that new trend in economic activity (both agricultural and non-agricultural), and on its significance in the implementation of the model of multifunctional and sustainable development. Given this conviction, entrepreneurs await financial support for their projects. In the current situation, taking

account of the noticeable absence of announcements about provision of such support, it is important to build a robust raw material base for processing plants and other non-agricultural links of RES production. RES is becoming an opportunity for a proportion of farmers and entrepreneurs to diversify the economic activities being conducted, which, however, requires a change in the production profile, focus on new input supply and outlet markets (sales of straw, green fodder, etc.), organisation of transport, or providing specialised machines and equipment.

Conclusions

The development and organization of the market of agricultural biomass intended for energy purposes is a relatively new issue, yet growing investors' interest in the sector may be observed. At the same time, the economic aspects play a decisive role as regards the success of such economic projects. In Poland, more than 1,500 installations operate which use renewable energy sources, with most biomass being used by individuals. Renewable energy allows stopping, or at least slowing significantly, the exploitation and pollution of the environment. Dynamic development of biomass production is mostly dependent on both prices of raw materials used for energy purposes and the guaranteed multiannual market outlet of biomass. Biomass is used to a small extent as a renewable energy source, despite the existing significant potential. However, a condition for the further development of such an activity is to solve the problem of the organization of biomass processing, and to reconcile such type of production with the field of food production.

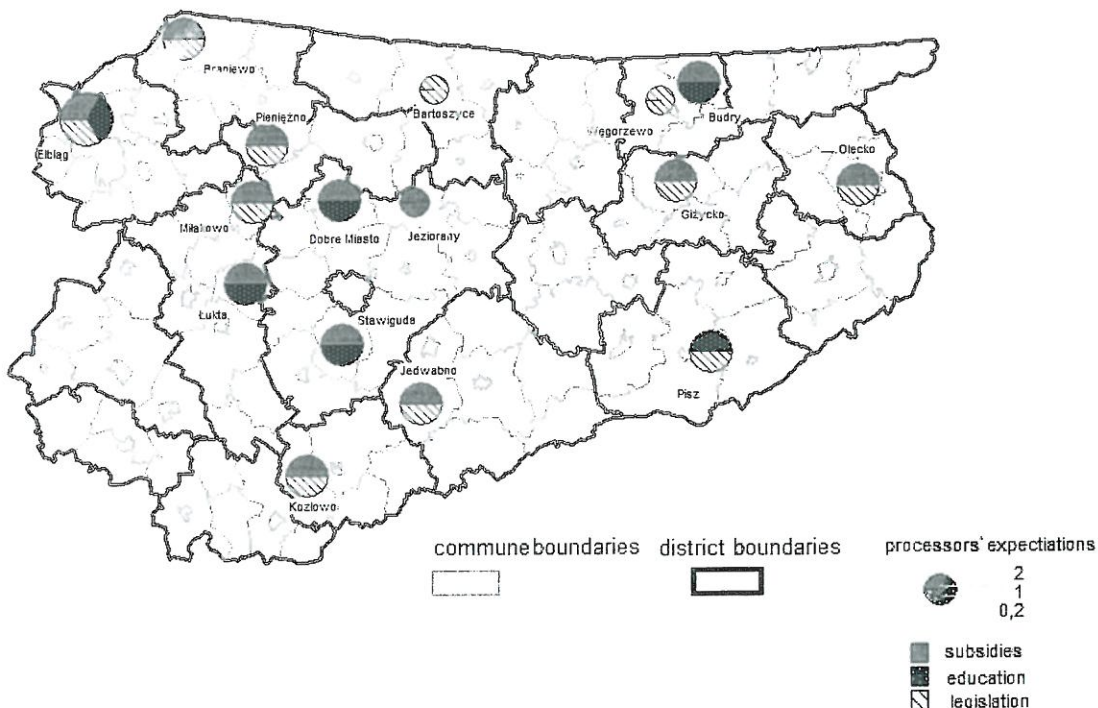


Fig. 5. Expectations of biomass processors from Warmińsko-Mazurskie Province, concerning the stimulation of biomass market.

GIS may appear to be a useful tool facilitating the organization of the system of biomass management for energy purposes. Due to the combination of information on biomass market and the local determinants, new analytical opportunities arise, which serve the optimization of biomass production and processing. Providing holding owners with the visualization of occurrences associated with RES development, allowing adaptation to the current situation in biomass market, while the potential processors may obtain, in a simple way, information on biomass sources available in the region.

The use of GIS tools in research has contributed to improve the efficiency of data collection and processing and sharing. The information that for each carries is clearer in the receipt and easier to identify.

The particular role of integrated systems for biomass acquiring and processing for energy purposes primarily results from the need for efficient use of the resources found in agriculture and rural areas. Furthermore, GIS tools may be used to monitor and manage the RES sector. Thematic maps prepared on the basis of data obtained from various sources allow us to full integration of all participants of the biomass market. Therefore, GIS is a very useful tool for reaching various groups of receivers with the already processed information.

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