Assessment of the agricultural land under steep slope in Lithuania

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Abstract

The aim of this research was to evaluate and describe agricultural land handicapped by steep slope and to assess agricultural experts' attitude towards impact of terrain factor on the generic farming activity. This paper analyses differences and similarities between Lithuanian rural elderships affected by steep slope constraint (i.e. ≥ 7° (15%) slope gradient) with the subsequent evaluation in selected agronomical variables. In total 514 rural elderships were classified into five groups by percentage of agricultural land with steep slope. The assessment of agricultural variables by steep slope groups revealed that the best developed are elderships (60.12%) falling into Group I, where mean value of area under steep slope was 0.32%. Very unfavourable conditions, especially for intensive farming, were identified in Group V (7.59% elderships), where the topographical character has a dominantly hilly terrain. Agricultural experts' (scientists) for survey was used assessing the respondents attitude (6-point Likert Scale) towards terrain impact on the items related to generic farming sector, i.e., "Agricultural development", "Farming systems use", "Land utilization possibilities" and "Soil erosion". The surveyed experts considered that terrain is a factor influencing land-use decisions and the item "Land utilization possibilities" has assumed the highest mean score (3.77). Therefore it should be a good overview of agricultural land with steep slope, as one of the most important natural agri-environmental constraint affecting generic farming possibilities in Lithuania.

Keywords: agricultural land, attitude survey, farming, hilly terrain, steep slope

Introduction

The topography determines mostly the spatial pattern of land use and its changes (Solaimani et al., 2009; Gobin et al., 2004). Slope is frequently used as a criterion to assess capability and suitability of land for agriculture (Van Orshoven et al., 2008; Lacko-Bartošová and Buday, 2013). In British land capability classification slope is recognized to have a marked effect on mechanical farming (Bibby and Mackney,

1969). According to British land capability classification slope over 15° are not suitable for arable crops, with slopes over 20° being difficult to plough, lime or fertilise. Naturally handicapped areas where efficient agriculture is not possible are behave as having steep slopes (>3.6°) (Andersen et al., 2004). Terrain is an important spatial determinant of cropland systems, which influence the management constraints (Van Asselen and Verburg, 2012). Slope has been retained as the sole topographic criterion for its decisive impact on the potential use of agricultural machinery. All this follows a very similar rationale adopted for forestry (Ray, 2001). Several different factors have an impact on erosion risk including climate, type of soil, terrain, erosion prevention methods and crop types (Morgan, 2005). The influence of terrain on erosion is of great importance (Aksoy and Kavvas, 2005). Steep slope criterion is important for classifying land according to its suitability for generic agricultural activity. Hilly areas are handicapped by a short growing season due to high altitude, or by steep slopes, or by a combination of the two (Eliasson et al., 2010). Sys et al. (1991) has noted that slope above 7.2° is considered to be unsuitable for wheat production. However, medium to low intensive pastures are the advisable land uses and still possible on these steeper slopes.

Slope as such has little or no direct influence on the yield of crops. However, the steeper the slope the more difficult it becomes to manage the land and to grow crops. In particular, mechanization is hampered and may require specific equipment, while access to land and all agricultural operations become more time-consuming. Steeper slopes are also associated with shallower soils in general (e.g. Leptosols, Regosols) and with a higher risk for soil degradation and landslides (Eliasson et al., 2010; Böttcher et al., 2009).

From the geographical point of view, Lithuania has four main relief units on its territory: lowlands, plains, plateau and hills (Cesnulevicius, 2010). Lowlands generally have altitudes up to 100 m a.s.l. and cover about 64% of Lithuania's area. Plains represent the terrain with altitudes from 100-150 m a.s.l. These lie on almost 12% of Lithuania's area. Plateaus are areas topping from 150-200 m a.s.l. The highest points of terrain are the hills. They generally have altitudes over 200 m a.s.l. The highest point of the terrain in Lithuania is 293.84 m a.s.l. named Aukstojo hill. Conditions for water erosion in Lithuania are most favourable on a hilly terrain. Every year such areas are deprived of 20-100 t/ha of the smallest soil particles and a high amount of nutrients (Vaicys and Mazvila, 2009). The variety of relief gives a great diversity to its general agricultural activity characteristics and certain specificity in hilly agricultural areas.

Land use and land cover at different locations in Lithuania is affected by different characteristics of terrain (altitude, slope steepness, length and exposure) and soil (texture, nutrients status, drainage conditions) (Mazvila et al., 2011). Slope steepness is the central parameter of agricultural terrain classification to its suitability for general agricultural activity in Lithuania (Eidukeviciene and Vasiliauskiene, 2001). As stated by Jankauskas (2012), the most vulnerable to water erosion are terrains having light soil texture on steep slopes. Most agricultural land areas from the hilly zone are prone to erosion due to the steep slopes and certain anthropic modifications of the environment and determine the possibility of farming development. Different soil cover (vegetation), water runoff volume, soil loss rate have influence to agrochemical properties of soil on eroded and sloping land (Jarašiūnas and

Kinderienė, 2015a). For example, the authors estimated that on a sandy loam texture on slopes of 8-8.9° under studied three different crop rotations conducted in the fields of a 27-year long experiment on moraine hilly terrain of the southern–central Žemaičiai Uplands (Western Lithuania) soil pH significantly negatively correlated with slope gradient. The hilly areas are characterized by a considerable limitation of the land utilization possibilities and by a considerable increase of the agricultural land farming costs due to the steep slope constraint. Svarcaite (2003) has noted in accordance with Lithuanian's terrain conditions, based on normative calculations the expenditures of technical exploitation on the hills over 7° increase 1.2 times, however on the hills of 5-7° – 1.14 times. According to the guidelines of Lithuanian general territorial plan (2002) strongly naturally handicapped areas where agriculture is heavily constrained and restricted to extensive farming, it is appropriate to encourage and support other alternative activities, i.e. afforestation, crafts and rural tourism development. Therefore it should be a good overview of agricultural land with steep slope, as one of the most important natural agri-environmental constraint. The assessment of the spatial distribution of the steep slope areas are used as attributes to the steep slope groups to describe and analyze the differences between them. At the territorial scale of rural elderships it's possible to access a relationship between the steep slope groups and selected statistical agricultural data.

The aim of this research is to evaluate and describe agricultural land handicapped by steep slope and to assess agricultural experts' attitude towards impact of terrain factor on the generic farming activity.

Materials and Methods

Grouping of elderships

A total of 514 rural elderships were classified into steep slope groups in line with percentage of agricultural land affected by steep slope constraint (i.e. ≥ 7° / 15%) on all agricultural land. The classification of rural elderships has comprised five groups. The central parameter of agricultural terrain classification to its suitability to general agricultural activity is slope steepness. Data on steep slopes were calculated and taken from state enterprise State Land Fund databases.

Data on selected agricultural variables (farm size, utilized and unutilized agricultural land, arable land, meadows and pastures, agricultural crops and dairy cows) are collected on the basis of a report from Agricultural Census 2010 (2012) published by Statistics Lithuania. The means of agricultural variables were calculated for every group of steep slope. Evaluation of agricultural variables reflects land use characteristics that may have an important role when responding to agricultural, environmental and socio-economic problems and planning in sloping agricultural area. The map was prepared using ArcMap 10 software.

Experts' survey

The data were collected between November and December 2013 through a questionnaire mailed to the agricultural experts (scientists). All agricultural experts participated in the survey were selected based on stratified sampling method

(Giddens, 2011). The sampling criterion was not lower than doctoral degree in agricultural sciences. A total of 8 agricultural experts returned questionnaires. The survey response rate obtained was 100%. A questionnaire was used to collect required data about experts' perceived attitude towards impact of terrain factor on agricultural development, farming systems use, land utilization possibilities and soil erosion process respectively, according to Lithuanian agro-environmental conditions. A six-point Likert scale (ranged from 0= no impact to 5= very high impact) was used (Likert, 1932). Questionnaire reliability was estimated by calculating Cronbach's alpha, which was 0.68. Data were analyzed using Statistical Package for the Social Sciences (SPSS 11.5).

Results and Discussion

Territorial distribution of steep slope

Out of the total agricultural land of Lithuania of 3 626 817 ha, agricultural land with steep slope occupies 37 425 ha or 1.03% of total agricultural land. The Group I is the most important and the largest in Lithuania for agriculture development due to quite favourable agro-ecological conditions, especially in nordic-central territorial part (Figure 1) and according to Mazvila et al. (2011) soils here provide almost optimal conditions for cultivation of all arable crops, fruit and vegetables. In the group prevails very fertile soil types: Cambisol, Luvisol. Soils of central part of Lithuania where Middle Lithuanian lowland predominates are best supplied with available phosphorus (P_2O_5) and potassium (K_2O). Only in the south-eastern part of the territory the most common type of soil is Arenosol, as soil type they have very low resistance to wind erosion, the soils are acidic (Vaicys and Mazvila, 2009). As indicated in Table 1, the mean of agricultural land with steep slope is the lowest (0.32%) and the count of elderships is here the highest (n=309). Due to prevailing very gentle slopes, soil erosion rate is registered as very low.

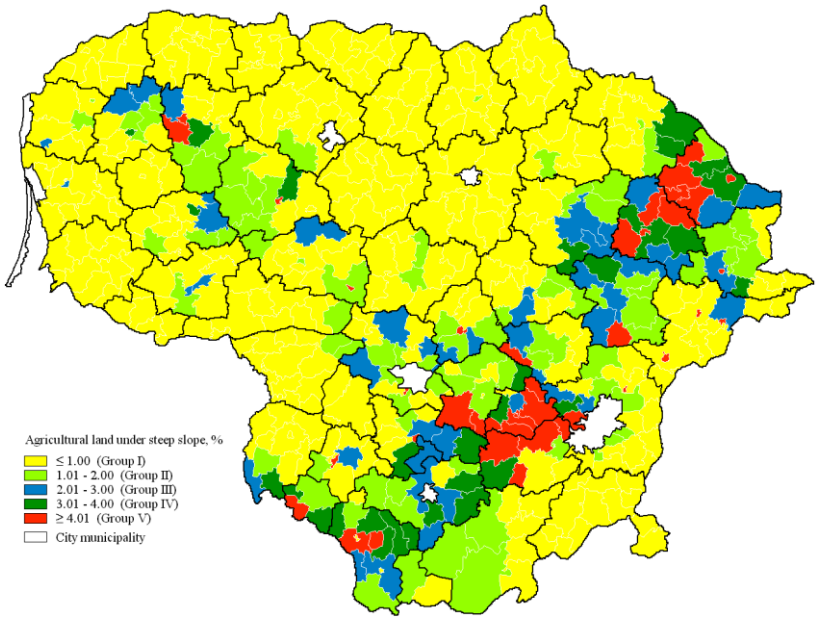

Figure 1. The map of Lithuanian rural elderships by steep slope groups.

The mean of steep slope area is in the Group II by 77.93% higher than in Group I. In this group 87 elderships fall. Most of the farming activities are oriented to continuous intensive cropping. The majority of elderships fall under the outskirts of Baltic ridge region. Soil erosion is more of a hazard and lower intensive farming systems than in Group I should be applied. All the cultivated hill lands whish are mainly in the elderships located in the south part where fine textured soil prevails and the risk of soil erosion by wind are direct cause to set-aside land (Jankauskas et al., 2004; Kudaba, 1983). According to Racinskas (1990), on hilly areas water erosion on sandy soil surface is less of a hazard and the runoff volume is three times smaller than on clays or clay loam.

The lowest difference (29.07%) of steep slope mean was determined between Groups III and IV. These groups have 48 and 31 elderships, respectively. The majority together of elderships are into Baltic ridge region. The soils of the ridge have low status of humus (from 1.6 to 2.2%). Agricultural land suitability for farming is considered moderate. These two groups offer beneficial conditions for the format medium and small size of farms. The recommended utilization of agricultural land is depended on retention and amelioration of arable land with fertile soils; available plant with forest on larger areas. The advisable cultivated agricultural crops are cereals (not wheat), feeding grasses cultivation. The dairy farms or cattle breeding should be expanded.

The biggest difference in mean of steep slope area was observed between Groups I and V where the mean was 96.53% higher in Group V. The group consisted of 39 elderships. In Group V soils are not suitable for successful growing of crops due to steep slopes which are subject to intensive water erosion, which cause potential reduction of yield and land degradation process (Kinderiene et al., 2013). The common characteristic of the soils in this group is intensive water erosion, but the key factor by mitigating land degradation is anthropogenic influence – high percentage (58.21%) of meadows and pastures on all agricultural land. In Lithuania vegetation have a great influence on soil erodibility on hilly agricultural landscape (Jarašiūnas and Kinderienė, 2015a). Many authors (Bieliauskas, 1986; Jankauskas et al., 2003; Kinderiene, 2006) have proposed and suggest different anti-erosion agro–environmental systems (crop rotations) to protect soil from degradation processes (erosion, nutrients leaching, surface runoff) in the Lithuanian agricultural land situated on hilly terrain. Kinderienė et al. (2013) observed that the slopes (≤ 8°) occupied with permanent grasses, where slightly and moderately eroded Eutric Albeluvisol prevailed, were resistant to soil erosion. Even so, in this group alternative activity, i.e. afforestation, crafts and rural tourism development should play the main role for rural development. This group offers very favourable conditions for dairy and cattle sector. Milius and Ribokas (2008) has noticed that in Lithuanian's hilly areas, mostly due to unfavourable natural constraints, agricultural activity became less profitable, but in a number of case is detrimental to.

Agro-statistical features

The results obtained indicate distinct agricultural land use variability's at Lithuanian rural elderships by steep slope groups. Results of the last Agricultural Census in Lithuania (Results of ..., 2012) shows that the number of farms is decreasing; the

average farm size has been growing. The value of average size of the farm revealed that the biggest farms (16.72 ha) were in Group I, thus the smallest (8.64 ha) in Group V, respectively (Table 1). Reidsma et al. (2007) according to the data of European countries has concluded that the size of the farm in hectares is highly correlated with the economic size of the farm and a larger farm is a priori expected to have more capital available for investments. The overall European trend of farm size development shows that from 2003 decrease proportion of small farms and increase proportion of bigger farms (Vosta, 2012).

Table 1. The mean of agricultural variables by steep slope groups

Variables	Group I	Group II	Group III	Group IV	Group V
Number of elderships	309	87	48	31	39
Agricultural land under steep slope, %	0.32	1.45	2.44	3.44	9.23
Farm size in ha a.l.	16.72	10.59	10.85	9.67	8.64
The share of utilized agricultural land on a.l., %	94.93	93.62	90.48	81.09	73.02
The share of unutilized agricultural land on a.l., %	5.07	6.38	9.52	18.91	26.98
The share of arable land area on utilized a.l., %	78.61	63.66	53.41	53.29	41.88
The share of meadows and pastures on utilized a.l., %	20.87	35.64	45.62	46.05	58.21
The share of agricultural crops on utilized a.l., %	74.15	58.83	48.95	48.29	37.21
Number of dairy cows per ha on a.l.	0.13	0.13	0.12	0.15	0.09

a.l.= agricultural land

During 2004–2014 in Lithuania the area of utilized agricultural land has increased approximately by 32,000 ha year by year. The research results show that the share of utilized agricultural land by the groups ranged from 73.02-94.93%. The lowest mean was observed in Group V that represents elderships highly handicapped by hilly terrain constraint and unfavourable conditions for intensive farming. In the Groups I, II and III the identified mean was higher than 90%. This may be mainly due to suitable terrain characteristics and fertile soils with farming focused on crops.

In Lithuania down to extensive farming the amount of arable land during the past ten year has decreased in 8.3% (Results of ..., 2012). The lowest mean of arable land

was estimated in Group V (41.88%), where the majority of agricultural land by reason of prevailing hilly terrain is not suitable for use of agricultural machinery. Thus, according to favourable farming conditions it's considered appropriate to retain and improve the sector of arable land with very fertile soil and mitigate poorly drained soil in Groups I and II, respectively. In this above mentioned steep slope groups the share of arable land amount to 78.61 and 63.66%, respectively. The estimated difference of arable land share was very low between Groups III and IV and has reached 53.41 and 53.29%, respectively.

According to Jankauskas and Fullen (2002), slopes over 8° in Lithuania are usually pastures with perennial grasses. Regarding meadows and pastures, the steep slope groups showed that between groups the means ranged from 20.87 (Group I) to 58.21% (Group V). Very small (0.43%) difference of the means was estimated among Groups III and IV. The meadows and pastures, especially under well drained and fertile soil, must be used for agricultural activity (Aleknavicius, 2007), thus on sloping land (>7°) with moderate and highly eroded soil animal husbandry sector should be developed (Maetens et al., 2012; Morgan, 2006). In the big farms having ≥50 ha of utilized land and situated on hilly terrain must be anti-erosive crop rotations applied (i.e. grain-grass and grass-grain) or established long–term grasslands (Van-Camp et al., 2004).

The area of agricultural crops in Lithuania has the tendency to go up. According to the last ten year, the majority of agricultural crops area has increased in agricultural land with fertile soil (land productivity point >40). The results of the assessment disclosed that the amount of agricultural crops varies from 37.21 to 74.15% by steep slope groups with the majority of the area in Groups II and I. Only 37.21% area of agricultural crops on utilized agricultural land was indicated in Group V. Furthermore, from an agro-environmental conservation point of view, in this group should be carefully considered when implementing to cultivate soil erosion-inducing cash crops.

A cattle farming is mainly located in western part of Lithuania. Here the highest acidification of soils is recorded where the calcareous layer lies deeper (1.5-3 m) (Vaicys and Mazvila, 2009). Therefore, according to natural agri-environmental conditions, animal husbandry should predominate in Groups IV and V. It's no wonder that the number of dairy cows per ha was highest (0.15) in Group IV, where meadows and pastures prevails on utilized agricultural land. An astonishing fact is that the lowest (0.09) number of dairy cows by steep slope groups was determined in Group V. Grazing is generally considered to be the most economical way of utilizing rangeland vegetation (Askin and Kizilkaya, 2009).

The assessment of agricultural characteristics by steep slope groups revealed that the best developed are eldership falling into Group I. Very unfavourable conditions, especially for intensive farming, were identified in Group V, where the hilly terrain has a dominantly topographical character. Consequently, a successful rural development policy in Lithuania require careful planning and strategy to combat land abandonment and deagrarization process and soil conservation programmes are an urgent need in the hilly agricultural areas significantly handicapped by steep slope constraint.

Agricultural experts' attitudes

The highest mean score of the respondents on their attitude towards impact of terrain factor on the items related to generic farming sector was estimated 3.77 to the item "Land utilization possibilities" (Table 2). The findings pointed out that the mean score evaluated of the agricultural experts' towards terrain impact on the item "Farming systems use" was a 3.52. The results shows that the mean score of the item "Soil erosion" was estimated 3.26. The survey results, according to the respondents' perception, revealed that the factor of terrain has a low (2.59) impact on the item "Agricultural development". Based on the results of the agricultural experts' survey it might be concluded that factor of terrain has highest impact the on land use patterns and its provided information that slope steepness, as main topographical parameter of the terrain, has direct influence on agricultural land utilization possibilities in the country. Empirical investigation of Eastern Lithuania region showed that the most frequently noticed topographical parameter of the terrain influencing the intensity of soil erosion was slope steepness (63.1% of respondents), followed by slope aspect (21.1%) and length (15.8%) (Jarašiūnas and Kinderienė, 2015b).

Table 2. Agricultural experts' attitude towards the items related to terrain impact on the generic farming

Items	n	M*	Standard deviation	Variation coefficient (%)
Agricultural development	8	2.59	0.43	17.26
Farming systems use		3.52	0.36	21.81
Land utilization possibilities		3.77	0.38	17.67
Soil erosion		3.26	0.41	15.93

M*: mean according to the Likert Scale (0-5 spectrums).

The results of the survey may serve when planning land use in sloping agricultural areas to avoid land abandonment and on purpose to develop agricultural sector especially in natural handicapped areas. The surveyed experts considered that in Lithuania terrain is a significant factor influencing land-use decisions. As stated by Jarašiūnas and Kinderienė (2015b), a questionnaire study showed that respondents (agricultural experts) of Eastern Lithuania recognized that the impact of terrain factor (compared to soil texture, vegetation, climate and soil type factors) on the potential of soil erosion processes is the highest in the region. In many cases, on slope steepness depends land use systems and the extent of water erosion rate (Bucur et al., 2011; Cerdan et al., 2011; Denas et al., 2006). Above all, soil conservation measures should be planned in hilly agricultural areas based on land use, agro-environmental and topographic conditions.

Conclusions

This paper focused on the analysis of agricultural land natural handicapped by steep slope constraint in order to find out differences and similarities between Lithuanian rural elderships. The analysis showed that agricultural land with steep slope occupies 1.03% of total Lithuanian agricultural land. The means of agricultural land under steep slope by groups ranged from 0.32–9.23%. Classification of elderships into groups provided that the majority of rural elderships (60.12%) fell in Group I, where mean of steep slope is 0.32%. Here were estimated the most favourable conditions to generic farming activities. Very unfavourable conditions, especially for intensive farming, were identified in Group V, where the hilly terrain has a dominantly topographical character. The mean of agricultural land under steep slope was estimated at 9.23%.

Empirical survey results according to the agricultural experts (scientists) perception revealed that factor of terrain has the highest impact on land utilization possibilities, thus, the lowest – on agricultural development, where the mean scores were 3.77 and 2.59, respectively. The surveyed experts considered that terrain is a significant factor influencing land-use decisions on the hilly undulating agricultural landscape in Lithuania.

Consequently, a successful rural development policy in Lithuania require careful planning to combat land abandonment and deagrarization processes and soil conservation programmes are an urgent need in the hilly agricultural areas natural handicapped by steep slope constraint.

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